Effect of preceding crop combination and N fertilization on yield of six oilseed rape cultivars (Brassica napus L.)

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Short title: Effects of previous crop combinations on oil-seed rape cultivars

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Key words: oilseed rape, seed yield, preceding crop combination, cultivars, nitrogen fertilization
Abstract

Informations about the effect of the cropping history on the seed yield of oilseed rape are extremely scarce. In 1992/93 and 1994/95, the effects of different preceding crop combinations (winter barley and winter wheat as preceding crops, oilseed rape and wheat as pre-preceding crops) on the yield of six double low oilseed rape cultivars were examined in a field trial at Hohenschulen Experimental Farm, NW Germany. In addition, eight nitrogen treatments (different amounts and distribution patterns) were tested for its potential to reduce negative effects of the preceding crops.

Following the cropping sequence oilseed rape - wheat oilseed rape yielded only 3.12 t/ha and after oilseed rape - barley 3.43 t/ha compared with 3.77 t/ha following wheat - barley and 3.71 t/ha following wheat - wheat. The number of seeds per m² showed a similar pattern, whereas the thousand seed weight partly compensated for the reduced seed number. It was highest if oilseed rape was grown two years ago. The cultivars differed significantly in their yield potential. Express (3.79 t/ha) yielded 0.6 t/ha more than Falcon (3.18 t/ha). Increasing amounts of fertilizer-N (80 to 200 kg N/ha) increased the seed yield from 3.21 t/ha up to 3.84 t/ha. Changes in the distribution pattern within one fertilizer amount had no effect on seed yield. Also, no interaction between preceding crop combination and the different cultivars or N treatments occurred. It is concluded, that crop management can not totally eliminate the negative effects of an unfavourable cropping history on seed yield of oilseed rape.

Introduction

In crop rotations oilseed rape is used as a favourable preceding crop to winter wheat, because wheat after oilseed rape outyields wheat after wheat (e.g. McEven et al. 1989, Christen et al. 1992, Kirkegaard et al. 1994). But little informations are available about the effect of different preceding crop combinations on the yield of oilseed rape itself. Andersson (1990) reported results of 35 field trials in 1983-1988 at 21 sites in Sweden examining the effect of preceding crops on the yield of spring rape and spring turnip rape. In average only relative small differences in seed yield caused by preceding crops (cereals, peas or fallow), but interaction with nitrogen fertilization occurred. Applying 60 kg N/ha lead to the highest yields after peas and fallow, whereas 90 or 120 kg N/ha had the strongest positive effect on oilseed rape yields where the preceding crop was winter wheat. With 120 kg N/ha the differences in yields following different crops were much reduced.

In Denmark during 1983 and 1991 trials were carried out with different intervals between oilseed rape in the crop rotations (Jakobsen and Olsen 1992). Growing rape every 2nd and every 3rd year caused a reduction in yield compared with rape grown for the first time, whereas growing rape every 4th and every 5th year did not reduce yield. Assessment of stem
rot (Sclerotinia sclerotiorum) and dark leaf spot (Alternaria spp.) revealed only low incidences with no relation to the different crop rotation. However, investigations of Seidel et al. (1985) as well as Svensson and Lerenius (1987) showed that the incidence of stem canker (Leptosphaeria maculans) and verticillium wilt (Verticillium dahliae), which can cause large yield losses, increase with a higher proportion of oilseed rape in the crop rotations.

According to a crop rotation trial with different proportions of oilseed rape (from monoculture up to a 5 year rotation) the seed yield of oilseed rape following oilseed rape was reduced by 8 to 10 % compared with oilseed rape after cereals (Christen and Sieling 1995). Only small differences were observed between winter wheat and winter barley as preceding crops. In addition, not only the direct preceding crop, but also oilseed rape grown two years ago decreased the seed yield (Sieling et al. (b)). Increased nitrogen fertilization could not eliminate the effect of the unfavourable cropping history. Since the cultivars differ in its development within the season as well as in its yield structure, an interaction between the cropping history and the cultivar may occur, but no informations are given in the literature.

The objective of this paper was to examine the effects of the preceding crop combination on the yield of six low glucosinolate, low erucic acid cultivars of autumn sown oilseed rape at different N fertilizer treatments.

**Material and Methods**

**Site and weather conditions**

The trial was carried out in 1993 and 1995 on a pseudogleyic sandy loam (Luvisol) at the Hohenschulen Experimental Farm of the University of Kiel, located in the NW of Germany some 15 km west of Kiel (Schleswig-Holstein).

The climate of NW Germany can be described as humid. Total rainfall averages 750 mm annually at the experimental site with c. 400 mm received from April to September, the main growing season, and some 350 mm during October to March (Table 1). In 1992/93 total rainfall was only 20 mm above average, but in 1994/95 it rained 250 mm more than average, especially in late summer and during winter. The mean air temperature was higher in 1994/95, however, the spring month were cooler than 1992/93.

**Treatments**

The factors and the factor levels tested in this field trial are shown in Table 2. Due to practicability the field trial design was a single-replicate split-plot with the preceding crop combination as main plot. The cultivars were planted in strips within the main plots, whereas the mineral N fertilizer treatments were randomized. All six cultivars were of low erucic acid and low glucosinolate content (double low).

The single plot size was 12 x 3 m. After harvest all plots were disc-harrowed, and the seed bed preparation consisted of ploughing and harrowing. Within each year all plots were planted with a seed rate of 3.0 kg/ha on the same date (26.08.1992 and 22.08.1994), regardless of the preceding crop in order to avoid any interactions due to different seed dates.
In September, 40 kg N/ha were applied to ensure a sufficient development before winter. In spring, nitrogen was applied as a split-dressing at the start of spring growth and at the start of stem elongation (calcium ammonium nitrate with 27 % N). To avoid sulphur deficiency, 50 kg S/ha as magnesium sulphate was given at the end of March/begin of April. At harvest, an area of 9 m$^2$ was harvested by combine and yield was standardized to t/ha based on 9 % moisture. The thousand seed weight was measured, the number of seeds per m$^2$ was calculated.

**Results**

Despite the differences in the seasonal weather, interactions between the harvest years and the treatments on the seed yield were not statistically significant and therefore only average figures over the years are presented. If winter wheat was grown two years before, the yield of oilseed rape was the similar after the direct preceding crops wheat or barley (Table 3). However, growing oilseed rape after only one break crop reduced the seed yield significantly. The extent of losses was strongly affected by the preceding crop. After the cropping sequence oilseed rape - wheat (R-W) only 3.12 t/ha and after oilseed rape - barley (R-B) 3.43 t/ha were observed compared with 3.77 t/ha following wheat - barley (W-B) and 3.71 t/ha following wheat - wheat (W-W). The number of seeds per m$^2$ showed a similar pattern, whereas the thousand seed weight partly compensated for the reduced seed number. It was highest if oilseed rape was grown two years ago.

The cultivars differed significantly in its yield potential (Table 4). Express (3.79 t/ha) yielded 0.6 t/ha more than Falcon (3.18 t/ha). Although no significant interaction between the cultivars and the preceding crop combination could be observed, some cultivars (e.g. Zeus) seemed to be more suitable to be grown after only a one year break than other (e.g. Ramses, Wotan). Comparing the effects of the directly preceding crops barley and wheat following oilseed rape (R-B, R-W), all cultivars yielded c. 0.4 t/ha less when following wheat, except in Zeus and Ramses which showed only negligible losses.

Averaged over all other treatments, increasing amounts of fertilizer-N increased the seed yield from 3.21 t/ha up to 3.84 t/ha (Table 5). Varying the distribution pattern within one amount had no effect. The lowest yields occurred after oilseed rape - wheat (R-W) when only 80 kg N/ha were applied. Significant interactions between N fertilization and the preceding crop combination or the cultivar did not occur. However, regarding again the seed yields of oilseed rape after oilseed rape - barley (R-B) and after oilseed rape - wheat (R-W), in some cases the timing of N application was important. Following wheat, applying the amount of 160 kg N/ha as 40/120 kg N/ha instead of 80/80 kg N/ha, increased seed yield by 0.4 t/ha, whereas following barley the reverse was observed. After barley, the first dressing should be increased in the 80 kg N/ha and 200 kg N/ha treatment.
Discussion

The seed yield of oilseed rape can be reduced by an unfavourable preceding crop (Christen and Sieling 1995). The relative yield losses of oilseed rape following oilseed rape instead of oilseed rape following barley was similar to the response of wheat grown after different preceding crops (Christen et al. 1992). In this study the preceding crop to oilseed rape was either winter barley or winter wheat, which did not affect the yield of the following oilseed rape, when grown after wheat (W-W or W-B). Difference between wheat and barley as preceding crops only occured, when they were used as a one year break crop after oilseed rape (R-W or R-B). Growing oilseed rape two years ago on the same plot reduced seed yield by 0.34 t/ha if following barley, and by 0.59 t/ha if following wheat. Therefore, not only the direct preceding crop, but also the crop grown two years ago can affect the yield of oilseed rape. Since all oilseed rape was planted at the same date regardless of the preceding crop, differences in planting dates can be excluded as a reason for the observed effects on seed yield.

One possible reason for the yield losses after oilseed rape as a pre-preceding crop could be that residues from the crop grown two years ago on the plot were ploughed back to the soil surface, from which the new crop had been infected (Jacobsen and Olsen 1992). On the other hand, the risk of nitrate leaching is increased after oilseed rape (Davies and Sylvester-Bradley 1995, Sieling et al. (a)). In addition, the yield as well as the N take off by the grain of winter wheat and winter barley following oilseed rape were higher than following wheat. Therefore, the pool of easily mineralizable soil organic matter was depleted and, in combination with the larger crop residues, nitrogen mineralisation during the following spring was lower. This hypothesis is supported by the (not significant) interaction between the preceding crop combination and the N fertilization (Table 5). However, the yield differences between the ‘R-W’ and the ‘W-W’-treatment decreased with increasing amounts of applied nitrogen. This effect could not be observed in oilseed rape following barley, presumably because of the smaller crop residues of barley and of the longer period between the harvest of barley and the planting of oilseed rape.

The interaction between the preceding crop combination and the cultivars were not statistically significant, indicating that the cultivars responded similar to the unfavourable cropping history. However, the yield losses of Zeus, especially when following oilseed rape-wheat, were smaller than of the other cultivars. This result is comparable to similar studies with the test crop wheat using a range of cultivars over six years (Christen and Sieling 1994). The observed yield losses were mostly due to a lower number of seeds per m². Presumably the number of pods per unit area responded so strong, because it is the most variable yield component of oilseed rape (Bilsborrow et al. 1993). Though the thousand seed weight is generally thought to be relatively constant, it was affected in the present study depending on the cropping history. Due to the larger number of plants the number of branches per plant and the number of pods per branch decreased, and in consequence the thousand seed weight.
increased (Table 3). It could be argued, that this might have been caused by a higher number of the number of volunteers when oilseed rape was grown two years ago.

The seed yield of oilseed rape decreased not only when the preceding crop, but also when the crop grown two years ago on the same plot was unfavourable (e.g. oilseed rape). Since no interaction with the cultivar or the nitrogen fertilization occurred, it must concluded, that it is not possible to absolutely eliminate the negative effects of an unfavourable cropping history by the crop management.

References


Table 1: Monthly rainfall (mm) and mean air temperature (°C) at Hohenschulen, Germany

<table>
<thead>
<tr>
<th></th>
<th>Mean air temperature (°C)</th>
<th>Total rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>17.2</td>
<td>17.3</td>
</tr>
<tr>
<td>September</td>
<td>13.6</td>
<td>13.1</td>
</tr>
<tr>
<td>October</td>
<td>6.8</td>
<td>7.8</td>
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<tr>
<td>November</td>
<td>5.4</td>
<td>7.0</td>
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<tr>
<td>December</td>
<td>2.8</td>
<td>4.2</td>
</tr>
<tr>
<td>January</td>
<td>2.8</td>
<td>1.1</td>
</tr>
<tr>
<td>February</td>
<td>1.2</td>
<td>4.6</td>
</tr>
<tr>
<td>March</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td>April</td>
<td>8.2</td>
<td>6.8</td>
</tr>
<tr>
<td>May</td>
<td>12.7</td>
<td>10.8</td>
</tr>
<tr>
<td>June</td>
<td>14.6</td>
<td>14.0</td>
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<tr>
<td>July</td>
<td>15.0</td>
<td>18.4</td>
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</table>
Table 2: Factors and factor levels of the field trial

1. Preceding crop combination*

<table>
<thead>
<tr>
<th>Preceding crop</th>
<th>Preceding crop</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 - oilseed rape</td>
<td>winter barley</td>
<td>(R-B)</td>
</tr>
<tr>
<td>P2 - oilseed rape</td>
<td>winter wheat</td>
<td>(R-W)</td>
</tr>
<tr>
<td>P3 - winter wheat</td>
<td>winter barley</td>
<td>(W-B)</td>
</tr>
<tr>
<td>P4 - winter wheat</td>
<td>winter wheat</td>
<td>(W-W)</td>
</tr>
</tbody>
</table>

2. Cultivars

C1 - Bristol
C2 - Express
C3 - Falcon
C4 - Ramses
C5 - Wotan
C6 - Zeus

3. Amount and application time of the mineral N fertilizer (kg N/ha)

<table>
<thead>
<tr>
<th>Date</th>
<th>Beginning of growth</th>
<th>Stem elongation</th>
<th>Σ</th>
</tr>
</thead>
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<tr>
<td>N1</td>
<td>40</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>N2</td>
<td>80</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>N3</td>
<td>40</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>N4</td>
<td>80</td>
<td>40</td>
<td>120</td>
</tr>
<tr>
<td>N5</td>
<td>80</td>
<td>80</td>
<td>160</td>
</tr>
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<td>N6</td>
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<td>120</td>
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<td>N7</td>
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<tr>
<td>N8</td>
<td>200</td>
<td>0</td>
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* - Winter wheat was grown the season before the trail started
Table 3: Effect of the preceding crop combination on yield (t/ha), thousand seed weight (g) and numbers of seeds/m² of oilseed rape (Hohenschulen, Germany, 1993 and 1995)

<table>
<thead>
<tr>
<th>Preceding crop combination</th>
<th>Seed yield (t/ha)</th>
<th>Thousand seed weight (g)</th>
<th>Number of seed per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseed rape - winter barley</td>
<td>3.43&lt;sup&gt;b*&lt;/sup&gt;</td>
<td>4.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69460&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oilseed rape - winter wheat</td>
<td>3.12&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.93&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63640&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Winter wheat - winter barley</td>
<td>3.77&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>79990&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Winter wheat - winter wheat</td>
<td>3.71&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.71&lt;sup&gt;b&lt;/sup&gt;</td>
<td>79450&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* - Means followed by the same letter are not significantly different at P=0.05.
Table 4: Effect of the preceding crop combination on yield (t/ha) of six oilseed rape varieties
(Hohenschulen, Germany, 1993 and 1995)

<table>
<thead>
<tr>
<th>Preceding crop combination</th>
<th>rape-barley</th>
<th>rape-wheat</th>
<th>wheat-barley</th>
<th>wheat-wheat</th>
<th>∅</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol</td>
<td>3.48</td>
<td>3.06</td>
<td>3.65</td>
<td>3.68</td>
<td>3.47b*</td>
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<tr>
<td>Express</td>
<td>3.76</td>
<td>3.31</td>
<td>3.95</td>
<td>4.14</td>
<td>3.79a</td>
</tr>
<tr>
<td>Falcon</td>
<td>3.22</td>
<td>2.81</td>
<td>3.49</td>
<td>3.21</td>
<td>3.18c</td>
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<tr>
<td>Ramses</td>
<td>3.16</td>
<td>3.10</td>
<td>3.95</td>
<td>3.74</td>
<td>3.49b</td>
</tr>
<tr>
<td>Wotan</td>
<td>3.42</td>
<td>2.95</td>
<td>3.83</td>
<td>3.56</td>
<td>3.44b</td>
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<tr>
<td>Zeus</td>
<td>3.53</td>
<td>3.51</td>
<td>3.76</td>
<td>3.95</td>
<td>3.69a</td>
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</table>

* - Means followed by the same letter are not significantly different at P=0.05.
Table 5: Interaction between the preceding crop combination and N-fertilization on yield (t/ha) of oilseed rape (Hohenschulen, Germany, 1993 and 1995)

<table>
<thead>
<tr>
<th>N fertilizer</th>
<th>Preceding crop combination</th>
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<th></th>
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<tr>
<td></td>
<td>rape-barley</td>
<td>rape-wheat</td>
<td>wheat-barley</td>
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<tr>
<td>40/40</td>
<td>3.09</td>
<td>2.82</td>
<td>3.49</td>
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<td>3.21&lt;sup&gt;*&lt;/sup&gt;</td>
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<tr>
<td>80/0</td>
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<td>3.51</td>
<td>3.33&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>40/80</td>
<td>3.38</td>
<td>2.93</td>
<td>3.55</td>
<td>3.76</td>
<td>3.41&lt;sup&gt;bc&lt;/sup&gt;</td>
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<tr>
<td>80/40</td>
<td>3.31</td>
<td>2.93</td>
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<td>3.69</td>
<td>3.41&lt;sup&gt;bc&lt;/sup&gt;</td>
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<tr>
<td>80/80</td>
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<td>3.77</td>
<td>3.88</td>
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<td>40/120</td>
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<td>3.55&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>120/80</td>
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* - Means followed by the same letter are not significantly different at P=0.05.