THE EFFECT OF LOW TEMPERATURE TREATMENTS ON FLOWER DEVELOPMENT IN WINTER OILSEED RAPE (cv. MIKADO)

A.M. TOMMEY and E.J.EVANS
Department of Agriculture, University of Newcastle,
Newcastle upon Tyne, NE1 7RU. U.K.

INTRODUCTION

In the United Kingdom, the winter oilseed rape crop is sown between mid August and early September to produce an overwintering plant with approximately five true leaves and a well developed root system (MAFF. 1986). Sowing date experiments have generally shown that when sowing is delayed beyond mid September, both seed and oil yields are reduced (Scott et al. 1973; Mendham and Scott. 1975). Jenkins and Leitch (1986), however, obtained consistently high yields from late September and October sowings, while Mendham et al. (1981), showed that late September sown crops could produce very high yields when the onset of spring growth was early.

Seed yield is strongly influenced by the amount of growth made by the crop from the beginning of stem extension onwards (Tayo and Morgan. 1979; Evans. 1984). Developmental changes within the shoot apex accompanying growth during this time, may further influence yield potential. A greater understanding of the environmental conditions influencing flower initiation in winter oilseed rape and the subsequent effects on developmental changes and yield is therefore of considerable interest to agronomists and plant breeders.

Two experiments were carried out under controlled environment conditions to assess the effects of low temperture treatments on flowering and pod canopy development in the cultivar Mikado.

MATERIALS AND METHODS

EXPERIMENT 1:

Seeds were sown in 6cm x 5cm modules containing Arthur Bowers potting compost and seedlings were singled at the cotyledon stage, following germination at 18°C to give 1 plant per module. Seven days after sowing, 72 plants were placed in separate Fisons growth cabinets at temperatures of 3,6 and 9 ± 0.5°C. Twenty-four additional plants were grown at a control temperature of 12 ± 0.5°C. Daylength (16 hours) and photon flux density (165±5$\mu Mm^{-2}s^{-1}$ PAR) were constant for all treatments.

Plants were kept for 20, 40 and 60 days at each of the three low temperatures and when each duration of low temperature was completed, plants were returned to the control temperature of 12 ± 0.5°C. For the control, plants were maintained at 12 ± 0.5°C throughout the duration of the experiment.

The temperature treatments were unreplicated, but within each cabine- modules were arranged in 4 blocks.

The progress of growth and apical development was followed by means of frequent dissections from samples of 4 plants taken at random from each block. The following measurements were recorded for each plant; 1) stage of apical development, 2) leaf number initiated, 3) expanded leaf number, and 4) plant dry weight. Plant material was dried in a ventilated oven at 85°C for 72 hours.

EXPERIMENT 2:

Plants grown at 6 ± 0.5°C for 0, 20, 40 and 60 days were grown on to maturity to evaluate treatment effects on subsequent plant development and yield. Following the low temperature treatments, plants were transferred from modules into 10 cm plastic pots and arranged in a 4x4 latin square design, where each plot consisted of 4 plants. Pots were placed on beds of sand in a cool glasshouse with supplementary heating to maintain a mean temperature above 5°C. The following non-destructive measurements were recorded for each plant; 1) onset of stem extension, 2) start of flowering, 3) end of flowering, and 4) maturity. The beginning of stem extension was registered when the first formed internode exceeded 1cm. The start of flowering was taken as the date when 2 or more flowers were visible on plants and the end of flowering as the date of petal fall from the last formed flower on the terminal raceme.

At maturity, a detailed analysis was carried out to obtain dry matter distribution, final seed yield and individual yield component values for each treatment.

RESULTS

Low temperature treatment resulted in a significant reduction in the induction period for plants of similar chronological age. This effect was most pronounced when plants were maintained at 40 and 60 day durations. Plants grown at the control temperature however, had an extended vegetative period (Table 1).

Table 1 Number of days from sowing to flower initiation for plants exposed to constant temperatures of 3,6 & 9°C for 0,20,40 & 60 days.

Temperature	Number of days 0	20	40	6
3°C	80.2	60.0	58.0	68.2
6°C	80.2	71.7	55.5	57.0
9°C	80.2	70.0	57.0	58.2
			SED	1.69

Additionally it was noted that leaf numbers declined with a reduction in temperature and also with an increase in the duration of low temperature treatment (Table 2).

Table 2 Total number of leaves initiated and expanded leaf numbers at flower initiation for plants exposed to constant temperatures of 3,6 & 9°C for 0, 20, 40 & 60 days.

Temperature	Number of days							
	0		20		40		60	
	INI	EXP	INI	EXP	INI	EXP	INI	EXP
3°C	23.3	10.2	21.3	7.0	14.8	4.0	12.0	3.3
6°C	23.3	10.2	22.8	8.2	18.0	5.0	16.5	4.8
9°C	23.3	10.2	22.3	8.7	21.5	6.2	20.5	6.0

Leaf No. Initiated: SED 0.38 Leaf No.Expanded: SED 0.37

Table 3 shows that total dry weight per plant at flower initiation followed a similar trend over all treatments, ranging from 0.18g at the lowest temperature and longest duration to 2.76g for the control.

Table 3 Total plant dry weight (g) at flower initiation of plants exposed to constant temperatures of 3, 6 & 9°C for 0,20, 40 & 60 days.

Temperature	Number of days			
	0	20	40	60
3°C	2.76	0.80	0.20	0.18
6°C	2.76	1.71	0.45	0.32
9°C	2.76	1.81	1.00	0.99
			SED	0.118

The length of the induction period for plants grown on to maturity was reduced by 25 days as the duration of the low temperature treatment, 6 ± 0.5°C, was increased from 0 to 40 days (Table 1). Although further reductions in leaf numbers and total dry weight per plant were observed when the duration increased to 60 days, the effect of flower initiation was not significantly different. Subsequent stages of development occurred in a similar order to flower initiation when considered on the basis of accumulated day degrees above 0°C (Figure 1).

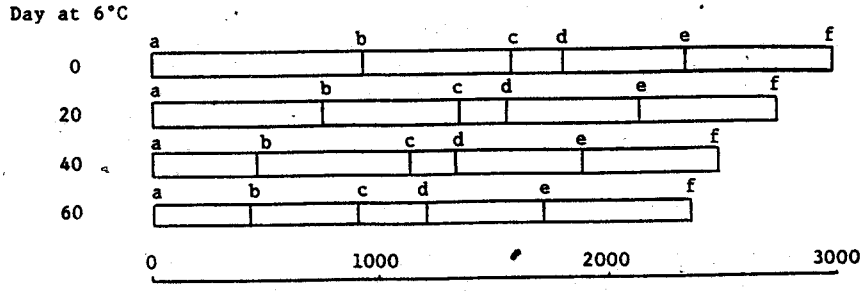

Figure 1. The developmental sequence of plants exposed to a temperature of 6°C for 0, 20, 40 & 60 days on the basis of accumulate day degrees above 0°C. a. sowing b.flower initiation c. stem extension d. flowering e. end of flowering f. maturity.

At maturity, no significant differences in seed yield were observed between plants exposed to 6 ± 0.5°C for at least 20 days during the vegetative period, but control plants produced significantly lower total seed weight in comparison. Both vegetative and total dry weight per plant were similarly reduced, although control plants did support significantly higher branch numbers. Consequently, mean branch weights for these plants was lower (Table 4).

Table 4 Seed yield and dry matter distribution (g) of individual plants exposed to a temperature of 6°C for 0, 20, 40 & 60 days.

	Number of days at 6°C					
	0	20	40	60	SED	SIG.
Total seed wt.	7.78	10.66	10.61	10.25	1.055	*
Total dry wt.	33.96	40.12	38.01	37.48	1.692	*
Vegetative wt.	16.71	18.47	17.22	17.19	0.516	*
Branch no.	7.69	6.50	6.75	6.38	0.111	***
Mean branch wt.	2.09	2.85	2.66	2.76	0.118	***

Yield component analysis is presented in table 5.

Table 5 Yield component analysis for individual plants exposed to a temperature of 6°C for 0, 20, 40 & 60 days.

	Number of days at 6°C					
	0	20	40	60	SED	SIG
Fertile pod no.	202	221	198	193	11.3	NS
Total pod wt.	17.25	21.65	20.78	20.28	1.467	*
Total seed no.	2,239	2,572	2,325	2,234	264.6	NS
Seed number/pod	10.77	11.43	11.71	11.16	0.883	NS
Seed weight/pod	0.009	0.011	0.013	0.012	0.0009	*
Seed weight(mg)	3.23	3.81	4.41	4.27	0.077	***

Differences between treatments in seed yields at final harvest were largely accounted for by differences in thousand seed weight and seed weight per pod. Small differences were observed in the number of potential and fertile pods per plant, but these differences became highly significant when plant hierarchy was taken into consideration (Table 6).

Table 6 Potential and fertile pod numbers of individual plants exposed to a temperature of 6°C for 0, 20, 40 & 60 days.

Days at 6°C	Primary Branches											
	TR		B1		B2		B3		B4-B7		Plant	
0	POT	FER	POT	FER	POT	FER	POT	FER	POT	FER	POT	FER
0	87	56	60	25	64	30	72	31	149	60	421	202
20	88	56	69	36	87	44	96	41	101	41	440	221
40	76	39	67	34	88	44	82	41	93	41	406	198
60	81	44	67	32	89	44	87	41	81	33	405	193
SED	2.0	3.2	3.8	1.9	6.4	3.9	6.1	3.1	12.1	7.0	18.8	11.3
SIG	***	***	**	**	**	*	*	*	**	*	NS	NS

A marked reduction in pod numbers on the first three primary branches was noted for control plants although a considerable degree of compensation occurred on the lower branches. These lower branches did not however compensate fully for the reduction in seed yield which occurred on the uppermost branches (Table 7).

Table 7 Total seed weight (g) of individual plants exposed to a temperature of 6°C for 0, 20, 40 & 60 days.

Days at 6°C	Primary Branches					
	TR	B1	B2	B3	B4-B7	Plant
0	2.95	1.03	1.12	1.08	1.61	7.78
20	3.30	1.85	2.33	1.99	1.20	10.66
40	2.20	1.95	2.46	2.14	1.86	10.61
60	2.54	1.66	2.49	2.13	1.43	10.25
SED	0.341	0.116	0.304	0.215	0.489	1.055
SIG	*	***	**	**	NS	*

DISCUSSION

The results have clearly demonstrated the importance of both low temperature and duration of low temperature on flower initiation and therefore on the length of the vegetative period. The quantitative effect of these low temperatures suggests that the optimum temperature of vernalisation for the cultivar Mikado, lies within a range 6 to 9°C. Plants grown at 3°C throughout the vegetative period had a significantly longer induction period, but when the duration was reduced to either 40 or 20 days, the dates of flower initiation were similar.

Mendham et al (1981), suggest that the vernalisation response to low temperature is not however the limiting factor for flower production but differentiation of a minimum number of 12 leaves. This was apparent for plants grown at 3°C (Tables 1 and 2).

The subsequent development sequence is to some extent dependent upon the date of flower initiation (Figure 1), although Thurling and Vijendra Das (1977), found that for spring rape, the mechanisms regulating the

duration of the stem extension growth phase were independent of those involved in flower initiation. The date presented here suggests that the mechanism in winter oilseed rape may be different.

It has been demonstrated that plant size at flower initiation is directly correlated with the number of axillary inflorescences(Mendham et al. 1981), and some evidence of this was observed in relation to low temperature treatments (Table 4). This increase in branch number was not however, associated with a significant increase in pod number per plant and furthermore the seed yields of these plants was substantially lower. This reduction in seed yield was linked to low seed weights obtained from the first three primary branches and although lower branches carried considerably more pods ($P<0.05$) compared to other treatments, this compensation was not realised in terms of additional seed yield.

Daniels and Scarisbrick (1983), found that the length of lower branches increases with canopy depth and although this change in branch size enables the lowermost pods to be raised to areas of higher light intensity, the energy needed for branch extension probably reduces the amount of assimilates available for seed growth. These results indicate that a prolonged vegetative period can significantly reduce pod growth due to restricted assimilate availability during critical developmental periods. In order to exploit the superiority of the terminal raceme and uppermost branches the production of lower branches should therefore be restricted.

REFERENCES

DANIELS R.W. AND SCARISBRICK D.H. (1983) Oilseed Rape Physiology. N.A.C. Yield of Oilseed rape Course Papers 1983 pp29-46.

EVANS E.J. (1984) Pre-anthesis growth and its influence on seed yield in winter oilseed rape. Aspects of Applied Biology 6 pp81-90.

JENKINS P.D. AND LEITCH M.H. (1986) Effects of sowing date on the growth and yield of winter oilseed rape (Brassica napus). Journal of Agricultural Science 105 pp405-420.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD (1986) Oilseed Rape Agricultural Development and Advisory Service Booklet P2278 pp1-4.

MENDHAM N.J. AND SCOTT R.K. (1975) The limiting effect of plant size at inflorescence initiation on subsequent growth and yield of oilseed rape (Brassica napus). Journal of Agricultural Science 84 pp487-502.

MENDHAM N.J., SHIPWAY P.A. AND SCOTT R.K. (1981) The effects of delayed sowing and weather on growth, development and yield in winter oilseed rape (Brassica napus). Journal of Agricultural Science 96 pp417-428.

SCOTT R.K., OGUNREMI E.A., IVINS J.D. AND MENDHAM N.J. (1973) The effect of sowing date and season on growth and yield of oilseed rape (Brassica napus). Journal of Agricultural Science 81 pp277-285.

TAYO T.D. AND MORGAN D.G. (1979) Factors influencing flower and pod development in oilseed rape (Brassica napus L.). Journal of Agricultural Science 92 pp363-373.

THURLING N. AND VIJENDRA DAS L.D. (1977) Variation in the pre-anthesis development of spring rape (Brassica napus L.). Australian Journal of Agricultural Research. 28 pp597-607.