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Abstract and Summary

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Growing 'high oleic low linolenic' (HOLL) oilseed rape for specialised markets

by

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ABSTRACT

The rapeseed oils from HOLL (high oleic and low linolenic) varieties are more suited to some food uses, notably frying oil, and also possibly for biolubricants.

Splendor, the first commercial winter HOLL oilseed rape variety, was sown on six sites in major arable areas in England and Scotland over three years.

Site and season were the most likely causes of variation in fatty acid profiles. The lowest content of the key fatty acid, oleic acid, was consistently found at the Scottish site. Input management had no or little impact on fatty acid profiles. Harvesting a crop before it was completely ripe may result in lower oleic acid content. Commercially, delaying harvest results in a less desirable fatty acid profile.

Oil from Splendor was not directly suitable for the key range of biolubricants and further increases in oleic acid content are required. The desired scale of these increases may only be possible with genetic modification.

Volunteers of previous more conventional crops had minimal effect on the fatty acid profile after a three year break from the previous oilseed rape where cultivations were carried out after harvest to minimise the dormancy of shed seed. This, along with the fact that the ingress of pollen from neighbouring fields has little or no impact on the fatty acid profile of the seed, suggests an opportunity for the UK to grow a significant area of HOLL varieties.

The results show that responses to fungicides are not assured and their use needs to be considered on a field-by-field basis. A malate test early in the season did not reliably predict the sulphur requirement of the current crop at the time S needs to be applied.

SUMMARY

INTRODUCTION

All edible oils and fats consist of triglycerides with a variety of fatty acids, which differ in chain-length (number of carbon atoms in molecule), degree of saturation (number of double bonds in carbon chain), position of double bonds within the carbon chain and geometry of each double bond (*cis* and *trans* isomers). Unsaturated fatty acids, which contain one or more double bonds between adjacent carbon atoms, are the primary cause of the development of oxidative fat decomposition during storage and high temperature cooking, because the double bonds are easily attacked by oxygen.

Oleic acid (C18:1) is the most abundant mono-unsaturated fatty acid (one double bond only) in all common edible oils. Compared with polyunsaturated fatty acids (two or more double bonds) oleic acid is more stable towards oxidation both at ambient storage temperatures and at the high temperatures which prevail when used as a biolubricant or during frying of food. Therefore, oils with high amounts of oleic acid are slower in developing oxidative rancidity during shelf-life or oxidative decomposition during frying than those oils that contain high amounts of polyunsaturated fatty acids.

Winter oilseed rape can be produced competitively in the UK. It has a desirable fatty acid profile when compared to other sources of vegetable oils. Plant breeders have been developing new conventionally bred varieties of winter and spring oilseed rape, appropriate for production in North Europe, that more closely meet the demands of both the food and non-food market. These varieties may be more suitable for the biolubricant and food markets, having a significantly increased mono-unsaturated acid profile (oleic acid) and a reduced content of less desirable polyunsaturated fatty acids (linolenic and linoleic) for these uses. Such HOLL (high oleic and low linolenic) varieties should help to expand the market for oilseed rape oil and protect the home market from imports from other countries that may also have access to such improvements.

This project used the first commercially available HOLL cultivar Splendor to test over three years with the overall aim:

To evaluate and promote the production and value of winter oilseed rape varieties that have been conventionally bred to meet as closely as possible the requirements for biolubricants and other specific uses.

The specific objectives were:

1. To establish a series of six trials/year in order to investigate the impact of agronomic practice, soil type and location on the yield, oil content and fatty acid profile of the varieties that more closely meet the requirements of the food and biolubricant markets. This will help to evaluate and ensure consistency of oil quality in the UK.
2. To establish a committee of stakeholders to steer the field trials, to co-ordinate the analysis and testing of samples and resulting oils produced by the field trials and to help to ensure that the potential for these new varieties is fully exploited.
3. To develop approaches, such as demonstration projects, to increase demand for the products of the new varieties.

The project was steered by a small committee established under the auspices of the National Non Food Crops Centre (NNFCC). This comprised producers (*via* the HGCA), plant breeders, research agronomists and major end users.

METHODS

The treatments (all receiving 30 kg/ha sulphur, except those specifically excluding this nutrient) were determined after a review of the possible impact of location and crop management on oil content and fatty acid profile of oilseed rape. They represented extremes of the major crop inputs, with a nitrogen dose of 190 kg/ha being around the recommended optimum nitrogen application. The autumn/winter application of a fungicide was for the control of phoma stem canker and/or light leaf spot. The full fungicide programme was the autumn/winter application followed by to further applications in the spring.

A total of six sites were sown for three years near Aberdeen, Lincolnshire, Bedfordshire, Norfolk, Gloucestershire and Kent or Wiltshire. Yields were recorded and the plot centres sampled by hand at harvest. These samples were analysed by Monsanto Laboratories for their fatty acid profiles.

RESULTS

Overall yields were low, particularly for the low nitrogen application rate and the responses to fungicides and sulphur occurred in only a few trials (Table 1).

N (kg/ha)	Fungicide	S (kg/ha)	2005 yield (t/ha)	2006 yield (t/ha)	2007 Yield (t/ha)
26	None	30	2.07	2.49	2.17
26	Winter	30	2.01	2.59	2.10
26	Full	30	2.15	2.64	2.28
190	None	30	3.07	3.34	2.78
190	Winter	30	3.20	3.38	2.84
190	Full	30	3.23	3.59	3.09
240	None	30	3.22	3.32	2.85
240	Winter	30	3.27	3.40	2.90
240	Full	30	3.34	3.68	3.10
190	None	-	-	3.04	2.39
190	Winter	-	-	3.03	2.55
190	Full	-	3.13	3.39	2.77

Table 1. Mean yield results from six sites, harvests 2005, 2006, 2007 (t/ha at 9% moisture)

Oil content of the samples was reduced by the application of nitrogen when the chosen 'optimum' dose of 190 kg/ha was compared to a minimal nitrogen dose sufficient to apply the required amount of sulphur in ammonium sulphate. There was no or very limited impact of input management on the fatty acid profile of Splendor in individual trials or overall (Table 2).

N	Fungicide	S	Oil 9%	C16 Palmitic	C18 Stearic	C18:1 Oleic	C18:2 Linoleic	C18:3 Linolenic
26	None	30	45.17	4.03	2.01	78.29	12.47	3.22
26	Winter	30	45.24	3.99	2.01	78.38	12.38	3.23
26	Full	30	45.64	3.97	2.04	78.62	12.21	3.17
190	None	30	43.25	3.95	1.96	78.25	12.67	3.18
190	Winter	30	43.46	3.97	1.96	78.16	12.66	3.25
190	Full	30	43.45	3.97	1.96	78.12	12.72	3.23
240	None	30	42.94	3.95	1.94	78.04	12.83	3.24
240	Winter	30	42.85	3.99	1.95	77.95	12.82	3.30
240	Full	30	43.15	3.93	2.01	78.12	12.68	3.28
190	Full	-	43.86	4.09	1.97	78.01	12.67	3.28

Table 2. Percentage oil in the seed at 9% dry matter and % fatty acids in oil, harvest 2005 (five sites), harvest 2006 (five sites) and harvest 2007 (six sites)

However, there was an impact of site and season on fatty acid profiles with the Scottish site having the lowest oleic acid content in all three years (Appendix B). In three trials samples were taken a week before harvest to simulate an early harvest. In one of these the oleic acid content was consistently lower than in samples taken on the day of harvest.

DISCUSSION

Within sites the fatty acid profiles were remarkable consistent between input treatments. However, there was more variation between sites with the site in Scotland having low values of oleic acid in all three harvest years. In addition, the linoleic acid levels at the Scottish site sometimes reached the unacceptable levels for frying oils. The likely explanation is that the cooler minimum temperatures during early pod fill at this location which increases the activity of oleate desaturase, the enzyme that catalyzes the conversion of oleic to linoleic acid.

Date of harvest may be an important factor. Three trials were sampled eight to eleven days before harvest and one of the sites had lower oleic acid content and higher levels

of the less desirable linoleic and linolenic acid in the 'early' harvest samples when compared to the 'timely' harvest samples. Commercial experience with Splendor suggests that the oleic acid content also reduces where harvest is delayed.

Tests by Fuchs Lubricants in Appendix C suggest that the oleic acid content of the oil needs to increase to above 90% for it to be used directly in a range of biolubricants. This may not be achieved by conventional breeding and is more possible with genetic modification. However, these levels of oleic acid may make the oil not suitable for frying because of lack of flavour.

All the trials were grown after at least a three year break from oilseed rape. Volunteers of more conventional varieties could reduce the levels of oleic acid in the sample but there was only a suggestion of this in the small hand samples in three of the 528 plots analysed. These were treated as missing plots. This demonstrates that sensible volunteer management after harvest and at least three years break from oilseed rape is sufficient basis to provide HOLL varieties. It is accepted that incoming pollen is unlikely to affect the oil quality but may affect the oil quality of any crop grown from the seed during multiplication.

The trials also tested the main input management options for one variety over three seasons. The results clearly demonstrate that responses to fungicides are not assured for this variety and their use needs to be considered on a field by field basis. The results also demonstrate that early season malate testing is not sufficiently reliable to use as a precise guide to sulphur application to the current crop at a time before it needs to be applied. A more comprehensive assessment of sulphur supply is required that also takes into account soil type, previous experience on the farm, rainfall and recent use of sulphur and manures.