EVALUATION OF *CAMELINA SATIVA* AS AN ALTERNATIVE OILSEED CROP

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SUMMARY

The increasing awareness of the value of oils with a low content of saturated fat and a high proportion of OMEGA-3 to OMEGA-6 type fatty acids has focused attention on finding commercial sources of such oils. Camelina has been identified as a useful plant source. Camelina (*Camelina sativa*), a member of the mustard family, is an oilseed plant with both summer annual and winter hardy biennial forms.

A series of field trials were conducted over a three-year period, as part of an EU-sponsored research programme across four countries. The objective was to establish the potential of winter hardy varieties of camelina, grown without the use of herbicides, fungicides or pesticides, as a commercial source of a high quality oil for human consumption.

The study has shown that winter camelina cannot produce an economic yield in Ireland where the use of herbicides and fungicides are excluded. The relatively mild wet winters encountered in Ireland result in very high levels of weed competition. The resultant dense, wet canopy encourages high levels of disease infection and creates conditions where excessive lodging occurs early in the season. The result is difficult harvesting conditions and low yields. The herbicide Trifluralin (Treflan) incorporated into the seedbed before sowing was identified as an effective herbicide for camelina. However, the full potential of the winter crop, using herbicides and an effective disease control programme, remains to be established.

INTRODUCTION

Camelina (*Camelina sativa*), popularly known as False Flax or Gold of Pleasure, is a very old, cultivated oilseed bearing species (Zubr, J. 1998). Its history goes back to the Bronze Age (Putnam *et al.*, 1993). Although widely grown up to the early 1940's commercial production ceased with the introduction of oilseed rape. The lower cost of hydrogenating rape oil and the lack of knowledge on the value of oils containing a high percentage of polyunsaturated fatty acids were the main causes of the lack of interest in Camelina.

The revival of interest in camelina oil now is due to its high linolenic acid content (38%) (Zubr, J. 1992). Linolenic is one of the OMEGA-3 fatty acids which are only found in linseed and edible fish oils (Crowley, J.G. and Fröhlich, A. 1998). The objectives of the present work were **(i) to establish the yield potential of winter hardy biennial varieties of camelina sown in the autumn/winter period** and (**ii) to study the effect of the agronomic variables, date of sowing, N rate, seed rate and herbicide use on crop performance**.

METHODS

Two field trials were sown at two sites with contrasting soil types in each of the three years 1996 to 1998. The soil types are classified as light textured sandy loam, derived from limestone gravel, with a pH of 7.0 at Oak Park and a deep free-draining grey podzolic derived from boulder clay with a loamy top soil and a clay loam to clay subsoil at Knockbeg.

The trials, in which seed rate, nitrogen level, time of sowing, sulphur and weed control were investigated, were sown in autumn/winter following a wheat crop. Maintenance phosphate and potash were applied according to soil test and 30 kg/ha N applied to the seedbed before sowing. The remainder of the required N, to meet the treatment specifications, was applied in February. To assess weed competition two parameters were measured, (i) weed counts were carried out in early spring and (ii) the **% weed DM** content of the crop was determined just before harvest. To generate the data required the total crop biomass was sampled just before harvest. The samples were then separated into crop and weed fractions. These fractions were dried separately and the total DM yield and the weed DM yield calculated. The level of weed competition was then expressed as the **% weed DM**, i.e. the % of the total biomass DM present as weed DM. Harvesting was carried out with a standard plot combine fitted with a 3 mm screen, directly without desiccation. At harvest a seed sample was taken from each plot and dried at 100^0C. Yields are quoted at 9% moisture content (mc).

RESULTS AND DISCUSSION

Growth patterns

No establishment problems were encountered provided the seed was sown into a fine seedbed, even where drilling was carried out in early December. Establishment was achieved within two weeks irrespective of drilling date. However, once the seedlings reached the four to six leaf stage there was little or no further growth until the following April. This was significant in terms of weed competition, as the over-wintering crop was vulnerable to weed establishment and development during this period. There was no winter damage of seedling diseases recorded in any year. Flowering began in early May and was generally completed by mid-June. The crop matured from mid-July to mid-August, depending on sowing date (Table 1).

Table 1: Growth and development patterns of winter camelina
(Average over 3 years 1996 – 1998)

Sowing date	Start of flowering	Date of maturity
25 September	10 May	20 July
15 October	20 May	2 August
10 December	1 June	18 August

The crop matures and dries down without the use of desiccants and is easily harvested with minor adjustments to the combine harvester. Because of the small seed size (TGW: 0.8 to 2.0 g) the use of a 3 mm screen helped to produce a clean sample.

Weed competition

Although spring camelina can be successfully grown without herbicides (Crowley, J.G. 1997), weed competition is much more problematic in the winter crop. For each of the three sowing dates weed seedlings/m^2 in spring and the weed content of the biomass at harvest are presented in Table 2.

Table 2: The effect of sowing date on weed number/m^2 and the % weed DM of autumn-sown camelina

Sowing date	1996		1997		1998	
	Weed no./m^2	% weed DM	Weed no./m^2	% weed DM	Weed no./m^2	% weed DM
25 Sept	176	38.4	294	54.5	218	27.2
15 Oct	148	22.8	200	6.5	136	33.4
10 Dec	146	27.4	208	26.3	117	19.1

In each of the three years the weed counts recorded in March were very high, in excess of 150 per m^2. Sowing date had no significant effect, although there is a trend towards lower weed numbers as sowing is delayed from September to December. More significantly, the crop canopy at harvest contained on average 28.2% weed material on a dry matter basis. This level of weed infestation resulted in reduced yields and very difficult harvesting conditions. As a result of the 1966 experience, where the variation in weed infestation across the trial area completely obliterated any imposed treatment effects, the herbicide trifluralin was used as a standard treatment in subsequent years, except where omitted as a plot treatment.

Trifluralin (Treflan) was very effective in controlling weeds in autumn-sown camelina, reducing the % weed DM at harvest from 29.3% to 3.0% on average over the three years (Table 3).

Table 3: Effect of trifluralin on the level of weed contamination (% weed DM) in autumn-sown camelina (Averaged over three sowing dates)

Herbicide	1996	1997	1998
+ Treflan	4.9	3.4	1.2
-Treflan	29.5	29.1	29.2

A range of herbicides available for use on oilseed rape was tested on winter camelina. Aside from the graminicides fluazifon-P (Fusilade) and propyzamine (Stratos) all the broadleaf herbicides tested caused some crop damage.

Pest and diseases

Over the trial period, *Sclerotinia*, *Botrytis*, *Peronospora* and *Ustilago* were recorded in the crop. Of these only *Botrytis* and *Sclerotinia* caused serious losses, with *Botrytis* the most widespread and damaging. The main factors influencing disease levels were site, levels of nitrogen, sowing date and herbicide use. Overall, the levels of disease infection encountered were very high in each of the three years, reducing the yield potential of winter camelina considerably. A summary of the results is presented in Tables 4 and 5.

Table 4: The effect of nitrogen level and site on the percentage of plants showing disease symptoms (*Sclerotinia* and/or *Botrytis*)

N-level (Kg/ha)	Oak Park			Knockbeg		
	1996	1997	1998	1996	1997	1998
50	1.6	17.0	5.7	17.7	18.6	13.6
80	3.4	28.1	7.2	23.1	31.8	17.5
110	6.0	28.8	5.3	31.4	42.8	30.6
140	11.1	35.2	7.8	39.8	40.5	43.2
Mean	5.5	27.3	6.5	28.0	33.4	26.2

Disease levels were significantly higher at Knockbeg, the more fertile and heavier soil site, in each of the three years. The number of infected plants also tended to increase as the N-level was increased. Over both years and sites *Botrytis* was the sole cause of the disease in 70% of the plants, with *Sclerotinia* also present in the remaining 30%. The time of sowing and the use of trifluralin (Treflan) effects on the number of diseased plants are summarised in Table 5.

Table 5: The effect of sowing date and trifluralin use on the percentage of plants showing disease symptoms

Date of sowing	1996		1997		1998	
	+	-	+	-	+	-
Sept.	26.3	44.7	31.8	49.0	45.5	49.8
Oct.	15.2	23.7	27.3	40.8	35.9	39.0
Dec.	6.1	23.7	14.1	38.2	10.2	14.3

+ = Trifluralin incorporated before sowing **-** = No herbicide used

Delaying sowing until December resulted in a very significant reduction (from 41.2% to 17.8%) in the number of diseased plants and also reduced the severity of the infection. The infection was generally confined to side branches, rather than the main stem as was the case in the earlier-sown crops. An indirect effect of the use of trifluralin was a reduction in the number of plants infected from 35.9% to 23.6% on average over the three years.

Lodging

Lodging, which can reduce yield, was a feature of the winter camelina crops in each of the three years. The severity of lodging was influenced mainly by site, N-level and time of sowing. A summary of the data for nitrogen and site effects are presented in Table 6.

Table 6: The effect of N-level on the degree of lodging (0-9) at two sites in each of three years

N-level Kg/ha	1996		1997		1998	
	K/beg	Oak Park	K/beg	Oak Park	K/beg	Oak Park
80	3.0	0	2.5	1.0	5.1	2.1
110	4.2	1.3	3.4	1.7	7.1	3.2
140	8.2	2.3	6.3	3.5	7.9	4.5

0 = No lodging **9** = Severe lodging

The results were consistent over the three years with lodging increasing with increasing levels of applied nitrogen. The degree of lodging was always much higher on the heavier more fertile site at Knockbeg. Early sowing (September) increased the degree of lodging at both sites (Table 7).

Table 7: The effect of sowing date and site on the degree of lodging (0-9) in winter camelina – 1998

Date of sowing	Site	
	Oak Park	Knockbeg
29 Sept.	5.2	8.3
24 Oct.	1.5	5.5
14 Dec.	0.5	3.7

0 = No lodging **9** = Severe lodging

Seed yield

The highest yield achieved over the period of the project was 2.6 t/ha. This was disappointing, relative to a yield of 2.86 t/ha, achieved with spring-sown camelina (Crowley, J.G. 1998), and well below the average commercial yield of winter oilseed rape at 3.5 to 4.0 t/ha.

The agronomic variables studied were nitrogen, seed rate, date of sowing, herbicide use and sulphur application. The main feature of the results was the negative response to increasing levels of applied nitrogen at the Knockbeg site. At the Oak Park site a positive response was recorded up to 140 kg of nitrogen per hectare (Table 8).

Table 8: The effect of site and nitrogen level on the yield (t/ha @ 9% mc) of autumn-sown camelina

N-level Kg/ha	1997		1998	
	Oak Park	Knockbeg	Oak Park	Knockbeg
50	1.96	2.18	2.13	2.56
80	2.37	2.33	2.37	2.52
110	2.64	2.33	2.56	2.11
140	2.86	2.20	2.84	2.18

At Oak Park a significant positive response is shown in each year, while at Knockbeg a negative response was recorded, particularly in 1998. This contrast, in response to nitrogen input, can only be explained by the higher levels of lodging (Table 6) and higher levels of disease infection (Table 4) encountered at the Knockbeg site. Thousand grain weight (TGW) measurements show a similar trend, with the TGW reduced from 1.28 gm at the 50 kg/ha N-level to 1.11 gm at the 140 kg/ha N-level. These low TGWs contributed to the poor yield performance and the negative response to increased nitrogen application recorded at Knockbeg.

Sowing date and the use of the herbicide trifluralin also had a very significant effect on yield. Over the three years and at each sowing date controlling weed incursion with trifluralin increased seed yield by 26% (Table 9).

Table 9: The effect of sowing date and trifluralin treatment (+ or -) on the yield (t/ha at 9% mc) of winter camelina (three year average)

Sowing date	Trifluralin treatment	
	+	-
Mid-Sept.	2.22	1.51
Mid-Oct.	2.39	1.94
Early Dec.	2.28	2.01

The effect of sowing date was dependent on whether or not weed growth was controlled. In the absence of weed control, delaying sowing until December increased the yield by 33%, on average, over the three years. With good weed control mid-October proved to be the optimum sowing date (Table 9).

CONCLUSIONS

- The trial work carried out shows that the yield potential of winter camelina grown without agro chemicals is in the region of 2.0 t/ha. This is significantly below the 2.5 t/ha achieved with the spring crop and well below that of winter oilseed rape at 3.5 to 4.0 t/ha.

- The highest yields were obtained by sowing into a fine seedbed around mid-October.

- Trifluralin was shown to be an effective and safe herbicide on winter camelina.

- Winter camelina was very susceptible to both *Botrytis* and *Sclerotinia*. Chemical control of these diseases will be necessary if acceptable yields are to be achieved.

- Improved varieties, capable of not lodging before harvest, are required before commercial production can be undertaken.

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