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WINTER OILSEED RAPE: EFFECT OF PARTIAL DEFOLIATION

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ABSTRACT

This study was initiated to determine the physiological basis for yield response from winter oilseed rape caused by partial defoliation as observed by Dr Vaidyanathan of ADAS Cambridge in previous years.

Two existing field experiments were monitored one at ADAS Boxworth (funded by MAFF Policy Division) and one at ADAS Rosemaund (funded by ADAS). Both were replicated randomised block designs. Defoliation was carried out at both sites during January 1991 using a reciprocating blade mower. The plots were sampled at growth stage 8.1 - 8.5. The samples were used to assess total biomass production, harvest index, yield components and distribution within the canopy.

No yield responses were observed. However at ADAS Boxworth there was a significant increase in harvest index in response to defoliation. The increase in harvest index was due to a significant decrease ($p \leq 0.05$)) in vegetative dry matter produced whilst seed production was maintained. Plant number and seed production from the terminal raceme were reduced, but increases in branch number and production from the lower branches resulted in no net change in seed production per unit area.

OBJECTIVES

To determine how early partial defoliation of oilseed rape affects crop growth and dry matter partitioning between the reproductive and vegetative parts of the plant and to show which yield parameters were affected and any change in harvest index.

An understanding of the mechanisms involved is needed to predict which crops are likely to respond positively to defoliation, and under what circumstances the practice may be detrimental.

INTRODUCTION

In MAFF funded experiments sited at ADAS Boxworth in 1989 and 1990, Dr Vaidyanathan (ADAS Cambridge) obtained yield responses of 0.37 t/ha (14%) and 0.35 t/ha (20%) from mid-December to early-January defoliation (GS 1.06-1.08) (R Sylvester-Bradley, 1985) of the winter oilseed rape crop. Defoliation consisted of the partial removal of the older leaves, care being taken to avoid removal of the apical meristem (apex). Dr Vaidyanathan (personal communication) suggested that the yield responses arose from manipulation of the endogenous plant hormone system reducing surplus vegetative growth. However, the mechanism by which this increased yield is gained has not been determined.

At ADAS Rosemaund, the application of experimental triazole plant growth regulators has reduced crop height and vegetative growth but given variable effects on yield. In 1989 and 1990, exceptionally large yield responses of 0.97 t/ha (34%) and 0.68 t/ha (21%) were obtained. It is worth noting that these two seasons were extreme drought years with the highest calculated soil moisture deficits since records started in 1951.

Before such a novel but simple crop management technique is widely adopted, an understanding of the effect on crop growth and development is required. One possible explanation for both effects is that a reduction in early vegetative growth of the crop is producing a higher harvest index. In a dry year, this could also lead to more efficient partitioning of available water into reproductive growth.

MATERIALS AND METHODS

Two existing experiments were used; one MAFF funded experiment at ADAS Boxworth (cv. Lictor) and the other at ADAS Rosemaund (cv. Falcon); for both, the treatments were replicated three times. All crop inputs except PGR and defoliation were as standard farm practice (see Appendix I for full crop diary). Selected treatments were monitored at both sites.

Treatments

Boxworth

1. Nil (Control)
2. Defoliated (9 January)
3. Defoliated (31 January)

Rosemaund

Main plots

1. Nil
2. Experimental ICI triazole growth regulator (GS 3.7)

Sub plots

1. Unmown. Nil (Control)
2. Defoliated (22 January)

The plots were defoliated with a reciprocating blade mower held so as to remove the older leaves but leave the growing point intact (the blade 3 - 6 cms above ground level in a crop 8 - 15 cms high). At Boxworth the crop was at GS 1.07 at both defoliation dates whilst at Rosemaund the crop was at GS 1.08.

An area 0.5 m x 8 rows was taken by careful cutting at ground level with secateurs from each of the selected treatments at GS 8.1-8.5 on 25 July at Boxworth and 30 July at Rosemaund.

The samples were collected by inserting the plants head first into large plastic bags to reduce loss of seed between field and laboratory.

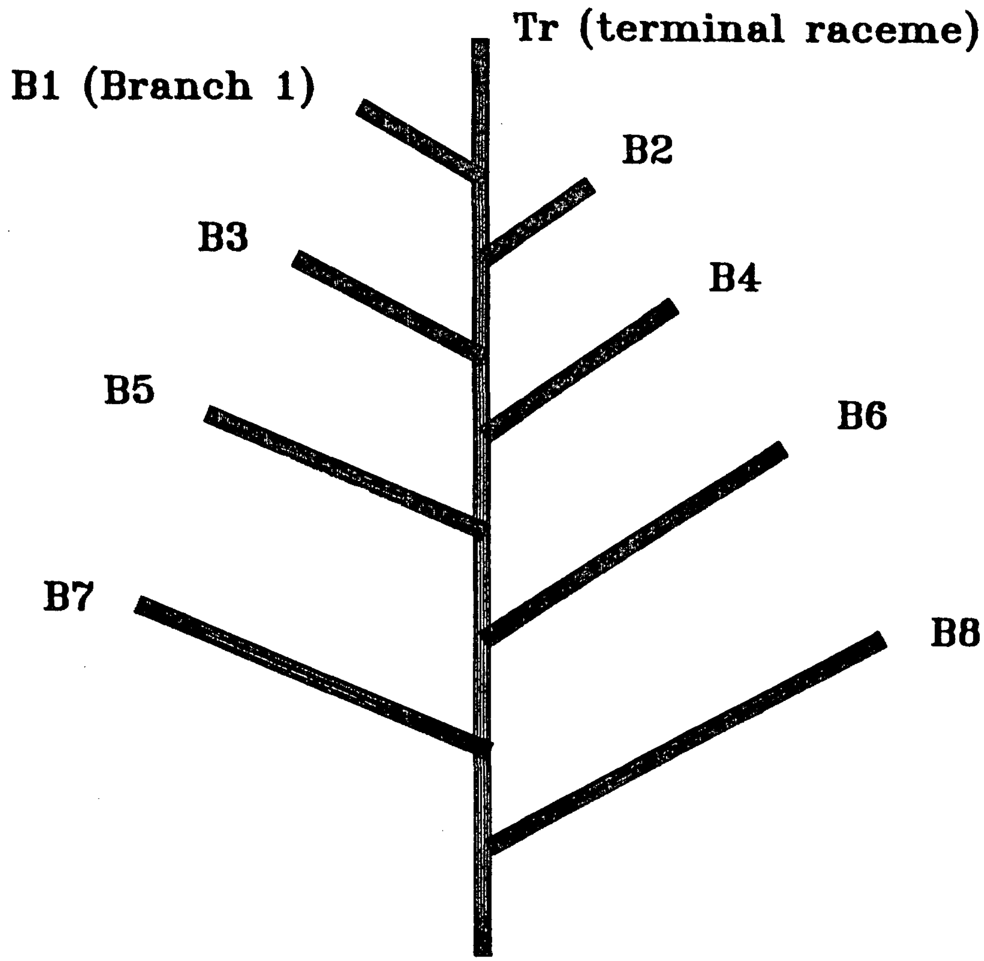
The whole sample was weighed immediately and total plant number counted. Two sub-samples of representative plants were then taken. One sample of five plants was weighed, chopped and oven dried at 101 °C to calculate total biomass production. Another sample of 20 plants was weighed, measured and each plant was then dissected, according to primary branch level (Fig. 1) to assess:-

Harvest index
Yield distribution
Yield components.

The trials were harvested on 1 August and 12 August at Boxworth and Rosemaund respectively using a plot combine to assess harvestable yield. Samples were taken off the combine from each plot to assess seed moisture content and % oil content.

The samples were sieved and moisture content measured using a GAC 2000 grain analysis computer. Oil content was measured by means of Nuclear Magnetic Resonance (NMR).

Fig.1. Oilseed rape primary branch nomenclature



RESULTS

Defoliation gave no significant increase in yield at either site (Table 1). At Rosemaund, defoliation gave a significant ($p \leq 0.05$) decrease in yield when in combination with the growth regulator. Defoliation similarly had no effect on the oil content of the harvested seed (Table 1).

The late defoliation (31 January) at Boxworth and the defoliation at Rosemaund produced similar effects. Both gave a slight reduction in total biomass produced and seed weight produced (Tables 2 and 4). This resulted in no effect (Boxworth, Table 2) or a reduction (Rosemaund, Table 4) in harvest index.

The early defoliation (9 January) at Boxworth produced a significant increase ($p \leq 0.05$) in harvest index (Table 2). This increase was due to a significant decrease ($p \leq 0.05$) in total biomass and maintenance of seed production despite a small decrease in plant number. Seed production was maintained by increased efficiency of the lower branches (no. of pods per branch and seed weight per pod (Table 4)) and a small increase in the number of branches.

Table 1 Effect of Defoliation and PGR on Yield and Oil Content at the Boxworth and Rosemaund sites.

Boxworth

Defoliation	Yield (t/ha @ 91% DM)	Oil content (% @ 100% DM)
None	3.58	47.2
9 January	3.66	46.9
31 January	3.62	47.6
SED	0.280	0.61
LSD	0.777	1.693
CV%	11.0	1.5

Table 1 Cont.

Rosemaund

PGR	Defoliation	Yield (t/ha @ 91% DM)	Oil content (% @ 100% DM)
None	None	2.68	43.4
	22 January	2.22	43.2
3 March	None	3.06	44.2
	22 January	2.40	43.1
	SED	0.232	0.68
	LSD	0.568	1.664
	CV%	11.0	1.9

Boxworth

Early (9 January) defoliation decreased the total biomass produced by the crop (Table 2). Pod number per unit area was maintained despite a slightly lower plant population by an increase in the number of pods per plant (Table 2). Defoliation decreased the number of pods per branch on the terminal raceme, and seed weight per pod and seed number per pod (Table 3) on the terminal raceme and higher branches but these reductions were offset by an increase on lower branches (Table 3) and an increase in the number of branches per plant (Table 2). Overall defoliation maintained seed production and reduced vegetative growth resulting in a significant increase in harvest index.

Late defoliation (31 January) slightly decreased total biomass production and plant number (Table 2). Number of pods per branch, seed weight per pod and seed number per pod were decreased on the upper racemes (Table 3). The number of pods per branch was slightly increased on the lower branches but seed weight per pod, seed number per pod (Table 3) and the number of branches per plant (Table 2) were unaffected. This resulted in a net reduction in seed produced per unit area and no increase in harvest index. Thousand seed weight weight was unaffected by defoliation at both dates.

Table 2. Boxworth: Effect of defloiation on plant growth parameters

Defoliation date	Harvest index (%)	Total biomass (g/m^2)	Seed weight (g/m^2)	Number of plants ($/m^2$)	Number of pods ($/m^2$)	Number of pods/plant	Number of branches/plant
None	27.5	2136	576	117.3	9947	85.2	7.0
9 January	45.3	1305	588	98.8	9685	100.5	8.33
31 January	28.6	1578	455	92.6	8687	96.3	7.33
SED	5.22	238.5	79.7	14.64	662.6	11.44	0.861
LSD	14.49	662.1	221.2	40.64	1839.4	31.76	2.390
CV%	18	17.5	18.2	17.4	8.6	14.9	14.0

($p \leq 0.05$)

Table 3. Boxworth: Effect of defoliation on yield components on a branch-by-branch basis

	No. of pods/branch				Seed weight/pod (mg)			
Defoliation time	None	9 Jan	31 Jan	Mean#	None	9 Jan	31 Jan	Mean#
Branch								
Tr	53.62	46.08	50.82	50.17	74.9	67.4	64.3	68.9
B1	8.91	14.16	11.51	11.53	61.5	52.8	46.5	53.6
B2	8.97	11.61	10.38	10.32	59.3	55.7	57.3	57.4
B3	8.63	12.72	9.60	10.32	55.4	55.0	56.0	55.5
B4	3.16	7.31	6.52	5.66	65.1	60.1	44.9	56.7
B5	1.35	5.31	4.40	3.69	38.1	65.3	41.2	48.2
B6	0.36	1.10	1.72	1.06	50.7	92.1	50.3	64.4
* Mean	12.14	14.04	13.56		57.9	64.0	51.5	
SED	2.882				16.04			
LSD	5.824				32.42			
*SED	1.089				6.06			
LSD	2.200				12.25			
#SED	1.664				9.26			
LSD	3.362				18.71			
CV%	26.6				35.1			

($p \le 0.05$)

Table 3 (continued)

Defoliation time	Seed no./pod				Thousand seed weight (g)			
	None	9 Jan	31 Jan	Mean#	None	9 Jan	31 Jan	Mean#
Branch								
Tr	15.12	13.15	12.64	13.64	4.95	5.16	5.12	5.08
B1	11.70	10.94	8.60	10.41	5.26	4.95	5.37	5.19
B2	11.85	12.3	11.10	11.75	5.03	4.55	5.32	4.96
B3	10.92	10.84	10.30	10.69	5.16	5.07	5.51	5.23
B4	14.02	12.50	8.88	11.80	4.44	4.85	5.09	4.79
B5	8.82	13.14	8.88	10.28	4.38	5.08	4.85	4.77
B6	9.06	18.84	9.95	12.63	5.12	5.19	5.34	5.22
* Mean	11.64	13.11	10.05		4.90	4.98	5.23	
SED	3.337				0.563			
LSD	6.744				1.14			
*SED	1.261				0.213			
LSD	2.548				0.43			
#SED	1.926				0.325			
LSD	3.892				0.66			
CV%	36.8				13.7			

($p \leq 0.05$)

Table 4. Rosemaund: Effect of defoliation on plant growth parameters

PGR	Defoliation date	Harvest index (%)	Total biomass (g/m^2)	Seed weight (g/m^2)	Number of plants ($/m^2$)	Number of pods ($/m^2$)	Number of pods/plant	Number of branches/plant
None	None	45.3	1956	875	82.7	10634	128.9	9.33
	22 January	35.7	1514	521	94.4	8684	92.3	8.67
3 March	None	39.3	1395	555	78.4	8431	107.0	8.00
	22 January	25.3	1586	396	76.5	5652	77.8	7.00
SED		5.45	402.6	177.4	14.43	1887.3	22.8	0.991
LSD		13.34	985.2	434.1	35.31	4618.2	55.8	2.425
CV%		18.3	30.6	37.0	21.3	27.7	27.5	14.7

($p \leq 0.05$)

Table 5. Rosemaund: Effect of defoliation on yield compenents on a branch-by-branch basis

	Number of pods per branch					Seed weight/pod (mg)				
PGR	None		3 Mar			None		3 Mar		
Defoliation	None	22 Jan	None	22 Jan	Mean#	None	22 Jan	None	22 Jan	Mean#
Branch										
Tr	39.1	28.4	36.7	31.4	33.9	78.9	88.8	88.8	87.2	85.9
B1	12.8	11.5	14.6	11.2	12.5	54.3	71.4	81.8	49.4	64.2
B2	14.4	9.5	15.7	11.8	12.9	64.1	64.0	85.9	58.4	68.1
B3	13.2	9.3	16.1	10.2	12.2	55.1	65.1	80.0	58.3	64.6
B4	10.3	7.0	12.4	9.5	9.8	51.1	68.9	77.4	54.1	62.9
B5	8.5	6.9	12.7	7.3	8.8	52.9	77.2	74.8	69.7	68.4
B6	3.5	4.7	7.5	4.7	5.1	107.3	68.6	73.7	51.4	75.2
*Mean	14.5	11.0	16.5	12.3		66.2	72.0	80.3	61.1	
SED	4.09					14.87				
LSD	8.18					29.74				
*SED	1.54					5.62				
LSD	3.08					11.24				
#SED	2.04					7.43				
LSD	4.08					14.86				
CV%	36.8					26.0				

($p \leq 0.05$)

Table 5 (continued)

	Seed no./pod					Thousand seed weight (g)				
PGR	None		3 Mar			None		3 Mar		
Defoliation	None	22 Jan	None	22 Jan	Mean#	None	22 Jan	None	22 Jan	Mean#
Branch										
Tr	14.12	16.02	14.84	16.65	15.41	5.56	5.44	5.98	5.32	5.576
B1	10.27	15.16	15.11	9.85	12.60	5.28	4.74	5.41	5.10	5.131
B2	12.07	13.82	15.83	11.57	13.32	5.31	4.81	5.38	5.08	5.144
B3	10.77	12.28	14.00	10.40	11.86	5.17	5.34	5.71	5.61	5.456
B4	9.54	13.36	14.30	10.93	12.03	5.23	5.30	5.46	5.04	5.257
B5	10.50	16.18	13.29	13.85	13.45	5.38	4.71	5.67	4.97	5.168
B6	20.83	13.21	14.20	9.73	14.49	5.22	5.29	5.25	5.43	5.311
* Mean	12.59	14.29	14.5	11.85		5.307	5.086	5.545	5.229	
SED	2.982					0.5540				
LSD	5.964					1.1080				
*SED	1.127					0.2094				
LSD	2.254					0.4188				
#SED	1.491					0.2770				
LSD	2.982					0.5540				
CV%	27.4					12.8				

($p \leq 0.05$)

Rosemaund

Both the plant growth regulator and defoliation produced a reduction in total biomass and seed production (Table 4). The number of pods on the higher racemes was decreased by defoliation but unaffected by PGR. There was, however, no resultant increase in pod number on the lower branches (Table 5). There was no effect on seed weight per pod, seed number per pod, or thousand seed weight by either treatment (Table 5). The reduction in seed production by both treatments was caused by a reduction in the number of branches per plant (Table 4) rather than a reduction in the production per branch.

DISCUSSION

The results of this study indicate that early partial defoliation of oilseed rape has a definite plant growth regulatory effect.

The investigation carried out was done on two field experiments which were already laid down and were not designed for this type of study. This gave a limited number of degrees of freedom (whole plot assessment, residual degrees of freedom; Rosemaund = 6, Boxworth = 4) which has made proving results significant by analysis of variance more difficult. The sampling procedures used were developed in discussion with Dr Eric Evans of Newcastle University and the statistical analysis used discussed with ADAS Information Services Unit and have been optimised to reduce the limitations. However, some effects which appear to have occurred can still not be proved statistically significant.

Both defoliation and the plant growth regulator (treatment 6) at Rosemaund delayed flowering. This caused peak petal fall to occur in synchrony with an unpredicted period of sclerotinia infection. The greater infection in the treated crops (a 10% increase over a background infection level of 70% of plants affected) made the plants more brittle causing greater seed loss during sampling and reductions in harvest index. This was not a direct treatment effect and the reverse could equally be expected in a season with different weather patterns.

Early defoliation (9 January) at Boxworth produced a significant ($p \leq 0.05$) reduction in total crop growth. This was achieved without detriment to seed production. The small reduction in plant numbers by defoliation was made up for by a greater number of branches per plant and increased seed production from the lower branches (Fig. 2). The increased production from lower branches was due partly to an increase in the number of pods per branch, but the main effect was an increase in the weight of seed per pod produced by small concomitant increases in seed number and weight.

If the changes in crop growth could be achieved with lower plant losses significant yield increases may be expected. The plant loss caused by the small pedestrian controlled mowers used in the experiments may also be expected to be greater than if large commercial machines are used. The small machines used have proportionally more wheeling damage and user damage per unit length of blade than a commercial machine. Difficulty in controlling the cutting height of the pedestrian machine can also lead to the complete removal of some plants.

The work at Boxworth in 1989 and 1990 produced mean yield benefits from defoliation of 0.37 t/ha and 0.35 t/ha respectively. It is worth noting that both of these years were drought years with soil moisture deficits on 1 July of 144.1 mm and 125.1 mm respectively. The water used to produce the extra biomass in the non-defoliated crop would not be available for reproductive growth, and could have inferred a yield penalty on the non-defoliated crop compared to the defoliated crop. During the 1990-91 season in which this experiment was done water was not so limiting (SMD on 1 July 46.4 mm) and no yield benefit from reduced dry matter production occurred.

Fig 2. Seed yield distribution
Seed weight in grams per branch for control and 9th January defoliated crops.
ADAS Boxworth, 1991.

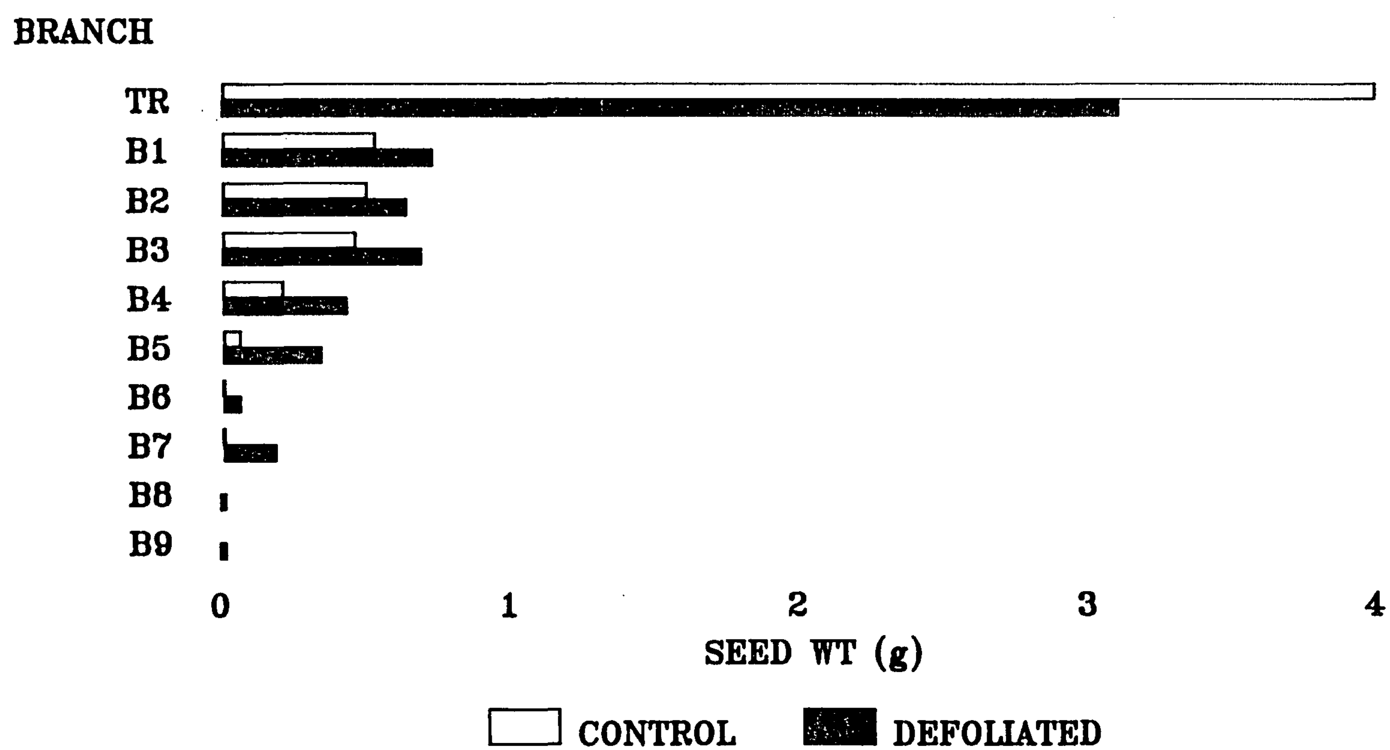


Table 6. Soil Moisture Deficit and Thermal Time from Sowing to Defoliation and Yield Response to Defoliation 1989-1991

Year	Boxworth			Rosemaund		
	SMD*	Yield response	ADD#	SMD*	Yield response	ADD#
	(mm)	(t/ha)	(°C)	(mm)	(t/ha)	(°C)
1989	144.1	0.37	1146	114	0.97 x	-
1990	125.1	0.35	1196	195	0.68 x	-
1991	46.4	0.06	893	76	0.12	1242

* SMD, Soil Moisture Deficit under winter wheat - 1 July
x Triazole plant growth regulator effects.
\# Accumulated day degrees above 0°C.

The non-defoliated crop at Boxworth produced 8.31 t/ha more dry matter than the 9th January defoliated crop. Most of this extra growth would be expected in early spring when soil moisture deficits are developing. The reduction in leaf area from defoliation would suggest that the non-defoliated crop would intercept more light and therefore have a higher transpiration rate than the defoliated crop. This differential would continue until the defoliated crop achieved 100% light interception and therefore maximum potential transpiration. In this study no measurements have been taken of leaf area or light interception at the time of defoliation or duing the spring. An indication of total crop growth prior to defoliation can be obtained by calculation of thermal time from drilling to defoliation (Table 6). The crop at Rosemaund in 1991 took 37 days from drilling to start of emergence by which time 458 of the total 1242 day degrees had occurred. The crops at Boxworth in 1989 and 1990 experienced an extra 300 day degrees compared to either crop in 1991. Increased autumn/winter growth as indicated in 1989 and 1990 at Boxworth could increase the differential in transpiration between defoliated and non-defoliated crops giving a larger yield benefit. If thermal time from drilling/emergence to defoliation is related to response to defoliation then it could become a useful tool for identifying seasons/crops which would benefit. Crop growth and development around the time of defoliation would be an area of great interest in future work.

If global warming continues as predicted and causes a drying of the British climate, then any increase in efficacy of water use will be of increasing importance if yields are to be maintained.

Another possible benefit from partial defoliation is the reduction of disease inoculum by removal of older leaves which carry disease through winter, although due to the timing of this study this effect was not recorded.

Early partial defoliation of oilseed rape may produce real and beneficial effects on crop growth. There are, however, questions that this initial study by its very nature has not answered. We do not yet know at what stage in the crops development the changes are occurring. We cannot say whether the optimum time for defoliation is determined by calendar date, thermal time, growth stage, or apical development stage. The investigation of this would be assisted by examining crops of different sowing dates within each site and season. The effect of defoliation on water use by the crop can be investigated by expanding the number of sites for the experiment and conducting the study over a number of seasons. The use of rain shelters and irrigation facilities would provide further scope for the study without relying purely on site/season effects.

Early partial defoliation shows definite potential as a crop husbandry technique to manipulate crop growth and development without the use of a plant growth regulatory chemical. As a management tool it is cheap, and should improve standing ability, flowering symmetry and hence maturity at harvest and reduce harvest losses by shedding. However, further research is required before our understanding of the causal mechanisms is sufficient to recommend this management technique as a commercial practice.

APPENDIX I. Details of site and crop on trial plots

Site:	Boxworth	Rosemaund
Soil series:	Hanslope	Bromyard
Soil texture:	Clay	Silty clay loam
Drainage:	Good	Good
Soil analysis:		
pH	7.7	6.9
P mg/l	99	19
K mg/l	187	130
Mg mg/l	95	72
Previous cropping:		
1990	Winter wheat	Winter barley
1989	Winter wheat	Winter wheat
1988	Spring beans	Spring peas
Cultivation:	Plough Maschio Roll Maschio Drill Roll	Rotavated Subsoiled Rotavated Drilled Roll
Cultivar:	Lictor	Lictor
Sowing date:	20.9.90	31.8.90
Seed rate (kg/ha):	7.3	4
Fertiliser (kg/ha):	FYM N 82 4.3.91 N 108 21.3.91	P 52 14.8.90 K 94 14.8.90 N 103 27.2.91 N 120 2.4.91
Herbicides:	Kerb 0.96 kg/ha 5.12.90	Fusilade 1.0 l/ha 16.10.90 Benazalox 1.25 l/ha 29.11.90
Fungicides:	Sportak 1.25 l/ha 12.3.91	Sportak 1.1 l/ha 10. 4.91 Benlate 0.4 kg/ha 20. 4.91
Insecticides:	None	Decis 250 ml/ha 16.10.90 Hostathion 1.0 l/ha 14. 6.91
Desiccant:	Reglone 3.0 l/ha Agral 0.4 l/ha 24.7.91	None
Harvest date:	1.8.91	13.8.91

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