PROJECT REPORT No. OS53

EFFECTS OF DRILLING DATE, SEED RATE, NITROGEN LEVEL AND PLANT GROWTH REGULATORS ON WINTER LINSEED

NOVEMBER 2001

Price: £6.50

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by

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This is the final report of a 27-month project, which started in September 1996. The work was funded by a grant of £58,236 from HGCA (project no. 1638) and £10,000 from Semundo Ltd.

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ABSTRACT

The introduction of winter linseed to the UK in 1995 was a consequence of the agronomic problems associated with the spring crop; late harvesting and lodging being the greatest of these. The identification of a truly winter hardy variety – Oliver – meant that there was the exciting possibility of developing an early harvesting break crop with potentially higher yields. To fully develop its potential an agronomy blueprint has been constructed taking into account the key variables of sowing date, seed rate and nitrogen input. This series of trials was conducted over a two-year period (1996-1998) across the UK to examine all these variables plus the effects of PGR's and fungicide input. The trials were conducted in two of the most difficult seasons in recent years and results were variable.

The variations in establishment and yield were wide both across sites and over both seasons. Drilling date was a very important factor with mid-late September producing the optimum results. Seed rate was also influential with lower seed rates (400-600 seeds/m^2) producing less lodging, and better yield at early sowings, and higher rates (600-900), more appropriate for early October sowings. Nitrogen had a considerable effect on yield with significant increases in yield from inputs between 50 and 100 kg/ha. Higher amounts tended to increase lodging. PGR's were found to have some benefits in preventing lodging, although some damage to yield may occur. Fungicide input is important, with grey mould and pasmo proving difficult to control. Response to the products tested was limited. Yield, generally, was extremely varied across all trials and seasons and more work is needed to develop reliable agronomy techniques.

1. INTRODUCTION

Linseed has occupied a very valuable position as a breakcrop on many farms in the UK. At its peak in the early to mid 90's it occupied over 150,000 hectares of production with over 7,000 growers. From the mid 90's there has been a decline in production which can be attributed in a large part to:

- Later harvests delaying the drilling of first wheat crops, thereby reducing their profitability.
- Lodged crops proving very difficult to harvest, producing poor yields, and deterring expansion of the crop.

The spring sown crop by 1996 had dropped back to an area estimated to be around 85,000 ha, but the introduction of winter sown linseed varieties into the market has been an exciting development.

Winter sown linseed provides the ideal opportunity to produce an early harvested break crop which removes many of the potential problems of spring sown linseed. Initial work by plant breeders attempted to place spring linseed varieties in the autumn, but because of winter hardiness problems it has proved universally unacceptable. Now however, genuine winter hardy linseed varieties are available.

The most exciting potential of winter linseed is that it is a new crop, not a new variety. Spring linseed, whilst an important break crop in the UK, is not very popular across the rest of Europe as a break crop. Winter linseed, on the other hand, although relatively new has already attracted much attention in France and Italy, as well as the UK.

The winter variety Oliver is the most promising of the true winter varieties, having proven to be the most winter hardy in 1995 sowing. French trial results from 1996 also showed that Oliver suffered the least frost damage of all available winter varieties (Cetiom Oleoscope No. 39). However, concern exists over its winter survival unless it is well established. Early trials suggest early sowing and high seed rate aid establishment and ensure adequate overwintered plants survival. The subsequent agronomy dilemma would be to manage the strong plant stand resulting from milder winters. The potential for lodging would be increased following such winters and lodged linseed crops are very difficult to harvest.

This project was established to explore the implications of drilling date and seed rate on the structure of winter linseed crops, and how this may affect nitrogen requirements. The other two key agronomic inputs of growth regulation and fungicide are also investigated.

This is very much an agronomy project designed for risk management. Winter linseed is a potentially very attractive crop, but without adequate knowledge of its responses to agronomic inputs its potential could be seriously damaged.

OBJECTIVES

- To determine the influence of drilling date and seed rate on the yield of winter linseed.
- To investigate whether the nitrogen requirements of the crop is modified by different drilling dates and seed rates.
- To monitor the influence of agronomic variables on the tillering of winter linseed, as it possesses much greater ability to tiller than spring linseed.
- To determine the effect of plant growth regulators on crop structure and lodging. The occurrence of lodging in linseed removes many of the crops potential advantages.
- The evaluation of fungicide inputs on yield.
- To determine whether geographical location has an influence on the performance of the crop.
- To develop agronomy strategies based on the above key variables that will be reliable and appropriate for a range of climatic conditions and soil types.

2. MATERIALS AND METHODS

Trials were conducted at the following 7 locations commencing in Autumn 1996, for two seasons.

- Andover, Hampshire	(Arable Research Centre)
- Dunmow, Essex	(Dalgety Agriculture)
- Pershore, Worcs.	(Westcrop Ltd)
- Abbot's Ripton, Cambs.	(Svalof Weibull)
- Caythorpe, Lincs.	(Arable Research Centre)
- Morpeth, Northumberland	(North of England Arable Centre)
- Anstruther, Fife	(Scottish Agronomy Ltd)

Details of sites are presented in Appendix 1.

2.1. Core Trials

Two core trials were included at all locations over 2 seasons.

a) Drilling date/seed rate interaction

b) Drilling date/nitrogen level/seed rate interaction

a) Drilling date/seed rate interaction

Drilling Dates — 3; Early September to early October, with approximately 2 weeks between each drilling date.

Seed Rates — 4; 400, 670, 940, 1200 seeds/m^2.
All 4 seed rates included at each drilling date.

Replicates — 4

Trial Design — Trials were of a split block design. Practical management constraints meant that drilling dates and seed rates cannot be fully randomised in each block. Drilling date blocks were randomly allocated in each replicate. Double guard plots were sown between blocks, with each guard being sown at the timing of its neighbouring block. This helps to minimise edge effect (Fig. 1). plot sizes varied between 1.5-2.1 m x 8-15 m. Trial design and randomisation were produced by BIOSS – University of Edinburgh, who also statistically analysed the data.

Figure 1 – Example of dd/sr trial design

R1	D 2	A 2	B 2	C 2	G	G	A 1	C 1	D 1	B 1	G	G	C 3	A 3	D 3	B 3
R2	B 1	A 1	C 1	D 1	G	G	B 2	A 2	C 2	D 2	G	G	C 3	D 3	B 3	A 3
R3	B 2	D 2	C 2	A 2	G	G	B 3	D 3	A 3	C 3	G	G	A 1	C 1	D 1	B 1
R4	D 1	A 1	C 1	B 1	G	G	D 2	A 2	B 2	C 2	G	G	D 3	B 3	C 3	A 3

1 DD1	A 400 seeds/m^2		G - Guard
2 DD2	B 670 seeds/m^2		
3 DD3	C 940 seeds/m^2		
	D 1200 seeds/m^2		

<u>Assessments</u>

General observations were made on emergence and establishment of the trials. Plant counts were under taken once each drilling date block was considered fully established in late autumn. Plants were counted in 4 x 1 metre fixed row lengths per plot. The same fixed row lengths were counted again in the spring to produce a tillers/m^2 count.

Assessments were made of lodging near to maturity. When trials were close to maturity the original fixed row lengths were lifted and plant and tiller counts undertaken. A random sample of 5 plants per row length were selected and boll numbers from there were counted. Height scores were carried out on each row length.

Trials were harvested by small plot combine at maturity and yields in tonnes/ha, corrected for moisture content were produced.

b) Drilling date/nitrogen level/seed rate interaction

Drilling Dates 2; Early September, early October

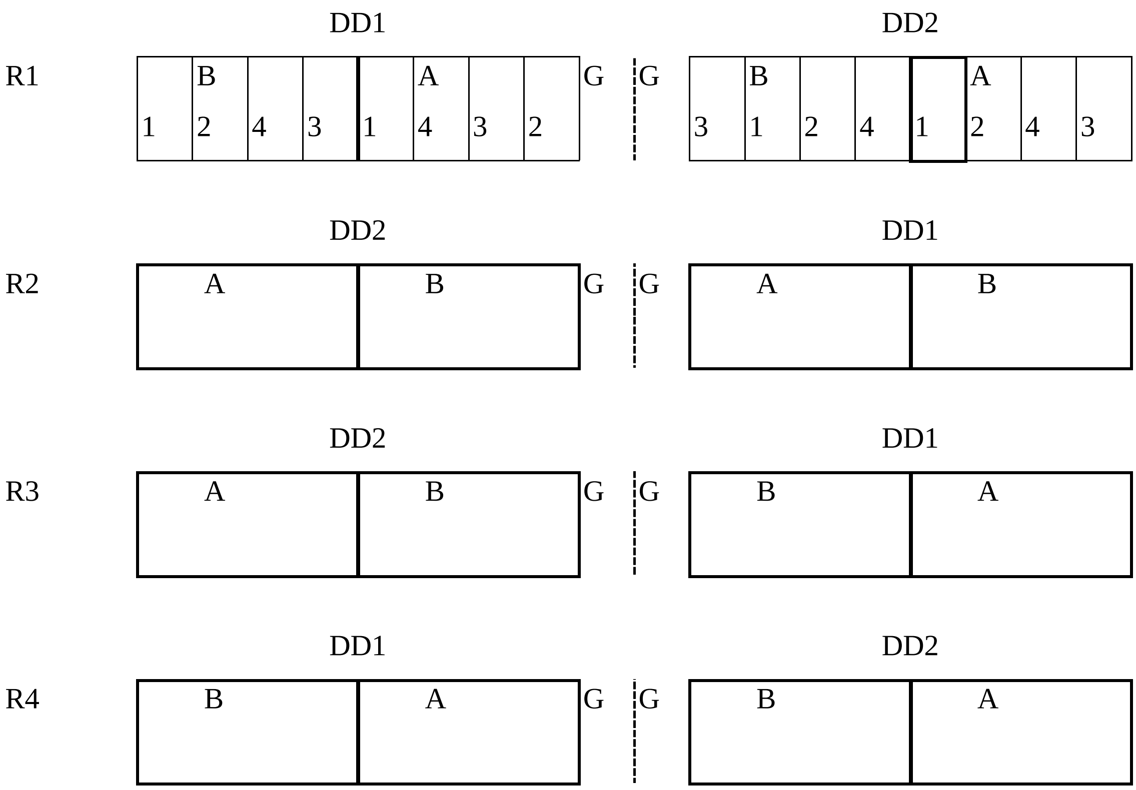
Nitrogen Levels 4; 0, 50, 100, 150 Kg/ha. Applied in March in a single application, or split if considered appropriate.

Seed Rates 2; 400, 1200 seeds/m^2.
All 4 seed rates included at each drilling date.

Replicates 4

Trial Design Split block design with two drilling date blocks in each replicate. Each block was subdivided into two seed rate sub-blocks, with nitrogen levels randomised within each sub-block. The drilling date blocks and seed rate sub-blocks were randomly allocated in each replicate. This design (Fig. 2), provides the best comparison of nitrogen level, which has the greatest priority in this trial. Guard buffers, similar to trial a, were also utilised in this trial design.

Figure 2 – Example of dd/n/sr trial design



A 400 seeds/m^2 | 1 0 Kg/ha N | G - Guard

B 1200 seeds/m^2 | 2 50 Kg/ha N

3 100 Kg/ha N

4 150 Kg/ha N

<u>Assessments</u> Tillers were counted in 4 x 1 metre fixed row lengths per plot in the spring. Lodging was scored at maturity. Each fixed row length was lifted close to maturity and counts undertaken on each as per trial a. Trials were taken to yield, and yields recorded as tonnes/ha corrected for moisture content.

2.2. Supplementary Trials

i) Cycocel Management

Year 1 – ARC-Andover, NEAC-Morpeth

Year 2 – Westcrop-Pershore, Scottish Agronomy-Fife

ii) Alternative Plant Growth Regulators

Year 1 – ARC-Caythorpe, SW-Abbot's Ripton

Year 2 – Dalgety-Dunmow, NEAC-Morpeth

iii) Fungicide Management

Year 1 – Westcrop-Pershore, Scottish Agronomy-Fife

Year 2 – ARC-Caythorpe, SW-Abbot's Ripton

i) Cycocel Management

Drilling Dates 1; Early September

Seed Rates 2; 400, 1200 seeds/m^2 * * (reduced to 940 seeds/m^2 for year 2)

Replicates 4

Treatments 3;
1) No plant growth regulator
2) 5C Cycocel applied at 2.5 l/ha at mid-end March
3) 5C Cycocel applied at 2.5 l/ha at plants 15-20cm tall.

(Treatments repeated on both seed rates)

Trial Design Trials were of randomised block design.

Assessments Lodging was scored at maturity. At maturity the fixed row lengths were lifted and tiller and boll counts undertaken as for the core trials. Plant heights were also scored. Trials were taken to yield.

ii) Alternative plant growth regulator

Drilling Dates 1; Early September

Seed Rates 1; 1200 seeds/m^2

Replicates 4

Treatments 6;

1) No plant growth regulator
2) 3C Chlormequat @ 2.5 l/ha
3) 3C Chlormequat @ 2.5 l/ha mid-end March + repeat application at 15.20 cm.
4) Cerone @ 0.5 l/ha
5) Upgrade @ 2.0 l/ha
6) Moddus @ 0.4 l/ha

Timing All treatments applied at 15-20 cm (unless indicated)

Trial Design Trials were of randomised block design.

Assessments As per 5C Cycocel trial.

iii) **Fungicide management**

Drilling Dates 1; Early September

Seed Rates 1; 1200 seeds/m^2

Replicates 4

Treatments 6;

	1997	**1998**
1)	No fungicide treatments	No fungicide treatments
2)	Rovral @ 3.0 l/ha	Bravocarb @ 2.0 l/ha
3)	Ronilan @ 1.0 l/ha	Bravocarb @ 2.0 l/ha (double appln.)
4)	Compass @ 3.0 l/ha	Folicur @ 1.0 l/ha
5)	Bravocarb @ 2.0 l/ha	Plover @ 0.5 l/ha
6)	Folicur @ 1.0 l/ha	Compass @ 3.0 l/ha

Timing All treatments applied at mid-flower (unless indicated)

Trial Design Trials wee of randomised block design.

Assessments Disease observations were undertaken, and trials were taken to yield.

3. RESULTS

3.1. 1996/97 Season

The most significant feature of the growing season was the drought conditions experienced in the autumn of 1996, and the spring of 1997 – the driest on record for around 200 years. This meant that seedbed preparation, especially on the heavier soils, was difficult and emergence of plants was delayed and erratic – particularly within the early drilled blocks. Autumn establishment was not helped by frosts in early November which caused some frost heave. The summer proved to be a contrast with very wet conditions in most areas, particularly in June, leading to high disease pressure in linseed crops.

The target drilling dates (table 1) were mostly achieved although the persistent dry conditions resulted in delays in the final drill date on some of the sites. Overall, a good spread of dates was achieved, with around 2 weeks between each drilling.

Table 1 – 1996 Drilling Dates

Site	Drill Date 1	Drill Date 2	Drill Date 3
Hants.	06/09/96	19/09/96	02/10/96
Worcs.	16/09/96	07/10/96	21/10/96
Essex	12/09/96	01/10/96	17/10/96
Cambs.	13/09/96	26/09/96	09/10/96
Lincs.	07/09/96	20/09/96	11/10/96
Northumberland	15/09/96	18/09/96	04/10/96
Fife	03/09/96	17/09/96	01/10/96

On the lighter soils, in Hampshire and Worcestershire, the trials emerged quickly and evenly – between 3-10 days from drilling for all 3 drilling dates. On the heavier soils the effects of the drought on emergence were more pronounced, with emergence of the drill date 1 blocks being erratic. Emergence, to rows fully visible, on these sites took between 30-39 days. The delay was greatest on the sites in Essex and Cambs. The later drill dates emerged more evenly, taking between 20-30 days. The exception was the Northumberland site, where the DD2 and DD3 blocks emerged 43 and 47 days respectively after sowing.

3.1.1. Core Trials

a) Drilling date/seed rate interaction

i) Yield components

Plant populations were assessed in late autumn. The uneven emergence caused by the drought meant that assessments on the Essex site could not be undertaken. The individual site data is given in appendix 2, with the over sites summary in table 2.

Table 2 – Mean linseed plant population – autumn 1996 (plants/m^2)

Drill date	**Seed rate (seeds/m^2)**	**400**	**670**	**940**	**1200**	**Mean**
Early		276	453	624	797	537
Mid		301	506	684	878	592
Late		314	453	595	832	548
	Mean	297	470	635	835	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=44)	24.7	28.6	49.5			

There was a highly significant ($p<0.001$) increase in plant population with seed rate, but differences between sowing dates did not quite attain formal statistical significant ($p=0.074$). The data from the individual sites shows that for the two most Northerly sites in Northumberland and Fife, the late drill data produced a significantly lower count, but the other three sites produced the lowest counts at the early drill date.

Counts were repeated in the spring on tiller numbers (table 3).

Table 3 – Mean linseed tiller population – spring 1997 (tillers/m^2)

Drill date	**Seed rate (seeds/m^2)**	**400**	**670**	**940**	**1200**	**Mean**
Early		459	671	836	1009	744
Mid		395	582	779	958	697
Late		274	415	551	667	477
	Mean	376	556	722	878	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=44)	61.9	71.4	123.7			

The spring tiller counts show a highly significant trend ($p<0.001$) in population with both seed rate and drill date. There is a strong linear trend in the seed rates. The same trends are replicated on the individual sites (appendix 2). The effect of the harsher winter condition experienced in Scotland is reflected in this site having the lowest tiller populations overall. This is particularly highlighted in the late drilling date.

Tiller counts were repeated close to maturity and boll numbers were also assessed. Due to time constraints and the fragile nature of the plants, not all assessments were completed. The over sites analysis again showed strong evidence ($p<0.001$) of a difference between seed rates and sowing dates. There was a large variation between sites in tiller numbers, with the Hants. site producing a mean of 463 tiller/m^2 and the Lincs. site producing 896 tillers/m^2. (Appendix 2).

Table 4 – Mean linseed tiller population – pre-harvest 1997 (tillers/m^2)

Drill date	**Seed rate (seeds/m^2)**	**400**	**670**	**940**	**1200**	**Mean**
Early		525	704	818	966	753
Mid		443	573	742	837	649
Late		335	457	560	633	497
	Mean	434	578	707	812	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=33)	35.9	41.4	71.8			

The analysis of the boll counts (table 5) shows that the major influence on boll numbers per plant is seed rate. There is a highly significant ($p<0.001$) linear decline in bolls per plant with increasing seed rate. There is also strong evidence that the late drill date produces a significantly ($p<0.004$) higher number of bolls per plant than the earlier drill dates (Appendix 2).

Table 5 – Mean boll numbers/plant – pre-harvest 1997

Drill date	**Seed rate (seeds/m^2)**	**400**	**670**	**940**	**1200**	**Mean**
Early		24.77	18.15	15.93	13.43	18.07
Mid		22.89	17.56	16.03	13.04	17.38
Late		31.05	23.37	19.96	16.28	22.67
	Mean	26.23	19.69	17.30	14.25	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=44)	1.623	1.874	3.246			

The drill date had a much greater influence on boll numbers on the northern sites as opposed to the Hants. and Cambs. sites, (Appendix 2).

Crop height and lodging

Crop heights and lodging were assessed at maturity on all sites (Appendix 2). The differential in crop height was dramatic between sites, but much less so across different seed rates and drill dates. The influence of drill date was generally much stronger on plant height than seed rate, with the early drill dates producing the tallest plants. This trend was true for all sites apart from Lincs., where the mid drill date tended to produce the tallest plants. The effect of seed rate on crop height was negligible, with perhaps a weak trend for the lowest seed rate at the early drill date producing the tallest plants.

Lodging pressure varied widely across the seven sites, with no lodging on the Lincs. site, to very high pressure on the Hants. site. The pattern of lodging followed the predicted route with both seed rate and drill date having a strong influence. Early drilling combined with high seed rates tended to produce the greatest degree of lodging, with the converse for low seed rates and late drilling.

ii) Yield

Yields were widely variable across all 7 sites, with a general trend of increasing yields with the more northerly site locations. The over trials table of means is presented in table 6.

Table 6 – Yield (t/ha) – over trials analysis 1997

Drill date	**Seed rate (seeds/m^2)**	**400**	**670**	**940**	**1200**	**Mean**
Early		1.556	1.672	1.598	1.614	1.610
Mid		1.668	1.760	1.687	1.683	1.699
Late		1.492	1.630	1.702	1.717	1.635
	Mean	1.572	1.688	1.662	1.671	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=66)	0.0612	0.0706	0.1224			

Differences in yield failed to reach formal statistical significance in comparisons of either drill date or seed rate. The individual sites showed widely varying trends of yield (Appendix 2). Analysis of sites are summarised below.

Hants.

There was a significant difference ($p<0.05$) in yield between drill dates, with the highest yield from the early drill date. There was also strong evidence ($p>0.001$) of increases in yield with the increase in seed rates. This trend was more pronounced at the late drill date.

Worcs.

A significant difference in yield between drill dates ($p=0.016$), with the early drill date the lowest yielding. There was no significant differences between seed rates.

Essex

There was some evidence of an interaction between drill date and seed rate although it did not reach statistical significance. The highest seed rate produced the best yield at DD3, and the poorest yield at DD1.

Cambs.

No evidence of drill date differences, but significant differences in yield between the different seed rates. There was a strong quadratic component to the yield increase, with yield increasing initially and then decreasing at the highest seed rate.

Lincs.

Significant difference in yield between drill dates ($p=0.003$), mainly due to the higher yield from the late drill date. Also, there was a significant ($p>0.001$) trend of increasing yield with seed rate; yield increasing approximately in proportion to increases in the seed rate.

Northumberland

There was a significant interaction ($p=0.036$) between seed rate and drill date, which shows that the yield response to an increasing seed rate differs depending on the drill date. The higher seed rates produced the best yields at the late drill date, and the worst yields at the early drill date.

Fife

There was a significant ($p=0.002$) difference in yield between the sowing dates, primarily due to the much lower yield from the late drill date. There was a significant ($p=0.0043$) linear trend in yield due to seed rate primarily due to the lower yield at the lowest seed rate.

b) Drilling date/nitrogen level/seed rate interaction

i) Yield components

Tiller populations were assessed in the spring once nitrogen applications had taken place. Five out of the seven sites were considered even enough to produce meaningful counts. The over sites summary (table 7) shows that there was no interaction between nitrogen and seed rate or drill date. This was as expected due to the nitrogen having only recently been applied. The main significance is the influence of seed rate and drill date producing higher counts at higher seed rate and earlier drill dates. All sites followed this trend, apart from Cambs., where there was no significant difference between the drill dates (appendix 3).

Table 7 – Mean tiller population – spring 1997 (tiller/m^2)

Seed rate (seeds/m^2)	**Drill date**	**N level (kg/ha)**	**0**	**50**	**100**	**150**	
400	Early		531	529	525	525	
	Late		294	331	316	336	
1200	Early		1122	1039	1025	1081	
	Late		714	739	715	745	
		Mean	665	660	645	672	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=60)	51.3	51.3	72.5	72.5	102.6	102.6	145.1

Tiller counts were repeated on the same fixed rows near maturity of the crop. Again, the over sites analysis (table 8) indicates that there was no interaction between nitrogen applied and tiller population. The overriding influence is that of drill date and seed rate, which were both highly significant ($p<0.001$). The only site where nitrogen seems to be influential is Northumberland, where there was a significant ($p=0.036$) linear decrease in tiller population from 0 to 150 kg/ha of nitrogen (appendix 3).

Table 8 – Mean tiller population – pre-harvest 1997 (tiller/m^2)

Seed rate (seeds/m^2)	**Drill date**	**N level (kg/ha)**	**0**	**50**	**100**	**150**	
400	Early		546	543	493	486	
	Late		336	351	322	344	
1200	Early		1042	980	927	932	
	Late		630	669	651	670	
		Mean	639	636	598	608	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=45)	27.7	27.7	39.2	39.2	55.4	55.4	78.4

The analysis of boll counts in the over sites summary (table 9) indicates that nitrogen has not had an overall significant influence on boll numbers. The biggest influence on boll numbers is seed rate (p<0.001) and drill date (p=0.007).

Table 9 – Mean boll numbers/plant – pre-harvest 1997

Seed rate (seeds/m^2)	**Drill date**	**N level (kg/ha)**	**0**	**50**	**100**	**150**	
400	Early		22.10	23.90	27.30	25.55	
	Late		31.30	29.90	31.90	31.05	
1200	Early		12.25	12.70	13.40	13.90	
	Late		14.40	15.35	16.90	16.05	
		Mean	20.01	20.46	22.37	21.64	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=60)	1.59	1.59	2.25	2.25	3.18	3.18	4.50

On some of the sites nitrogen did have an influence on boll numbers (appendix 3). On the Hants. site, there was a significant quadratic (p=0.005) trend for increase in boll counts until 100 kg/ha N and then smoothing out at 150 kg/ha. On the Cambs. Site the linear trend for nitrogen x seed rate was significant (p=0.029), with an increasing count in response to nitrogen at the higher seed rate but not at the lower seed rate. On the Lincs. site there was a very significant (p=0.010) 3 way interaction between seed rate, drill date and nitrogen. There was a strong quadratic (p<0.001) trend for an increased boll count up to 100 kg/ha followed by a sharp reduction at 150 kg/ha.

Crop height and lodging

Lodging was recorded at maturity on all sites along with a limited set of crop height data (where time and labour availability allowed) (Appendix ?). Again drill date had the biggest influence on crop height, with the early drill date producing the tallest plants at both seed rates. Nitrogen did not seem to have an influence on height on any of the assessed sites, but there was a weak trend for the low seed rate to be slightly taller than the high seed rate.

Nitrogen level had a very strong influence on lodging across all sites (apart from Lincs., where no lodging over 45^0 was recorded). As expected the highest application rates produced the greatest degree of lodging. This effect was most pronounced at the earlier drill date, with a similar trend at the late drill date. The higher seed rate induced more lodging than the low seed rate, with the differential increasing at the higher nitrogen inputs.

ii) Yield

The over sites analysis of yields (table 10) indicate the nitrogen had a significant influence on yield (p=0.020). There was a strong linear trend to increasing yield with increasing nitrogen input. There was no evidence that seed rate or drill date was a significant influence.

Table 10 – Yield (t/ha) – over trials analysis 1997

Seed rate (seeds/m^2)	**Drill date**	**N level (kg/ha)**	**0**	**50**	**100**	**150**	
400	Early		1.282	1.472	1.512	1.469	
	Late		1.176	1.404	1.471	1.523	
1200	Early		1.230	1.356	1.419	1.478	
	Late		1.430	1.563	1.552	1.632	
		Mean	1.280	1.449	1.488	1.525	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=60)	0.058	0.058	0.083	0.083	0.117	0.117	0.166

The analysis of the individual sites (appendix 3) shows great variation in response to nitrogen.

Hants.

There was a significant interaction (p>0.001) between sowing date and seed rate, with the high seed rate at the late DD higher yielding than the lower seed rate. This feature is reversed at the early DD. There was a significant (p>0.001) yield response to nitrogen, due mostly to the low yield when no nitrogen was applied.

Worcs.

A highly significant (p>0.001) interaction between nitrogen and yield, with yield increasing steadily up to 100 kg/ha and then no further increase beyond this. There is also a significant interaction between nitrogen and drill date (p=0.038) with a greater response to nitrogen at the later drill date.

Essex

Yield was significantly influenced by nitrogen, with a strong linear trend (p=0.002) for increased yield as nitrogen increased.

Cambs.

The only significant factor was an interaction between seed rate and drill date (p=0.045), with a higher yield from the low seed rate at the early DD, and the opposite at the late DD.

Lincs.

There was a significant (p=0.039) interaction between seed rate and nitrogen, with the higher seed rate giving a higher yield than the lower seed rate at all nitrogen levels. This gain was least with no nitrogen applied.

Northumberland

Yield decreased significantly (p=0.003) as nitrogen level increased. This effect was much more pronounced at the higher seed rate.

Fife

There was a highly significant (p=0.001) difference in yield between the nitrogen levels. The quadratic component was very significant, reflecting how yield initially increased and then decreased as nitrogen inputs increased. There was also a significant (p=0.041) interaction between seed rate and drill date, where there is a marker difference in yield between drill dates at the lower seed rate, abut not at the higher seed rate.

3.1.2. Supplementary Trials

a) Cycocel Management

The agronomic effect of the application of chlormequat + choline chloride (5C Cycocel) to linseed was investigated on 2 sites; Hampshire and Northumberland. The two application timings were; end March and plants at 15-20 cm.

i) Yield components

Pre-harvest tiller and boll counts were undertaken. There was no significant treatment effects (table 11) on tiller numbers – the only significant feature on both sites ($p<0.001$) was the higher tiller counts as the higher seed rate.

Table 11 – Mean tiller population – pre-harvest 1997 (tillers/m^2)

			Chlormequat + Choline Chloride (2.5 l/ha)	
Seed rate (seeds/m^2)	**Application**	**Untreated**	**End March**	**Plants @ 15-20 cm**
400		511	612	546
1200		995	1084	1101
	Seed rate	**Application**	**Seed rate / Application**	
SED (df=5)	39.3	48.2	68.1	

The pre-harvest boll counts (table 12) similarly showed no significant treatment effect. The boll count on both sites was significantly lower ($p<0.001$) at the higher seed rate.

Table 12 – Mean boll numbers/plant – pre-harvest 1997

			Chlormequat + Choline Chloride (2.5 l/ha)	
Seed rate (seeds/m^2)	**Application**	**Untreated**	**End March**	**Plants @ 15-20 cm**
400		17.12	17.99	17.31
1200		8.10	9.31	9.19
	Seed rate	**Application**	**Seed rate / Application**	
SED (df=5)	1.212	1.484	2.099	

Lodging and crop height were also assessed, with results shown in table 13. The results from the two sites indicate a degree of shortening produced by the application of chlormequat, with the greatest effect from the earlier application timing. There was no general difference in height between the two seed rates. There was a subtle trend to a reduction in lodging produced by both application timings on the Northumberland site. On both sites the higher seed rate produced a higher incidence of lodging.

Table 13 – Lodging and crop height – harvest 1997

				Chlormequat + Choline Chloride (2.5 l/ha)			
Seed rate	**Application**	**Untreated**		**End March**		**Plants @ 15-20 cm**	
(seeds/m^2)		**Hants.**	**North.**	**Hants.**	**North.**	**Hants.**	**North.**
400	**Lodging (>45^0)**	56.2	56.2	67.5	42.5	56.2	43.7
1200		72.5	61.2	77.5	52.5	72.5	55
400	**Crop height (cm)**	79.5	84.2	78.5	70.4	76	76.9
1200		78	86.8	77.2	73.6	83.5	82.1

ii) Yield

There were no consistent differences evident over the sites (table 14). There was a weak trend on seed rate with the low seed rate tending to produce a higher yield than the high seed rate and an indication that both applications tended to depress yield over the untreated.

Table 14 – Yield (t/ha) – over trials analysis 1997

			Chlormequat + Choline Chloride (2.5 l/ha)	
Seed rate (seeds/m^2)	**Application**	**Untreated**	**End March**	**Plants @ 15-20 cm**
400		2.102	2.038	2.083
1200		1.914	1.770	1.857
	Seed rate	**Application**	**Seed rate / Application**	
SED (df=5)	0.1192	0.1460	0.2065	

b) Alternative Plant Growth Regulators

The products were tested on 2 sites; Cambs. and Lincs. All products were applied when plants were between 15-20 cm, apart from tr. 3 – which was a double application of chlormequat. The earlier timing for this was end of March. The treatments were applied only at one seed rate (1200 seeds/m^2).

Lodging and crop height were assessed on both sites with the results shown in table 15. The chlormequat based treatments (2, 3 & 5) produced the greatest reduction in height, by around 3-6 cm less than the untreated. This reduction in height resulted in some reduction in lodging, with tr. 5 on the Cambs. site - chlormequat + 2-chloroethylphophonic acid - having the greatest anti-lodging effect. There was a pronounced difference in crop height between the two sites, with the Lincs. trial being dramatically shorter than the Cambs. site. There was very limited yield component data produced form these trials due to their uneven nature. Boll counts were carried out on the Cambs. site which indicated no significant difference between treatments.

Table 15 – Lodging and crop height – harvest 1997

Treatment	**(l/ha)**	**Lodging (>45^0)**		**Crop height (cm)**	
		Cambs.	**Lincs.**	**Cambs.**	**Lincs.**
1) Untreated		50	30	53	38
2) Chlormequat	(2.5)	45	25	49.8	35
3) Chlormequat Double Application	(2.5)	35	25	46.5	33
4) 2-Chloroethylphosponic acid	(0.5)	20	35	52	39
5) Chlormequat + 2-chloroethylphophonic acid	(2.0)	5	30	48.8	37
6) Trinexapac-ethyl	(0.4)	70	35	53.3	38

<u>Yield</u>

The over trials analysis shows no consistent significant differences between treatments over the 2 trials (table 16). On the Lincs. site however there was a highly significant ($p<0.001$) difference in yield between treatments, with treatment 4 (2-chlorethylphosphoric acid) and treatment 5 (Chlormequat + 2-chlorethylphosphoric acid) giving a significantly lower yield than treatment 1 (Untreated), treatment 2 (Chlormequat) and treatment 3 (Chlormequat – double appln.).

Table 16 – Yield (t/ha) and boll counts (bolls/plant) – 1997.

		CAMBS.		**LINCS.**	
Treatment	**(l/ha)**	**Bolls/plant**	**Yield (t/ha)**	**Yield (t/ha)**	**Mean yield**
1) Untreated		19.00	0.90	1.85	1.37
2) Chlormequat	(2.5)	22.75	0.83	1.84	1.33
3) Chlormequat Double Application	(2.5)	21.5	0.90	1.98	1.44
4) 2-Chloroethylphosponic acid	(0.5)	19.75	0.87	1.68	1.28
5) Chlormequat + 2-chloroethylphophonic acid	(2.0)	21.00	0.87	1.60	1.24
6) Trinexapac-ethyl	(0.4)	18.50	0.74	1.70	1.22
SED		1.880	0.079	0.069	0.093
df		15	15	15	5

c) Fungicide Management

Fungicide trials were undertaken on 2 sites; Worcs. and Fife. Products were applied at mid-flower. The main diseases identified on both sites were *botrytis cinerea* (grey mould) and *mycosphaerella linicola* (pasmo). Disease observations indicated low levels of Pasmo and Botrytis in the post-flowering period. Disease levels increased in the immediate pre-harvest period on the Worcs. Site. All treatments looked visually cleaner than the untreated at harvest.

i) Yield

The over trials analysis shows a highly significant difference ($p<0.001$) in yield between the treatments, despite the large differences in yields between the two sites. The relative ordering of the treatment means was the same for both sites (table 17).

Table 17 – Yield (t/ha) – 1997

Treatment	(l/ha)	Yield (t/ha) Worcs.	Fife	Mean
1) Untreated		1.21	1.85	1.53
2) Iprodione	(3.0)	1.31	1.99	1.65
3) Vinclozolin	(1.0)	1.23	1.88	1.55
4) Iprodione + thiophanate methyl	(3.0)	1.38	2.12	1.75
5) Chlorothalonil + carbendazim	(2.0)	1.44	2.17	1.81
6) Tebuconazole	(1.0)	1.37	2.04	1.70
SED		0.041	0.145	0.030
df		15	15	5

The highest mean yielding treatment – chlorothalonil + carbendazim – was significantly higher yielding than any other treatment apart from iprodione + thiophanate methyl. All treatments apart from vinclozolin were significantly higher yielding than the untreated.

3.2. 1997/98 Season

In contrast with the previous season, the autumn of 1997 saw almost ideal drilling conditions with the majority of the trials being sown into good seedbeds with adequate moisture. The winter was much milder than 1996/97 and plant loss over winter was much less pronounced. All trials emerged from the winter looking lush and forward. The spring and summer proved to be wet on the whole, with May being the wettest for 180 years. Harvest conditions proved to be difficult in the north.

Table 18 – 1997 Drilling Dates

Site	Drill Date 1	Drill Date 2	Drill Date 3
Hants.	05/09/97	22/09/97	06/10/97
Worcs.	07/09/97	20/09/97	11/10/97
Essex	10/09/97	25/09/97	08/10/97
Cambs.	15/09/97	29/09/97	14/10/97
Lincs.	05/09/97	20/09/97	04/10/97
Northumberland	12/09/97	24/09/97	09/10/97
Fife	10/09/97	20/09/97	02/10/97

As in the previous season the 3 drill dates spanned a period of approximately one month, from early September to early October (table18). Establishment of each drilling date was even with the early drill date emerging in 8-15 days, and the late drilling date in 15-38 days. The two northern trials in Northumberland and Fife taking longer to establish than the others.

3.2.1. Core Trials

a) Drilling date/seed rate interaction

i) Yield components

Assessments of plant population were undertaken once all drill dates had established in autumn 1997. The over sites summary (table 19). There was a highly significant ($p<0.001$) linear trend in counts as seed rate increased. There was also a significant difference in counts between drill dates ($p<0.001$) with the lowest count at the latest drill date. Whilst all sites followed the mean trend of increasing plant counts with seed rate increases (appendix 4), there were differences between sites in drill date response. On the Hants. site, the lowest count was achieved from the middle drill date, which was significantly lower than DD1 and DD3. On the Northumberland site however, the middle drill date produced the highest counts significantly.

Table 19 – Mean linseed plant population – autumn 1997 (plants/m^2)

Drill date	**Seed rate (seeds/m^2)**	**400**	**670**	**940**	**1200**	**Mean**
Early		350	563	780	947	660
Mid		327	553	758	920	639
Late		264	436	533	670	476
	Mean	314	517	690	845	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=55)	34.8	40.2	69.6			

The spring tiller counts (table 20) contrasted strongly with the counts form the previous spring, with the mean count at each drill date being approximately double that of the equivalent drill date from 1997. As with the autumn plant counts, there was a highly significant difference between seed rates with a linear trend ($p<0.001$), and also between drill dates ($p<0.001$). There was a good correlation between sites with the same trends in counts with seed rate and drill date (appendix 4).

Table 20 – Mean linseed tiller population – spring 1998 (tillers/m^2)

Drill date	Seed rate (seeds/m^2)	400	670	940	1200	Mean
Early		957	1253	1562	1670	1360
Mid		770	1097	1274	1474	1154
Late		501	720	874	1018	778
	Mean	743	1023	1237	1388	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=55)	86.7	100.1	173.4			

At maturity counts were repeated on the same fixed row lengths on plants and tillers. Both plant and tiller counts show a highly significant difference between seed rate and drill date (table 21). The tillers to plants ratio shows that the highest ratio (1.79:1) is achieved with the lowest seed rate at the early drill date, and the lowest ratio (1.25:1) with the high seed rate at the final drill date (Appendis 4).

Table 21 – Mean linseed plant and tiller population – pre-harvest 1998 (per m^2)

Drill date	Seed rate	400		670		940		1200		Mean	
	(seeds/m^2)	P	T	P	T	P	T	P	T	P	T
Early		293.9	526	409.5	682	519.6	823	618.4	911	460.3	735
Mid		300.2	503	436.8	667	540.2	753	641.8	881	479.7	701
Late		234.3	356	334.7	469	478.6	604	556.4	694	401.0	531
	Mean	**276.1**	**462**	**393.7**	**606**	**512.8**	**727**	**605.5**	**829**		
	Drill date	**Seed rate**		**Drill date/Seed rate**							
SED (df=61)	19.68	22.72		39.36		P=Plants/m^2					
SED (df=56)	32.6	37.6		65.2		T=Tillers/m^2					

Boll counts were undertaken on sub-samples from the fixed row lengths. The counts showed a significant ($p<0.001$) linear reduction of bolls per plant with increasing seed rate, which was consistent with the previous season (table 22). Although there is a suggestion from the means that the late drill date produces a higher boll count than the earlier drill date, this was heavily influenced by the results from the Cambs. site, where the late drill date produced a boll count that was more than double that of the other two drill dates (Appendix 4). This was almost certainly because this site produced the lowest tiller density for the late drill date – 189 tillers/m^2 lower than the other sites mean for this drill date.

Table 22 – Mean boll numbers/plant – pre-harvest 1998

Drill date	Seed rate (seeds/m^2)	400	670	940	1200	Mean
Early		19.84	15.21	12.36	11.11	14.65
Mid		18.23	14.01	11.60	10.12	13.49
Late		23.70	16.92	13.66	11.29	16.39
	Mean	20.59	15.38	12.54	10.84	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=66)	1.338	1.545	2.675			

Crop height and lodging

Crop height and lodging were assessed at maturity on all sites apart from Essex where time did not allow (Appendix 4). The influence of drill date was again stronger than seed rate on crop height, with the early drill dates producing the tallest plants. This trend was true for all sites apart from Northumberland, where the latest drill date tended to give the tallest crop. The effect of seed rate on crop height was again weak, with a marginal trend for the high seed rate producing the shortest plants.

Lodging pressure was generally lower than the previous season, with only 4 sites recording lodging over 45^0. Of the sites that did record lodging, the Lincs. and Cambs. sites both had severe pressure with all seed rates at the early drill date being almost completely lodged. Lodging was reduced for the later drill dates but with little differentiation between seed rates. On the Worcs. site there was less pressure, with the early and mid drill dates having significantly more lodging than the late drill date. On this site seed rate did not seem to be influential in lodging pressure.

ii) Yield

Similar to 1997, there were substantial differences between sites in average yield (table 23). Overall, there was no evidence of an interaction between drill date and seed rate. There was a significant (p=0.020) difference in yield between drill dates. Yield was significantly higher at the final drill date than the earlier two dates. There was strong evidence (p=0.009) of a linear trend in yield as seed rate increased, however, yields were the same at the two top seed rates.

Table 23 – Yield (t/ha) – over trials analysis 1998

Drill date	Seed rate (seeds/m^2)	400	670	940	1200	Mean
Early		1.295	1.444	1.467	1.419	1.405
Mid		1.381	1.380	1.453	1.490	1.426
Late		1.419	1.521	1.597	1.608	1.536
	Mean	1.365	1.448	1.505	1.505	
	Drill date	**Seed rate**	**Drill date/Seed rate**			
SED (df=66)	0.0489	0.0565	0.0978			

The yield trends (appendix 4) for each site are summarised below.

Hants.

Drilling date was the biggest influence on yield on this site with very significant differences between dates ($p<0.001$). The late drill date produced a significantly higher yield at all seed rates that the comparative rates at the other two drill dates. There was also a significant difference in yield between the 940 and 400 seed/m^2 rates, with the higher seed rate giving the best yield.

Worcs.

There was a highly significant ($p<0.001$) interaction between seed rate and drill date. Within mid and late drill dates, yields are not significantly different between seed rates. However, at all seed rates, the mid drill date gives a significantly higher yield than the low drill date.

Essex

There was very strong evidence of a difference in yield between drilling dates ($p=0.002$). Yield increased as the drill date was delayed. Yields at all three drill dates were significantly different from each other. There was no evidence that seed rate affected yield.

Cambs.

The dominant effect on this site was due to drill date, with a highly significant difference ($p<0.001$) in yield between dates. Yields for early and mid sowing are not statistically different from each other however, the late sowing was significantly higher ($p<0.001$) than the two earlier sowings. Although drill date was the significant factor, there was an indication that differences in yield between seed rates vary depending on date.

Lincs.

Drill date was not a significant factor on this site with very similar mean yields between sowings. There was however, a highly significant ($p<0.001$) linear trend in yield as seed rate increased.

Northumberland

There was no evidence of differences in yield between drill dates. However, there was a very significant difference in yield between seed rates ($p<0.001$). The linear and curved trends for seed rate were both significant as yield increased with seed rate until the highest level. Yields at the top two seed rates were not significantly different from each other but all other comparisons were significant.

Fife

Yield between drill dates just reaches formal statistical difference ($p=0.05$), with the early drill date producing the highest yield at all but the highest seed rate. There was also a significant linear trend in yield ($p=0.042$) due to seed rate.

b) Drilling date/nitrogen level/seed rate interaction

i) Yield components

Tiller counts were completed in spring 1998 at sites out of seven, with the major areas of influence being seed rate and drill date. As with the previous season, in the over site analysis (table 24), the tiller counts were significantly higher at the higher seed rate ($p<0.001$) and early drill date ($p<0.001$). The only individual site where drill date was not a significant influence on tiller numbers was Northumberland. On the Lincs. site, unexpectedly, due to the close proximity between application and assessment, nitrogen had a significant influence on tiller numbers. There was a significant quadratic trend ($p<0.001$) to the counts with an increase from the lowest nitrogen level to the two middle levels with counts then dropping back at the top level (Appendix 5).

Table 24 – Mean tiller population – spring 1998 (tillers/m^2)

Seed rate (seeds/m^2)	**Drill date**	**N level (kg/ha)**	**0**	**50**	**100**	**150**	**Mean**
400	Early		901	960	944	971	944
	Late		573	580	613	586	588
1200	Early		1839	1900	1902	1867	1877
	Late		1197	1276	1234	1232	1235
		Mean	1128	1179	1173	1164	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=60)	85.9	85.9	121.4	121.4	171.8	171.8	242.9

When tiller counts were repeated pre-harvest, the over site analysis showed a significant (p=0.034) seed rate/drill date interaction (table 25). Nitrogen level did not have a significant influence on tiller numbers. The Cambs site was the only site where nitrogen had a significant influence on counts (p=0.013), with a decreasing count from increased nitrogen (Appendix 5).

Table 25 – Mean tiller population – pre-harvest 1998 (tillers/m^2)

Seed rate (seeds/m^2)	**Drill date**	**N level (kg/ha)**	**0**	**50**	**100**	**150**	**Mean**
400	Early		512	549	534	510	526
	Late		351	406	428	437	405
1200	Early		1030	957	953	862	951
	Late		659	715	687	683	686
		Mean	638	657	651	623	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=60)	33.3	33.3	47.0	47.0	66.5	66.5	94.1

The boll counts from the over sites summary (table 26), show a significant influence from seed rate, drill date and nitrogen. Counts were significantly higher at the lower seed rate (p<0.001), at the later drill date (p=0.014) and between nitrogen levels (p=0.003). Counts increased as nitrogen increased and the linear component was highly significant (p<0.001). All sites followed this general trend, with the Cambs. site having the greatest differential in counts between early and late drilling. The strongest influences on counts were seed rate and nitrogen level.

Table 26 – Mean boll numbers/plant – pre-harvest 1998

Seed rate (seeds/m^2)	Drill date	N level (kg/ha)	0	50	100	150	Mean
400	Early		18.13	20.74	24.35	28.98	23.05
	Late		22.85	29.75	29.98	32.68	28.81
1200	Early		7.62	10.98	12.24	13.99	11.21
	Late		10.48	11.97	14.12	15.93	13.12
		Mean	14.77	18.36	20.17	22.89	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=75)	1.529	1.529	2.162	2.162	3.058	3.058	4.324

Crop height and lodging

Lodging occurred on only 5 of the 7 sites, and crop height recorded on 6 of 7 sites (Appendix 5). Drill date was again the dominant factor in influencing lodging. The early drill date experienced the greatest degree of lodging, with the most severe lodging on the Cambs. and Lincs. sites. On these sites nitrogen did not have an influence on lodging at the early drill date, with all nitrogen levels recording severe lodging. At the later drill date there was clear differential lodging with nitrogen rate, with a linear increase in lodging as nitrogen level increased. The higher seed rate generally induced greater lodging than the low seed rate, with this effect being more pronounced at the later drill date. The Worcs. site experienced a higher degree of lodging at the later drill date than on the other sites, with the lower seed rate tending to induce more lodging than the high seed rate at the early drill date.

The early drill date produced the tallest plants at both seed rates, and this was consistent over all sites. There was little evidence that nitrogen had any influence on crop height

i) Yield

In the over trials analysis (table 27) there is no real evidence of any interactions. Yield is significantly higher ($p=0.007$) at the higher seed rate, and significantly higher ($p<0.001$) at the later sowing date. There is overwhelming evidence of a difference between nitrogen levels ($p<0.001$), with a very strong linear component ($p<0.001$). There is also a curved component close to significance ($p=0.052$), showing that yield benefit tails off at the higher nitrogen levels.

Table 27 – Yield (t/ha) – over trials analysis 1998

Seed rate (seeds/m^2)	**Drill date**	**N level (kg/ha)**	**0**	**50**	**100**	**150**	**Mean**
400	Early		1.061	1.206	1.387	1.419	1.268
	Late		1.209	1.491	1.665	1.712	1.519
1200	Early		1.201	1.400	1.536	1.573	1.427
	Late		1.353	1.607	1.736	1.771	1.617
		Mean	1.206	1.426	1.581	1.619	
	SR	**DD**	**N**	**SR/DD**	**SR/N**	**DD/N**	**SR/DD/N**
SED (df=60)	0.0464	0.0464	0.0656	0.0656	0.0927	0.0927	0.1311

The analysis for the individual sites (Appendix 5) are summarised as follows:

Hants.

Nitrogen had a very significant ($p<0.001$) influence on yield, with a strong linear trend of increasing yield with nitrogen input. Neither drill date or seed rate had a significant influence on yield although the later drill date and higher seed rate tended to produce higher yields.

Worcs.

There was a highly significant ($p<0.001$) difference in yield between nitrogen levels. Both the linear and quadratic trends are statistically significant. The yield increased with nitrogen input initially but was similar at the two highest levels. There was also a highly significant interaction ($p<0.001$) between seed rate and sowing date where for the early sowing, yield is much higher at the higher seed rate. However, yields are similar for the two seed rates at the later sowing.

Essex

Drill date was the dominant influence on yield on this site, with the later drilling producing more than double the yield of the early date. There was a significant drill date x nitrogen interaction ($p=0.018$), with the later drill date being much more responsive to nitrogen application than the early drill date.

Cambs.

There were significant differences in yield between nitrogen levels ($p=0.013$) and between sowing dates ($p=0.022$). Yield was higher at the later sowing date, and significantly lower at the highest nitrogen level than the other three levels.

Lincs.

There were statistically significant interactions for drill date x nitrogen ($p=0.022$), seed rate x nitrogen ($p=0.001$) and seed rate x drill date ($p=0.004$). Within each nitrogen level the yields from both drill dates are similar apart from the zero nitrogen rate, where the yield from the late drill date is significantly lower. Yield was also statistically lower at the lower seed rate than the higher seed rate where no nitrogen was applied.

Northumberland

The dominant effects on this site were due to seed rate and nitrogen. Yield was significantly higher ($p=0.002$) at the higher seed rate. Yield also differed significantly ($p<0.001$) between nitrogen levels. Yield increased with increase in nitrogen but the benefit reduces as the nitrogen input rises.

Fife

There was a strong and highly significant ($p<0.001$) yield increase from added nitrogen on this site. There was also significant ($p<0.001$) yield increase from added nitrogen on this site. There was also significant linear interaction between drilling date and nitrogen ($p=0.002$), indicating that the increase in yield with nitrogen differed between the two drill dates.

3.2.2. Supplementary Trials

a) Cycocel Management

This trial, a repeat of the previous seasons, was carried out on two sites; Worcs. and Fife. The higher seed rate was reduced from 1200 to 940 seeds/m^2.

i) Yield components

Pre-harvest tiller counts were only undertaken on the Fife site and showed that the earlier application of chlormequat produced a significantly higher tiller count ($p=0.048$) than either the later application or the untreated (table 28). The tiller count was also significantly higher at the higher seed rate ($p<0.001$).

Table 28 – Mean tiller population – pre-harvest 1998 (tillers/m^2)

			Chlormequat + Choline Chloride (2.5 l/ha)	
Seed rate (seeds/m^2)	**Application**	**Untreated**	**End March**	**Plants @ 15-20 cm**
400		384	426	412
940		709	822	714
	Seed rate	**Application**	**Seed rate / Application**	
SED (df=15)	24.2	29.7	42.0	

The pre-harvest boll counts were carried out on both sites (table 29). The only significant factor was seed rate with the counts being significantly higher (p=0.003) at the lower seed rate.

Table 29 – Mean boll numbers/plant – pre-harvest 1998

			Chlormequat + Choline Chloride (2.5 l/ha)	
Seed rate (seeds/m^2)	**Application**	**Untreated**	**End March**	**Plants @ 15-20 cm**
400		21.37	20.75	22.00
940		11.88	12.75	11.75
	Seed rate	**Application**	**Seed rate / Application**	
SED (df=5)	1.691	2.072	2.930	

Lodging and crop height were assessed in both trials, with results shown in table 30. Similar to the previous season, the crop heights show both timings of chlormequat producing some crop shortening. There was little or no lodging on the Fife site and no indication of a reduction in lodging on the Worcs. site. The higher seed rate on the Worcs. site had a lower lodging incidence than the low seed rate.

Table 30 – Lodging and crop height – harvest 1998

				Chlormequat + Choline Chloride (2.5 l/ha)			
Seed rate	**Application**	**Untreated**		**End March**		**Plants @ 15-20 cm**	
(seeds/m^2)		**Worcs.**	**Fife**	**Worcs.**	**Fife**	**Worcs.**	**Fife**
400	**Lodging (>45%)**	66.7	0	66.7	0	65	0
940		47.2	10	55.6	0	49	0
400	**Crop height (cm)**	68.3	58.2	64.8	57.8	67.2	58.6
940		69.8	60.3	65.7	58.6	65.3	57.3

ii) Yield

The analysis of the two sites shows strong evidence of higher yield at the higher seed rate (p=0.006). However, there is no evidence of any effect from chlormequat application or any treatment/seed rate interaction (table 31).

Table 31 – Yield (t/ha) – over trials analysis 1998.

			Chlormequat + Choline Chloride (2.5 l/ha)	
Seed rate (seeds/m²)	**Application**	**Untreated**	**End March**	**Plants @ 15-20 cm**
400		1.691	1.705	1.815
940		2.035	2.061	1.932
	Seed rate	**Application**	**Seed rate / Application**	
SED (df=5)	0.0590	0.0723	0.1022	

j) Alternative Plant Growth Regulator

The trials were carried out on the Essex and Northumberland sites. The products used, rates and application timing were the same as the previous season. Lodging and crop height assessments were again carried out, with results given in table 32. All treatments, apart from tr. 6 (Trinexapac-ethyl), produced some degree of crop shortening, although no one particular treatment stood out. Lodging was almost completely absent on both sites. A limited set of yield component assessments was carried out on the Northumberland site, with tiller counts and boll counts undertaken pre-harvest. These assessments showed no significant differences between treatments.

Table 32 – Lodging and crop height – harvest 1998

Treatment	**(l/ha)**	**Lodging (>45^0)**		**Crop height (cm)**	
		Essex	**North.**	**Essex.**	**North.**
1) Untreated		0	1	63.2	73.5
2) Chlormequat	(2.5)	0	0.7	60.3	64.1
3) Chlormequat Double Application	(2.5)	0	0.75	61.8	65.5
4) 2-Chloroethylphosponic acid	(0.5)	0	0.75	58.5	69.3
5) Chlormequat + 2-chloroethylphophonic acid	(2.0)	0	0.88	59.0	65.3
6) Trinexapac-ethyl	(0.4)	0	0.55	62.6	75.8

Yield

There was no evidence of differences between treatments in the over trial analysis (table 33). The analysis of the Essex site however, shows highly significant differences in yield between treatments ($p<0.001$). Treatment 2 (Chlormequat – single application), is shown to be significantly higher yielding than any other treatments apart from treatment 3 (Chlormequat – double application). Treatment 4 (2-chlorethylphosphonic acid) and 6 (Trinexapac-ethyl), both produced yields lower than the control.

Table 33 – Yield (t/ha) and yield components – 1998

		NORTHUM.			ESSEX.	
Treatment	**(l/ha)**	**Tillers/m^2**	**Bolls/plant**	**Yield (t/ha)**	**Yield (t/ha)**	**Mean yield**
1) Untreated		634	10.52	2.36	0.683	1.521
2) Chlormequat	(2.5)	546	11.52	2.27	0.908	1.59
3) Chlormequat Double Application	(2.5)	623	7.20	2.16	0.863	1.510
4) 2-Chloroethylphosporic acid	(0.5)	652	9.60	2.51	0.590	1.551
5) Chlormequat + 2-chloroethylphophoric acid	(2.0)	694	9.05	2.33	0.703	1.515
6) Trinexapac-ethyl	(0.4)	610	9.20	2.32	0.600	1.457
SED		65.4	1.522	0.103	0.0557	0.1650
df		15	15	15	15	5

k) Fungicide Management

The products evaluated in season 1997/98 differed to some degree from those trialled in the previous season, to concentrate on products which had produced the best performance in terms of yield. Chlorathalonil + carbendazim was applied as a double as well as a single timing and difenoconazole was also tested.

The trial for this season was located at the Cambs. site. All products were applied at mid-flower with treatment 3 (Chlorothalonil + carbendazim) being repeated after 3 weeks. The main diseases present were *mycosphaerella linicola* (pasmo) and *botrytis cinerea*. The post flowering period saw levels of *pasmo* on the untreated up to 15%. All treatments visually carried lower levels of infection than the untreated up to the capsule stage.

Yield

There was very strong evidence of a difference in yield between treatments (table 34), (p=0.002). Both the untreated and the tebuconazole treatment (4) were significantly lower yielding than the iprodione + thiophanate methyl (6) treatment. The chlorothalonil + carbendazim treatments (2 & 3) were also significantly higher yielding than the untreated, although the double application (3) produced a lower yield than the single application (2).

Table 34 – Yield (t/ha) 1998

Treatment	**(l/ha)**	**Yield (t/ha)**
1) Untreated		0.77
2) Chlorothalonil + carbendazim	(2.0)	1.02
3) Chlorothalonil + carbendazim (Double Application)	(2.0)	0.96
4) Tebuconazole	(1.0)	0.70
5) Difenoconazole	(0.5)	0.88
6) Iprodione + thiophanate methyl	(3.0)	1.13
SED		0.087
df		15

4. DISCUSSION

It would have been difficult to choose two more difficult trialling seasons back to back. The 1996/97 season saw drought conditions in the autumn and spring, leading to a wet summer – particularly June. In contrast 1997/98 season saw excellent establishment conditions, with a mild autumn and winter. The spring and summer again proved to be wet, with May seeing record rainfall. Harvesting conditions were particularly difficult in the north of the country.

It is with the above in mind that the results from the series of trials should be interpreted.

Sowing date

Timing of sowing is an important factor in establishment of the crop. Plant establishment and survival is greatly enhanced when crops are sown in early to mid September. October sowings were much more prone to producing unacceptably low over-wintered plant populations. The sowing ‘window’ is narrower in the north of the country, where frost heave/winter kill is a greater threat, particularly on the lighter soil types. The heavier soils in the southern part of the country allow more flexibility in sowing date. It is difficult to place too much emphasis on establishment results from autumn 1996 because of the drought. The worst affected sites (Hants., Cambs. and Lincs.), produced the best establishment results from the late drill date, and the converse for the early drill date. In drought conditions, seed can remain viable for long periods until there is adequate moisture for germination, however in these cases the later drilled blocks established relatively quicker than the earlier blocks. This was because they were drilled closer to the period when rain eventually did arrive and were able to take best advantage. There were exceptionally dry conditions, and it would be unwise to purposely delay drilling and increase the risk of winter kill.

The influence of drill date on yield is very difficult to determine on the evidence of the two seasons’ trials. There was no overall difference between drill date in 1997, but the late drill date in 1998 significantly out-yielded the two earlier timings. The data from the individual sites showed widely varying trends in 1997 – with some sites producing their best yields into the early drill date and others from the late drill date. In 1998, the majority of the sites produced their best yields from the late drill date.

Seed rate

The seed rates utilised were purposely selected to test the extremities of performance of the crop. As expected the highest seed rates produced a much greater plant population than the lowest. This differential was carried all the way through to final tiller numbers. The low seed rates produced a much higher tiller-plant ratio than the high seed rates. The boll count was also much higher per plant for the low seed rate in comparison to the high seed rate. As expected, where lodging pressure was high, the higher seed rates tended to induce a higher degree of lodging than the low seed rates. This pattern was exaggerated at the earlier drill dates. The influence of seed rate on crop height was negligible.

The effect of seed rate on yield is unclear. There were no significant overall differences in 1997 between seed rates; however, in 1998 there was a trend for yield to increase as seed rate increased. The increase tended to flatten out at the highest seed rates.

Nitrogen

These trials were designed to answer two key questions. Firstly, what is the optimum amount of nitrogen requirement of the crop modified by changes in drill date and seed rate. The results indicate that nitrogen had very little influence on tiller production. Nitrogen did influence boll numbers, however, with increasing nitrogen application leading to an increase in boll numbers. This was more pronounced in the 1998 trials.

Nitrogen application had a strong influence on lodging on sites where lodging was a factor. Lodging tended to increase as nitrogen input rose and this trend was exaggerated at the early drill dates. Seed rate also had a large influence, with the higher seed rates inducing more lodging than the lower. There was little evidence that nitrogen had any effect on crop height.

Yield was significantly affected by nitrogen input, with significant increases in yield as nitrogen level increases. Generally the largest increase is obtained from zero application to 50 kg/ha. At the higher levels of input lodging tends to detract from the yield.

Plant Growth Regulations

a) Cycocel Management

The results indicate that cycocel may have some influence on tiller production, but results were variable. The application of cycocel did produce a degree of crop shortening and lodging was also slightly reduced – mainly as the high seed rate. There was no clear indication, which of the timings were more effective. There was a weak trend for cycocel to slightly depress yield.

b) Alternative Plant Growth Regulation

There were no significant effects on tillering or boll numbers from any of the treatments tested. Height reductions were apparent from most of the treatments with the chlormequat-based treatments giving the most consistent effects. In season 1997, the chlormequat-based treatments gave some reduction in lodging, with chlormequat + 2-chloroethylphosphoric acid having the greatest effect. There was virtually no lodging on the two sites in 1998.

Yield results from the trials indicate that 'ethyphon'-based treatments and trinexapac-ethyl may have yield suppressant effects.

Fungicide Management

Virtually all treatments tested had a beneficial effect in terms of yield. The most beneficial treatment in year 1997 was bravocarb on all these sites. The higher disease pressure in 1998 meant that all treatments were severely tested and surprisingly the double application of bravocarb produced no better results than the single application. Earlier applications of fungicide may be more appropriate than mid-flower, as the two main diseases – botrytis and pasmo – are very difficult to control once established.

CONCLUSIONS

1) Timing of sowing is probably the key factor in establishment of the crop. Mid-end September seems to be the optimum sowing date, but this could be extended in favourable conditions in the southern part of the country.

2) If crops are sown in October in lighter soils, they can be extremely vulnerable to winter kill. Heavier soils are more tolerant.

3) Optimum seed rates vary depending on drill date and soil type. For early drilling, lower seed rates – 400-600 seeds/m² - are likely to yield as well as, if not better than, higher rates. For later drillings higher seed rates are more appropriate – however at over 1000 seeds/m², lodging can be a serious problem.

4) Lower plant densities result in more tillering, therefore if sown early even low seed rates can be prone to lodging due to excessive tillering.

5) Nitrogen application can have a major influence on lodging and yield. The optimum input depends very much on soil fertility, but is likely to be in the range of 50-100 kg/ha. The combination of high nitrogen inputs with high seed rate, is highly likely to induce lodging. From the trials there is no strong evidence that nitrogen requirement is altered by drilling date.

6) Plant growth regulations can have a useful effect in preventing, or reducing lodging. They are more likely to be of benefit in high lodging pressure situations. In low pressure situations and with certain products some yield suppression can occur. Late March/early April applications seem to be more successful than later applications.

7) Disease in linseed can severely reduce yield. The fungicides applied were only partially successful in containing disease. The most successful treatment was bravocarb. Earlier treatment than mid-flower, and repeat applications, may be more appropriate.

8) More work needs to be done to develop reliable agronomy blueprints. The results from two exceptionally difficult seasons cannot be considered a typical set of responses.

5. REFERENCES

CETIOM. 1997. Oléoscope N°. 39, May/June 1997

6. APPENDICES

Appendix 1. Site details

NEAC **Cockle Park Experimental Farm**
Morpeth, Northumberland

	1996-97	**1997-98**
Grid Reference	NZ 203 912	NZ 205 918
Soil Type	Clay loam	Clay loam
Previous Cropping	W.Barley 1996 W. Wheat 1995	W. Barley 1997 W. Barley 1996
Harvest Dates	17/09/97 - SR/DD 18/09/97 - SR/DD/N 19/09/97 - 5C Cycocel	17/09/98 - SR/DD & SR/DD/N 18/09/98 - Alternative PGR
Herbicide	Trifluralin 1.2 l/ha (pre-em) Ally 30g/ha Fusilade 1.0 l/ha + Agral	Ally 30g/ha Falcon 1.0 l/ha
Fungicide	Sportak 45 0.4 l/ha + Bravo 500 1.0 l/ha	Bravocarb 2.0 l/ha
Insecticide	None	None

Scottish Agronomy **Carnbee, Anstruther, Fife**

	1996-97	**1997-98**
Grid Reference	NO 536 055	NO 529 064
Soil Type	Sandy clay loam	Sandy clay loam
Previous Cropping	Winter Wheat	Winter Wheat
Harvest Dates	10/09/97	15/09/98
Herbicide	Quantum 30g/ha 08/11/96 Falcon 0.75 l/ha 13/05/97	Treflan 1.7 l/ha 11/11/97
Fungicide	None	Bravocarb 2.0 l/ha 05/06/98 Bravocarb 2.0 l/ha 25/06/98
Insecticide	None	None

ARC **Little Park Farm, Abbotts Ann Andover, Hants.**

	1996-97		**1997-98**	
Grid Reference	SU 328 440		SU 323 441	
Soil Type	Andover 1		Andover 1	
Previous Cropping	Set Aside		S. Barley	
Harvest Dates	30/07/97- DD/N/SR 2/08/97 - DD/SR		28/07/98	
Herbicide	Ally 30g/ha	27/03/97	Ally 30 g/ha	13/02/98
	Vindex 1 l/ha	23/04/97	Eagle 40 g/ha	02/04/98
	Basagran 2l/ha	23/04/97		
Fungicide	None		Bravocarb 2.0 l/ha	13/05/98
Insecticide	None		None	

ARC **Elms Farm, Demontford University Caythorpe campus, Caythorpe, Lincs.**

	1996-97	**1997-98**
Grid Reference	SK 967 478	SK 986 481
Soil Type	Silty clay loam	Silty clay loam
Previous Cropping	Winter Wheat	Spring Barley
Harvest Dates	15/08/97	09/08/98
Herbicide	Ally 30 g/ha	Ally 30 g/ha 16/03/98
Fungicide	None	Bravocarb 2.0 l/ha 20/05/98
Insecticide	None	Cypermethrin 0.25 l/ha 21/10/97

Dalgety **Throws Farm, Stebbing**
Gt. Dunmow, Essex

	1996-97	1997-98
Grid Reference	TL 644 216	TL 652 227
Soil Type	Clay	Clay
Previous Cropping	W. Wheat	W.Wheat
Harvest Dates	29/07/97	02/08/98
Herbicide	Ally 30g/ha Falcon 0.75 l/ha	Ally 30 g/ha
Fungicide	None	Bravocarb 2.0 l/ha
Insecticide	None	Cypermethrin 0.25 l/ha

Svalof Weibull **Grange Farm, Abbots Ripton**
Cambs.

	1996-97	1997-98
Grid Reference	TL 257 352	TL 252 773
Soil Type	Clay loam	Clay loam
Previous Cropping	Winter Wheat	Spring Barley
Harvest Dates	06/08/97	03/08/98
Herbicide	Ally 30 g/ha	Ally 30 g/ha 16/03/98
Fungicide	None	Bravocarb 2.0 l/ha 18/05/98 Bravocarb 2.0 l/ha 14/06/98
Insecticide	Cypermethrin 0.25 l/ha	Cypermethrin 0.25 l/ha

Westcrop **Wick Manor Farm, Pershore**
Worcestershire.

	1996-97	1997-98
Grid Reference	SO 964 460	SO 948 444
Soil Type	Sandy loam	Sandy loam
Previous Cropping	S. Barley	S. Barley
Harvest Dates	29/07/97	12/08/98
Herbicide	Ally 15g/ha 01/04/97 Falcon 0.75 l/ha 06/03/97	Ally 30 g/ha 03/03/98
Fungicide	None	Bravocarb 2.0 l/ha
Insecticide	None	Cypermethrin 0.25 l/ha

Appendix 2. 1997 Drill Date / Seed Rate trial - Yield components, yield, crop height and lodging

Autumn plant population (plants/m2)

DD/SR	Fife	Hants.	North.	Cambs.	Lincs.	Mean
E_400	289.5	288.0	301.3	185.3	314.0	275.6
E_670	504.3	476.0	513.2	321.0	448.0	452.5
E_940	746.0	718.0	666.0	440.3	550.5	624.1
E_1200	951.2	900.0	893.2	511.5	727.5	796.7
M400	319.0	354.0	312.0	237.5	283.0	301.1
M670	561.7	650.0	502.3	344.8	470.8	505.9
M_940	695.0	908.0	669.5	484.3	665.5	684.5
M_1200	906.2	1130.0	879.8	664.0	808.7	877.7
L_400	247.0	454.0	297.2	306.3	265.3	314.0
L_670	380.0	570.0	415.0	440.5	459.3	453.0
L_940	520.0	744.0	509.5	572.7	630.7	595.4
L_1200	770.7	1102.0	781.0	695.0	809.0	831.5

Spring tiller population (tillers/m2)

DD/SR	Fife	Hants.	North.	Cambs.	Lincs.	Mean
E_400	317.5	422.0	695.7	475.8	384.8	459.1
E_670	483.3	684.5	1165.9	502.7	518.5	671.0
E_940	606.5	924.0	1252.4	752.2	642.5	835.5
E_1200	605.2	1111.5	1770.7	756.5	800.7	1008.9
M400	291.0	236.0	625.0	485.2	339.8	395.4
M670	406.5	465.5	865.9	589.0	584.0	582.2
M_940	498.0	634.0	1189.4	800.5	773.2	779.0
M_1200	589.7	937.5	1460.1	967.0	834.0	957.7
L_400	144.8	237.0	171.6	568.0	247.3	273.7
L_670	219.3	430.0	247.6	737.2	440.3	414.9
L_940	340.8	576.5	394.2	870.0	572.2	550.7
L_1200	398.0	700.0	584.6	931.0	723.7	667.5

Harvest tiller population (tillers/m2)

DD/SR	Fife	Hants.	North.	Lincs.	Mean
E_400	343.3	405.0	574.1	776.0	524.6
E_670	579.7	523.5	846.1	866.0	703.8
E_940	731.7	599.5	931.5	1010.0	818.2
E_1200	897.2	785.0	1165.8	1014.0	965.5
M 400	299.8	271.5	525.4	676.0	443.2
M 670	441.3	381.0	672.9	796.0	572.8
M_940	596.7	465.0	805.5	1100.0	741.8
M_1200	756.7	694.0	897.6	998.0	836.6
L_400	262.7	207.5	293.5	578.0	335.4
L_670	293.2	308.0	352.2	876.0	457.4
L_940	371.8	423.0	408.5	1038.0	560.3
L_1200	465.8	495.0	550.7	1022.0	633.4

Harvest boll counts (bolls/plant)

DD/SR	Fife	Hants.	North.	Cambs.	Lincs.	Mean
E_400	30.3	16.5	17.1	35.2	24.8	24.8
E_670	20.0	14.2	10.5	28.0	18.0	18.1
E_940	14.8	14.0	8.6	24.5	17.8	15.9
E_1200	11.3	11.8	8.3	21.3	14.5	13.4
M400	27.3	14.8	19.9	30.8	21.8	22.9
M670	15.7	13.5	13.8	26.3	18.5	17.6
M_940	13.0	14.1	12.5	22.0	18.5	16.0
M_1200	11.2	13.1	9.8	17.8	13.3	13.0
L_400	49.0	14.8	35.0	26.5	30.0	31.1
L_670	34.7	13.3	25.0	21.0	22.8	23.4
L_940	23.8	14.4	23.2	19.8	18.8	20.0
L_1200	17.0	13.5	17.7	19.0	14.3	16.3

1997 Drill Date / Seed Rate trial - Crop height (cm)

DD	SR	Hants	Worcs	Essex	Cambs	Lincs	North	Fife
DD1	400	68	78	54.4	87	36	83.25	76
DD2	400	56.9	73	52	84.3	38	80	75
DD3	400	56.7	72	52.2	70.9	38	80.75	71
DD1	670	68	76	54.1	86.1	38	81.5	76
DD2	670	69.4	75	52.6	83.1	42	79.75	77
DD3	670	58.7	73	52	75.5	33	82.25	71
DD1	940	68.5	74	51	81.8	37	81.75	74
DD2	940	62.5	74	52.7	81.2	41	80	72
DD3	940	58.4	72	50.5	78.6	35	79.25	71
DD1	1200	68.3	73	53.2	81.3	37	80.25	74
DD2	1200	61.1	73	51.6	81.7	41	79.25	71
DD3	1200	56.4	69	52	80	37	78.5	67

1997 Drill Date / Seed Rate trial - Lodging (%>45^0).

DD	**SR**	Hants	Worcs	Essex	Cambs	North	Fife
DD1	400	33.7	16	0	0	4.25	6.3
DD2	400	20.5	7.7	0	0	8	5
DD3	400	3.7	0	5	0	3.75	0
DD1	670	67.5	39	0	3.8	5	12.5
DD2	670	38.7	12	7.5	0	13	6.3
DD3	670	2.5	5	0	0	6.75	3.8
DD1	940	76.2	58	28	7.5	21.25	20
DD2	940	40	40	15	0	23	22.5
DD3	940	10	12	3	0	7.5	2.5
DD1	1200	71.2	73	39	22.5	30	40
DD2	1200	40	51	20	1.25	20	22.5
DD3	1200	12.5	18	5	0	23.25	23.8

Drill date / seed rate trial 1997. Yield (t/ha)

DD/SR	Fife	Hants.	North.	Cambs.	Essex	Worcs.	Lincs.	Mean
E_400	1.99	0.75	2.48	1.80	1.29	1.04	1.55	1.56
E_670	1.35	0.90	2.40	1.92	1.35	1.11	1.89	1.67
E_940	2.13	0.93	1.73	1.94	1.47	1.12	1.86	1.60
E_1200	2.32	0.86	1.81	1.93	1.25	1.13	2.00	1.61
M400	2.00	0.39	3.13	1.79	1.48	1.30	1.60	1.67
M670	2.20	0.63	3.01	2.06	1.52	1.24	1.66	1.76
M_940	2.02	0.72	2.53	1.91	1.54	1.22	1.88	1.69
M_1200	2.12	0.79	2.42	1.81	1.48	1.17	1.99	1.68
L_400	1.60	0.26	2.47	2.00	0.84	1.29	1.99	1.49
L_670	1.78	0.49	2.68	2.05	1.29	1.20	1.93	1.63
L_940	1.82	0.64	2.68	2.12	1.33	1.19	2.13	1.70
L_1200	1.73	0.70	2.68	1.92	1.69	1.17	2.13	1.72

Appendix 3. 1997 Drill Date / Nitrogen level / Seed Rate trial - Yield components, yield, crop height and lodging.

Spring tiller population (tillers/m2).

DD/SR/N	Fife	Hants.	North.	Cambs.	Lincs.	Mean
E_400_N0	344.0	645.5	839.0	469.0	357.5	531.0
E_400_N50	316.0	663.5	886.5	437.8	341.8	529.1
E_400_N100	333.3	653.5	888.2	407.5	344.3	525.3
E_400_N150	325.3	665.0	784.5	488.5	360.0	524.6
E_1200_N0	489.8	469.5	1954.2	911.7	783.0	1121.7
E_1200_N50	538.2	1351.0	1702.5	791.7	811.2	1039.0
E_1200_N100	514.7	1350.5	1680.2	816.7	764.2	1025.3
E_1200_N150	506.5	1494.5	1821.7	834.2	747.7	1081.0
L_400_N0	173.3	288.0	310.3	452.3	246.0	294.0
L_400_N50	221.5	250.5	390.5	520.7	273.3	331.3
L_400_N100	179.5	295.0	408.0	475.0	223.3	316.1
L_400_N150	204.3	332.5	331.5	546.7	263.3	335.6
L_1200_N0	436.8	954.0	553.0	940.2	686.5	714.1
L_1200_N50	379.8	929.5	690.5	961.2	732.5	738.7
L_1200_N100	383.3	901.5	596.7	1038.5	654.5	714.9
L_1200_N150	385.0	983.0	679.2	974.7	703.0	745.0

Harvest tiller population (tillers/m2)

DD/SR/N	Fife	Hants.	North.	Lincs.	Mean
E_400_N0	383.0	565.0	585.5	650.0	545.9
E_400_N50	357.8	509.0	618.5	688.0	543.3
E_400_N100	307.0	493.0	562.2	610.0	493.1
E_400_N150	332.0	485.0	512.7	616.0	486.4
E_1200_N0	772.0	1065.0	1311.2	1020.0	1042.1
E_1200_N50	787.0	1115.5	1088.0	928.0	979.6
E_1200_N100	720.7	998.0	1153.2	834.0	926.5
E_1200_N150	714.5	1057.0	1122.5	832.0	931.5
L_400_N0	228.8	206.5	325.3	582.0	335.6
L_400_N50	322.5	197.5	315.8	570.0	351.4
L_400_N100	249.0	235.0	266.3	536.0	321.6
L_400_N150	354.3	242.0	285.0	494.0	343.8
L_1200_N0	430.0	655.0	666.7	770.0	630.4
L_1200_N50	476.5	676.5	686.2	838.0	669.3
L_1200_N100	448.5	743.5	573.2	838.0	650.8
L_1200_N150	497.3	715.0	599.2	868.0	669.9

Harvest boll counts (bolls/plant)

DD/SR/N	Fife	Hants.	North.	Cambs.	Lincs.	Mean
E_400_N0	23.8	12.0	16.8	36.2	21.8	22.1
E_400_N50	26.5	13.5	15.8	36.0	27.8	23.9
E_400_N100	26.5	16.0	17.5	38.2	38.2	27.3
E_400_N150	32.7	16.3	19.8	36.7	22.3	25.6
E_1200_N0	11.3	6.7	7.7	19.0	16.5	12.3
E_1200_N50	11.8	8.8	9.0	20.0	14.0	12.7
E_1200_N100	11.5	9.3	9.3	22.8	14.3	13.4
E_1200_N150	14.0	9.5	11.0	23.8	11.3	13.9
L_400_N0	57.2	12.8	35.2	26.8	24.5	31.3
L_400_N50	47.0	16.5	34.0	27.5	24.5	29.9
L_400_N100	53.2	20.0	37.0	24.8	24.5	31.9
L_400_N150	52.5	19.5	38.2	24.3	20.8	31.1
L_1200_N0	20.5	7.7	13.8	15.3	14.8	14.4
L_1200_N50	20.5	10.5	12.3	15.8	17.8	15.4
L_1200_N100	23.5	11.5	17.5	16.3	15.8	16.9
L_1200_N150	21.0	11.3	16.0	17.5	14.5	16.1

1997 Drill Date / Nitrogen level / Seed Rate trial - Crop height (cm)

DD	**SR**	**N**	Hants	Cambs	Lincs	North	Fife
DD1	400	0	73.2	51.6	38	85	75
DD1	1200	0	72.4	52	39	84	73
DD2	400	0	56.5	50.3	37	82	71
DD2	1200	0	55.8	50	38	77	71
DD1	400	50	73.2	53	44	86	76
DD1	1200	50	73.6	51.7	39	84	73
DD2	400	50	59.4	51.4	34	81	70
DD2	1200	50	59.9	49	35	77	71
DD1	400	100	72.8	52	40	87	77
DD1	1200	100	72	53.7	39	83	76
DD2	400	100	58.4	50.6	40	81	74
DD2	1200	100	61.4	50.2	36	79	71
DD1	400	150	72.4	52.2	39	84	78
DD1	1200	150	73.2	51.7	39	84	77
DD2	400	150	59.2	52	36	80	73
DD2	1200	150	60.7	51.1	38	80	73

1997 Drill Date / Nitrogen level / Seed Rate trial - Lodging (%>45^0).

DD	SR	N	Hants	Worcs	Essex	Cambs	North	Fife
DD1	400	0	2.5	0	0	0	1.25	0
DD1	1200	0	2.5	8	5	11.3	33.75	15
DD2	400	0	0	0	0	0	0	0
DD2	1200	0	0	0	0	2.5	8.75	5
DD1	400	50	5	0	0	1.3	12.25	5
DD1	1200	50	32.5	35	6	16.3	45	50
DD2	400	50	0	0	0	0	1.75	2.5
DD2	1200	50	22.5	10	0	8.75	32.5	35
DD1	400	100	32.5	14	0	3.8	35	35
DD1	1200	100	47.5	52	33	30	60	60
DD2	400	100	5	7	5	0	8	2.5
DD2	1200	100	27.5	23	14	13.8	41.25	55
DD1	400	150	60	22	5	7.5	53.75	57
DD1	1200	150	91.3	80	44	36.3	73.75	62.5
DD2	400	150	17.5	7	0	0	1.25	5
DD2	1200	150	72.5	31	18	22.5	45	67.5

Drill date / Nitrogen level / Seed rate trial 1997. Yield (t/ha)

DD/SR/N	Fife	Hants.	North.	Cambs.	Essex	Worcs.	Lincs.	Mean
E_400_N0	1.88	1.15	2.17	1.44	0.93	0.59	0.84	1.28
E_400_N50	2.18	1.28	2.39	1.44	1.08	0.94	0.99	1.47
E_400_N100	2.03	1.25	2.19	1.36	1.31	1.27	1.17	1.51
E_400_N150	1.78	1.28	1.77	1.38	1.09	1.29	1.69	1.47
E_1200_N0	1.75	0.90	1.93	1.15	1.17	0.68	1.01	1.23
E_1200_N50	1.83	1.10	1.60	1.32	1.26	0.98	1.40	1.36
E_1200_N100	1.93	1.25	1.20	1.23	1.40	1.26	1.67	1.42
E_1200_N150	1.72	1.19	1.29	1.28	1.54	1.29	2.04	1.48
L_400_N0	1.41	0.39	2.48	1.65	0.96	0.49	0.87	1.18
L_400_N50	1.82	0.54	2.58	1.52	1.08	1.07	1.21	1.40
L_400_N100	1.65	0.57	2.38	1.59	1.33	1.24	1.54	1.47
L_400_N150	1.72	0.66	2.59	1.61	1.09	1.19	1.80	1.52
L_1200_N0	1.72	0.77	2.66	1.72	1.37	0.62	1.16	1.43
L_1200_N50	1.90	1.03	2.35	1.67	1.35	0.95	1.68	1.56
L_1200_N100	1.79	0.95	1.97	1.66	1.45	1.15	1.90	1.55
L_1200_N150	1.63	0.99	1.83	1.70	1.91	1.09	2.29	1.63

Appendix 4. 1998 Drill Date / Seed Rate trial - Yield components, yield, crop height and lodging

Autumn plant population (plants/m2)

DD/SR	Fife	Hants.	North.	Cambs.	Essex	Worcs.	Mean
E_400	271.3	345.5	277.0	452.8	367.0	385.6	349.9
E_670	393.0	576.0	390.3	744.9	647.5	624.2	562.6
E_940	583.7	865.0	511.2	1007.8	834.6	878.0	780.1
E_1200	687.2	918.5	611.5	1265.0	1107.1	1089.9	946.5
M400	258.0	326.0	319.5	364.6	364.1	330.2	327.1
M670	414.5	496.0	473.0	666.6	660.9	605.1	552.7
M_940	584.2	708.5	642.2	925.7	856.1	830.3	757.9
M_1200	702.0	771.0	844.2	1130.9	1108.0	963.9	920.0
L_400	253.8	347.0	215.8	126.0	370.3	271.1	264.0
L_670	378.0	560.0	411.5	262.4	555.9	448.6	436.1
L_940	557.2	705.0	476.8	334.0	536.8	589.8	533.3
L_1200	657.2	906.0	569.0	395.6	750.1	740.6	669.8

Spring tiller population (tillers/m2)

DD/SR	Hants.	North.	Cambs.	Essex	Worcs.	Lincs.	Mean
E_400	1047.5	943.2	1735.1	613.7	820.7	583.2	957.2
E_670	1386.5	1376.5	2025.2	787.8	1160.5	778.5	1252.5
E_940	1628.0	1957.5	2422.7	1005.9	1406.7	949.0	1561.6
E_1200	1726.5	2107.3	2584.9	1020.2	1422.0	1162.0	1670.5
M400	1113.5	912.2	987.3	490.1	565.0	554.7	770.5
M670	1387.0	1246.0	1477.4	782.1	828.5	861.0	1097.0
M_940	1620.0	1759.7	1579.0	904.3	958.2	820.5	1273.6
M_1200	1761.0	2124.3	2007.5	887.1	1130.0	935.2	1474.2
L_400	746.5	569.5	167.0	327.4	660.5	537.0	501.3
L_670	1070.5	862.8	335.0	517.7	960.2	574.0	720.0
L_940	1183.5	1263.3	483.4	612.7	1002.0	701.0	874.3
L_1200	1360.0	1432.3	538.8	795.0	1240.7	742.7	1018.2

Harvest plant population (tillers/m2)

DD/SR	Fife	Hants.	North.	Cambs.	Essex	Lincs.	Mean
E_400	278.9	271.5	189.9	318.7	278.8	425.5	293.9
E_670	402.4	377.0	291.8	402.7	402.3	580.7	409.5
E_940	557.6	454.5	349.0	503.9	560.8	691.7	519.6
E_1200	640.6	518.5	420.2	566.4	640.4	924.2	618.4
M400	285.2	265.0	216.4	267.7	307.0	460.0	300.2
M670	413.5	371.5	370.2	388.9	423.8	652.7	436.8
M_940	571.0	487.0	458.7	489.6	611.8	623.2	540.2
M_1200	722.7	509.5	534.6	621.8	754.9	707.2	641.8
L_400	254.7	275.5	172.6	95.4	232.6	374.8	234.3
L_670	391.1	404.0	233.2	165.1	380.5	434.5	334.7
L_940	584.3	487.5	386.5	244.3	543.1	625.7	478.6
L_1200	688.4	589.5	393.8	279.6	655.7	731.2	556.4

Harvest tiller population (tillers/m2)

DD/SR	Fife	Hants.	North.	Cambs.	Essex	Lincs.	Mean
E_400	431.6	556.0	378.8	813.6	431.5	544.0	525.9
E_670	579.2	672.0	522.6	952.0	578.9	785.5	681.7
E_940	680.3	816.0	651.0	1110.9	743.0	937.0	823.0
E_1200	822.9	867.0	771.1	1050.8	822.6	1130.0	910.7
M400	371.5	622.5	358.6	636.6	410.5	620.7	503.4
M670	505.7	730.0	506.3	862.8	538.3	856.7	666.6
M_940	653.0	785.5	585.5	1001.1	721.9	770.7	753.0
M_1200	791.4	883.0	745.7	1120.9	861.7	885.2	881.3
L_400	302.4	545.5	299.0	183.2	263.2	540.0	355.6
L_670	437.3	663.5	428.3	292.5	403.8	588.0	468.9
L_940	624.0	713.5	524.0	431.8	554.7	776.7	604.1
L_1200	733.2	836.5	556.7	459.5	662.5	913.5	693.7

Harvest boll count (bolls/plant)

DD/SR	Fife	Hants.	North.	Cambs.	Essex	Worcs.	Lincs.	Mean
E_400	20.1	27.1	5.5	28.3	20.1	18.7	19.1	19.8
E_670	18.0	20.1	2.9	20.5	18.0	12.1	14.9	15.2
E_940	12.3	16.7	2.2	17.1	13.5	10.8	14.1	12.4
E_1200	11.3	16.9	1.6	16.6	11.3	9.2	10.9	11.1
M400	17.4	26.4	4.5	29.4	16.0	19.3	14.5	18.2
M670	15.5	19.7	2.5	20.2	14.8	13.1	12.3	14.0
M_940	11.9	16.8	1.5	17.0	11.3	10.6	12.0	11.6
M_1200	10.6	16.5	1.0	13.3	10.1	8.8	10.6	10.1
L_400	18.7	26.7	7.8	60.7	19.9	15.9	16.2	23.7
L_670	15.5	18.9	4.1	42.7	16.2	9.0	12.1	16.9
L_940	11.4	15.3	2.2	37.3	12.0	6.7	10.8	13.7
L_1200	8.8	13.5	1.9	29.7	9.3	6.8	9.0	11.3

1998 Drill Date / Seed Rate trial - Crop height (cm)

DD	**SR**	Hants	Worcs	Cambs	Lincs	North	Fife
DD1	400	83.6	77.8	87.5	67.7	70.3	72.6
DD2	400	77.7	82	84.3	56.9	68	70.2
DD3	400	74.1	58.8	70.9	56.7	69.8	65.1
DD1	670	79.8	75.8	86.1	68.2	72.1	73.3
DD2	670	76.7	83.5	83.1	60.4	65.5	68
DD3	670	74.4	61	75.5	58.7	69.9	62
DD1	940	79.9	74.2	81.8	68.5	69.8	70.4
DD2	940	77	79	81.2	62.5	66.5	65.9
DD3	940	74.1	61	78.6	58.4	71.8	64
DD1	1200	77.2	75.8	81.3	68.3	70.4	70.2
DD2	1200	76.9	79.5	81.7	61.1	66	64.3
DD3	1200	72.6	62.3	80	56.4	70.5	64.1

1998 Drill Date / Seed Rate trial - Lodging (%>45^0).

DD	SR	Worcs	Cambs	Lincs	North
DD1	400	80.6	100	100	1.4
DD2	400	63.9	98.7	71.2	0.8
DD3	400	2.8	35	0	0.6
DD1	670	77.7	98.7	100	1.1
DD2	670	75	100	87.5	0.8
DD3	670	5.6	50	0	0.6
DD1	940	66.7	98.7	100	1.4
DD2	940	69.4	100	90	0.5
DD3	940	5.6	55	0	0.5
DD1	1200	63.9	98.7	100	1.9
DD2	1200	77.8	98.7	90	0.6
DD3	1200	8.3	70	0	0.5

Drill date / seed rate trial 1997. Yield (t/ha)

DD/SR	Fife	Hants.	North.	Cambs.	Essex	Worcs.	Lincs.	Mean
E_400	1.675	1.730	1.967	0.925	0.630	1.062	1.073	1.295
E_670	1.840	1.790	2.192	1.045	0.725	1.388	1.128	1.444
E_940	1.808	1.860	2.295	0.960	0.623	1.413	1.310	1.467
E_1200	1.578	1.850	2.162	0.960	0.518	1.480	1.368	1.416
M400	1.385	1.620	2.115	1.133	0.895	1.433	1.088	1.381
M670	1.250	1.710	2.212	1.045	0.793	1.473	1.178	1.380
M_940	1.563	1.820	2.352	0.960	0.810	1.400	1.265	1.453
M_1200	1.750	1.770	2.397	1.075	0.745	1.408	1.288	1.490
L_400	1.440	1.890	1.992	1.458	1.005	1.042	1.105	1.419
L_670	1.485	1.980	2.115	1.532	1.188	1.080	1.270	1.521
L_940	1.560	2.010	2.322	1.770	1.118	1.110	1.288	1.597
L_1200	1.613	1.990	2.280	1.617	1.305	1.107	1.343	1.608

Appendix 5. 1998 Drill Date / Nitrogen level / Seed Rate trial - Yield components, yield, crop height and lodging.

Spring tiller population (tillers/m2).

DD/SR/N	Hants.	North.	Cambs.	Essex	Worcs.	Lincs.	Mean
E_400_N0	850.5	748.5	1385.2	617.5	981.2	537.7	853.5
E_400_N50	914.0	815.0	1358.5	640.5	1021.2	692.0	906.9
E_400_N100	951.0	709.5	1345.0	692.0	1017.2	696.2	901.8
E_400_N150	946.0	788.2	1505.5	614.7	1065.0	548.0	911.2
E_1200_N0	1553.5	1830.7	2753.5	940.0	2055.8	1002.0	1689.2
E_1200_N50	1709.0	1689.2	2786.0	1015.0	2149.3	1166.5	1752.5
E_1200_N100	1565.5	1887.0	2739.5	1027.7	2048.0	1270.7	1756.4
E_1200_N150	1520.0	1938.5	2792.0	944.5	2031.0	1055.0	1713.5
L_400_N0	647.0	642.0	287.8	376.5	708.0	582.2	540.6
L_400_N50	688.0	614.5	274.0	364.0	752.0	573.2	544.3
L_400_N100	749.0	598.5	345.5	377.3	759.7	613.2	573.9
L_400_N150	666.0	690.7	315.0	379.8	702.5	558.0	552.0
L_1200_N0	1119.5	1527.2	679.5	731.5	1374.0	1285.5	1119.5
L_1200_N50	1366.0	1634.5	565.7	713.7	1408.7	1405.2	1182.3
L_1200_N100	1408.0	1550.5	633.0	773.7	1290.5	1286.5	1157.0
L_1200_N150	1321.0	1638.2	490.0	793.5	1296.2	1414.2	1158.9

Harvest tiller population (tillers/m2).

DD/SR/N	Fife	Hants.	North.	Cambs.	Lincs.	Mean
E_400_N0	413.0	453.5	331.8	749.7	610.5	511.7
E_400_N50	431.3	477.5	358.0	655.2	825.0	549.4
E_400_N100	383.0	506.0	336.5	714.5	731.0	534.2
E_400_N150	400.5	458.5	379.8	707.7	602.2	509.8
E_1200_N0	795.0	920.5	784.5	1495.0	1155.2	1030.0
E_1200_N50	870.7	856.5	650.0	1349.0	1058.5	957.0
E_1200_N100	737.0	780.5	745.7	1252.5	1251.7	953.5
E_1200_N150	731.5	720.5	737.5	1172.0	950.5	862.4
L_400_N0	278.5	380.5	293.0	255.3	546.7	350.8
L_400_N50	280.8	444.0	310.8	285.3	709.7	406.1
L_400_N100	255.5	493.0	300.5	283.3	809.2	428.3
L_400_N150	265.8	420.5	349.3	295.8	851.7	436.6
L_1200_N0	698.2	724.5	529.2	516.7	824.2	658.6
L_1200_N50	665.0	832.0	609.2	460.5	1006.2	714.6
L_1200_N100	653.2	791.0	551.0	524.0	915.5	687.0
L_1200_N150	662.5	761.0	583.0	417.3	989.7	682.7

Harvest boll counts (bolls/plant)

DD/SR/N	Fife	Hants.	North.	Cambs.	Worcs.	Lincs.	Mean
E_400_N0	15.3	15.7	30.4	19.9	14.6	12.9	18.1
E_400_N50	15.7	22.7	30.0	27.9	13.3	15.0	20.7
E_400_N100	23.5	22.9	34.6	26.1	19.9	19.1	24.3
E_400_N150	25.1	25.7	57.8	27.7	14.3	23.2	29.0
E_1200_N0	10.0	9.4	5.7	7.6	4.1	8.9	7.6
E_1200_N50	10.6	12.5	7.8	12.5	8.5	14.0	11.0
E_1200_N100	13.0	16.6	9.2	14.4	7.9	12.3	12.2
E_1200_N150	13.8	17.4	8.5	16.6	12.2	15.5	14.0
L_400_N0	18.6	13.2	23.8	52.4	14.6	14.4	22.8
L_400_N50	19.8	20.1	37.0	59.4	20.3	22.0	29.7
L_400_N100	21.6	22.5	40.7	52.4	20.4	22.3	30.0
L_400_N150	24.9	34.4	32.7	59.4	22.6	22.1	32.7
L_1200_N0	9.3	7.2	6.6	27.8	4.5	7.4	10.5
L_1200_N50	10.7	10.5	6.0	29.4	6.7	8.5	12.0
L_1200_N100	12.0	13.7	7.9	27.6	10.0	13.4	14.1
L_1200_N150	12.4	17.2	8.4	34.9	9.0	13.6	15.9

1998 Drill Date / Nitrogen level / Seed Rate trial - Crop height (cm)

DD	**SR**	**N**	Hants	Worcs	Cambs	Lincs	North	Fife
DD1	400	0	79.6	74.2	87.2	67.6	72.8	72
DD1	1200	0	77.3	70.7	81.5	68.8	74.6	70
DD2	400	0	58.5	73.2	74.1	53.6	65.8	66
DD2	1200	0	60.1	70.2	78.3	51.5	66.8	66
DD1	400	50	84.3	76.5	87.3	66.6	71.9	75
DD1	1200	50	75.6	73.2	78.4	70.3	74.9	73
DD2	400	50	67.5	77	73.8	55.2	64.4	68
DD2	1200	50	70.6	76.5	79.3	57	67	69
DD1	400	100	82.9	75.5	85.7	70.1	73.8	74
DD1	1200	100	75.8	73	77.1	68.2	74.4	73
DD2	400	100	67.1	79.5	76.9	56.4	66	67
DD2	1200	100	71.4	78	79.7	56.8	68.9	65
DD1	400	150	83.3	78.5	87	68.9	73.8	77
DD1	1200	150	75.1	74.5	78.6	69.7	74.8	75
DD2	400	150	66.1	80.2	76.9	54.8	66.3	70
DD2	1200	150	69.8	75	78.1	61.4	68.8	68

1998 Drill Date / Nitrogen level / Seed Rate trial - Lodging (%>45^0).

DD	SR	N	Worcs	Cambs	Lincs	North	Fife
DD1	400	0	47.2	100	100	0.9	0
DD1	1200	0	22.2	100	70	0.8	0
DD2	400	0	11.1	13.7	0	0.6	0
DD2	1200	0	12	35	0	0.5	0
DD1	400	50	72.2	100	100	0.5	0
DD1	1200	50	55.6	97.5	90	1.8	5
DD2	400	50	25	40	15	0.6	0
DD2	1200	50	50	52.5	12.5	0.9	0
DD1	400	100	69.4	100	100	1.5	2.5
DD1	1200	100	58.3	95	100	2.8	0
DD2	400	100	50	52.5	37.5	1	0
DD2	1200	100	58.3	71.2	77.5	0.9	0
DD1	400	150	72.2	100	100	2	0
DD1	1200	150	61.1	95	100	16.3	47.5
DD2	400	150	66.7	68.7	45	0.9	0
DD2	1200	150	55.6	82.5	100	2.1	5

Drill date / Nitrogen level / Seed rate trial 1998. Yield (t/ha)

DD/SR/N	Fife	Hants.	North.	Cambs.	Essex	Worcs.	Lincs.	Mean
E_400_N0	1.287	1.200	1.240	0.892	0.735	1.070	1.002	1.061
E_400_N50	1.420	1.670	1.525	0.807	0.588	1.258	1.177	1.206
E_400_N100	1.792	1.880	1.795	0.850	0.613	1.510	1.267	1.387
E_400_N150	2.067	1.960	1.960	0.710	0.530	1.440	1.262	1.419
E_1200_N0	1.437	1.270	1.585	0.775	0.593	1.430	1.320	1.201
E_1200_N50	1.850	1.660	2.043	0.747	0.580	1.565	1.353	1.400
E_1200_N100	2.088	1.920	2.173	0.822	0.605	1.712	1.430	1.536
E_1200_N150	2.462	2.110	2.130	0.697	0.533	1.708	1.370	1.573
L_400_N0	1.535	1.000	1.383	1.488	0.868	1.322	0.870	1.209
L_400_N50	1.597	1.580	1.700	1.447	1.255	1.570	1.285	1.491
L_400_N100	1.807	2.120	1.903	1.470	1.295	1.737	1.322	1.665
L_400_N150	2.050	2.220	1.965	1.340	1.290	1.760	1.357	1.712
L_1200_N0	1.575	1.140	1.543	1.562	1.110	1.445	1.095	1.353
L_1200_N50	1.842	1.620	2.050	1.642	1.390	1.482	1.225	1.607
L_1200_N100	2.035	2.110	2.193	1.397	1.380	1.710	1.327	1.736
L_1200_N150	1.975	2.260	2.387	1.377	1.288	1.830	1.280	1.771