Contamination of Edible Double-Low Oilseed Rape Crops via Pollen Transfer from High Erucic Cultivars

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Abstract: Contamination of double-low oilseed crops with pollen from high erucic varieties grown primarily on set-aside land may result in erucic acid concentrations above 2% resulting in its rejection as a double-low edible oilseed. An analysis of cross contamination between high and low erucic acid crops was carried out in field trials at Cockle Park, and Purley Farm, Essex in the 1992–1993 and 1993–1994 seasons. Contamination was generally low and at random across the test areas. This random fluctuations in erucic acid concentrations appeared to be due to insect activity rather than wind mediated pollen transfer. Roto-rod traps used at Cockle Park to measure pollen flow downwind from isolated blocks of oilseed rape showed that in both seasons a rapid exponential decline in pollen concentration occurred with distance from the source. Results presented in this study would suggest that contamination between edible and high erucic crops does not present a major problem under field scale cultivation.

INTRODUCTION

New opportunities have arisen for the production of high erucic oilseed rape with the developments in industrial uses of rape oil and the EU’s set-aside policy for industrial crops. EU financial support to growers for the production of rapeseed for human consumption is linked to the harvested seed containing less than 2% erucic acid. The introduction of high erucic rapeseed into arable rotations presents potential problems for the low erucic edible crop through pollen contamination. Pollen contamination between high and low erucic acid crops can occur either through the direct transfer of pollen from one crop to the other (wind or insect mediated) or from the seed of high erucic crops persisting in the soil to become volunteers in subsequent low erucic acid edible crops. Both contaminant sources could increase the erucic acid concentration of the edible crop above the acceptable EU limit resulting in severe financial penalties to producers. In view of the potential problems which may arise as a result of pollen transfer, an isolation zone of 100 m for the growth of high erucic crops neighbouring double-low edible oilseed crops was imposed by MAFF for the 1994 harvest with a reduction to 50 m for crops harvested in 1995 (MAFF pers comm).

Although oilseed rape is largely self-fertile it seems that an external agent is required for the efficient transfer of pollen from anthers to stigma (Williams 1985). The large concentrations of oilseed rape pollen found in the air above oilseed rape crops (Williams 1984), together with the fact that oilseed rape pollen grains are almost spherical (about 25 μm in diameter) and of a
comparable size to fungal spores many of which are dispersed by wind (Gregory 1974) shows the potential for wind mediated cross-pollination. The movement of pollen by wind has the potential for increasing both self- and cross-pollination as plants grown in the glasshouse were shown to set more pods with more seeds per pod when shaken as opposed to auto-pollination in still air in the absence of insects (Williams 1978). Insects, especially bees, are undoubtedly attracted to rape crops and transfer pollen between plants (Williams 1985).

The aim of this study was to investigate the contamination of double-low oilseed rape by the transfer of pollen from high erucic plants, by means of pollen traps and detailed erucic acid analysis of the resulting seed of the double-low receptor plants. The use of erucic acid concentration as a marker enables the role of wind and insect mediated pollen transfer to be studied in relation to the potential problems which may arise.

**EXPERIMENTAL**

Isolated field trials were established at Cockle Park, Northumberland and Purley Farm, Essex in the 1992–1993 and 1993–1994 seasons to quantify the effects of pollen transfer from a high erucic cultivar on the erucic acid content of seed harvested from the low erucic crop. The experimental design consisted of a square made up of four quadrats, each 10 m by 10 m of a double-low variety intercepted by two 3 m wide central strips of a high erucic variety. At Cockle Park, trials in both seasons were established in the autumn with the double-low variety Falcon and the high erucic variety Martina. At Purley Farm, the trials were a combination of the spring sown double-low variety Global and a high erucic breeding line JJK 9501. Standard cultural procedures were used in the management of all trials.

At Cockle Park in both seasons, the four low erucic acid blocks were subdivided into one square metre sampling areas, and following hand harvest a representative sample of seed was taken from a subsample of 20 plants. Sampling at Cockle Park in the 1992–1993 season excluded a 1 m area between the two cultivars which was removed to avoid any contamination through cross-pollination with indigenous Brassica spp. At Purley Farm, the trials were a combination of the spring sown double-low variety Global and a high erucic breeding line JJK 9501. Standard cultural procedures were used in the management of all trials.

The 1992–1993 Cockle Park trial together with an isolated block of the double-low variety Falcon (70 m × 20 m) established in the 1993–1994 season, were used to assess distances travelled by oilseed rape pollen. During peak flowering, roto-rod traps (McCartney and Lacey 1991) were positioned at crop height at distances of 2, 5, 10 and either 20, 40 or 50 m from the edge of the crop. Roto-rod traps were always assembled downwind and were in operation between 10:00 and 15:00 h for a maximum of 5 h depending upon weather conditions. Roto-rod traps consist of a pair of vertical arms which are rotated at high speed (about 3500 rpm which is equivalent to sampling air at 160 litre min⁻¹) by a small 6 V electric motor. Roto-rod traps capture airborne particles such as pollen grains by impacting them on rapidly rotating arms containing a removable sticky film. Following exposure, the trapping surfaces were removed, mounted on microscope slides, and the pollen grains counted by scanning 20 fields each 161 µm wide across the width of each arm of the trap, and the counts converted into number of pollen grains per m³ of air (McCartney et al 1986). The concentration of pollen grains in the air was calculated from the pollen deposit on the arms of the roto-rods knowing the dimension of the arms, the speed of rotation and the duration of sampling (McCartney and Lacey 1991). A local meteorological station sited within 1 km of both trials provided hourly data of changes in wind speed and direction.

**RESULTS AND DISCUSSION**

The movement of oilseed rape pollen by wind or insects has far reaching implications beyond the contamination of edible oilseed crops by high erucic cultivars grown for industrial uses. Considerable focus has been directed at the implications from the potential release of transgenic oilseed rape plants into the environment and cross-pollination with indigenous Brassica spp. Causal associations have also been made in the popular press in recent years linking increases in pollen levels in the atmosphere, where oilseed rape pollen may add significantly to the atmospheric pollen load in the spring and early summer months, to increasing incidences of hay-fever and asthma attacks.

Results from the pollen transfer studies at Cockle Park in the 1992–1993 and 1993–1994 seasons are presented in Fig 1(a) and 1(b). Erucic acid concentrations ranged from 0 to 6.3% and from 0 to 9.9% in respective seasons. Data show that the levels of contamination were generally low and appeared at random throughout the double low blocks. Of the 324 blocks sampled in the 1992–1993 season 3.7% had erucic acid concentrations of 2% and above. In the 1993–1994 season, 13 (4%) of the 324 blocks sampled had erucic acid concentrations of 2% and above but all of these blocks were located adjacent to the high erucic cultivar. The high erucic acid concentrations of blocks adjacent to the high erucic cultivar could be attributed to pollen transfer through plant contact. At Purley Farm, erucic acid concentrations were higher in 1992–1993 ranging from 0 to 4.3%
compared to 0 to 1.4% in 1993–1994 (Fig 2(a) and (b), respectively).

The random fluctuations in erucic acid concentrations in these trials suggest that insect activity is the major source of pollen contamination. If pollen movement was largely mediated by wind then concentration gradients would have been in evidence in the four blocks of double-low oilseed rape. The concentration gradients would have been greatest adjacent to the high erucic source and declined with distance from the
Fig 2. Erucic acid content (%) of spring grown, double low variety Global grown in close proximity to the high erucic variety Industry at Purley Farm, Essex. (a) 1992–1993, (b) 1993–1994.
source. In both seasons at Cockett Park there was no obvious relationship between erucic acid concentration and the prevailing wind direction which was NNE and NE in the 1992–1993 and the 1993–1994 seasons, respectively. Similar conclusions were drawn by Scheffler et al (1993) from a study of herbicide resistance with transgenic plants. In this trial the spring cultivar Westar was planted in a 1.1 ha field trial with transgenic plants in a 9 m diameter circle at the centre surrounded by non-transgenic plants to a distance of at least 47 m in all directions. Detectable pollen movement decreased rapidly over the first 12 m and became negligible at 47 m, irrespective of wind direction.

Pollen concentrations, as measured by roto-rod traps differed greatly from day to day in both seasons. Wind speed accounted for 74% of the daily variation in pollen concentration measured at 2 m from the source in the 1992–1993 seasons. Pollen concentrations recorded in the 1992–1993 season decreased rapidly with distance downwind of the source (Table 1). When averaged across all sampling dates the concentration of pollen measured at 5 m and 10 m had decreased to 62.3 and 32.7% of that measured at 2 m from the source. Even on very windy days (e.g. 18 May) when hourly average wind speed during the sampling period was 3–6.3 m s\(^{-1}\), results did not deviate from the mean and 75% of the pollen measured at 2 m had disappeared at a distance of 5 m from the source. Although daily variation in pollen concentrations was again evident in the 1993–1994 season (Table 2) recorded concentrations were similar to those recorded during the previous season. Pollen concentrations again decreased rapidly with distance downwind of the block so that 24 and 48% of the pollen measured at 2 m had disappeared at distances of 5 and 10 m from the source. McCartney and Lacey (1991) found that pollen concentrations from a 20 × 20 m isolated block of spring oilseed rape were reduced by 90% at a distance of 10 m downwind of the edge of the block. The same authors theoretically studied the potential for pollen dispersal from a field using a dispersal model and predicted that pollen concentrations halved between 1 and 10 m. The data presented here support the views of Scheffler et al (1993) and McCartney and Lacey (1991) where small scale field trials have been used to study pollen dispersal. However, Timmons et al (1995) have shown that oilseed rape pollen has a greater capacity for long-range dispersal when larger sources of pollen are studied.

The low levels of erucic acid in the contamination trials together with data from the roto-rod trap experiments and from the monitoring of adjacent high erucic and edible oilseed crops (unpublished data) suggest that direct pollen contamination of edible double-low crops by high erucic cultivars grown on set-aside land is not a major problem, especially on a field scale. Indirect contamination from volunteer high erucic crops may be a greater problem, but one which farmers are well aware of (Ramans 1995) and forms the basis of further study.

**TABLE 2**

Pollen grain concentrations per m\(^3\) of air sampled measured downwind of a 70 × 20 m isolated block of autumn sown oilseed rape in the 1993–1994 season

<table>
<thead>
<tr>
<th>Date</th>
<th>Distance (m)</th>
<th>Average wind speed (m s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>26 May 1994</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>31 May 1994</td>
<td>72</td>
<td>65</td>
</tr>
<tr>
<td>1 June 1994</td>
<td>125</td>
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<tr>
<td>6 June 1994</td>
<td>862</td>
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<tr>
<td>7 June 1994</td>
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<td>332</td>
</tr>
<tr>
<td>8 June 1994</td>
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<td>57</td>
</tr>
<tr>
<td>9 June 1994</td>
<td>159</td>
<td>113</td>
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<td>6</td>
</tr>
<tr>
<td>13 June 1994</td>
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</tr>
<tr>
<td>14 June 1994</td>
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<tr>
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<td>361</td>
</tr>
<tr>
<td>Average</td>
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<td>171</td>
</tr>
<tr>
<td>Percent</td>
<td>76-0</td>
<td>52-0</td>
</tr>
</tbody>
</table>

* Distance sampled was 40 m.

**REFERENCES**


