HGCA

PROJECT REPORT No. OS22

WINTER LINSEED:

I. COMPARISON OF WINTER AND SPRING VARIETIES

II. WEED CONTROL TRIALS

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WINTER LINSEED: I. COMPARISON OF WINTER AND SPRING VARIETIES

by

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This is the final report of a six month project which started in March 1996. The work was funded by a grant of £6,433 from the Home-Grown Cereals Authority (Project No. OS12/1/96).

Contents

Summary

Linseed variety trials were grown at three locations during the 1995-96 season to compare yield potential of winter and spring linseed. The effect of sowing date on the performance of spring linseed was also investigated.

In the 1995/96 season, the two commercially available winter hardy varieties, Arctica and Oliver, were grown in autumn-sown plots as controls. Their mean seed yield was 55% greater than the mean of the seven mid-March sown spring linseed varieties in spring trials and 78% greater than their mid-April sown mean yield. A general trend for improved oil content from autumn sowing was seen. Spring linseed varieties, sown in the autumn, showed a clear susceptibility to winter damage and gave very low yields, or failed to survive at all.

The same winter varieties, grown in spring, showed only moderate yield. It was concluded that the greater yield obtained from the autumn plots was the result of more effective exploitation of soil moisture, rather than variety performance as such.

A strong effect of sowing date on seed yield in spring-sown linseed was noted in these experiments. Early-sown plots gave higher yields than later sown plots by an average of 15 % but these improvements were small compared with the advantage shown by the winter linseeds sown in autumn. It was concluded that the advantage came from better utilisation of available soil moisture in a dry season. However, a considerable range of seedling vigour was observed which supported earlier experience, and breeder's advice, that establishment may be more reliable if delayed until early April, especially for small-seeded varieties, given adequate moisture.

The winter linseed trials came to harvest 2-4 weeks earlier than those of spring-sown linseed. For spring-sown linseed, no maturity advantage was gained from early sowing.

1.0 Introduction

Winter linseed is a new and potentially attractive break crop, with a number of claimed advantages over the spring crop, including better ease of establishment, summer drought resistance and much earlier harvest than spring-sown linseed. The first varieties were added to the National List in 1996 and with a combination of UK seed production from autumn 1995 (1,000 tonnes) and with imported seed, have given rise to an estimated crop area of 30,000 hectares for harvest 1997. Autumn-sown trials for 1996 harvest showed a clear differential in winter hardiness between varieties from winter breeding programmes and spring varieties.

There are, however, a number of potential disadvantages which require thorough investigation before the crop can be grown with confidence. These include reports of poor standing ability, possible susceptibility to winter kill and to disease. Data offering direct comparisons of spring and winter linseed have been very limited. With rapidly developing grower interest in winter linseed, independent work was required to compare the two crops.

The series of comparative trials described here was designed to address these issues.

1.1 Previous NIAB Experience

In addition to the statutory observation plots grown for National Listing purposes, NIAB have conducted small-scale, privately funded trials, on autumn-sown linseed at Cambridge during the years 1993-95. These trials included spring linseed varieties, sown at the same time, to provide a benchmark with which to assess the winter material. During this period all varieties survived well in comparatively mild winters and achieved harvest maturity in late July. In a very dry run of years, yields were around 1.9 t/ha while yields of spring linseed in the Eastern Counties were disappointing, rarely exceeding 1 t/ha in trials.

In autumn 1995, with interest building in winter linseed, a series of three trials funded by breeders was sown by NIAB to provide performance testing for official entries and other varieties entered for winter screening. With the support of the HGCA, spring trials of selected variety types were sown adjacent to the winter trials at all three sites to provide a comparison of growth and performance between spring and winter linseed.

2.0 Materials and Methods

At each of the three NIAB winter trial sites, replicated plots were established at each of two drilling dates. The purpose was to provide direct comparisons of yield and agronomic performance between spring and winter linseed and a comparison of early and late spring establishment for spring linseed. A range of variety types was chosen to explore any variety interaction with time of establishment.

2.1 Sites and drilling dates

Site	Autumn	Early spring	Late spring
NIAB, Cambridge	25 Sep 95	14 Mar 96	09 Apr 96
Headley Hall, Yorkshire	28 Sep 95	29 Mar 96	22 Apr 96
Morley EHF, Norfolk	03 Oct 95	11 Mar 96	28 Mar 96

2.2 Varieties

The following varieties were selected for inclusion in the spring-sown trials to provide: a) direct comparison with the winter trials and b) a range of types with which to investigate the sensitivity of spring drilling date.

NB While there is no botanical/vernalisation differentiation of winter and spring linseed, a clear range of cold tolerance has been observed. The varieties described below as winter linseeds are from specific winter breeding programmes.

Variety	Type
Oliver	**Winter linseed** control, short, medium early when spring sown, small seeds.
Arctica	**Winter linseed** control, short and extremely early when spring sown,small seeds.
Nordica	**Winter linseed**, tall, very early maturing variety, with small seeds.
Bolas	Spring type commercialised for winter use, short, moderately early, large seeds.
Antares	Spring control, medium height and maturity, large seeds, noted for good early vigour.
Barbara	Spring control, medium/short, medium maturity, large seeds.
Mikael	Spring control, short, medium early maturity, large seeds
Zoltan	Spring control, medium/short, medium maturity, large seeds.
Blue Chip	Spring type, late maturity, tall, large seeds.
Flanders	Spring type, early maturity, medium/tall, small seeds.

2.3 Plots and replication

Plots were approximately 24 x 2.0 m at drilling and these were cut back to a final length of 20m for harvest. Two replications were used for each sowing at each site.

3.0 Observations on the 1995/96 winter trials series

3.1 Establishment and winter hardiness The winter trials established quickly to give good, uniform plots. The winter was marked by severe frosts from mid-December onwards, with all three of the trial sites achieving their coldest temperatures between 29 December and 1 January.

Site	Grass minimum	Date
Cambridge	-12.4°C	29/12
Headley Hall	-12.8°C	30/12
Morley	-9.6°C	1/02

Serious scorch was noted from mid-December with temperatures of -7 and -9°C.

Of the lines screened in the winter trials, a great range of winter hardiness was observed, from complete kill to complete survival, although even the hardiest varieties showed some scorch. Some varieties recovered from severe frost scorch by means of tiller growth to give thin populations of plants which matured late, giving very low yields. The winter hardiness records for the control varieties, assessed at the end of winter, are summarised as follows:

Variety	Mean	Cambridge	Morley	Headley Hall
Oliver	9	9	9	8
Arctica	8	8	8	7
Bolas	3	3	4	1

Winter hardiness scale: (9 = very good,1 = very poor)

3.2 Maturity With a late spring and generally cool summer, the winter plots were rather later to mature than previous experience would have predicted, with the three trials being combined between 5th and 20th August (Table 3) compared with the late July maturity previously observed. This reflects the picture in cereal crops, where the winter wheat harvest was later than in recent seasons but droughted spring crops were harvested early. In many seasons the winter linseed harvest may well fall conveniently between barley and wheat combining.

3.3 Yield The mean yield of Arctica and Oliver (2.11 t/ha), both of which are now commercially available, were comparable with winter linseed yields in previous seasons. The very low yield of Bolas (0.66 t/ha), a spring type, which had out-yielded both varieties in 1995, and the complete failure of other varieties, provided a stark warning against using such types in the winter.

3.4 Lodging The dry season produced generally short plants and, consequently, lodging was not a factor in 1996. Evidence from previous seasons suggests, however, that some winter linseed varieties can grow very tall and can then be susceptible to lodging, with adverse consequences on yield, harvestability and disease infection.

4.0 Spring-sown plots

4.1 Establishment

At Cambridge the first sowing was into a moist seedbed but emergence was slow in the cold weather that prevailed in the early spring. Subsequent populations were thinner and less uniform than those of the winter plots. The second sowing was into a rapidly drying, rather coarse seedbed and, though a proportion of seeds germinated, irrigation was required to promote germination. Even so, populations achieved from this second sowing were thinner and less uniform again than those from the first.

At Morley, a fine moist seed bed was achieved from the first sowing, but this dried out rapidly in the cold windy conditions and emergence was rather poor and established populations were thin but uniform. The second sowing was also into a fine moist seedbed and warm weather allowed rapid and uniform germination resulting in thicker populations than the first sowing.

At Headley Hall seedbed conditions for both sowings were good so that satisfactory, uniform populations were achieved.

Records of emergence and establishment (Tables 1a and 1b) show variety effects amongst the spring sowings. Barbara, Antares, Blue Chip and Nordica all showed rapid emergence. These are all large-seeded varieties with the exception of Nordica which is a small-seeded winter type. Bolas (small-seeded), and Mikael (large-seeded) showed conspicuously poor emergence at the early drilling but at the later drilling only Bolas was particularly poor.

The eventual establishment of plant populations largely reflected the emergence scores although at Headley Hall there was no differentiation because of the very good seedbed conditions. From the early sowing, Barbara, Blue Chip and Nordica established most thickly while Bolas, Oliver and Mikael were the thinnest. The same pattern was maintained for the second sowing but with less marked differentiation.

In summary, spring sowings invariably gave less even emergence and thinner populations than the autumn sowings. While all plots established well in the autumn, significant variety interaction was seen in spring sowings at Cambridge and Morley in terms of speed of emergence and plot establishment.

4.2 Crop growth

Tables 2a-2c show records of early vigour, earliness of flowering and plant height for the spring-sown trials. Early vigour was not entirely related to speed of emergence. Here Arctica, Antares, Barbara and Zoltan were identified as marginally better than other varieties at both sowings, with Oliver the least vigorous.

Both earliness of flowering and plant height records reflected well known variety attributes at all three sites. There was very little effect of spring sowing date on heights which were approximately 20cm shorter than the heights achieved in the autumn-sown plots.

A comparison of spring drilling dates for linseed

Table 1a Emergence (1 - slow, 9 - fast)

Variety	Mean		Cambridge		Morley		Headley Hall	
	Early	Late	Early	Late	Early	Late	Early	Late
Oliver	4.8	5.5	4.8	5.5	3.0	5.0	6.5	6.0
Arctica	6.8	6.8	6.5	5.5	6.0	7.5	8.0	7.5
Bolas	3.5	4.2	6.0	3.5	1.0	4.0	3.5	5.0
Nordica	7.5	7.5	8.0	7.0	5.5	7.0	9.0	8.5
Antares	7.6	8.0	6.8	7.0	7.0	8.0	9.0	9.0
Barbara	8.0	8.5	7.5	7.5	8.0	9.0	8.5	9.0
Mikael	4.3	5.7	4.5	5.5	3.5	5.5	5.0	6.0
Zoltan	5.8	6.7	5.5	4.5	5.5	7.5	6.5	8.0
Blue Chip	7.5	8.2	7.0	7.0	7.5	9.0	8.0	8.5
Flanders	4.9	5.8	5.3	4.0	5.0	7.5	4.5	6.0

Table 1b Establishment (1 - very thin, 9 - very thick)

Variety	Mean		Cambridge		Morley		Headley Hall	
	Early	Late	Early	Late	Early	Late	Early	Late
Oliver	6.3	7.3	5.0	6.0	5.0	7.0	9.0	9.0
Arctica	7.5	8.2	6.0	6.5	7.5	9.0	9.0	9.0
Bolas	5.5	6.8	5.5	6.0	2.0	5.5	9.0	9.0
Nordica	8.2	8.7	7.5	8.0	8.0	9.0	9.0	9.0
Antares	7.8	8.7	7.0	8.0	7.5	9.0	9.0	9.0
Barbara	8.5	8.7	7.5	8.0	9.0	9.0	9.0	9.0
Mikael	6.2	7.8	5.0	6.0	4.5	8.5	9.0	9.0
Zoltan	7.2	8.3	7.0	7.0	5.5	9.0	9.0	9.0
Blue Chip	8.2	8.3	7.0	7.0	8.5	9.0	9.0	9.0
Flanders	7.5	8.3	6.5	7.0	7.0	9.0	9.0	9.0

A comparison of spring drilling dates for linseed

Table 2a Early Vigour (1 - poor, 9- good)

Variety	Mean		Cambridge		Morley		Headley Hall	
	Early	Late	Early	Late	Early	Late	Early	Late
Oliver	3.8	4.2	4.0	3.5	3.5	4.5	4.0	4.5
Arctica	7.2	7.3	5.5	6.0	7.0	7.5	9.0	8.5
Bolas	5.5	5.3	5.5	5.0	3.5	4.0	7.5	7.0
Nordica	6.3	6.7	8.0	6.5	5.5	7.5	5.5	6.0
Antares	7.0	7.7	5.5	7.0	7.5	8.0	8.0	8.0
Barbara	7.3	7.7	7.5	7.5	8.5	9.0	6.0	6.5
Mikael	5.2	6.5	5.0	6.5	4.5	6.0	6.0	7.0
Zoltan	7.0	7.3	7.5	6.5	7.0	8.5	6.5	7.0
Blue Chip	5.7	5.7	6.5	5.5	7.0	7.5	3.5	4.0
Flanders	5.2	6.0	4.0	5.0	5.5	7.0	6.0	6.0

Table 2b Earliness of Flowering (1 - late, 9 - early)

Variety	Mean		Cambridge		Morley		Headley Hall	
	Early	Late	Early	Late	Early	Late	Early	Late
Oliver	4.8	3.3	7.5	5.0	5.0	3.0	2.0	2.0
Arctica	7.5	8.5	7.0	8.5	7.5	8.0	8.0	9.0
Bolas	6.8	7.2	8.0	9.0	7.0	5.0	5.5	7.5
Nordica	8.7	8.5	8.0	9.0	9.0	9.0	9.0	7.5
Antares	5.7	6.2	8.0	7.0	6.5	6.0	2.5	5.5
Barbara	6.5	7.5	8.0	8.0	8.0	7.0	3.5	7.5
Mikael	8.3	8.7	8.0	9.0	8.0	8.0	9.0	9.0
Zoltan	5.0	6.5	8.0	8.0	4.5	7.0	2.5	4.5
Blue Chip	4.2	2.2	6.5	2.0	5.0	3.5	1.0	1.0
Flanders	4.2	3.2	6.0	4.5	5.0	4.0	1.5	1.0

Table 2c Plant Height (cm)

Variety	Mean		Cambridge		Morley		Headley Hall	
	Early	Late	Early	Late	Early	Late	Early	Late
Oliver	40.4	41.5	43.5	42.0	36.0	38.0	41.7	44.6
Arctica	46.6	45.1	44.8	44.5	45.5	42.0	49.5	48.8
Bolas	45.4	43.3	45.5	42.0	45.5	42.5	45.3	45.3
Nordica	41.4	41.5	45.9	41.0	33.0	40.0	45.3	43.6
Antares	52.5	54.8	52.8	53.5	50.0	53.0	54.7	57.8
Barbara	45.5	45.6	47.8	44.5	40.5	45.0	48.3	47.5
Mikael	41.3	40.5	44.1	39.5	38.5	40.0	41.5	42.1
Zoltan	45.6	41.9	48.3	42.0	42.0	41.0	46.7	42.8
Blue Chip	46.3	46.2	48.1	45.0	42.0	45.0	48.8	48.7
Flanders	46.4	47.3	44.7	44.0	47.0	45.0	47.5	52.8

4.3 Maturity

Almost no maturity differential was observed between the early and late-spring drilled trials at any of the three sites, so that at each site the two trials were harvested together. At Cambridge, the combination of crop maturity and weather allowed the earliest harvest, on 19 August. At both Morley and Headley Hall maturity was later and harvest was further delayed by the onset of wet weather by approximately ten days beyond maturity until 16/17 September. This was a reminder of the great difficulty that can be experienced in harvesting linseed in a wet autumn and of the principal advantage of winter linseed, namely earliness of harvest maturity.

4.4 Yield and Quality

Rainfall at all three sites was low and yields were poor. Table 3 compares variety yields from the two spring sowings with each other and the autumn sowing of the varieties in common. At all three sites the yield of the best winter-hardy, autumn-sown variety, was considerably higher than the best yield achieved in adjacent spring-sown trials. Thus the mean yield of autumn-sown Oliver was 2.34 tonnes per hectare, compared with the yield of 1.48 tonnes per hectare from Blue Chip in the early spring-sowing.

The early spring drilled plots were consistently higher yielding than the late-sown plots.

At Cambridge and Morley, the oil content of the seed was higher in the autumn-sown trials than the spring-sown trials, (Table 4), for the common varieties. However, at Headley Hall the reverse was true.

While the mean figures for oil content in the two spring sowings were very similar, inspection of individual site data shows considerable variation for individual varieties, which was not consistent from site to site.

Table 3 Seed yield at 9% moisture in t/ha

	Overall mean			Cambridge			Morley			Headley Hall		
		Spring-sown			Spring-sown			Spring-sown			Spring-sown	
	Autumn-sown	Early	Late	Autumn-sown	Early	Late	Autumn-sown	Early	Late	Autumn-sown	Early	Late
Harvest Date	14-Aug	7-Sep	7-Sep	5-Aug	19-Aug	19-Aug	20-Aug	16-Sep	17-Sep	16-Aug	17-Sep	17-Sep
Variety												
Oliver (c)	2.34	1.23	1.14	2.75	1.00	0.89	2.10	*	1.42	2.16	1.18	1.11
Arctica (c)	1.87	1.20	1.06	2.07	0.91	0.75	1.60	1.52	1.38	1.93	1.18	1.06
Bolas	0.66	1.21	1.07	0.61	0.89	0.75	0.64	*	1.37	#	1.25	1.08
Nordica		1.28	1.01		1.24	0.79		1.38	1.29		1.23	0.94
Antares		1.38	1.24		0.90	0.76		1.74	1.67		1.51	1.30
Barbara		1.44	1.17		1.29	0.87		1.62	1.55		1.40	1.09
Mikael		1.29	1.21		0.94	0.85		1.68	1.58		1.25	1.21
Zoltan		1.43	1.21		1.33	0.96		1.65	1.60		1.31	1.08
Blue Chip		1.48	1.26		1.26	1.18		1.85	1.64		1.33	0.95
Flanders		1.30	1.13		0.95	0.76		1.59	1.51		1.36	1.13
Control mean in t/ha	2.11			2.41			1.85			2.05		
se(variety mean)	0.1622	0.0786	0.0651	0.0944	0.1042	0.0517	0.0922	0.0897	0.0607	0.1232	0.0779	0.1686
LSD(variety means) (P=0.05)	0.673	0.236	0.194	0.425	0.333	0.165	0.362	0.326	0.194	2.215	0.261	0.539

= variety showing complete winter kill at Headley Hall

Table 4 Oil content as % seed yield at 9% moisture

Variety	Mean			Cambridge			Morley			Headley Hall		
		Spring-sown			Spring-sown			Spring-sown			Spring-sown	
	Autumn-sown	Early	Late	Autumn-sown	Early	Late	Autumn-sown	Early	Late	Autumn-sown	Early	Late
Oliver	40.2	38.8	38.9	42.0	38.2	37.7	38.9	*	38.1	39.7	40.3	40.7
Arctica	41.7	40.5	40.6	42.3	39.0	39.0	41.3	39.8	40.6	41.4	40.6	42.1
Bolas	38.8	39.3	39.0	39.6	38.6	38.0	38.0	*	38.1	*	40.8	41.1
Nordica		38.9	38.6		38.7	37.7		*	38.3		40.0	39.9
Antares		38.5	38.8		37.6	37.3		37.5	38.2		40.3	40.8
Barbara		39.5	39.0		39.5	38.3		38.8	39.1		40.2	39.7
Mikael		38.8	39.4		37.7	38.4		*	39.4		40.7	40.6
Zoltan		39.2	39.6		39.3	38.2		37.7	39.5		40.7	41.0
Blue Chip		40.5	39.6		40.1	38.4		40.4	39.6		41.0	40.9
Flanders		40.0	40.2		39.6	38.8		39.0	40.1		41.3	41.8
Mean		**39.4**	**39.4**		**38.8**	**38.2**		**38.9**	**39.1**		**40.6**	**40.9**

5.0 Conclusions

5.1 Comparing winter and spring linseed

A clear yield advantage of winter linseed over spring linseed in the 1996 harvest season was demonstrated in a series of replicated trials. Further advantages of the winter crop appear to be ease of establishment and early harvest when compared with the spring crop. The most easily attributable cause of the higher yields of winter linseed is drought avoidance, most likely as a consequence of the development of earlier and more extensive rooting systems than is possible for spring-sown plants. Because of this the true strength of winter linseed may be stability of yield, rather than absolute yield. The yield advantage of winter linseed in a season free of drought stress remains to be fully investigated.

Oil content of seed from the autumn-sown plots was higher than from either of the spring sowings. If consistent from season to season, this would be a further financial incentive to grow the crop, because of the increased oil premium received by growers.

The winter linseeds seen so far have shown only moderate or poor resistance to lodging in seasons when conditions have promoted the development of tall crops. Work over the coming seasons will be required to identify the ideal plant model for winter linseed.

Winter linseed was 2-4 weeks earlier to harvest than spring linseed in a season in which, as has been described, winter linseed was comparatively late and spring linseed was earlier to harvest than in some seasons. It may well be more realistic to think of winter linseed as possibly 4-6 weeks earlier than spring linseed.

5.2 Comparing spring drilling dates

The highest yields were obtained from the earliest sowings. However indications of the vulnerability of the crop to poor seedbed conditions were seen at two sites (Cambridge and Morley), and careful consideration of variety and seed quality should be made when contemplating early sowing. As a generalisation, large-seeded varieties tend to show better seedling vigour, which is desirable for rapid establishment in cold conditions and in situations of early seed-bed moisture loss.

Early sowing of spring linseed varieties did not show anywhere near the same advantage over normal sowing dates as did autumn sowing of winter-hardy varieties, in either yield or maturity.

PROJECT REPORT No. OS22

WINTER LINSEED II. WEED CONTROL TRIALS

by

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This is the final report of a 20 month project which started in October 1995. The work was funded by a grant of £7,456 from the Home-Grown Cereals Authority (Project No. OS10/1/95).

Contents

Summary

Winter linseed is now commercially available in the UK. It has many advantages over spring linseed which make it more attractive to growers, these being its early maturity, its higher yield potential and it is less susceptible to attack from the flax flea beetle.

A one-year investigation, from October 1995 to August 1996, at ADAS Boxworth, Cambridge evaluated a number of pre-emergence and post-emergence herbicides, at set timings, to winter linseed to determine their performance on seed quality and yield. Herbicides included trifluralin, linuron, metazachlor, metsulfuron-methyl, bentazone, bromoxynil plus ioxynil plus clopyralid, amidosulfuron and clopyralid. The objectives were to evaluate broad-leaved weed control programmes for winter linseed in terms of their efficacy and crop safety. This encompassed both autumn and spring weed control programmes in comparison with untreated controls.

Linseed plant populations were decreased by pre-emergence applications of metazachlor. Amidosulfuron was most effective spring applied herbicide on cleavers and when in combination with metsulfuron-methyl, as a tank-mix or a sequence, chickweed was also controlled.

At the time of writing (February 1997) amidosulfuron is not approved for use in winter linseed. Data has been submitted by the chemical company towards full label approval of the product for spring application, but it is unlikely to be available for spring 1997. This study has shown that there no alternatives that provide the degree of control of cleavers shown by amidosulfuron. There was no effect of post-emergence herbicides on yield of seed. Gross margins were decreased by between £11 and £100 by herbicide treatment.

Objectives

- To evaluate broad-leaved weed control programmes for winter linseed in terms of their efficacy and crop safety.
- To determine the effect of the weed population on seed yield by comparison of the untreated controls with spring weed control programmes.
- To determine the importance of autumn weed control by comparison of spring herbicide applications with full weed control programmes.
- To determine the effect of spring post-emergence herbicide programmes in terms of the efficacy and crop safety by comparison with untreated controls.

Changes to the project

The initial project was a pilot study to develop cost-effective weed control strategies for winter linseed. The experiment was established and pre-emergence treatments were applied, but due to high crop mortality the effect of pre-emergence herbicide treatments on yield was not assessed. The results from this experiment are discussed as Experiment 1. The experiment was moved to an established crop of winter linseed in the spring and spring herbicides were applied. The details of this are discussed as Experiment 2.

Experiment 1. The effect of pre-emergence herbicides on weed control in winter linseed

Materials and methods

Site

The experiment was located on a well structured clay soil of the Hanslope series, following winter wheat. Details of crop and site are presented in Appendix I.

Treatments

Chemical ($l\ ha^{-1}$)	Timing
Untreated	
1.75 trifluralin	Pre-drilling incorporated
2.0 trifluralin	Pre-emergence
1.0 linuron	Pre-emergence
3.5 trifluralin + linuron	Pre-emergence
2.0 metazachlor	Pre-emergence

Product name, active ingredient, concentration and product application rates are given in Table 1.

Table 1. *Product name, active ingredient, concentration (g a.i. l^{-1}) and product application rate.*

Active ingredient	Product name	g a.i. l^{-1}	Manufacturer	Application rate ($l\ ha^{-1}$)
trifluralin	Portmans Trifluralin*	480	Portman	1.75
trifluralin	Portmans Trifluralin	480	Portman	2.0
linuron	Afalon	450	AgrEvo	1.0
linuron + trifluralin	Linnet	106:192	PBI	3.5
metazachlor	Butisan S	500	BASF	2.0

*incorporated pre-drilling

Trifluralin was applied to the soil on 13 October 1995 and all plots were cultivated using a rotary cultivator on 13 October 1995. The trial was drilled on 16 October 1995. Pre-emergence herbicides were applied on 18 October 1996.

Herbicides were applied using an Oxford Precision Sprayer fitted with F110-04 nozzles in a total volume of 225 $l\ ha^{-1}$ at 250 kPa pressure. Details of application dates, growth stages and weather conditions at time of spraying are given in Appendix II.

Experiment design

A fully randomised two-way factorial design with 4 replicates. Plot size was 3.5m x 24m.

Assessments

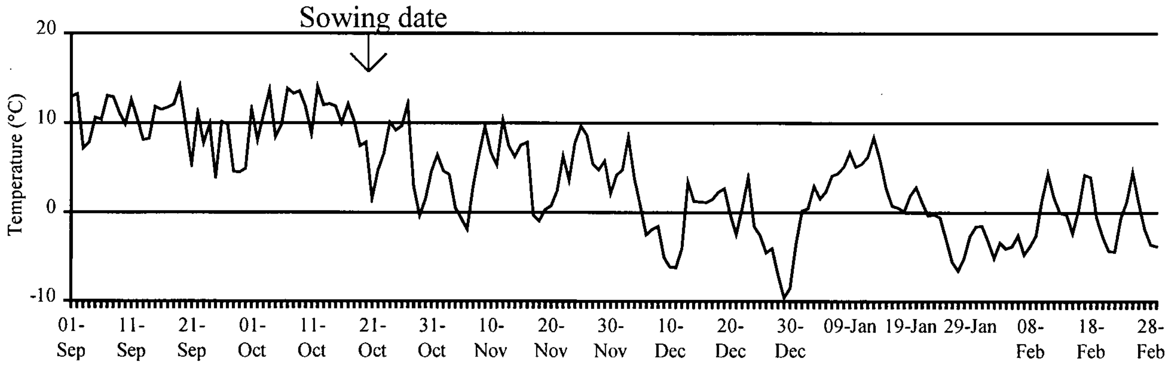
Plant counts were done on 19 December 1995 in 10 x 0.5m rows per plot.

Weed counts were done on 4 January 1996 in 4 x 0.25m^2 quadrats per plot.

Results

The pre-emergence herbicides were applied within three days of sowing to a very dry seedbed. The first linseed cotyledons appeared on 11 November 1995. Emergence was slower than expected because of the cold, dry conditions and as a result the crop only reached 1 to 2 true leaves by December. Continuing cold weather caused very high crop mortality through the winter and the termination of this trial (Fig. 1).

Fig. 1. Minimum air temperatures from September to February (°C)



Due to the high mortality of the crop, it was no longer possible to assess the effect of the pre-emergence herbicide treatments on the crop yield. Initial crop safety and efficacy of the treatments were however recorded.

Plant populations were significantly ($p<0.01$) affected by herbicide application (Table 2). Pre-drilling incorporated trifluralin decreased populations by 13% and metazachlor decreased populations by 20%.

Weed populations were very low and very variable. All chemicals, except linuron, decreased weed populations (Table 3).

Table 2. *Linseed plant number on 19 December 1995 (plants m^{-2})*

Chemical ($l\ ha^{-1}$)	Timing	Population (plants m^{-2})
Untreated		393.0
1.75 trifluralin	Pre-drilling incorporated	341.7
2.0 trifluralin	Pre-emergence	364.8
1.0 linuron	Pre-emergence	391.5
3.5 trifluralin + linuron	Pre-emergence	362.0
2.0 metazachlor	Pre-emergence	314.1
SED	When comparing the untreated with herbicide treated	23.93
	When comparing between herbicide treatments	32.11
df		71
CV%		12.0

Table 3. *Weed populations on 4 January 1996*

Chemical ($l\ ha^{-1}$)	Timing	Chickweed	Total weeds
Untreated		7.2	8.7
1.75 trifluralin	Pre-drilling incorporated	2.0	2.2
2.0 trifluralin	Pre-emergence	2.2	2.7
1.0 linuron	Pre-emergence	3.5	13.8
3.5 trifluralin + linuron	Pre-emergence	1.0	1.8
2.0 metazachlor	Pre-emergence	0.0	1.5
SED	When comparing the untreated with herbicide treated	4.79	6.85
	When comparing between herbicide treatments	6.43	9.19
df		71	71
CV%		200.9	173.6

Discussion

This experiment provided vital information on the crop safety of pre-emergence herbicides. Pre-drilling incorporated trifluralin and pre-emergence metazachlor decreased plant populations. This result was supported by a further experiment on the farm where plant populations were severely decreased by metazachlor but final yield was unaffected. Weed populations were low and no conclusions can be drawn from the weed control data.

Experiment 2. The effect of post-emergence weed control in winter linseed

Materials and methods

Site

The experiment was located on a well structured clay soil (Hanslope series) following a winter wheat. Appendix III gives details of previous cropping and soil information.

Treatments

	Early spring post-emergence	Late spring post-emergence
1	Untreated	-
2	metsulfuron-methyl	-
3	bentazone + bromoxynil + clopyralid	-
4	amidosulfuron (Full Rate)	-
5	metsulfuron-methyl + amidosulfuron (Full Rate)	-
6	bentazone + amidosulfuron (Full Rate)	-
7	clopyralid + amidosulfuron (Full Rate)	-
8	bromoxynil + clopyralid + amidosulfuron (Full Rate)	-
9	bentazone + bromoxynil + clopyralid + amidosulfuron (Full Rate)	-
10	bromoxynil + clopyralid + amidosulfuron (Reduced Rate)	-
11	clopyralid + amidosulfuron (Reduced Rate)	-
12	bentazone + bromoxynil + clopyralid	amidosulfuron (Full Rate)
13	bentazone + bromoxynil + clopyralid	amidosulfuron (Reduced Rate)
14	metsulfuron-methyl	amidosulfuron (Full Rate)

Product name, active ingredient, concentration and product application rates are given in Table 4.

Table 4. *Product name, active ingredient, concentration (g a.i. l^{-1}) and product application rate.*

Active ingredient	Product name	g a.i. l^{-1}	Manufacturer	Application rate ($l\ ha^{-1}$)
metsulfuron-methyl	Ally	200	Dupont	30 g ha^{-1}
bentazone	Basagran	480+	BASF	2 l ha^{-1}
bromoxynil + clopyralid	Vindex	240 + 50	Dow Elanco	1 l ha^{-1}
amidosulfuron (Full Rate)	Eagle	750	AgrEvo	40 g ha^{-1}
amidosulfuron (Reduced Rate)	Eagle	750	AgrEvo	30 g ha^{-1}
bentazone	Basagran	480	BASF	2 l ha^{-1}
clopyralid	Dow Shield	200	Dow Elanco	0.5 l ha^{-1}

Early spring post-emergence herbicides were applied on 22 April 1996 and the late spring post-emergence herbicides were applied on 30 May 1996.

Herbicides were applied using an Oxford Precision Sprayer fitted with F110-04 nozzles in a total volume of 225 l ha^{-1} at 250 kPa pressure. Details of application dates, growth stages and weather conditions at time of spraying are given in Appendix IV.

Experiment design

A fully randomised two-way factorial design with 4 replicates. Plot size was 3.5m x 24m.

Assessments

Weed counts were done on 25 June 1996 in 4 x 0.25 m^2 quadrats per plot.
Linseed branches were counted on 2 July 1996 in 5 x 0.1 m^2 quadrats per plot.
The experiment was harvested on 04 / 05 August 1996 with a Sampo Rosenlew 2025 plot combine. Grain samples were taken at harvest and analysed for moisture content and specific weight using a Dickey-John GAC 2000 moisture computer. Chemical analysis was done by Analytical Chemistry, ADAS Wolverhampton for oil content by NMR.

Results

The first cotyledons of linseed were seen on the 23 October 1995 with a good even crop cover established by the beginning of November. Flowers opened on 1 June 1996.

Total linseed branch number was unaffected by chemical application (Table 5).

Table 5. *The effect of treatment on total branch number (branches m^{-2})*

Trt No	Early spring post emergence (22 April 1996)	Late spring post emergence (30 May 1996)	branches m^{-2}
1	Untreated	-	645
2	metsulfuron-methyl	-	569
3	bentazone + bromoxynil + clopyralid	-	648
4	amidosulfuron (Full Rate)	-	722
5	metsulfuron-methyl + amidosulfuron (Full Rate)	-	662
6	bentazone + amidosulfuron (Full Rate)	-	647
7	clopyralid + amidosulfuron (Full Rate)	-	623
8	bromoxynil + clopyralid + amidosulfuron (Full Rate)	-	655
9	bentazone + bromoxynil + clopyralid + amidosulfuron (Full Rate)	-	664
10	bromoxynil + clopyralid + amidosulfuron (Reduced Rate)	-	642
11	clopyralid + amidosulfuron (Reduced Rate)	-	631
12	bentazone + bromoxynil + clopyralid	amidosulfuron (FR)	612
13	bentazone + bromoxynil + clopyralid	amidosulfuron (RR)	679
14	metsulfuron-methyl	amidosulfuron (FR)	673
	SED (47 d.f.) When comparing the untreated with herbicide treated		40.4
	SED (47 d.f.) When comparing between herbicide treatments		23.3
	CV%		12.5
	sig.		NS

FR - Full rate

RR - reduced rate

Dunnet's test was used to compare the herbicide treatments with the untreated. The level of chickweed control, either as plants or ground cover, was significantly different from the untreated in treatments 5 and 14 (Tables 6 and 8). These treatments combined the use of metsulfuron-methyl with amidosulfuron either as a tank mix applied or as a sequence.

Cleaver numbers were generally controlled by any treatment that contained amidosulfuron. The level of cleaver control was significantly different from the untreated in treatments 4 to 10 and 12 (Table 6). Control of cleaver number was poorest where amidosulfuron was applied late (30 May) but there was still some control of ground cover by these treatments. Ground cover of cleavers was significantly decreased by treatments 4 to 13 (Table 8).

Black-grass numbers were variable and not significantly ($p<0.05$) affected by herbicide treatment, this was as to be expected due to the lack of activity of the herbicides on grass weeds (Table 7).

Table 6. *Weed populations on 25 June 1996 (plants m^{-2}). Log transformations with back transformed means in brackets. Figures in* **bold** *denote treatments differing significantly ($p<0.05$) from the untreated in Dunnet's test.*

Tr. No	**Early Spring post emergence (22 April 1996)**	**Late spring post emergence (30 May 1996)**	**Chickweed**	**Cleavers**
1	Untreated	-	3.1 (23.1)	3.1 (23.2)
2	metsulfuron-methyl	-	2.6 (12.7)	3.7 (38.8)
3	bentazone + bromoxynil + clopyralid	-	3.1 (21.4)	2.9 (16.3)
4	amidosulfuron (Full Rate)	-	2.7 (13.4)	**1.3 (2.8)**
5	metsulfuron-methyl + amidosulfuron (Full Rate)	-	**0.8 (1.2)**	**1.4 (3.0)**
6	bentazone + amidosulfuron (Full Rate)	-	2.6 (11.8)	**0.9 (1.3)**
7	clopyralid + amidosulfuron (Full Rate)	-	3.1 (21.1)	**1.1 (2.1)**
8	bromoxynil + clopyralid + amidosulfuron (Full Rate)	-	2.8 (15.3)	**0.9 (1.6)**
9	bentazone + bromoxynil + clopyralid + amidosulfuron (Full Rate)	-	2.6 (11.8)	**0.9 (1.4)**
10	bromoxynil + clopyralid + amidosulfuron (Reduced Rate)	-	2.4 (10.5)	**1.1 (2.0)**
11	clopyralid + amidosulfuron (Reduced Rate)	-	3.3 (26.1)	2.1 (7.4)
12	bentazone + bromoxynil + clopyralid	amidosulfuron (FR)	3.0 (18.8)	**1.3 (2.8)**
13	bentazone + bromoxynil + clopyralid	amidosulfuron (RR)	2.4 (10.0)	2.0 (6.4)
14	metsulfuron-methyl	amidosulfuron (FR)	**1.3 (2.5)**	2.9 (17.3)
	CV%		31.2	40.8
	SED (47 d.f.) When comparing the untreated with herbicide treated		0.47	0.47
	SED (47 d.f.) When comparing between herbicide treatments		0.58	0.58
	sig.		0.001	<0.001

FR - Full rate

RR - reduced rate

Table 7. *Black-grass populations on 25 June 1996 (plants m^{-2}).*

Tr. No	Early Spring post emergence (22 April 1996)	Late spring post emergence (30 May 1996)	Black-grass
1	Untreated	-	14.1
2	metsulfuron-methyl	-	9.5
3	bentazone + bromoxynil + clopyralid	-	21.0
4	amidosulfuron (FR)	-	15.0
5	metsulfuron-methyl + amidosulfuron (FR)	-	22.5
6	bentazone + amidosulfuron (FR)	-	1.0
7	clopyralid + amidosulfuron (FR)	-	9.3
8	bromoxynil + clopyralid + amidosulfuron (FR)	-	15.0
9	bentazone + bromoxynil + clopyralid + amidosulfuron (FR)	-	17.0
10	bromoxynil + clopyralid + amidosulfuron (RR)	-	33.3
11	clopyralid + amidosulfuron (RR)	-	21.0
12	bentazone + bromoxynil + clopyralid	amidosulfuron (FR)	12.8
13	bentazone + bromoxynil + clopyralid	amidosulfuron (RR)	11.0
14	metsulfuron-methyl	amidosulfuron (FR)	4.0
	CV%		136.8
	SED (47 d.f.) When comparing the untreated with herbicide treated		11.57
	SED (47 d.f.) When comparing between herbicide treatments		14.18
	sig.		NS

FR - Full rate

RR - reduced rate

Table 8. *Percentage ground cover of chickweed and cleavers on 25 June 1996 - log transformation (Back transformed means in brackets). Figures in* **bold** *denote treatments differing significantly (p<0.05) from the untreated in Dunnet's test.*

Tr. No	Early Spring post emergence (22 April 1996)	Late spring post emergence (30 May 1996)	Chickweed	Cleavers
1	Untreated	-	2.4 (10.4)	2.6 (12.1)
2	metsulfuron-methyl	-	1.8 (5.1)	2.8 (16.2)
3	bentazone + bromoxynil + clopyralid	-	2.1 (6.8)	2.1 (7.2)
4	amidosulfuron (FR)	-	1.8 (5.0)	**0.6 (0.9)**
5	metsulfuron-methyl + amidosulfuron (FR)	-	**0.4 (0.6)**	**0.8 (1.2)**
6	bentazone + amidosulfuron (FR)	-	1.6 (4.1)	**0.2 (0.2)**
7	clopyralid + amidosulfuron (FR)	-	2.1 (6.9)	**0.6 (0.8)**
8	bromoxynil + clopyralid + amidosulfuron (FR)	-	1.8 (5.1)	**0.4 (0.6)**
9	bentazone + bromoxynil + clopyralid + amidosulfuron (FR)	-	1.6 (3.9)	**0.3 (0.4)**
10	bromoxynil + clopyralid + amidosulfuron (RR)	-	1.6 (4.1)	**0.3 (0.3)**
11	clopyralid + amidosulfuron (RR)	-	2.5 (11.1)	**0.9 (1.5)**
12	bentazone + bromoxynil + clopyralid	amidosulfuron (FR)	1.9 (5.8)	**0.9 (1.4)**
13	bentazone + bromoxynil + clopyralid	amidosulfuron (RR)	1.2 (2.5)	**0.9 (1.4)**
14	metsulfuron-methyl	amidosulfuron (FR)	**0.6 (0.8)**	1.8 (5.2)
	SED (47 d.f.) When comparing the untreated with herbicide treated		0.39	0.42
	SED (47 d.f.) When comparing between herbicide treatments		0.48	0.51
	CV%		35.2	56.7
	sig.		<0.001	<0.001

FR - Full rate

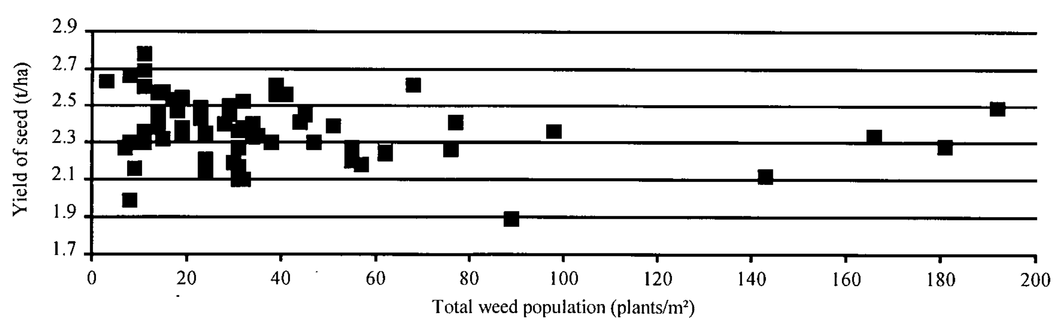
RR - reduced rate

Table 9. Yield of seed at 91% DM

Tr. No	Early Spring post emergence (22 April 1996)	Late spring post emergence (30 May 1996)	Yield (t ha^{-1})
1	Untreated	-	2.35
2	metsulfuron-methyl	-	2.42
3	bentazone + bromoxynil + clopyralid	-	2.40
4	amidosulfuron (FR)	-	2.37
5	metsulfuron-methyl + amidosulfuron (FR)	-	2.40
6	bentazone + amidosulfuron (FR)	-	2.47
7	clopyralid + amidosulfuron (FR)	-	2.39
8	bromoxynil + clopyralid + amidosulfuron (FR)	-	2.47
9	bentazone + bromoxynil + clopyralid + amidosulfuron (FR)	-	2.48
10	bromoxynil + clopyralid + amidosulfuron (RR)	-	2.34
11	clopyralid + amidosulfuron (RR)	-	2.37
12	bentazone + bromoxynil + clopyralid	amidosulfuron (FR)	2.17
13	bentazone + bromoxynil + clopyralid	amidosulfuron (RR)	2.32
14	metsulfuron-methyl	amidosulfuron (FR)	2.25
	SED (47 d.f.) When comparing the untreated with herbicide treated		0.083
	SED (47 d.f.) When comparing between herbicide treatments		0.102
	CV%		6.1
	sig.		NS

There were no differences in crop yield (Table 9).

Fig. 2. The relationship between total weed number and crop yield.



Overall there was no relationship between total weed populations and yield of seed (Fig. 2). In a simple regression only 2% of the variance was accounted for.

Tukeys test was used to compare all possible pairwise comparisons for oil content. The test indicated that at the 5% confidence level the oil content of treatments 7, 8 and 13 were significantly different from treatment 2 (Table 10). There was no apparent reason to explain these differences but no single treatment was significantly different from the untreated.

Table 10. *Oil content at 91% DM*

Tr. No	Early Spring post emergence (22 April 1996)	Late spring post emergence (30 May 1996)	Oil (%)	Tukeys test
1	Untreated	-	40.56	ab
2	metsulfuron-methyl	-	39.49	a
3	bentazone + bromoxynil + clopyralid	-	41.27	ab
4	amidosulfuron (Full Rate)	-	41.40	ab
5	metsulfuron-methyl + amidosulfuron (Full Rate)	-	40.93	ab
6	bentazone + amidosulfuron (Full Rate)	-	41.54	ab
7	clopyralid + amidosulfuron (Full Rate)	-	41.75	b
8	bromoxynil + clopyralid + amidosulfuron (Full Rate)	-	41.66	b
9	bentazone + bromoxynil + clopyralid + amidosulfuron (Full Rate)	-	41.27	ab
10	bromoxynil + clopyralid + amidosulfuron (Reduced Rate)	-	41.22	ab
11	clopyralid + amidosulfuron (Reduced Rate)	-	41.27	ab
12	bentazone + bromoxynil + clopyralid	amidosulfuron (FR)	40.88	ab
13	bentazone + bromoxynil + clopyralid	amidosulfuron (RR)	41.68	b
14	metsulfuron-methyl	amidosulfuron (FR)	40.93	ab
	SED (47 d.f.) When comparing the untreated with herbicide treated		0.478	
	SED (47 d.f.) When comparing between herbicide treatments		0.586	
	CV%		2.0	
	sig.		0.023	

Gross margins were calculated using the costs in Table 11.

Gross margins were decreased by use of herbicides (Table 12). The gross margin penalty was less were single sprays were used.

Table 11. costs used to calculate gross margins (£ ha^{-1})

Active ingredient	Product name	Application rate ($l\ ha^{-1}$)	Cost (£ ha^{-1})
metsulfuron-methyl	Ally	30 g ha^{-1}	16.50
bentazone	Basagran	2 l ha^{-1}	34.00
bromoxynil + clopyralid	Vindex	1 l ha^{-1}	9.28
amidosulfuron (Full Rate)	Eagle	40 g ha^{-1}	16.25
amidosulfuron (Reduced Rate)	Eagle	30 g ha^{-1}	12.19
bentazone	Basagran	2 l ha^{-1}	34.00
clopyralid	Dow Shield	0.5 l ha^{-1}	27.75
Spray application			6.25
Linseed			165 (£ t^{-1})

Table 12. Gross margin over chemical and application costs (£ ha^{-1})

Tr. No	Early Spring post emergence (22 April 1996)	Late spring post emergence (30 May 1996)	Gross margin (£ ha^{-1})	Difference from untreated (£ ha^{-1})
1	Untreated	-	387.50	-
2	metsulfuron-methyl	-	375.80	-11.70
3	bentazone + bromoxynil + clopyralid	-	346.70	-40.80
4	amidosulfuron (FR)	-	368.50	-19.00
5	metsulfuron-methyl + amidosulfuron (FR)	-	357.50	-30.00
6	bentazone + amidosulfuron (FR)	-	350.30	-37.20
7	clopyralid + amidosulfuron (FR)	-	343.80	-43.70
8	bromoxynil + clopyralid + amidosulfuron (FR)	-	374.90	-12.60
9	bentazone + bromoxynil + clopyralid + amidosulfuron (FR)	-	344.20	-43.30
10	bromoxynil + clopyralid + amidosulfuron (RR)	-	358.70	-28.80
11	clopyralid + amidosulfuron (RR)	-	344.40	-43.10
12	bentazone + bromoxynil + clopyralid	amidosulfuron (FR)	286.60	-100.90
13	bentazone + bromoxynil + clopyralid	amidosulfuron (RR)	314.50	-73.00
14	metsulfuron-methyl	amidosulfuron (FR)	325.30	-62.20
	SED (47 d.f.) When comparing the untreated with herbicide treated		13.74	
	SED (47 d.f.) When comparing between herbicide treatments		16.83	
	CV%		6.7	
	sig.		<0.001	

Discussion

The weeds present in this study were those most commonly found in winter linseed crops. Plant number was unaffected by post-emergence applications of herbicide. Chickweed was only controlled by metsulfuron-methyl in a tank mix or in sequence with amidosulfuron. Amidosulfuron was also very effective in controlling cleavers. Unfortunately amidosulfuron is not approved for use in winter linseed at the time of writing (February 1997). Data has been submitted by the chemical company towards full label approval of the product for spring application, but it is unlikely to be available for spring 1997. This study has shown that there are no alternatives that provide the degree of control of cleavers as shown by amidosulfuron. There were no yield increases from the use of herbicides in winter linseed and gross margin was decreased through their use, this was probably due to low levels of weeds present in the experiment.

Conclusions

- The pre-emergence herbicides metazachlor and trifluralin decreased plant populations.
- Amidosulfuron, applied post-emergence was effective in the control of cleavers. In combination with metsulfuron-methyl, amidosulfuron provided an effective spring treatment for weed control in winter linseed.
- Yield of seed was unaffected by treatment.
- Gross margins were lower after use of herbicides.

Recommendations

Future work should screen alternative chemicals, tank-mixes and sequences suitable for use in winter linseed. When suitable herbicides are identified then work can progress to produce guidelines on weed thresholds and optimum time of removal. Non-chemical methods should be evaluated to enhance linseeds image of a low-input environmentally sound breakcrop.

Appendix I. Details of site and crop - Experiment 1

Site:	ADAS Boxworth		Experiment 1
Field name:	Side Hill		
Soil texture:	Clay		
Drainage:	Good		
Soil analysis:	pH	:	7.9
	P mg/l (index)	:	24(2)
	K mg/l (index)	:	305(3)
	Mg mg/l (index)	:	114(3)
	OM%	:	3.7
Previous cropping:	1995 Winter Wheat		
	1994 Winter Wheat		
	1993 Winter oilseed rape		
Previous cultivation:	Bale, disc, Opico x 2		
Crop:	Cultivar	:	Oliver
	Sowing date	:	16 October 1995
	Seedrate (kg ha^{-1})	:	33 (600 seeds/m^2)
	Fertiliser (kg ha^{-1})	:	None
Herbicides:	As treatment		
Fungicides:	None		
Insecticides:	None		
Desiccant:	None		

Appendix II. Details of herbicide application - Experiment 1

Date	Max. temp (°C)	Min. temp (°C)	Wind direction	Wind speed (m.p.h)	Drift	Growth Stage	Previous weather	Weather at application	Soil surface condition
18 October	15.31	5.42	north-west	2-4	slight	pre-em	dry, cool	sunny, warm	dry
13 October	19.19	9.74	south-west	1.2-2	slight	pre-drilling	misty, damp	cool, damp	dry

Appendix III. Details of site and crop - Experiment 2

Site:	ADAS Boxworth		Experiment 2
Field name:	Childerley		
Soil texture:	Clay		
Drainage:	Good		
Soil analysis:	pH	:	8.2
	P mg/l (index)	:	4
	K mg/l (index)	:	3
	Mg mg/l (index)	:	3
	OM%	:	3.7
Previous cropping:	1995 Winter Wheat		
	1994 Winter Wheat		
	1993 Failed spring beans		
Previous cultivation:	Chop and spread, Heavy disc×2, Flexitine, Maschio, Drill, Roll.		
Crop:	Cultivar	:	Oliver
	Sowing date	:	3 October 1995
	Seedrate (kg ha^{-1})	:	51 (856 seeds/m^2)
	Fertiliser (kg ha^{-1})	:	60 N
Herbicides:	As treatment		
Fungicides:	none		
Insecticides:	none		
Desiccant:	19 July 96 Reglone 3.0 l ha^{-1} Enhance 0.4 l ha^{-1}		
Harvest date:	4 / 5 August 1996		

Appendix IV. Details of site and crop - Experiment 2

Date	Max. temp (°C)	Min. temp (°C)	Wind direction	Wind speed (m.p.h)	Drift	Growth Stage	Previous weather	Weather at application	Soil surface condition
22 April	12.49	5.82	SSW	4-6	mod	22-23	dry, warm	damp, cool	damp
30 May	24.77	13.05	NE	1.2-2	slight	33-37	dry, warm	sunny, warm	dry