



**PROJECT REPORT No. 179**

**EFFECTS OF SOWING AND  
HARVEST DATES, NITROGEN,  
PGR AND FUNGICIDE ON  
YIELD AND MALTING  
QUALITY OF SPRING BARLEY**

JANUARY 1999

Price £8.00



**EFFECTS OF SOWING AND HARVEST DATES, NITROGEN, PGR AND  
FUNGICIDE ON YIELD AND MALTING QUALITY OF SPRING  
BARLEY**

by

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This is part of the final report of a three year project which started in September 1990. The work reported herein was funded by a grant of £115,823 from HGCA (Project No 0004/2/90). Work carried out on winter barley under the same grant number and costing £44,527 is reported in Project Report No 180.

The Home-Grown Cereals Authority (HGCA) has provided funding for this project but has not conducted the research or written this report. While the authors have worked on the best information available to them, neither HGCA nor the authors shall in any event be liable for any loss, damage or injury howsoever suffered directly or indirectly in relation to the report or the research on which it is based.

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## SUMMARY

*Appearing in brackets after each statement is a reference to the appropriate chapter/section on which the statement is based.*

The objective of the spring barley component of this project was to examine the effects of various husbandry treatments on the yield, malting quality, the financial output of spring barley and its recovery from dormancy (2).

Five east coast sites ranging from Lincolnshire to Inverness were sown with cv Blenheim in 1991, 1992 and 1993 (3).

The treatment variables applied to these trials were time of sowing, rate of nitrogen fertiliser, growth regulator and late fungicide (3).

Terpal growth regulator had a significant shortening effect but negligible effect on yield in a series that was generally devoid of lodging (4.1).

Late fungicide (Tilt Turbo) applied at ear emergence produced yield responses ranging from negligible to 0.7 t/ha (4.2).

The yield penalty from delayed sowing averaged 0.48 t/ha in 1991, 0.64 t/ha in 1992 and 0.79 t/ha in 1993. The daily yield penalty from delayed sowing varied between 36 kg grain/ha/day in 1992 to 42 kg grain/ha/day in 1993 (4.3).

The yield response to nitrogen fertiliser was much lower where sowing was delayed, indicating a reduction the optimum level of fertiliser (4.4).

Terpal growth regulator reduced grain size, increased screening losses and tended to reduce grain nitrogen % (5.11).

Despite a late disease threat that was often close to negligible, late fungicide tended to increase grain size and reduce screening losses (5.12).

Early sowing resulted in larger grains such that each day of sowing delay increased screening losses by an average of 0.25% (5.13).

Early sown crops had a lower grain nitrogen %: the increase in grain nitrogen % associated with delayed sowing averaged 0.005% per day (5.13).

High rates of nitrogen fertiliser increased screening losses (5.14).

The improved malt extract attributable to early sowing

(0.7 soluble percent) was entirely attributable to reduction in grain nitrogen and screening losses. The use of growth regulator resulted in lower friability and slower modification (6).

A regression of grain nitrogen and diastatic power did not support the widely held view of a close relationship (6).

Grain cut before reaching harvest maturity tended to be higher in germinative energy. Harvesting early did not penalise recovery from dormancy (7).

Late applications of fungicide tended to increase the incidence of splitting (8.1).

Warm, well ventilated, storage conditions significantly improved germinative energy (8.2).

Applications of plant growth regulator (Terpal) or fungicide (Tilt Turbo) had no deleterious effect on the gibberellin-controlled development of amylase enzymes in harvested grains (8.3).

Residue analysis for the two active ingredients in the late fungicide treatment (propiconazole and tridemorph) produced results that were close to the limit of detection. The use of these fungicides at, or close to ear emergence was unlikely to result in significant residues in the grain (8.4).

The rate of recovery from dormancy was not significantly influenced by the husbandry variables adopted in this trial series. Drying and storage conditions were the most important factors influencing recovery from dormancy (9.1).

The yield penalty for each day's delay in sowing averaged 39.6 kg/ha/day (9.2).

There was a positive interaction between time of sowing and rate of nitrogen fertiliser affecting yield but no significant interaction affecting grain nitrogen percent or screening losses (9.2).

The use of growth regulator (Terpal) had no effect on yield and a small adverse effect on malting barley price. In the absence of significant lodging, Terpal reduced gross margin by £20 per hectare. Given the straw strength of most modern spring barley malting varieties, the use of such a growth regulator to stiffen straw was likely to have an adverse effect on malting quality and gross margin (9.32).

Application of late fungicide increased yield by 0.25 t/ha and it improved the malting price, mainly through the reduction in deductions for screenings. The average improvement in gross margin was £24/ha (9.33).

Even with a mildew susceptible variety such as cv Blenheim, there were some trials in which the response was not cost-effective. The frequency of an uneconomic response is now likely to be higher due to the prevalence of varieties with mildew MLO resistance such as Chariot. 9.34 The malting premium was reduced by approximately 16p for every kg of additional nitrogen fertiliser over the range 70 to 150 kg/ha: change in grain nitrogen accounted for two thirds of this and increase in screening losses for the remaining one third (9.33).

The difference in gross output between the two times of sowing was £125/ha: early sowing improved the malting premium by nearly £8/t (9.35).

The average difference between the two sowing dates was 19.8 days. At an average malting barley price of £130, the penalty for delayed sowing was £6.31 per day (9.35).

The optimum rate of nitrogen was significantly higher for the early sown treatment. For malting barley the optimum rate was reduced by approximately 2.25 kg N/ha/day and for feed barley the daily adjustment was close to 2 kg N/ha/day (9.35).

The optimum rate of nitrogen was lower when 1997 prices and costs were applied (9.35).

## 1. INTRODUCTION

In Scotland most of the spring barley crop consists of malting varieties (>80%), a high proportion is grown with the hope of attracting a malting premium. In reality between 40 and 60% of the crop meets the specification needed to attract a premium; increasing this proportion would add considerably to industry income.

In his classic paper Bishop (1948) developed an extract prediction system for maltsters based on grain nitrogen and Thousand Corn Weight (TCW). Bathgate (1987) showed how maltsters were changing to screening losses instead of TCW at intake to adjust malting barley premiums. The change to screening loss determination was encouraged by two factors. The international shipping standard for export barley used screening losses over a 2.5mm screen. Determinations for screening losses tend to be more accurate than for TCW because sample size is normally many times larger and it takes less time.

The introduction of a 2.5mm screen in Scotland for determining screening losses and the consequent deductions coincided with harvests in 1989 and 1991 that were both high in screening losses. In England the screen size was increased to 2.25mm. There was a need to identify the effect that various husbandry decisions have on screening losses. At the request of the malting industry SAC was already assessing varieties for screening losses as part of the recommended variety testing system. Any treatment that affects ear population or grain size is also likely to affect screening losses. A survey of spring barley crops (ESCA 1982) produced useful pointers to the effect of time of sowing on both ear population and Thousand Corn Weight. Paterson, Blackett and Gill (1983) indicated that ethephon-based growth regulators tended to increase the ear population and reduce grain size. Heavily diseased crops tend to reduce grain size so the use of fungicide was expected to reduce screening losses. These husbandry variables were planned into the project.

Some seasons induce longer lasting dormancy than others. Although the home industry has learnt to live with the problem it does present additional separation and conditioning costs and it can severely damage the export market in malting barley if a load is contaminated with dormant barley and fails the germination energy test on delivery. Dormancy was considered to be more likely in barley grown in the more northerly parts of the United Kingdom.

Although the malting industry had begun to develop warm storage regimes to deal with dormant barley, it might be simpler and cheaper if such barley could be avoided by a change to its husbandry in the field.

The opportunity was taken in 1992 to demonstrate the influence of sound conditioning on recovery from dormancy as the student working on the project needed to conduct a simple trial for her report on the placement.

Selecting varieties with quick recovery from dormancy was not part of this project as the Institute of Brewing Barley Committee's Scottish Working Party were already screening new varieties in conjunction with SAC. The planned husbandry variables might influence factors contributing to dormancy such as development stage, respiration and enzymatic activity, so the project provided a useful opportunity to check.

Traditional harvest advice to growers of malting barley has been to delay harvest as this improves malting quality: implicit in this advice was an improvement in germinative energy. Growers close to Scotland's east coast have been reluctant to follow this advice because of the risk of ear loss. Losses can be massive; a gale in late July of 1988 reduced the yield of some winter barley varieties in a SAC trial by over 40% (SAC 1989). Such large losses are relatively rare but an average loss of one ear per square metre may be viewed by the grower as significant despite the fact that the yield loss actually involved would be miniscule at approximately 10 kg/ha.

A further source of harvest loss is attributable to brackling. If harvesting is delayed, some short strawed varieties such as Camargue brackle: the straw creases with the result that the ear-bearing part falls below the cutter-bar height.

Both causes of ear loss have encouraged Scottish farmers to harvest earlier than many maltsters would advise. This part of the project investigated the effect of harvesting early on the dormancy and water-sensitivity of spring barley.

Germination characters other than dormancy affect the acceptability of barley for malting. In some seasons a significant proportion of the crop can be rejected because of physical defects that affect how the grain malts, one of these is splitting.

A gap can develop between the palea and lemma surrounding the barley grain, the endosperm may also crack longitudinally along the ventral crease to reveal the starch substrate, this is known as splitting. If only the gap develops and there is no cracking of the endosperm, the condition is known as gape.

Maltsters reject barley if splitting exceeds a few % because split grain presents the maltster with both product and processing problems:

If split grain does not germinate during the malting process, the standard for unmalted grains may be exceeded.

If a significant amount of starch has been hydrolysed to sugars in the field, this potential for alcohol production may be washed away during the malting process, thus reducing the malt extract or predicted spirit yield.

Grain with splits, gapes or separated husks adversely affects drainage during malting.

Split or gapping grain provides a substrate for the development of microorganisms; if these develop during malting they may affect the malting process and the value of the malt.

If microorganisms develop on split grain, they may produce mycotoxins. If split grain is not used for malting, it is likely to be fed to livestock so the mycotoxin risk remains important.

Many malting companies have achieved or are achieving ISO 9000 accreditation. If they put out product below specification they risk the loss of both their accreditation and their customer. The best way to avoid this risk is to refuse to accept bulks with even a few percent of split grain. In 1996 gape was very common on cv Chariot in Scotland; if *Fusarium* was associated with the gape, one maltster rejected the grain.

In 1992 the malting market closed down early in North-East Scotland; the presence of splitting and other germination problems was so widespread that merchants were not prepared to accept samples and maltsters were unwilling to risk accepting a sample that would later prove to be outside their customer's specification.

Given the commercial interest in splitting, and its prevalence in 1992 it was an opportune occasion to screen the trials for this character, particularly as cv Blenheim was known to be prone to splitting.

Malting yield and distillery yield are important characters for maltsters but how a bulk malts can be crucial if the modification or friability do not match brewer or distiller requirements. The inclusion of a micro-malting facility meant this project could address the question 'do husbandry variables such as time of sowing, fungicide and growth regulator practice affect malting'?

During the malting process amylolytic enzymes breakdown the endosperm degrading starch and protein. Gibberellins induce the synthesis and secretion of these endosperm-degrading enzymes from the aleurone layer

(MacLeod et al 1964). One of the husbandry variables selected for this project contained a gibberellin inhibitor so the opportunity was taken to use expertise developed by Professor Palmer at Heriot-Watt University to investigate whether this effect was sufficiently persistent to affect malting. Changes in the production of gibberellins can be measured by the change in  $\alpha$ -amylase production (Filner and Varner 1967).

The growth regulator used in this project was BASF's Terpal. Terpal is a formulated mixture containing 305 g/litre of mepiquat chloride and 155 g/litre 2-chloroethylphosphonic acid. Mepiquat chloride inhibits gibberellin production: gibberellins stimulate the elongation and division of cells but they are also involved in germination. 2-chloroethylphosphonic acid releases ethylene in the plant; ethylene blocks the transport of auxins resulting in cells that are shorter, thicker and stronger.

The question posed in this study was 'does the application of Terpal growth regulator have an effect on the ability of malting barley to produce the enzymes required during germination?'. If Terpal reduces gibberellin activity, this in turn will reduce the supply of the enzymes that breakdown starch and protein and produce a satisfactory fermentation during brewing.

The application of fungicide as a treatment during ear emergence provided the opportunity to analyse grain for fungicide residues.

## **2. OBJECTIVES**

To examine the effects of sowing date, rate of nitrogen fertiliser, growth regulator, late fungicide and harvest date on yield of spring barley, its malting quality, financial output and its recovery from dormancy.

### 3. MATERIALS AND METHODS

#### 3.1 Field trials

Spring barley was grown on five east coast sites in 1991, 1992 and 1993 spread in each year from Lincolnshire to Inverness; site details including husbandry inputs are given in Appendix 1. Blenheim was chosen as a variety that can produce a range of malting problems in a difficult year and it provided continuity within the project. It had two other advantages in that its mildew resistance was sufficiently low to provide a useful guide to the need for late fungicide and when grown for malting it seldom lodges.

The treatment list was as follows:

Code	Nitrogen (kg/ha)	Terpal Growth Regulator (1 l/ha)	Late Fungicide	
			Tilt	Turbo at GS49-59
A	Low	Yes		Yes
B	Low	Yes		No
C	Low	No		Yes
D	Low	No		No
E	Moderate	Yes		Yes
F	Moderate	Yes		No
G	Moderate	No		Yes
H	Moderate	No		No
J	High	Yes		Yes
K	High	Yes		No
L	High	No		Yes
M	High	No		No

Two times of sowing were adopted; the early time was intended to represent the first reasonable sowing opportunity and the late time was arbitrarily chosen as not less than two weeks later; in some cases wet weather extended this to nearly four weeks.

Three nitrogen treatments were imposed, the intermediate one was intended to represent normal malting practice for the area and rotation, the other two were 40 kg/ha above and below it.

Half the treatments received Terpal growth regulator (mepiquat chloride and 2-chloroethylphosphonic acid). The intention was to assess the effects of Terpal growth regulator in the absence of lodging so as to quantify any damaging effects that Terpal might have. This treatment provided samples for a study at Heriot-Watt University into the effect of Terpal on enzyme development in germinating barley grain supervised by Professor Palmer.

All trials were given fungicide protection during stem extension to control any mildew that developed. Half the treatments received an ear emergence application of Tilt Turbo fungicide (propiconazole and tridemorph). The intention was to assess its effect on yield and

malting quality. This treatment also provided the opportunity to assess the grain for the residues of both propiconazole and tridemorph.

Yield was assessed on all plots using a plot combine; the yields were corrected to 15% moisture content.

### 3.2 Barley analysis

Samples from all sites were forwarded to SAC Edinburgh for drying at a safe temperature (below 30 degrees Centigrade) and conditioning (at 20 degrees Centigrade). Sub-samples were analysed for 1000 corn weight, screening losses, grain nitrogen, germination capacity and germination energy as detailed in Appendix 2. Given the generally good germination capacities, the embryo work was replaced by an investigation into the causes of split grain in 1992 and 1993.

### 3.3. Micro-malting

Samples from various sites were micro-malted by Robert Kilgour & Co. using the analytical techniques approved and published by the Institute of Brewing (1992). The samples were restricted to early and late sowings of treatments E, F, G and H (the middle nitrogen rate). Micro-malting is an expensive, time-consuming technique that mimics the commercial-scale process in order to provide samples for analysis: the treatments selected had to fit a batch process limited to eight samples to obviate differences between batches.

The sites were as follows:

1991	1992	1993
Whitehouse	Crosshall	Crosshall
Aldroughty	Panlathy	Sunnybrae
	Withcall	Withcall

The sites were used to provide statistical replication.

### 3.4 Time of harvest studies

In each of the three years samples of barley were harvested early with shears, tied into small sheaves, dried, threshed and stored in the same conditions as grain from the conventional harvest. The threshing took place some weeks after harvesting.

The samples were restricted to treatment G (intermediate nitrogen treatment with late fungicide but no growth regulator). In the first year the samples were taken approximately 20 and 10 days before harvest; in subsequent years the samples were taken approximately 14 and 7 days before harvest.

The sites were as follows:

1991	1992	1993
Whitehouse	Withcall	Crosshall
Boghall	Crosshall	Bush
	Panlathy	

Germinative energy was assessed on the sheaf samples once the marker samples in the main trial approached 90% recovery using the method described in appendix 2.

### 3.5 splitting

The technique for assessing split grain is given in appendix 2. For each site in 1992 and 1993, at both sowing dates, samples from treatment H were screened for splitting. The results identified the sites with significant levels of splitting; two replicates were then assessed on these sites. The sites chosen in 1992 were Sunnybrae and Aldroughty and in 1993 they were Crosshall and Aldroughty.

### 3.6 Storage study

Grain at 15% moisture content from three trial locations was subjected to two storage regimes:

- a. Good Conditions - dried down to 12 % moisture  
stored in linen bags  
on slatted shelves  
at 20 degrees centigrade
- b. Adverse Conditions - no further drying  
stored in plastic bags  
no ventilation  
at about 4 degrees centigrade

The good conditions were identical to the conditions in which malting samples were kept throughout the project.

### 3.7 Growth regulator studies

The following treatments were selected at both the early and late sowing dates:

	Nitrogen (kg/ha)	Growth regulator
B	70	yes
D	70	no
K	150	yes
M	150	no

Samples were taken from the following sites:

1991	1992
Sunnybrae	Panlathy
Aldroughty	

The grain was dehusked with sulphuric acid using the procedures described by Nimmo (1982) and either germinated in distilled water, or de-embryonated and germinated in a solution of gibberellic acid. Alpha-amylase was then extracted and assayed using a modification of the methods developed by Ranki and Sopanen (1984).

### **3.8 Residue analysis**

Tilt Turbo 475EC was applied to half the plots between growth stage 45 and 59. Selected treatments from the 1991 Aldroughty site were analysed for residues; it was sprayed on 24 June when the early sown treatments were at growth stage 59 and the late sown treatments were at growth stage 49. Tilt Turbo contains 125g propiconazole and 350g tridemorph per litre; the application rate was one litre per hectare.

Analysis for propiconazole residues was by an adaptation of the method of Specht and Tillkes (1980). The samples were minced and subsamples treated with acetone. Aqueous salt and dichloromethane were added and pesticides extracted into the organic phase. The extract was dried with sodium sulphate before concentration on a rotary evaporator at 35 degrees centigrade. Clean-up of the extract to remove co-extractives was by gel permeation chromatography. Propiconazole in the extracts was determined by gas chromatography using a 30m DB608 megabore column and electron detection. The detection limit for the method employed is 0.01 mg/kg.

#### 4. RESULTS & DISCUSSION - FIELD PERFORMANCE

The site results are presented in Appendix 3 tables 101-130 and the over year results in Appendix 4 tables 201-206.

##### 4.1 Growth regulator

###### 1991

Terpal growth regulator had no effect on yield at four of the sites; but at Sunnybrae it reduced yield by .24 t/ha or 4% (table 108), this was similar to the reduction in 1000 corn weight. There was some lodging, not exceeding 30% at Aldroughy (Table 109), closely linked to nitrogen fertiliser rate (table 110), some brackling at Sunnybrae (table 107), linked to nitrogen, time of sowing and the absence of late fungicide (table 108) and a little leaning at Boghall (table 103). Terpal shortened the crop at all four sites, ranging from 6cm at Whitehouse (table 102) to 15cm at Boghall (table 104).

###### 1992

Terpal had no effect on yield at Withcall (table 116) but it reduced yield slightly at the four Scottish sites; only at Aldroughy (table 120) was this significant at 0.25 t/ha. There was no lodging at any site; the leaning at Aldroughy (table 120) was negligible but at Sunnybrae (table 118) it reached high levels especially on the late sown, unprotected and heavily fertilised treatments. Terpal growth regulator shortened all crops by amounts varying from 5cm at Withcall (table 116) to 14cm at Aldroughy (table 120).

###### 1993

At both Crosshall (table 122) and Sunnybrae (table 128) there were significant yield benefits from using growth regulator; as grain size was reduced in both cases where growth regulator was applied, the yield response was attributable to additional grains per unit area. There was no lodging but at Sunnybrae (table 127) there were high levels of leaning especially in the late sown treatments: at this site, growth regulator had no effect on the leaning despite shortening the crop by 7cm.

###### 1991-93

Terpal growth regulator demonstrated activity by shortening the crops. At only one of the 15 sites was there appreciable lodging, this occurred vary late and Terpal had no effect on its extent. Terpal had a negligible effect on grain yield, the insignificant reductions in 1991 and 1992 balancing exactly the insignificant positive response in 1993.

## 4.2 Late fungicide

### **1991**

All trials received overall applications of fungicide to cope with early attacks of mildew and Rhynchosporium. The response to Tilt Turbo during ear emergence ranged from a negligible 0.07 t/ha at Boghall (table 104) to an impressive and highly cost-effective 0.7 t/ha, at Whitehouse (table 102) where late fungicide had a large effect on the preservation of green leaf area.

### **1992**

At Crosshall (table 112) and Panlathy (table 114) there were no yield benefits due to the ear emergence spray with Tilt Turbo; a mildew assessment during grain development produced no active mildew. Only at Withcall (table 116) and Aldroughty (table 120) were there significant yield responses to late applied fungicide; at Aldroughty the mildew on the untreated mean was 21.9% compared with 4.7% where fungicide was applied.

### **1993**

There were small improvements in yield attributable to late fungicide at all five sites but these only reached statistical significance at Crosshall and Withcall. Although late fungicide reduced disease levels at Crosshall and Bush, disease development after ear emergence was minimal on these sites; only at Aldroughty was there any appreciable late development of mildew.

### **1991-93**

At some sites the disease pressure was low, at others the early fungicide application to all plots was sufficient to control disease. The relatively modest benefits were attributable to a minority of sites: in at least one case late fungicide extended the duration of green leaf area. The disease ratings for Blenheim in 1993 were 3 for mildew and 5 for Rhynchosporium (HGCA 1992).

## 4.3 Time of sowing

### **1991**

Apart from the Sunnybrae site (table 108), the other four sites gave significant responses to early sowing averaging .72 t/ha. As the difference between sowing dates for these four sites was 14-18 days, it demonstrated the narrowness of the optimum sowing window.

The Sunnybrae results were odd in that the early sown date was the latest of the series and the period between sowing dates was the longest at 22 days. The Sunnybrae site received its first mildew spray on 7 June 66 days

after the first sowing date. Although not recorded, early mildew did infect the early sown plots but not the late sown plots. On 22 July when mildew was recorded, the early sown plots carried the heavier infection. The early sown treatment was supposed to coincide with the first realistic sowing date: as plant development on the early sown treatment was unusually slow, it is likely that it was sown too early.

### 1992

Apart from the Crosshall site (table 112), the other four sites gave significant responses to early sowing averaging 0.78 t/ha. The interval between sowing dates varied from 14 days at Aldroughty and Withcall to 27 at Sunnybrae, with Crosshall at 24 days.

Crosshall was on a sandy clay loam, a relatively heavy site. After the first sowing there was heavy rain at the end of the March with 62mm falling in 48 hours: this was sufficient to wash nitrogen down the soil profile, reducing and delaying its availability to the developing crop. At this site the early sown treatments were exposed to adverse conditions for brairding and looked short of nitrogen. At this site the low nitrogen early sown treatments yielded 0.44 t/ha less than the equivalent late sown treatments, whereas the early sown high nitrogen treatments outyielded the late sown by 0.58 t/ha.

### 1993

Apart from the Withcall site (table 126), the other four sites gave significant responses to early sowing averaging just over 1 t/ha. The interval between sowing dates varied from 16 days at Withcall and Aldroughty to 35 days at Sunnybrae with Bush at 20 and Crosshall at 23 days. Despite the long delay in sowing at Sunnybrae (table 128), the yield penalty was only 0.68 t/ha compared with a massive 2.01 t/ha penalty at Aldroughty (table 130). This indicated that the benefit of early sowing may be eroded if followed by adverse weather.

Early sowing increased straw length in the three southern sites but decreased it at Sunnybrae.

### 1991-93

Tables 201 to 206 in appendix 4 summarise the results by year for the 15 sites. The yield penalty from delayed sowing averaged 0.48 t/ha in 1991, 0.64 t/ha in 1992 and 0.79 t/ha in 1993; each of these differences was highly significant. Over the three years the time difference between the early and late sowings was increased from an average of 16 days in 1991 to 22 days in 1993. The daily yield penalty from delayed sowing averaged 40 kg/ha/day in 1991, 36 kg/ha/day in 1992 and 42 kg/ha/day in 1993. These figures were remarkably consistent given

the range of years, geographical distribution and site effects.

#### 4.4 Nitrogen

##### **1991**

In all trials the middle nitrogen rate gave a significant yield increase relative to the low nitrogen rate, this averaged 0.3t/ha. In the three more southerly trials the high rate also provided a significant yield response, all three were typical arable rotations with a high proportion of cereals. The Sunnybrae site (table 108) was a second cereal following three years of grass and Aldroughty (table 110) followed carrots so both sites were of relatively higher nitrogen status.

Time of sowing had an effect on nitrogen response, The yield response to the first increment averaged 0.39 t/ha for the early sown treatment compared with 0.21 t/ha for the late sown treatment. The yield response to the second increment averaged 0.12 t/ha for the early sown treatment and there was a negligible negative response for the late sown treatment.

##### **1992**

The responses ranged from .21 t/ha at Aldroughty to .98 t/ha at Crosshall where there was a large interaction with time of sowing.

The yield response to the first increment averaged 0.52 t/ha for the early sown treatment compared with 0.25 t/ha for the late sown treatment. The yield response to the second increment averaged 0.40 t/ha for the early sown treatment and 0.08 t/ha for the late sown treatment.

##### **1993**

At all sites there was a significant positive yield response to the first increment of nitrogen fertiliser. The response to the second increment varied from a significant depression at Withcall (table 126) to significant increases at Crosshall (table 122) and Bush (table 124).

Time of sowing has an effect on nitrogen response. The yield response to the first increment averaged 0.56 t/ha for the early sown treatment compared with 0.39 t/ha for the late sown treatment. The yield response to the second increment averaged 0.26 t/ha for the early sown treatment and 0.03 t/ha for the late sown treatment.

##### **1991-93**

For each kg/ha of nitrogen applied over the range between the low and moderate rates, the grain yield response was

significant both statistically and economically (table below) whereas the responses to applications in excess of the moderate rate were statistically insignificant in 1991 and 1993 and unlikely to be cost-effective.

	<u>Average yield response (kg grain/ha)</u>	
	Low to Moderate N	Moderate to High N
1991	7.5	1.5
1992	9.8	6.0
1993	11.8	3.8

The yield response above the moderate level was significantly lower than below the moderate level; these results conform to the expected pattern.

The averages, tabled above were the mean of early and late sown treatments, the interaction is tabled below:

	<u>Average yield response (kg grain/ha)</u>			
	Low to Moderate N		Moderate to High N	
	Early sown	Late sown	Early sown	Late sown
1991	9.8	5.5	3.0	-0.3
1992	13.0	6.3	10.3	2.0
1993	13.8	9.8	6.5	0.8

The yield response to a nitrogen fertiliser increment was much lower where sowing was delayed. This indicated that the optimum level of nitrogen fertiliser for a site was substantially lower where sowing was delayed.

## 5 RESULTS & DISCUSSION - BARLEY ANALYSIS

The site results are presented in Appendix 3 tables 101-130 and the over year results in Appendix 4 tables 201-206.

### 5.1 Grain size and nitrogen

#### 5.11 Growth regulator

##### 1991

At all sites Terpal growth regulator reduced 1000 grain weight but only two of the reductions were statistically significant.

Apart from South Thoresby (table 106), the application of growth regulator had a significant detrimental effect on screening losses ranging from 5 to 12%.

Apart from South Thoresby (table 106), growth regulator did not have a significant effect on grain N%. At South Thoresby growth regulator increased grain nitrogen by a barely significant amount: as growth regulator had no effect on yield this could not be linked to the normal inverse relationship with yield. By contrast Sunnybrae (table 108) was the only site where growth regulator did produce a significant reduction in yield but the grain N% was the same for both treatments at this site.

##### 1992

The use of Terpal growth regulator in the absence of appreciable lodging reduced grain size with the reductions being significant at Crosshall (table 112), Sunnybrae (table 118) and Aldroughty (table 120). The adverse effect on average grain size accounted for some small reductions in yield.

At all sites Terpal increased the screening losses; the amounts were statistically significant and averaged 2.5% resulting in a discount of nearly £2/t.

At all sites grain N% was reduced if Terpal growth regulator was used, the reduction was significant at Panlathy (table 114); the reduction averaged 0.04%, worth about £2/t. At all sites the amount of nitrogen held in the grain was less where Terpal was used, and significantly so at three of the five sites; the average reduction was 3.4 kg N/ha. As Terpal tends to produce additional green tillers some of the crop's nitrogen was probably diverted to these rather than the grain.

##### 1993

Terpal growth regulator tended to reduce grain size, this was significant at Crosshall (table 122), Bush (table

124) and Sunnybrae (table 128). Similarly, growth regulator resulted in higher screening losses, these were significant at Crosshall (table 122), Bush (table 124) and Sunnybrae (table 128).

On average growth regulator reduced grain nitrogen by 0.03% but this was only significant at Bush (table 124). Growth regulator had no effect on the amount of nitrogen taken into the grain.

### **1991-93**

A general consequence of the use of Terpal growth regulator was a smaller 1000 corn weight. In some circumstances Terpal results in serious secondary tillering: some of these tillers produce grains that are harvested and these tend to be immature and smaller once they have been dried. Sometimes the secondary tillering is sufficient to increase yield. Although secondary tillering was not recorded at these sites, the production of small grains as a result of Terpal application was supported by the screening data (tables 202, 204 & 206).

Grain from plots treated with Terpal tended to have a slightly lower Nitrogen % (tables 202, 204 & 206). The reduction averaged 0.01% in 1991, 0.04% in 1992 and 0.03% in 1993, the latter two reductions were statistically significant. Although there was some evidence in 1992 that less nitrogen was removed in the grain of Terpal-treated plots, this was a relatively small effect and it was inconsistent over sites and years.

## 5.12 Late fungicide

### **1991**

At Boghall (table 104), late fungicide had no effect on grain size or screening losses: at this site there was no late development of disease and the effect on yield was also insignificant. At all the other sites, the effect on yield was significant and this tended to be accounted for by increased grain size; there were also significant reductions in screening losses ranging from 3 to 9%.

The effect of late fungicide on grain nitrogen was variable and small with no site having an effect greater than 0.03% grain nitrogen.

### **1992**

Despite sites such as Crosshall (table 112) and Panlathy (table 114) having no recordable late mildew, late fungicide improved 1000 grain weight; three sites, Crosshall, Withcall (table 116) and Aldroughty (table 120), produced statistically significant improvements, the other two were positive but not statistically

significant.

A similar situation prevailed with screenings, late fungicide reduced screenings on all five sites, three of them were statistically significant, the same as for 1000 corn weight. The mean reduction was only 3%, worth about £2/t, but at Withcall (table 116) screenings were inherently higher and the differential was over 8%, worth nearly £6/t.

At all sites, treatment with late fungicide increased the amount of nitrogen taken up by the crop but only at Aldroughty was it significant. The mean increase was 2.6 kg N/ha. Additional yield diluted this uptake to produce a neutral effect on grain N% at all sites other than Withcall (table 116), the site with the largest yield response and a below average uptake of additional nitrogen.

### 1993

Only at Withcall (table 126) was there a significant increase in grain size attributable to late fungicide; similarly there was a significant reduction in screening losses which were exceptionally high at this site.

Late fungicide had no effect on grain nitrogen % despite a tendency to increase yield by a small amount (average 0.136 t/ha).

### 1991-93

The influence of late fungicide varied between sites depending on the disease threat; the grain size response tended to be positive and there was generally a significantly beneficial effect on screening losses.

Late fungicide had a negligible effect on grain nitrogen % yet yield was increased by an average of 4% over the 15 sites. The dilution effect commonly associated with higher yields did not occur where late fungicide was used. Christian and Carrek (1991) analysed senescent leaves and found that where fungicides had not been used the nitrogen concentration was higher indicating reduced transference of protein to the developing grains. Christian and Carrek's findings help to explain the lack of a dilution effect in this series.

## 5.13 Time of sowing

### 1991

Apart from Aldroughty (table 110) where there was a small negative response, early sowing did not affect 1000 corn weight.

The distribution of grain size was affected in that screening losses through a 2.5mm sieve were higher at all

sites when sowing was delayed; the additional losses ranged from 3% at South Thoresby (table 106) and Sunnybrae (table 106) to 10% at Whitehouse (table 102). Costed at 70p per percent, this was significant disadvantage associated with late sowing.

Grain nitrogen content tended to be inversely related to yield in that the early sown treatments on all sites apart from Sunnybrae (table 108) had a lower grain N%.

## 1992

Early sowing tended to produce grain with a heavier 1000 corn weight; this was significant at Aldroughty (table 120) and Crosshall (table 112).

At all five sites, early sowing reduced the screening losses; at Aldroughty (table 120) the reduction failed to reach statistical significance. 1992 was an outstanding year in Scotland in that screenings were generally well below the level that triggers deductions; Withcall (table 115), the Lincolnshire site, was the only site with premiums substantially reduced by screenings; there would have been small deductions for screenings on the late sown treatments at Crosshall (table 111) and Sunnybrae (table 117). Even treatments expected to have adverse effects produced low screenings with the result that treatment differentials were small but they were consistent.

The grain nitrogen percent results were variable. The only significant results were reductions due to early sowing at Panlathy (table 114) and Sunnybrae (table 118). Although early sown treatments tend to take up more nitrogen in kg/ha, the additional yield exerts a diluting effect. At Aldroughty (table 120) the additional nitrogen taken up by the early sown treatment was substantially greater than elsewhere (21 kg N/ha compared with an average of 3 kg N/ha): the previous cropping at this site included potatoes in 1991 and carrots in 1989.

## 1993

Early sowing produced grain with a heavier 1000 corn weight at Crosshall (table 122), Withcall (table 126) and Sunnybrae (table 128). There was no difference at the Aldroughty (table 130) and Bush (table 124) sites despite these being the sites with the high yield responses to time of sowing. Grain populations per square metre were derived from yield and 1000 corn weight data to provide the following table: this showed that relative to the later sown treatment, there were relatively more grain sites to be filled at Bush and Aldroughty on the early sown treatments.

	<u>Grains/m<sup>2</sup> in '000s</u>		
	Early sown	Late Sown	Early sown as % of late sown
Crosshall	14.6	13.8	106
Bush	10.3	8.5	121
Withcall	10.9	11.2	97
Sunnybrae	13.1	12.3	107
Aldroughty	11.9	7.8	153

Screening losses were significantly reduced by early sowing at all sites other than Crosshall (table 122).

Grain nitrogen was significantly reduced by early sowing at all sites, the mean reduction was 0.126%. The effect of time of sowing on grain nitrogen uptake was very variable; early sowing increased uptake significantly at Bush (table 124) and Aldroughty (table 130) but reduced uptake at Crosshall (table 122).

Early sown crops tend to produce more ear-bearing stems and so have the potential to produce more grain sites per unit area. Conditions, later in the growing season, have a significant influence on the extent to which grain sites are filled. In some cases early sowing produced too many grain sites leading to a reduction in grain size relative to later sown treatments: in other cases early sowing created sufficient photosynthetic potential to provide for a larger grain size.

### 1991-93

In general early sowing produced better filled grains. The increase in screening loss per day of delayed sowing averaged 0.25%.

Early sowing resulted in lower grain nitrogen %. The increase in grain nitrogen per day of delayed sowing averaged 0.005%.

## 5.14 Nitrogen

### 1991

Grain size tended to be slightly larger at the lower nitrogen rates probably as there were fewer grain sites to fill. Of greater statistical and commercial significance were the screening losses; at every site losses increased with the higher rates of nitrogen fertiliser. Between the middle and high nitrogen rates the losses increased by an average of 5% with the two northerly sites worse than average.

Grain N% increased by an average of 0.08% between the low and middle rate of nitrogen fertiliser and by an average of 0.12% between the middle and high rates.

## 1992

Apart from Panlathy (table 114), grain size tended to be slightly smaller at the higher nitrogen rates, but only at Aldroughy (table 120) was this trend statistically significant. The grain size response to nitrogen is erratic in that it is influenced by the number of additional grain sites created by the additional nitrogen and the ability of the site and season to fill them.

Additional nitrogen increased screening losses. The first increment increased losses by an average of 2.3% and the second increment by 3.0%; the differentials were most severe at the Withcall (table 116) site.

## 1993

Grain size was reduced at the higher nitrogen rates, similarly screenings were increased.

Additional nitrogen increased grain nitrogen % and tended to result in a higher uptake although this latter point was less consistent.

## 1991-93

A reduction in grain size was generally associated with additional fertiliser nitrogen; in consequence screening losses increased. The increase in screening losses averaged 0.07% for each kilogramme of nitrogen applied between the low and moderate rates and 0.1% for each kilogramme of nitrogen applied between the moderate and high rates. These losses were obtained in the absence of significant lodging mainly due to the selection of a variety with stiff straw.

The increase in screening loss with additional nitrogen was more marked where sowing was delayed.

### Screening losses (% <2.5mm)

N level	Early sown				Late sown			
	Low	Mod	High	Increase	Low	Mod	High	Increase
1991	17.1	20.9	25.5	8.4	22.4	26.8	33.0	10.6
1992	7.9	9.1	11.8	3.9	9.5	12.9	16.3	6.8
1993	10.9	12.1	14.1	3.2	13.9	16.6	20.8	6.9
Mean	12.0	14.0	17.1		15.3	18.8	23.4	

The increase in screening loss was also larger at the higher nitrogen rates.

The increase in grain nitrogen content with additional fertiliser averaged 0.0020% for each kilogramme of nitrogen applied between the low and the moderate rates and 0.0023% for each kilogramme applied between the moderate and high rates. Sowing date had little effect on the rate of grain nitrogen accumulation with additional fertiliser nitrogen.

## 5.2 Germination capacity

Germination capacity was measured to confirm that samples were alive and sound. The lowest recorded figures for each trial were:

### % Germination Capacity

1991	Early sown	Late sown
Whitehouse	97.5	98.5
Boghall	95	98
South Thoresby	97	98.5
Sunnybrae	97	97
Aldroughty	98.5	90 (average 97%)

Apart from two low figures at Aldroughty, all capacity data were satisfactory and at Aldroughty there was no indication of a treatment effect.

### % Germination Capacity

1992	Early sown	Late sown
Crosshall	98	97.5
Panlathy	98.5	97.5
Withcall	98	97.5
Sunnybrae	86.5	*
Aldroughty	93	75

The two northern sites, Sunnybrae and Aldroughty, did not meet the normal malting germination specification in that more than 5% of the grains failed to germinate.

The average germination capacities for the two sowing dates at Aldroughty were:

Early Sown 96.5 (mean of 24)  
Late Sown 85.3 (mean of 24)

The interval between harvest date for these two treatments was only four days at Aldroughty, yet the effect on germination capacity was severe; the high incidence of splitting in the late treatment was further evidence of impaired germination. The differences resulting from the other treatments were insignificant, 1% for growth regulator, less than 2% for late fungicide and just over 3% for nitrogen rate.

### % Germination Capacity

1993	Early sown	Late sown
Withcall	98	98.5
Crosshall	97	98
Bush	97.5	98
Sunnybrae	94	82
Aldroughty	98	92

The late sown samples from Sunnybrae contained relatively high levels of splitting. Impaired germination was also found in the late sown treatment at Aldroughty in 1992.

The germination energy data for late sown samples at Aldroughty in 1992 and 1993, and Sunnybrae in 1993 must be interpreted with caution.

### **5.3 Germinative energy**

The 5ml germinative energy test provided an assessment of dormancy, the 8ml of water sensitivity. The tests were carried out when the marker treatment (G) for a particular site and sowing date first reached 90% following a series of weekly tests after harvest (see appendix 2 for details). The difference between the 5 and 8ml results is the estimate of the proportion of grain that is water-sensitive at the time of the test; water-sensitive grain may require adjustments to the malting regime if optimum yield is to be obtained.

#### 5.31 Growth Regulator

In 1991 growth regulator increased dormancy by small amounts: at Sunnybrae (table 108) and Aldroughty (table 110, the difference was statistically significant but small at 4%.

In 1992 growth regulator had no effect on dormancy and water-sensitivity at all five sites.

In 1993 growth regulator increased water-sensitivity at Withcall (table 126) by 3%; this was not only a small amount in actual terms but it was only just over the threshold for significance at the 5% level.

Overall growth regulator had no beneficial effect on recovery from dormancy and water-sensitivity; any adverse effects were sporadic and small.

#### 5.32 Late Fungicide

In 1991 late fungicide increased the recovery from dormancy by a small amount at Aldroughty (table 110) and reduced the water-sensitivity at Sunnybrae (table 108), again by a small amount: both effects achieved a low level of significance.

In 1992 late fungicide produced better 8 ml germinative energy figures at Sunnybrae (table 118) and Aldroughty (table 120) but because of differences in the 5 ml results, the differences in water-sensitivity were not significant.

In 1993 late fungicide produced small, but statistically significant adverse effects, on both dormancy and water-sensitivity at Sunnybrae (table 128) but these should be treated with caution given the degree of splitting and low germination capacity in the late sown part of this

trial.

Meaned over the 15 sites, late fungicide increased dormancy from 15.5% to 17.3% and increase water-sensitivity from 39.1% to 40.5%: both effects are theoretically adverse but their extent was tending to wards the negligible.

### 5.33 Time of sowing

The normal data-sets (tables 101-130) did not provide comparable results for time of sowing because of the different dates of recovery for the two times of sowing. Some estimation of the effect of sowing date was obtained by comparing the dates on which the early and late sown markers first achieved 90% on the 5ml germinative energy test; at this level dormancy is less than 10% and it was assumed that the markers had sufficiently recovered from dormancy.

The dates of recovery of the marker samples in 1991 were as follows:

	Early sown	Late sown
South Thoresby	25 Oct	11 Oct
Whitehouse	25 Oct	18 Oct
Boghall	6 Dec	15 Nov
Sunnybrae	6 Dec	6 Dec
Aldroughty	6 Dec	6 Dec

Delays in bringing the Sunnybrae and Aldroughty samples down to Boghall for conditioning at 20 degrees C may have contributed to their slow recovery from dormancy, this emphasised the need for careful and timely treatment of grain immediately after harvest.

The dates of recovery in 1992 were as follows:

	Early sown	Late sown
Withcall	28 Sep	5 Oct
Crosshall	19 Oct	19 Oct
Panlathy	19 Oct	19 Oct
Sunnybrae	*	*
Aldroughty	19 Oct	*

On 9 November the early sown indicator for the Sunnybrae site recorded only 28% GE in the 5ml test. The late sown Aldroughty plots were low in germination capacity so the GE data was misleading. For sites with a sound Germination Capacity, Withcall, Crosshall and Panlathy, the date of full recovery from dormancy was not affected by time of sowing but there were small differences when the individual plots were analysed. At Crosshall and Panlathy, both times of sowing were analysed at the same time and in both cases the early time of sowing had the higher 5ml GE. For the Withcall site 48 hour results have been quoted because of a mishap with the 72 hour data.

The dates of recovery in 1993 were as follows:

	Early sown	Late sown
Withcall	24 Sep	1 Nov
Crosshall	25 Oct	25 Oct
Bush	22 Nov	29 Nov
Sunnybrae	22 Nov	*
Aldroughty	18 Oct	15 Nov

The late sown samples from Sunnybrae in 1993 were still 40% dormant on 7 February 1994.

There were no consistent effects, the sites varied with late sowing at the Lincolnshire site in 1991 breaking dormancy a fortnight ahead of the early sown marker, whereas in 1993 it was five and half weeks later. A comparison was only possible for twelve of the sites: at eight of them the effect of time of sowing on the date of recovery from dormancy was no more than one week.

#### 5.34 Nitrogen

In 1991 and 1992 rate of fertiliser nitrogen had no effect on recovery from dormancy or the proportion of water-sensitive grain. In 1993 results at Withcall (table 126) and Aldroughty (table 130) indicated that at the low rate of fertiliser, dormancy was increased: at Withcall, there was also an increase in water-sensitivity.

## 6. RESULTS & DISCUSSION - MICRO-MALTING

Refer to Appendix 7 for explanation of the various terms and analyses used in micro-malting. Although absolute figures are very important to the industry, in this project the relativities were of more relevance.

### 6.1 Results

		Total N			
		1991	1992	1993	Mean
Early sown		1.78	1.53	1.59	1.63
Late sown		1.85	1.63	1.69	1.72
Late fungicide	+	1.84	1.59	1.64	1.69
	-	1.80	1.58	1.64	1.67
PGR	+	1.83	1.57	1.63	1.68
	-	1.81	1.60	1.65	1.69
Sed		0.015	0.018	0.024	

		Soluble Nitrogen Ratio			
		1991	1992	1993	Mean
Early sown		34.2	39.3	38.8	37.4
Late sown		32.9	37.5	37.3	35.9
Late fungicide	+	34.1	38.9	38.2	37.1
	-	33.0	38.0	37.9	36.3
PGR	+	32.7	37.2	37.5	35.8
	-	34.5	39.7	38.7	37.6
Sed		0.24	0.94	0.58	

		Fine Coarse Difference		
		1992	1993	Mean
Early sown		0.3	0.5	0.4
Late sown		0.5	0.9	0.7
Late fungicide	+	0.4	0.7	0.6
	-	0.4	0.7	0.6
PGR	+	0.4	0.8	0.6
	-	0.4	0.6	0.5
Sed		0.096	0.175	

Both the Soluble Nitrogen Ratio and the Fine Coarse difference data indicated that grain from the early sown treatment modified faster than grain from the later sown

treatments. Late fungicide had no effect on modification during malting. Growth regulator tended to reduce modification.

		Friability			
		1991	1992	1993	Mean
Early sown		70.9	90.0	90.0	83.6
Late sown		63.8	85.0	87.1	78.6
Late fungicide	+	69.7	88.0	88.4	82.0
	-	65.1	87.1	88.7	80.3
PGR	+	66.0	87.3	88.4	80.6
	-	68.9	87.7	88.7	81.8
Sed		1.83	1.25	1.38	

In 1991 the malt was on the margin of acceptability. In all three years malt from the early sown treatment was more friable and closer to the target for a good distilling malt. Other than in 1991 when there were large differences in the screening losses, fungicide had no effect on friability. Although not statistically significant in any one year, growth regulator did appear to have a small adverse effect on friability.

		Extract Fine			
		1991	1992	1993	Mean
Early sown		78.1	80.2	80.3	79.5
Late sown		77.8	79.6	79.7	79.0
Late fungicide	+	77.3	80.0	80.2	79.2
	-	77.6	79.9	79.6	79.0
PGR	+	77.8	79.8	80.0	79.2
	-	78.2	80.1	79.8	79.4
Sed		0.27	0.19	0.19	

		Extract Coarse			
		1991	1992	1993	Mean
Early sown		77.3	79.9	79.8	79.0
Late sown		76.8	79.2	78.8	78.3
Late fungicide	+	77.4	79.6	79.4	78.8
	-	76.7	79.6	79.2	78.5
PGR	+	76.8	79.4	79.2	78.5
	-	77.3	79.7	79.4	78.8
Sed		0.28	0.19	0.18	

The early sown treatment consistently produced more extract and there was a tendency for extract to be reduced where growth regulator was applied.

#### Fermentability

		1991	1992	1993	Mean
Early sown		87.9	87.6	87.4	87.6
Late sown		87.6	87.3	87.2	87.4
Late fungicide	+	87.6	87.4	87.4	87.5
	-	87.9	87.6	87.6	87.7
PGR	+	87.9	87.7	87.7	87.8
	-	87.7	87.3	87.3	87.4
Sed		0.07	0.22	0.11	

The effects on fermentability were small; early sown grain tended to have a higher fermentability but the difference was only significant in 1991. If late fungicide had an effect it tended to be slightly adverse whereas growth regulator tended to have a small beneficial effect.

#### Predicted Spirit Yield

		1991	1992	1993	Mean
Early sown		412	424	423	420
Late sown		407	419	418	415
Late fungicide	+	411	421	420	417
	-	409	422	419	417
PGR	+	409	422	420	417
	-	411	422	419	418
Sed		1.31	1.27	1.87	

Early sown grain produced higher spirit yields; late fungicide and growth regulator had no effect on spirit yield.

### Diastatic Power

		1992	1993	Mean
Early Sown		89	92	91
Late sown		91	94	93
Late fungicide	+	91	91	91
	-	89	96	93
PGR	+	88	93	91
	-	92	94	93
Sed		1.6	4.7	

Diastatic Power was not included in the 1991 range of analyses. Apart from the detrimental effect of growth regulator in 1992 there were no statistically significant effects.

### Viscosity

		1992	1993	Mean
Early sown		1.45	1.50	1.48
Late sown		1.45	1.47	1.46
Late fungicide	+	1.45	1.49	1.47
	-	1.45	1.48	1.47
PGR	+	1.45	1.48	1.47
	-	1.45	1.49	1.47
Sed		0.081	0.010	

The only statistically significant result was the relatively higher viscosity on the early sown grain in 1993. All results were in the range normally accepted for a brewing malt.

In 1993 germinative energy was also assessed at the time of malting.

### Germinative Energy (5ml) 1993

		+	-	+	-	Mean
Late Fungicide		+	-	+	-	
Growth Regulator		+	+	-	-	
Early Sown		95	95	92	96	95
Late Sown		87	89	87	87	88
SeD interaction		6.52				
time of sowing		3.26				
Fungicide	+	90	92	SeD Fungicide		3.26
PGR	92	91	PGR		3.26	

These samples were analysed at least eight months after harvest, having been stored at 20 degrees Centigrade in a well ventilated store in cloth bags. Although the late sown grain appeared to be 7% more dormant than the early sown, the germinative capacity of the Sunnybrae late sown grain was 12% lower than the early sown grain: this will have contributed approximately half the difference rendering it unreliable and not statistically significant.

#### Germinative Energy (8ml) 1993

Late Fungicide	+	-	+	-	Mean
Growth Regulator	+	+	-	-	
Early Sown	45	47	44	52	47
Late Sown	35	42	37	43	39
SeD interaction	2.12				
time of sowing	1.06				
Fungicide	+	-	SeD Fungicide		1.06
PGR	40	46	PGR		1.06
	42	44			

Subtracting the 8 ml data from the 5 ml data provided an estimate of water sensitivity, there were no differences attributable to time of sowing.

## 6.2 Discussion

The effects of nitrogen and grain size on malt yield were quantified by Bishop (1948).

$$\text{Predicted extract} = \text{Varietal K} - (11 \times \text{N}\%) + (0.22 \times \text{TCW})$$

Using Bishop's equation, the mean increase in extract attributable to early sowing was 0.7 but there were differences in both the nitrogen content of the grain (-0.076%) and its size (+0.61g). Applying these differences to Bishop's equation exactly accounted for the gain in extract. The early sown grain also malted more satisfactorily judged by its friability and modification.

The mean increase in extract attributable to late fungicide was 0.3; this treatment produced grain with a slightly lower nitrogen % (0.013%) and a better grain size (1.34g). The theoretical gain in extract attributable to these two factors was 0.58. Although this raised the possibility that late fungicide might have other effects detrimental to the malting process, this was not evident in the friability and modification data.

The mean decrease in extract attributable to the application of growth regulator was 0.3; again there were differences in both the nitrogen content of the grain (-0.023%) and 1000 corn weight (-1.58g). Applying these differences to Bishop's equation would reduce the extract by less than 0.1. This indicated that the adverse effect of growth regulator on extract might not be limited to the effects on grain size. The loss of friability and slower modification provided supporting evidence that crops treated with Terpal growth regulator could be more difficult to malt satisfactorily and require adjustments to the steeping regime or germination conditions.

Because early sown grain produced both a higher extract and a higher fermentability, it had a clearly beneficial effect on spirit yield. By contrast the beneficial effect of late fungicide on extract was balanced by an adverse effect on fermentability. The beneficial effect of plant growth regulator on fermentability was small and both malting yield and ease of malting were adversely affected to a more significant extent.

The difference in grain nitrogen attributable to time of sowing in 1992 and 1993 was a significant 0.1%: it was surprising that this range in grain nitrogen did not give rise to useful differences in diastatic power. The regression coefficients for total nitrogen and diastatic power were 0.667 in 1992 and 0.344 in 1993; these regression coefficients did not support a close relationship between high levels of grain nitrogen, or protein, and high diastatic power.

## 7. RESULTS - TIME OF HARVEST STUDIES

### 7.1 Results

Whitehouse 1991		<u>Germinative energy %</u>							
		5ml				8ml			
days before harvest		20	10	0	Mean	20	10	0	Mean
Early sown		63	70	65	66	54	45	28	42
Late sown		64	64	64	64	52	45	33	43
	Mean	64	67	65		53	45	31	
Sed		6.2				17.1			
	harvest date	3.9				8.4			
	sowing date	3.1				7.8			

Boghall 1991		<u>Germinative energy %</u>							
		5ml				8ml			
days before harvest		20	10	0	Mean	20	10	0	Mean
Early sown		74	68	63	68	78	56	48	61
Late sown		80	63	57	67	85	64	40	63
	Mean	77	66	60		82	60	44	
Sed		7.9				5.9			
	harvest date	4.6				7.2			
	sowing date	4.3				3.4			

Because the harvested samples were taken from the combine bulk after normal conditioning and the sheaf samples were dried and threshed separately, care must be taken over comparisons with the harvest sample.

Sowing date had no effect on either the 5 or 8 ml results. Grain cut early produced higher 8 ml figures at both sites and a better 5 ml result at Boghall. At both sites water-sensitivity was reduced by early harvest and dormancy was reduced at Boghall but not at Whitehouse.

Withcall 1992		<u>Germinative energy %</u>							
		5ml				8ml			
days before harvest	14	5	0	Mean	14	5	0	Mean	
Early sown	84	72	82	79	72	48	52	57	
Late sown	98	84	51	78	99	63	26	63	
Mean	91	78	67	79	86	56	39	60	

Only one replicate was sampled at the Withcall site.

Crosshall 1992		<u>Germinative energy %</u>							
		5ml				8ml			
days before harvest	14	7	0	Mean	14	7	0	Mean	
Early sown	76	86	95	86	43	31	15	30	
Late sown	83	72	83	79	59	27	19	35	
Mean	80	79	89		51	29	17		
Sed		5.9				9.4			
time of sowing		2.6				2.9			
time of harvest		4.2				6.6			

Panlathy 1992		<u>Germinative energy %</u>							
		5ml				8ml			
days before harvest	14	7	0	Mean	14	7	0	Mean	
Early sown	93	74	97	88	79	49	30	53	
Late sown	96	88	94	93	61	31	40	44	
Mean	95	81	96		70	40	35		
Sed		6.7				11.2			
time of sowing		8.9				5.2			
time of harvest		4.7				7.9			

Time of sowing had no consistent effect on 5 or 8 ml results. On 12 October when these germinative energies were assessed, the earliest sample date, 14 days before harvest, had recovered from dormancy at Withcall and Panlathy, whereas the 5/7 day sample had not reached 90% germinative energy in the 5ml test. The 8ml test gave clear evidence at all three sites that the 14 day before harvest sample was less water-sensitive than the 5/7 day before harvest.

Crosshall 1993		<u>Germinative energy %</u>							
		5ml				8ml			
days before harvest		14	7	0	Mean	14	7	0	Mean
Early sown		97.0	97.0	90.7	94.2	97.3	77.7	63.3	79.4
Late sown		96.7	90.7	95.3	94.2	90.3	76.0	53.7	73.3
Mean		96.8	93.9	93.0		93.8	76.9	58.5	
Sed					3.00				7.93
	time of sowing				1.73				4.57
	time of harvest				2.12				5.60

Bush 1993		<u>Germinative energy %</u>							
		5ml				8ml			
days before harvest		14	7	0	Mean	14	7	0	Mean
Early sown		98.7	91.7	78.3	89.6	93.7	68.0	53.0	71.6
Late sown		98.0	99.3	72.0	89.8	94.0	83.7	31.0	69.6
Mean		98.3	95.5	75.2		93.8	75.8	42.0	
Sed					6.09				3.58
	time of sowing				3.52				2.06
	time of harvest				4.31				2.53

Date of sowing had no effect on the 5 ml and 8 ml results at both sites.

At both sites the grain harvested 14 days before combining was better on the 8 ml test than grain harvested 7 days later: the combine-harvested grain was slower to recover from dormancy in this test than the earlier harvested sheaf-sampled grain.

## 7.2 Discussion

The 5 ml test provided estimates of the proportion of grains that had recovered from dormancy.

The proportion of dormant grains = 100 - 5 ml figure.

The 8 ml test measured the proportion of grains sensitive to the amount of water used during malting; this proportion was derived as follows:

100 - 8 ml figure - % of dormant grains.

Time of sowing provided no consistent effect on % dormancy and % water-sensitivity.

harvest occasion	% dormancy			% water-sensitivity		
	1st	2nd	combine	1st	2nd	combine
Early sown	16.3	20.1	18.4	9.9	26.3	40.3
Late sown	12.0	19.9	26.3	10.8	26.6	39.0
Mean	14.2	20.0	22.4	10.4	26.5	39.7

As the late sown sheaf samples were less mature than the early sown samples, these results contradicted the established view that unripe grain was likely to penalise recovery from dormancy.

The time of harvest results for grain cut approximately two weeks before harvest and grain cut approximately one week before harvest also challenged the established view both for dormancy and water-sensitivity. Grain harvested approximately one week before combine ripeness was nearly 6% more dormant than grain harvested approximately two weeks before combine ripeness: this was a large difference relative to the actual amount of dormancy measured. At only two of the individual sites was the difference statistically significant and at three of the sites the difference was negligible or inconsistent but overall the effect was both substantial and significant. Five of the seven sites registered a significant difference in water-sensitivity; grain harvested two weeks before combine ripeness was 16% less water-sensitive than grain harvested about one week later: this was a large difference relative to the actual amount of water-sensitivity present.

A comparison between grain harvested approximately a week before combine ripeness and the combined grain provided similar evidence but it must be treated with caution due to the possibility that drying the sheaf samples may have brought forward the date of recovery from dormancy.

Baxter and Jenkyn (1990) harvested Triumph at weekly intervals between 12 August and 13 September; only on the first date were germination capacity and germinative energy reduced; by 18 August the germination capacity exceeded 99% and the germinative energy reached 95%. On subsequent dates the germinative energy varied between 94 and 98%. By contrast Thomas, Swanston and Taylor (1987) had only two dates of harvest, mid-September and mid-October: they found that in varieties with the erectoides dwarfing gene, such as cv Golden Promise, germinative energy was unaffected by the delay. For varieties with the prostrate dwarfing gene, or no dwarfing gene, delayed harvest reduced germinative energy by a small but highly significant amount. cv Blenheim does not have the erectoides dwarfing gene.

Comparisons for both the first and second harvest occasions, and the second and combine harvest occasions produced small differences in dormancy similar to Baxter and Jenkyn's results between 18 August and 13 September. Both series of comparisons also produced relative large, consistent and significant differences in water-sensitivity favouring the earlier harvested grain.

These results would tend to support early harvesting of malting barley on the grounds that it reduces the risk of exposure to ear loss, it is not detrimental to dormancy and it is likely to reduce water-sensitivity. However Baxter and Jenkyn (1990) also micro-malted samples from their experiment and discovered that early harvesting affected the malting process leading to reduced friability and under-modification with its attendant problems of high wort viscosity and high beta-glucans.

## 8 RESULTS - OTHER STUDIES

### 8.1 Splitting

#### 8.11 Results.

% Split grain	1992		1993	
	Early	Late	Early	Late
time of sowing				
Withcall, Lincs	0	0	1	0
Crosshall, Borders	2	1	3	3
Panlathy, Angus	0	3	1	1
Sunnybrae, Aberdeen	4	4	0	6
Aldroughty, Elgin	3	4	4	2

The progression northwards in 1992 followed commercial experience in which split grain was mainly a problem in North-East Scotland. In 1993 there was no clear progression.

#### % Split grain

Time of sowing	1992			1993		
	Early	Late	SeD	Early	Late	SeD
Aldroughty	2.67	6.04	0.77	2.33	1.08	0.494
Sunnybrae	2.92	4.58	0.78			
Crosshall				2.92	2.17	0.854

In 1992 splitting was increased where sowing was delayed on the two sites in North-East Scotland; whereas in 1993 the early sown treatment at Aldroughty increased splitting, with Crosshall showing a similar trend.

#### % Split grain

Growth regulator	1992			1993		
	+	-	SeD	+	-	SeD
Aldroughty	4.5	4.2	0.77	1.66	1.75	0.49
Sunnybrae	4.42	3.08	0.78			
Crosshall				2.25	2.83	0.85

Growth regulator had no effect on levels of splitting.

#### % Split grain

Late fungicide	1992			1993		
	+	-	SeD	+	-	SeD
Aldroughty	5.79	2.92	0.77	2.33	1.25	0.49
Sunnybrae	5.25	2.25	0.78			
Crosshall				3.00	2.08	0.85

In 1992 late fungicide increased the level of splitting by a statistically significant amount. In 1993 late fungicide again increased splitting at Aldroughty whereas the difference at Crosshall was not significant.

	% Split grain				1993			
	1992							
Nitrogen fertiliser	Low	Mod	High	SeD	Low	Mod	High	SeD
Aldroughty	4.3	4.9	3.9	0.94	1.06	0.69	0.81	0.60
Sunnybrae	2.94	3.69	4.63	0.95				
Crosshall					2.63	2.38	2.63	1.05

The amount of splitting was not affected by the different rates of nitrogen fertiliser.

### 8.12 Discussion

Little is understood about the mechanisms controlling splitting and the factors contributing to its appearance. There are seasons, such as 1992, in which it is very important in Scotland. Circumstantial evidence with the variety Natasha, some years ago, indicated that those crops that matured early had higher levels of splitting than crops cut later; this and the seasonal nature of splitting suggest that weather conditions at some unspecified vulnerable stage in crop development are important rather than the time of sowing. This supposition was borne out by the limited results comparing time of sowing in this trial series.

It did appear that the more northerly sites were more likely to be adversely affected by splitting. Cranstoun (1996) assessed the average weekly rainfall in the Cambridge, Border and Aberdeen areas in the four weeks prior to harvest 80% complete: it varied from 7.1 mm at Cambridge to 18.6 mm at Aberdeen for spring barley. The average daily maximum temperature varied from 24 degrees centigrade at Cambridge to 16 degrees at Aberdeen. It is likely that the exposure of northern crops to cooler, wetter conditions in the weeks prior to harvest increases the risk of splitting.

The adverse effect of late fungicide on splitting was not only statistically significant, it was also consistent at all four sites. As cv Blenheim is relatively vulnerable to both splitting and mildew, choice of a variety with better disease resistance provides potential for reducing both the direct risks of splitting and any risk of enhancing it through the use of late fungicide.

## **8.2 Storage trial**

### **8.21 Results**

	<u>Germination Energy % (5ml test, 72 hours)</u>	
	Good Conditions	Adverse Conditions
Bulks		
1	59	31
2	74	7
3	89	2
Mean	74	13
	SeD 17.3	

Only bulk 3, when stored in good conditions, was near full recovery from dormancy at the end of this experiment but the results produced consistently large effects.

### **8.22 Discussion**

The two sets of conditions represented storage extremes; this simple trial was not designed to demonstrate which of the storage variables was having the most influence. The demonstration did provide clear evidence that post-harvest handling and storage seriously exacerbated dormancy problems following a difficult harvest. Kelly, Armitage, Woods and Proudlove (1994) subsequently demonstrated that grain recovered from dormancy more rapidly at warm storage temperatures and that cool temperatures delayed recovery. Briggs and Woods (1993) were able to relate the rate of recovery from dormancy to the storage temperature over a range from 8 to 40 degrees centigrade. Baxter, Proudlove and Davies (1991) found that barley dried to 12% moisture content recovered more rapidly from dormancy than undried barley at 16% moisture content. The simple trial reported here mirrors the broad findings of these three recent HGCA projects.

This trial was carried out on samples that had been carefully pre-dried to 15% moisture. Kreyger's tables (1972) quantify the relationship between storage temperature, moisture content of cereals in bulk and the preservation of germination capacity. At storage temperatures above 20 degrees centigrade a bulk at 19% moisture is likely to lose germination capacity a fortnight after cutting. Evidence from Baxter et al (1991) indicated that the effect on germinative energy was very sensitive to high moisture content. Even though the samples used in this trial were pre-dried to 15% moisture, large differences were observed; the differences would have been even more marked or would have lasted much longer if the poor conditions had been applied to grain at 17% moisture or grain that had

included a greater delay between harvest and drying.

The experiment provided useful confirmation that the conditioning and storage regime adopted for this project had a beneficial effect on recovery from dormancy.

### 8.3 Growth regulator studies

#### 8.31 Results

<u>Alpha-amylase activity 1991</u>					
time of sowing nitrogen	Early		Late		Mean
	Low	High	Low	High	
- Terpal	65	54	51	65	59
+ Terpal	63	105	37	103	77
Mean	64	79	44	84	
			Sed PGR		13.6
	Low N	High N			
- Terpal	58	60	Sed N		13.6
+ Terpal	50	104	Sed PGR x N		19.2
Mean	54	82			

At the high nitrogen rate, Terpal increased production of alpha-amylase. A regression of alpha-amylase on grain nitrogen content produced an r value less than 0.3 indicating that change in protein content was not a significant contributing factor.

#### Alpha-amylase activity of de-embryonated grain treated with gibberellic acid 1991

time of sowing nitrogen	Early		Late		Mean
	Low	High	Low	High	
- Terpal	132	131	80	122	116
+ Terpal	155	132	104	138	132
Mean	144	132	92	130	
			Sed PGR		11.3
	Low N	High N			
- Terpal	106	127	Sed N		11.3
+ Terpal	130	135	Sed PGR x N		16.0
Mean	118	131			

Where de-embryonated grain was used the amylase enhancement with Terpal at the high rate of nitrogen fertiliser was much smaller and not statistically significant.

In 1992 Terpal had no effect on the development of alpha-amylase in the aleurone during malting (Appendix 5

Figures 1 and 2) nor on the development of Beta-amylase in the starchy endosperm during malting (Figures 3 and 4). There was no evidence that Terpal applied to the high nitrogen treatment had any effect on amylase production. There was no evidence that more amylase was produced by the high nitrogen treatment.

In 1992 samples with and without the late fungicide treatment (Tilt Turbo) were also examined. Tilt Turbo had no effect on the potential of the aleurone layer to synthesise alpha-amylase during malting (Figures 5 and 6), nor on the potential for beta-amylase development (Figures 7 and 8).

### 8.32 Discussion

The hypothesis behind this work was that the use of a gibberellin inhibitor to shorten and stiffen barley plants during stem elongation might adversely affect the availability of gibberellin during germination and thus reduce the production and amylolytic activity of enzymes during malting (Huey 1992).

The lack of any effect in 1992 supports the conclusion that although Terpal is an anti-gibberellin its application during stem extension did not reduce the physiological potential of the aleurone layer of harvested grain to synthesise alpha-amylase during malting.

The 1991 enhancement of amylase where Terpal was applied in conjunction with high rates of fertiliser nitrogen did not fit the hypothesis and it wasn't repeated in 1992. In the absence of Terpal there was no evidence in either year that amylase production was affected by date of sowing. At low fertiliser nitrogen levels the application of Terpal had no effect on amylase production. The work reported by Huey (1992) on the same samples using gibberellic acid on de-embryonated grain indicated that Terpal did not significantly enhance amylase production in heavily fertilised crops.

In bringing out a recommendation for splitting the Terpal applications, BASF have recognised that the activity of Terpal is relatively short-lived (BASF 1994). This work showed that any theoretically deleterious effect on amylase production did not persist and affect malting. The absence of any deleterious effects on the gibberellin-controlled development of enzymes during malting is beneficial to those growers, especially of malting winter barley, who need to stiffen their crops.

## **8.4 Residue Analysis**

### **8.41 Results**

Replicate	<u>Propiconazole in mg/kg</u>			
	Early Sown		Late Sown	
	1	2	1	2
Low nitrogen	nd	0.01	nd	0.01
Medium nitrogen	0.01	0.01	0.01	nd
High nitrogen	nd	nd	0.03	nd

nd = not detected

The propiconazole residues that were detected were very low and close to the detection limit.

Efforts to detect tridemorph were unsuccessful.

### **8.42 Discussion**

The Aldroughty site in 1991 received an overall application of Radar and Patrol on 4 June. Radar's active ingredient is also propiconazole so the plots analysed actually received a total of 250g/ha propiconazole; despite this, levels were close to the detection level indicating that even late applied fungicides are unlikely to accumulate in the grain. At 0.01 mg/kg, the amount of propiconazole residual in the grain at harvest on this 6 t/ha crop was 60mg/ha equivalent to 0.024% of the dose applied.

The failure to detect tridemorph and the extremely low levels of propiconazole detected provide useful evidence that normal crop protection measures do not result in significant levels of residue.

## 9 GENERAL DISCUSSION

### 9.1 Dormancy

Given the damp nature of the Scottish harvest, and to a lesser extent the English harvest, some dormancy is necessary to prevent sprouting in the ear and its irreversible damage to grain quality. Ideally barley should be sufficiently dormant to cope with conditions that might cause sprouting but it should recover quickly from dormancy once the crop has been harvested.

Malting is a batch process in which relatively large bulks are steeped, germinated and kilned to a schedule. Grains that do not germinate or do not modify at the normal rate within the batch time do not contribute as expected to malt yield and they may result in the malt being outside specification for unmalted grains.

Dormant grain fails to germinate and modify as expected so maltsters take precautions to avoid malting dormant grain. Germinative energy testing, separate storage and conditioning programmes such as the one developed by Kelly, Armitage and Woods (1994) are commonly used precautions. If dormant barley is included in a bulk, then the date of malting is delayed incurring greater storage and financing charges but separate storage is expensive. Warm conditioning breaks dormancy quickly but it is costly and it increases the risk of insect infestation: Kelly et al (1994) showed that insects might take 80 days to develop from egg to adult at 20 degrees centigrade but at 30 degrees centigrade their development cycle was reduced to only 20 days.

Export malting barley has to meet a minimum germinative energy on delivery of 95% (HGCA 1994). Disregarding this standard not only costs the industry rejected shipments, it seriously damages the UK's reputation as an exporter of malting barley.

Other than choice of variety, this project has shown that prior to harvest the grower has very little influence over the rate of recovery from dormancy. Time of sowing, rate of nitrogen fertiliser, use or not of Terpal plant growth regulator or late fungicide had negligible effects on recovery from dormancy. The time of sowing results were derived from three different studies, reported in sections 5.33, 6.4 and 7.4; none of these studies indicated consistent effects. In many respects this is a useful result because it does not limit husbandry decisions in those regions prone to dormancy.

Cochrane (1993) placed cv. Triumph in controlled environment conditions at 12 and 20 degrees centigrade for the period after anthesis. Eighty days after harvest the 4 ml germinative energy figures were approximately 5% and 70% respectively for the 12 and 20 degree temperature regimes. Cranstoun (1996) showed

that the average daily maximum temperatures in July at Cambridge, Kelso (Scottish Borders) and Aberdeen (close to Sunnybrae) varied from 23 at Cambridge to 17 at Aberdeen. Cranstoun (1996) also showed that Aberdeen was 12% wetter than Cambridge in August and 29% wetter in September: at Cambridge the spring barley harvest was completed by on average by 31 August compared with only 37% of the Aberdeen harvest complete by that date.

The small storage trial (section 8.2) indicated that handling after harvest had a profound influence on dormancy. This agreed with the results of Briggs and Woods (1993) and Kelly, Armitage and Woods (1994). The importance that maltsters attach to drying and storage is such that in Scotland they have traditionally taken in much of their requirement ex-combine. This trial supported the other dormancy work that the focus for providing grain with sound germinative characters should be on its handling after, not before harvest.

## **9.2 Agronomic**

The yield penalty for each day's delay in sowing averaged 39.6 kg/ha with an enormous range from only 1.3 kg/ha/day to 125.6 kg/ha/day. It was noticeable that the penalty was consistently large at the Aldroughty site with an average of 99.7 kg/ha/day. The Lincolnshire and Scottish Border sites tended to have a lower penalty (average 23.1 kg/ha/day) but South Thoresby in 1991 was high at 55.0 kg/ha/day so the trend was not consistent and in one year the Aberdeenshire site produced a low penalty of 10.9 kg/ha/day. Inclement growing weather between the two sowing days as happened at Crosshall in 1992 (penalty only 3.3 kg/ha/day) was a likely contributor to some of the inconsistency. Witney and Elbanna (1985) reviewed the effect of untimely crop establishment on crop yield losses. Their yield loss curves were close to symmetrical on either side of the optimum. The winter barley curve was rather flatter than the spring barley curve; yield depression in winter barley took 5 weeks to achieve 5% whereas in spring barley Witney and Elbanna calculated it took only three weeks. In this series the yield depression was just over 10% in 20 days. In Witney and Elbanna's paper, there appeared to be 25 results at 21 day point and 18 of these exceeded a yield loss of 10%. Witney and Elbanna produced good evidence that the relationship between delay and yield loss was not linear in that their yield depression at the 42 day point was 18.5%. In this series the differences between the two sowing dates was too short and the variation between seasons and sites was too large for this relationship to be tested.

This series of trials has demonstrated the penalty for late sowing but Witney and Elbanna's yield loss predictions carried similar penalties for early sowing. The Crosshall site experienced a heavy rainfall event

soon after the first sowing. The yield on the early sown low nitrogen treatment was only 93% of the equivalent late sown treatment whereas at high nitrogen it was 109%. The early sown low nitrogen treatment averaged only 77.2 kg N/ha in the grain compared with 84.7 kg N/ha in the late sown while the high nitrogen treatments averaged 104.3 and 94.2 kg N/ha respectively. Heavy rainfall events soon after sowing not only cause leaching they can also delay crop access to nitrogen as it is washed down the soil profile. Any sowing period can be followed by adverse weather and the Crosshall site demonstrated that growers should be prepared to adjust their top-dressing where such an event occurs. Another adverse effect of heavy rainfall events soon after sowing is soil capping: brairding, or crop emergence, can be physically impeded or prevented by the soil cap.

Witney and Elbanna's prediction curves indicated heavy penalties associated with large differences from the optimum time, the impact was approximately equally divided on either side of the optimum. In this series the early sown treatment was defined as representing the first reasonable sowing opportunity. Given the substantial yield penalty where sowing took place two to three weeks later, it would be useful to quantify the penalty from sowing before the first reasonable sowing opportunity; some of Witney and Elbanna's yield loss due to early untimely sowing would have been attributable to unsatisfactory seedbeds. Would growers achieve a better overall result for their spring barley if they accepted that sowing should start before the first reasonable opportunity? Further work would be needed to address this problem.

The table below provides evidence that time of sowing interacts with nitrogen fertiliser rate in respect of yield.

Yield of grain (t/ha) at 85% DM Mean of all 15 sites			
	Early sown	Late sown	Mean
Low nitrogen	5.81	5.36	5.59
Moderate nitrogen	6.29	5.65	5.97
High nitrogen	6.56	5.69	6.13
Mean	6.22	5.57	
SeD	Time of sowing	0.081	***
	Nitrogen	0.041	***
	Interaction	0.070	***

The early sown treatment had a much larger response (0.75 t/ha) to nitrogen fertiliser than the late sown treatment

(0.33 t/ha). The optimum nitrogen rate was reduced where sowing was delayed; this aspect is explored in the financial appraisal.

For growers of malting barley the premium is a vital component of the gross margin; grain nitrogen percent and screening losses have an important influence on the size of the premium.

**Grain N% (Mean of all 15 sites)**

	Early sown	Late sown	Mean
Low nitrogen	1.46	1.54	1.50
Moderate nitrogen	1.53	1.61	1.57
High nitrogen	1.62	1.71	1.67
Mean	1.53	1.63	
SeD			
Time of sowing		0.035	***
Nitrogen		0.009	***
Interaction		0.013	NS

Both delayed sowing and additional nitrogen fertiliser resulted in grain of higher nitrogen percent but there was no significant interaction.

**Screening losses (% < 2.5mm)**

	Early Sown	Late sown	Mean
Low nitrogen	12.0	15.3	13.6
Moderate nitrogen	14.0	18.8	16.4
High nitrogen	17.1	23.3	20.2
Mean	14.4	19.1	
SeD			
Time of sowing		1.29	***
Nitrogen		0.82	***
Interaction		1.15	NS

Both delayed sowing and additional nitrogen fertiliser resulted in grain with higher screening losses; the interaction was not statistically significant.

Delayed sowing carried a yield penalty and additional penalising adjustments to the malting premium for both grain nitrogen and screening losses: the premium penalties were increased at the higher rates of nitrogen fertiliser.

### 9.3 Financial appraisal

#### 9.31 Malting

This appraisal was based on an average spring barley malting price of £130 per tonne with adjustments for grain nitrogen and screening losses. Bathgate (1987) provided a typical buying guide for malting barley showing how variation in grain nitrogen and screenings would effect the price quoted for a malting sample.

During this project the following adjustments were commonly applied in Scotland. The grain nitrogen adjustment was 50 pence for each 0.01% nitrogen deviation from the standard. Companies tended to adopt different standards but the one used in this analysis was 1.60% nitrogen. The screenings adjustment was 70 pence for each percentage screening loss in excess of 10% through a 2.5mm screen. Because the relativities were important in this project, the malting price of samples with less than 10% screenings was adjusted upwards by 70 pence for each percentage that the loss was less than 10%.

In practice the average malting barley price varies considerably with the balance between world demand and supply for malting barley, the trade in malt, old crop carry-over and the relationship between the pound sterling and the ECU. In 1997 a base price for malting barley of £90 per tonne was more appropriate than the £130 used in this study. This lower figure has been used for demonstration purposes in Table 403: 1997 nitrogen costs have also been adopted.

Maltsters make regular revisions to their contracts: the reasons appear to be twofold. In some years maltsters discover that their contracts operate in a disadvantageous way: the low average nitrogen content of the 1992 crop meant that contracts with premiums adjusted for benefits under 1.60% nitrogen were costly in relation to prices on the spot market. The second reason is the competitive nature of business; contracts are partly designed to secure business, therefore the terms must appear to relatively attractive.

In Appendix 5 the malting barley price adjustments based on screenings and nitrogen have been applied to the treatments to produce average premiums for each year (tables 301 & 302). Grain output in pounds sterling per hectare have been derived from the premium and yield data (tables 301 & 302).

Another way to use the premium data is that a low figure represents a high risk that a particular treatment combination will not be accepted by maltsters.

### 9.32 Growth regulator

The price of Terpal allowed for in this project was £12 per hectare, the cost of one litre. The use of growth regulator had no effect on yield, a small (£1.30) adverse effect on malting barley price (table 302) and a cost (£12). In the absence of lodging, the use of Terpal growth regulator reduced gross margin by £20 per hectare excluding application costs. Lodging was generally avoided in this series by the choice of a stiff strawed variety (cv Blenheim). Spring barley varieties have improved markedly in straw strength in the last 20 years so it should be practicable in most situations to avoid the use of a growth regulator when growing spring barley for malting.

### 9.33 Late fungicide

The price of Tilt Turbo at one litre per hectare was £22. Late fungicide increased yield by 0.25 t/ha and it increased the premium by £2.84/t (table 302) giving an improved grain output of £46/ha and an improved gross margin of £24 per hectare.

In some trials late fungicide was not needed, either because disease pressure was very low or else because the earlier treatment was sufficiently persistent. Most varieties entering commercial use now have much better resistance to mildew than cv Blenheim; MLO resistance has been successfully incorporated into varieties such as Alexis, Chariot, Derkado and many others, with the result that mildew is rarely seen in these varieties. Although Tilt Turbo was cost effective on cv Blenheim, there were trials where this was not the case and with more disease resistant varieties the frequency of a cost-effective response would be reduced. If disease threatens then growers need to take into account the likely depression in malting price in addition to the effect on yield.

### 9.34 Nitrogen

Nitrogen was costed at 28p per kg. In practice the cost of nitrogen has varied considerably in recent years within a range of approximately 27 to 37 pence.

Increasing the nitrogen from the low rate to the moderate rate increased the average gross margin by only £4. This was made up of an additional nitrogen cost (£11), a relatively large increase in yield (0.39 t/ha), and a £6 reduction in premium (table 302). Increased grain nitrogen accounted for two thirds of the fall in premium and screening losses the remaining one third.

Increasing the nitrogen from the moderate rate to the high rate decreased the average gross margin by £33. The yield benefit was only 0.15 t/ha and the premium penalty was £7; the penalty was again approximately two thirds due to increased grain nitrogen content and one

third due to increased screening losses.

Increasing the rate of nitrogen fertiliser reduced the malting premium by 16p/t for each additional kg of nitrogen over the range 70 to 150 kg/ha.

### 9.35 Time of sowing

The difference in gross output between the two times of sowing was £125/ha (table 302) made up from a yield difference of a 640 kg/ha and malting premium difference of nearly £8/ha due variations in both grain nitrogen and screening losses.

The average delay in sowing was 19.8 days so the average penalty for each day sowing was delayed was £6.31 assuming an average malting barley price (AMBP) of £130/t. At an AMBP of only £90/t, the penalty would have been reduced to £5.05/ha/day. At feed prices of £100/t the daily penalty was £3.39 and at £75/t the daily penalty is further reduced to £2.52.

The interaction between sowing day and nitrogen application indicated earlier had a significant effect on the finances (tables 303, 304 and 305).

Table 304 provides the margin over nitrogen cost at the 1993 AMBP of £130. The optimum nitrogen rate for early sowing was close to the moderate rate (110 kg): for the late time of sowing it was probably below the low rate (70 kg). Between the two times of sowing the reduction in optimum nitrogen rate averaged approximately 2.25 kg N per hectare per day.

At a feed price of £100/t, the optimum nitrogen rate for early sowing was close to the high rate (150 kg): for the late time of sowing it was close to and probably slightly above the moderate rate (110kg). Between the two times of sowing the reduction in optimum rate of nitrogen averaged approximately 2 kg N per hectare per day.

Looked at on a daily basis the adjustment in optimum nitrogen is small: but if growers take into account the normal spread of their drilling period and the incidence of delays due to adverse weather, an adjustment for a ten day delay in drilling is not only worthwhile but practicable especially if top-dressing at brairding is adopted.

Comparing tables 304 and 305 it can be shown that a decline in barley price and a rise in nitrogen fertiliser price reduce the optimum nitrogen rate. The clearest evidence for this was that for the early sowing (tables 304 and 305): the change in margin over nitrogen costs between the low and moderate applications was +£22 at an AMBP of £130 and -£1 at an AMBP of £90 and a rise in nitrogen cost of 7p per kg. To provide a good quantitative estimate of the change in optimum rate with

prices and costs would require more than three levels of nitrogen adopted in this series.

## 10 CONCLUSIONS

10.1 The yield of spring barley falls with delays in sowing; if sowing is followed by exceptionally wet weather this effect may be masked by leaching losses.

10.2 Yield responses to late fungicide are common using mildew-susceptible varieties such as Blenheim; sometimes they occur even in the absence of significant disease pressure.

10.3 In the absence of lodging, Terpal growth regulator has no effect on yield.

10.4 Spring barley responds to nitrogen fertiliser but to a significantly lesser extent if sowing is delayed.

10.5 Late sowing reduces quality by raising both grain nitrogen content and screening losses.

10.6 High rates of nitrogen fertiliser reduce quality by raising both grain nitrogen and screening losses.

10.7 Terpal growth regulator increases screening losses but slightly reduces grain nitrogen.

10.8 Late fungicide reduces screening losses.

10.9 Early sown crops modify more rapidly and are more friable.

10.10 Terpal can have adverse effects on modification and friability.

10.11 Terpal growth regulator, and Tilt Turbo fungicide, do not have an adverse effect on the development of amylolytic enzymes during malting.

10.12 Residues of Tilt Turbo are barely detectable in harvested samples.

10.13 Nitrogen fertiliser rates should be adjusted according to date of sowing: the adjustment varies according to barley feed price, the size of the malting premium and cost of nitrogen fertiliser. For a malting crop grown during this project it was close to 2.25 kg N/ha/day.

10.14 Recovery from dormancy is not significantly affected by agronomic treatments other than choice of variety; it may be improved by early harvesting. It is heavily dependent on treatment at and after harvest, in particular the drying and storage arrangements.

10.15 Late fungicide may increase the incidence of split grain in vulnerable conditions.

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### ACKNOWLEDGEMENTS

SAC gratefully acknowledges the support of HGCA in funding this project.

Thanks are due to the farmers and site managers responsible for the fifteen trial sites and to ADAS for arranging and managing the English sites.

I am greatly indebted to Mr Ronnie Page and Mr Alan Sibbald of Robert Kilgour and Company, Dunnikier Maltings, Kirkcaldy, not just for analysis of malting samples but for guidance on germination assessment and interpretation of malting results. Staff at SASA, East Craigs scrutinised the germination capacity results without finding sufficient potential for further germination studies; instead Dr Pat Cochrane provided useful guidance in the development of the splitting work.

The growth regulator studies were carried out by Professor GH Palmer at the Department of Biological Sciences, Heriot-Watt University; he was assisted for most of the work by Mr M Huey.

APPENDIX 1

SITE DETAILS 1991

Sites: Whitehouse, Ploughlands, Maxton, St Boswells  
 Boghall, Bush, Penicuik, Midlothian  
 Sunnybrae, Craibstone, Aberdeen.  
 Aldroughty, Elgin.  
 South Thoresby, Alford, Lincolnshire.

Details of trials

Grid reference	Whitehouse	Boghall	Sunnybrae	Aldroughty	South Thoresby
Elevation	NT638 330	NT243648	NJ879111	NJ180624	TF399764
Soil Series	100m	220m	73m	30m	45m
Soil Texture	Kedslie	Alluvium	Countesswells	Boyndie	*
pH	Sandy Clay Loam	Loam	Sandy loam	Sandy loam	Sandy loam
P	6.7	6.5	6.2	6.1	7.2
K	Moderate	High	Moderate	High	Moderate
Mg	Moderate	Moderate	Very low	Moderate	Low
S	High	High	Medium	Moderate	Low
Mn	*	Low	*	*	*
	Very low	*	*	*	*

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Previous cropping:	1990 S Barley	W Barley	Cereal	Carrots	W Wheat
	1989 W Wheat	W Wheat	Grass	S Barley	W wheat
	1988 Oilseed Rape	W Wheat	Grass	S Barley	Oilseed rape
	1987 W Barley	W Wheat	Grass	S Barley	W barley

Design & replication Three replicate split plot trials with sowing date as main plots

Variety	Blenheim				
Seed Rate (kg/ha)	180	190	202	195	191
Sowing date	See treatments				
Seed-bed fertiliser (kg/ha)	0:70:70	0:70:70	0:118:118	0:60:84	0:40:40
Spring N (kg/ha)	See treatments				

Whitehouse  
 Herbicide HARMONY M (30g) + DUPLOSAN (11) on 14 May  
 Boghall ALLY (30g) + TERSEPT (3kg) on 14 May  
 Sunnybrae DUPLOSAN (11) on 14 May  
 Aldroughty ALLY (15g) + DUPLOSAN (1.11) on 14 May  
 South Thoresby BANLENE PLUS (2.5 l/ha) on 21 May

Fungicide MISTRAL (11) on 22 May  
 CALIXIN (.71) on 23 May  
 CORBEL (1.1) + BAVISTIN FL (0.5 l) on 7 June  
 CORBEL (0.51) on 14 May  
 CORBEL (.661) + DEROSAL (.5 kg/ha) on 21 May

MISTRAL (11) + BAVISTIN (.31) on 5 June  
 TILT TURBO (1 l/ha) on 27 June  
 PATROL (.75 l) + RADAR (.5 l) on 5 June

Insecticide TILT TURBO GS45-59 applied as a late fungicide treatment to half the plots  
 SPANNIT (1.51) on 10 May

Trace Elements CUTONIC Mn (101) + CUTONIC Cu (11) on 22 May  
 CUTONIC Mn (51) on 6 June  
 MANGANESE SULPHATE (6kg) on 14 May  
 MANGANESE SULPHATE (4kg) on 5 June  
 MANGANESE SULPHATE (5kg) on 24 May  
 MANGANESE SULPHATE (6kg) on 11 June  
 None

Harvest Date Early 28 Aug 91  
 Late 28 Aug 91  
 1 Sep 91  
 6 Sep 91  
 9 Sep 91  
 20 Aug 91  
 30 Aug 91  
 14 Aug 91  
 21 Aug 91

**SITE DETAILS 1992**

Sites: Crosshall, Greenlaw, Berwickshire.  
 Panlathy, Carnoustie, Angus.  
 Sunnybrae, Craibstone, Aberdeen.  
 Aldroughty, Elgin.  
 Withcall, Louth, Lincolnshire.

**Details of trials**

Grid reference	Crosshall	Panlathy	Sunnybrae	Aldroughty	Withcall
Elevation	NT 763 424	NO 572 384	NJ 879 111	NJ 176 624	TF 262 381
Soil Series	70m	60m	73m	30m	150m
Soil Texture	Whitsome	Balrownie	Countesswells	Sandy loam	Andover
PH	Sandy clay loam		Sandy loam	Sandy loam	Silty clay
P	5.9	6.4	6.2	5.9 (Limed)	8.1
K	High	High	Mod	High	*
Mg	Mod	Mod	V Low	High	*
Mn	Mod	Mod	Mod	*	*
	Low	Low	*	*	*

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Previous cropping:	1991 S Barley	Oilseed Rape	Cereal	Potatoes	W Wheat
	1990 W Wheat	W Barley	Cereal	S Barley	W Wheat
	1989 Peas	W Wheat	Grass	Carrots	Oilseed Rape
	1988 Potatoes	Potatoes	Grass	S Barley	*

Design & replication Three replicate split plot trials with sowing date as main plots

Variety	Blenheim			
Seed Rate (kg/ha)	188	190	227	196
Sowing date	See treatments	See treatments	See treatments	See treatments
Seed-bed fertiliser (kg/ha)	0:60:60	0:60:60	0:132:132	56:56:75
Spring N (kg/ha)	18 March	23 March	before cultiv.	combine-drilled
	See treatments	See treatments	before sowing	before sowing

	Crosshall	Parlathy	Sunnybrae	Aldroughty	Withcall
Herbicide	HARMONY M(35g) + DUPLOSAN (21) on 20 May	ALLY (15g) + DUPLOSAN (21) on 13 May	STARARNE 2 (.5 l/ha) + COUPLER (.71/ha) on 19 May (early) & 1 June (late)	None needed	AVADEx (22kg) on 30 Mar OPTICA (1.51) + OXYTRIL CM(.51) on 2 May DORIN (.51) on 26 May
Fungicide	CALIXIN (.71) on 13 May CORBEL (11) + BAVISTIN (.5kg) on 26 May	CORBEL (11) on 27 May	CALIXIN (.71/ha) on 19 May (early) & 1 June (late) MISTRAL (1 l/ha) + BAVISTIN (.51/ha) on 8 June (early) & 17 June (late)	CORBEL (0.51/ha) on 28 May	

TILT TURBO GS45-59 applied as a late fungicide treatment to half the plots

Trace Elements	Harvest Date	Early	Late
CUTONIC Mn (51) on 13 & 26 May	18 Aug	26 Aug	7 Aug
CUTONIC Mn (51) on 13 & 27 May	24 Aug	1 Sep	7 Aug
MANGANESE SULP (4 kg/ha) on 27 May			
MANGANESE SULP (6.5 kg/ha) on 28 May			
MANGANESE SULP (4 l/ha) on 26 May and 10 June			



	<b>Crosshall</b>	<b>Bush</b>	<b>Sunnybrae</b>	<b>Aldroughty</b>	<b>Withcall</b>
<b>Herbicide</b>	ALLY (15g) + DUPLOSAN (21) on 19 May	ALLY (15g) + DUPLOSAN (21) on 12 May	SWIPE 560 (3.51/ha) on 28 May	ALLY (25g/ha) + CMP (0.61) on 15 May	AVADEx BW GRANULAR (22 kg) pre-emergence
					ALLY (20g) on 18 April

<b>Fungicide</b>	CALIXIN (11) + BAVISTIN (.25kg) on 12 May	CORBEL(11) + BAVISTIN(.25) on 24 May	MISTRAL (11)+ BAVISTIN (.25) on 27 May (early sown) and 8 June (late sown)	MISTRAL (11) + BAVISTIN (.25) on 20 May (early sown) and 27 May (late sown)	GENIE (.21) on 5 May
	TILT TURBO (11) on 8 June		TILT TURBO (11) on 22 June and 13 July for early and late sown treatments	TILT TURBO (11) on 15 June and 29 June for early and late sown treatments	GENIE (.21) + CORBEL (.31) on 5 June

TILT TURBO GS45-59 applied as a late fungicide treatment to half the plots

<b>Trace Elements</b>	CUTONIC Mn (51) on 12 May	CUTONIC Mn(101) on 19 May	nil	nil	nil
<b>Harvest Date</b>	Early 31 August Late 18 September	7 September 23 September	23 September 8 October	1 September 1 September	18 August 18 August

TREATMENT DETAILS

Code	Nitrogen (kg/ha)	Terpal Regulator (1l/ha)	Growth (1l/ha)	Tilt	Late Fungicide Turbo at GS49-59
A			Low		Yes
B			Low		No
C			Low		Yes
D			Low		No
E			Mod		Yes
F			Mod		No
G			Mod		Yes
H			Mod		No
J			High		Yes
K			High		No
L			High		Yes
M			High		No

1991 Sowing dates	WHITEHOUSE	BOGHALL	SUNNVBRAE	ALDROUGHTY	SOUTH THORESBY
EARLY	30 Mar	30 Mar	2 Apr	26 Mar	14 Mar
LATE	16 Apr	16 Apr	24 Apr	9 Apr	28 Mar

Nitrogen rates (all sites)  
 LOW 70 kg/ha  
 MODERATE 110 kg/ha  
 HIGH 150 kg/ha

Terpal applied (1 litre/hectare + Cittowett)  
 EARLY 11 Jun GSSZ37  
 LATE 11 Jun GSSZ32  
 6 Jun GSSZ32-37  
 14 Jun GSSZ32-37  
 20 Jun GSS37  
 27 Jun GSS37-39  
 6 June GSS32-37  
 20 June GSS32-37  
 8 Jun

Late Fungicide applied  
 EARLY 24 Jun GSSZ50  
 LATE 24 Jun GSSZ45  
 20 Jun GSSZ51-53  
 10 Jul GSSZ59  
 24 Jun GSS49  
 20 Jun  
 1 Jul

**1992**

Sowing dates	CROSSHALL	PANLATHY	SUNNVBRAE	ALDROUGHTY	WITHCALL
EARLY	17 March	17 March	9 April	8 April	26 February
LATE	10 April	8 April	6 May	22 April	11 March

Nitrogen rates (kg/ha)

LOW	60	60	70	80	70
MOD	100	100	110	120	110
HIGH	140	140	150	160	150

Terpal applied (1 litre/hectare + Cittowett)

EARLY	29 May	4 June	16 June	9 June	25 May
LATE	4 June	8 June	26 June	16 June	3 June

Late Fungicide applied (Tilt Turbo at 1 l/ha)

EARLY	22 June	17 June	6 July	16 June	10 June
LATE	22 June	22 June	14 July	26 June	17 June

**1993**

Sowing dates	CROSSHALL	BUSH	SUNNVBRAE	ALDROUGHTY	WITHCALL
EARLY	10 March	19 March	22 March	10 March	24 February
LATE	2 April	8 April	26 April	26 March	12 March

Nitrogen rates (kg/ha)

LOW	70	80	80	70	60
MOD	110	120	120	110	100
HIGH	150	160	160	150	140

Terpal applied (1 litre/hectare + Cittowett)

EARLY	28 May	1 June	11 June (GS37)	4 June	10 June (GS45)
LATE	8 June	15 June	22 June (GS39)	22 June (GS47)	10 June (GS45)

Late Fungicide applied (Tilt Turbo at 1 l/ha)

EARLY	24 June	24 June	13 July (GS69)	9 July	29 June (GS69)
LATE	2 July	5 July	22 July (GS68)	11 July	29 June (GS69)

### 1. Germination Capacity

The germination capacity test provided a measure of the percentage of grains that were capable of germinating once dormancy was broken.

After cleaning over a 2.2mm sieve, 200 grains were placed in a screw-top flask in 200ml of diluted hydrogen peroxide; 5ml of 30% (100 volume) hydrogen peroxide were diluted with 200 ml of sterile water. After three days in an incubator at 18-21 degrees centigrade, the grains were extracted, rinsed and the unchitted grains removed and counted; those grains with no visible radicle or plumule were counted as unchitted. The unchitted grains were then peeled and replaced in the flask for one more day, and counted as chitted if the plumule or radicle were visible at the end of this extra period.

### 2. Germinative Energy

The germinative energy test provided a measure of the percentage of grains that had recovered from dormancy on a given date and the percentage of grains that were no longer water-sensitive on the same date.

After cleaning the grain over a 2.2mm sieve, two lots of 100 grains were placed in 9cm plastic petri dishes on two layers of filter paper; the upper layer was Whatman No 1 Black as this provided a better contrast with the germinating grain. 5ml of sterile water was added to one petri dish and 8ml to the other. The petri dishes were then wrapped in cling-film and stored in an incubator at 18-21 degrees centigrade. Unchitted grains were counted after 24, 48 and 72 hours.

During the weeks following harvest barley tends to recover from dormancy; some lots may recover within six weeks, others may take several months. For these trials an indicator treatment was selected, it was treatment G (middle rate of nitrogen fertiliser plus late fungicide but no growth regulator); the indicator treatments were tested weekly for both early and late sowings. As soon as the 5ml test exceeded 90% for the indicator treatment all treatments at that site and sowing date were tested. Normally the 72hr data are used but where the 48hr data provided better discrimination between treatments it has been used in this report.

### 3. Grain size and nitrogen

Sieving, 1000 corn weight and nitrogen analyses were carried out using the normal industry standards.

#### 4. Split grains

A staining technique was used to ease the identification of split grain. In a split grain, the starch is no longer fully covered. Grains were immersed in potassium iodide to stain any exposed starch. After washing the stained grains were counted.

Table 101 WHITEHOUSE 1991

APPENDIX 3

Code	Yield t/ha at 85% DM	TCW (g)	Screenings % <2.5mm	Germ Energy 5ml 8ml	Grain N%	Green leaf %	Straw length cm	
<u>Early Sown</u>								
A	6.08	48.3	25.7	80	44	1.50	43	63
B	5.38	46.1	36.0	69	39	1.36	15	63
C	6.06	50.4	21.8	75	35	1.41	60	70
D	5.48	49.8	29.3	74	48	1.39	13	71
E	6.41	48.2	33.0	69	36	1.50	63	65
F	5.63	43.5	47.5	69	47	1.58	20	65
G	6.32	51.3	27.2	77	37	1.54	60	76
H	5.89	47.6	36.5	72	31	1.58	23	74
J	6.65	46.4	38.4	64	41	1.68	65	69
K	5.85	45.2	49.6	70	41	1.69	23	69
L	6.69	48.6	31.5	78	48	1.65	65	76
M	6.26	46.7	37.1	78	43	1.69	33	79
<u>Late sown</u>								
A	5.94	50.6	34.2	62	50	1.44	68	70
B	5.14	45.1	48.3	60	42	1.54	30	70
C	5.74	50.5	27.5	68	35	1.50	78	70
D	4.87	48.1	38.4	74	39	1.58	33	75
E	6.11	47.7	41.3	61	30	1.68	70	73
F	5.14	42.7	61.1	81	41	1.69	33	73
G	5.77	48.4	32.7	64	32	1.68	68	76
H	5.28	46.9	46.9	63	39	1.53	45	74
J	5.96	46.9	53.9	62	32	1.83	80	73
K	5.27	43.4	64.2	67	48	1.72	33	72
L	6.30	49.6	40.7	68	35	1.71	80	81
M	5.27	46.6	49.3	72	34	1.81	38	80
Sed	0.167		3.30			0.072		2.1

**Table 102 Whitehouse Treatment means**

	Yield t/ha at 85% DM	TCW (g)	Screenings % <2.5mm	Germ Energy 5ml 8ml	Grain N%	Green leaf %	Straw length cm
Nitrogen (kg/ha)							
70	5.59	48.7	32.7	70	42	1.47	43
110	5.82	47.1	40.8	70	37	1.50	48
150	6.03	46.7	45.6	70	40	1.73	53
Sed	0.059		1.17			0.025	0.7
Growth Regulator (Terpal)							
+	5.80	46.2	44.5	68	41	1.60	45
-	5.83	48.7	34.9	72	38	1.59	50
Sed	0.048		0.95			0.021	0.6
Late Fungicide (Tilt Turbo)							
+	6.17	48.9	34.0	69	38	1.59	67
-	5.46	46.0	45.4	71	41	1.60	28
Sed	0.048		0.95			0.021	0.6
Time of Sowing							
Early	6.06	47.7	34.5	73	41	1.55	40
Late	5.57	47.2	44.9	67	38	1.65	55
Sed	0.048		0.95			0.021	0.6

**Table 103 BOGHALL 1991**

Code	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Green Leaf %	Straw length cm	Leaning %
<u>Early Sown</u>								
A	6.90	48.4	18.4	83	57	1.39	10	0
B	6.76	48.6	16.3	84	64	1.36	10	0.3
C	6.65	50.6	11.2	91	65	1.47	28	0
D	6.83	48.7	13.3	89	60	1.55	35	0.7
E	7.54	47.5	20.9	94	52	1.52	25	0.7
F	7.15	47.0	22.7	94	66	1.51	15	2.0
G	7.02	50.8	12.1	91	62	1.57	38	0.3
H	7.21	51.6	14.7	86	63	1.50	20	2.3
J	7.69	47.7	23.3	88	57	1.56	43	3.7
K	7.47	46.5	28.0	91	54	1.67	18	7.3
L	7.87	50.9	11.0	89	61	1.68	40	2.7
M	7.60	49.2	16.6	93	60	1.68	35	4.3
<u>Late sown</u>								
A	6.59	46.3	27.1	68	40	1.45	38	0.7
B	6.68	47.1	27.5	66	39	1.47	74	0.7
C	6.21	49.6	17.1	83	58	1.47	86	0
D	6.79	51.9	12.8	73	47	1.53	43	0
E	6.99	47.1	29.0	59	39	1.51	74	0.7
F	6.72	45.0	36.5	56	39	1.60	23	0.7
G	6.87	51.8	16.2	75	48	1.62	50	1.3
H	6.77	50.4	17.6	74	40	1.63	40	4.0
J	6.86	45.1	39.6	63	35	1.77	35	5.0
K	6.80	45.5	39.3	87	34	1.73	23	2.3
L	7.29	51.0	18.9	79	38	1.72	53	1.3
M	6.83	49.0	22.2	67	37	1.71	96	6.7
Sed	0.247		3.40			.096		1.7

**Table 104 Boghall treatment means**

	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Green Leaf %	Straw length cm	Leaning %	
Nitrogen (kg/ha)									
70	6.68	48.9	18.0	80	54	1.46	27	78	0.3
110	7.04	48.6	21.2	79	52	1.56	32	82	1.5
150	7.23	48.4	24.9	82	47	1.69	35	88	4.2
Sed	0.087		1.20			.034			0.60
Growth Regulator (Terpal)									
+	7.01	46.9	27.4	78	48	1.55	25	75	1.8
-	7.00	50.5	15.3	82	53	1.59	37	90	2.0
Sed	0.071		0.98			0.028			0.50
Late Fungicide (Tilt Turbo)									
+	7.04	48.9	20.4	80	51	1.56	36	83	1.4
-	6.97	48.4	22.3	80	50	1.58	26	82	2.6
Sed	0.071		0.98			0.028			0.50
Time of Sowing									
Early	7.23	49.0	17.4	89	60	1.54	26	81	2.0
Late	6.79	48.3	25.3	71	41	1.60	36	84	2.0
Sed	0.071		0.98			0.028			1.7

**Table 105 SOUTH THORESBY 1991**

Code	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Straw length (cm)
Early						
A	6.05	50.1	12.3	95 72	1.36	60
B	5.82	49.7	14.0	89 72	1.36	60
C	5.65	49.9	10.3	92 73	1.32	61
D	5.69	50.0	12.7	96 78	1.25	56
E	6.47	51.3	12.6	92 79	1.43	61
F	6.17	50.9	15.0	96 76	1.42	58
G	6.29	51.1	11.0	92 83	1.35	64
H	6.30	50.8	12.0	94 81	1.27	65
J	6.71	49.2	14.7	92 78	1.62	64
K	6.47	50.3	15.8	95 68	1.60	62
L	6.69	51.4	13.1	93 75	1.57	64
M	6.49	51.8	14.3	94 79	1.43	65
Late						
A	5.00	51.0	11.8	94 72	1.45	54
B	5.03	50.3	16.2	93 74	1.43	54
C	5.32	51.5	14.9	95 80	1.49	70
D	5.23	51.6	14.9	97 80	1.46	65
E	5.78	51.5	13.8	95 82	1.54	59
F	5.38	49.4	19.1	94 70	1.55	56
G	5.61	51.3	14.0	95 81	1.60	69
H	5.50	51.9	20.3	98 75	1.52	67
J	6.02	50.7	17.0	97 80	1.72	60
K	5.49	49.0	22.1	92 73	1.82	56
L	5.84	51.5	17.1	99 79	1.68	73
M	5.31	50.7	21.2	98 85	1.64	69
Sed	0.225	1.50	2.04	2.54 6.9	0.10	4

**Table 106 South Thoresby treatment means**

	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Straw length (cm)
Nitrogen (kg/ha)						
70	5.48	50.5	13.4	94	76	1.39
110	5.94	51.0	14.8	95	79	1.46
150	6.13	50.6	17.0	96	76	1.64
Sed	0.080	0.53	0.72	0.88	2.43	0.04
						1.41
Growth regulator (Terpal)						
+	5.87	50.3	15.4	94	75	1.53
-	5.83	51.1	14.7	95	79	1.47
Sed	0.065	0.43	0.59	0.73	1.99	0.03
						1.15
Late Fungicide (Tilt Turbo)						
+	5.95	50.9	13.6	94	78	1.51
-	5.74	50.6	16.5	95	77	1.48
Sed	0.065	0.43	0.59	0.73	1.99	0.03
						1.15
Time of Sowing						
Early	6.23	50.6	13.2	93	76	1.42
Late	5.46	50.9	16.9	96	78	1.58
Sed	0.065	0.43	0.59	0.73	1.99	0.03
						1.15

**Table 107 SUNNYBRAE, ABERDEEN 1991**

Code	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Straw length cm	Mildew % 22 Jul
Early							
A	5.68	47.8	19.3	79 49	1.53	75.7	2.7
B	5.40	46.7	26.3	90 53	1.55	73.3	3.3
C	5.70	49.9	16.0	88 41	1.60	85.0	3.0
D	5.60	49.0	14.3	83 47	1.60	85.3	3.0
E	6.04	46.7	23.6	76 42	1.61	76.3	3.3
F	5.41	46.5	31.1	82 53	1.63	74.7	3.7
G	5.96	48.1	16.5	82 42	1.69	87.3	4.0
H	5.62	49.1	18.9	79 41	1.61	88.3	3.3
J	5.72	48.0	28.4	75 36	1.64	78.7	4.3
K	5.09	44.4	46.0	86 38	1.73	81.3	4.3
L	5.92	48.1	21.5	89 39	1.68	88.7	2.7
M	5.80	47.6	24.3	91 37	1.70	90.3	3.3
Late							
A	6.16	49.0	19.4	85 40	1.49	68.0	2.0
B	5.38	45.7	34.3	76 40	1.56	74.0	1.3
C	6.26	49.0	16.3	87 41	1.58	86.7	1.0
D	5.70	48.8	23.6	81 42	1.57	85.0	1.7
E	6.26	47.3	27.3	83 36	1.60	75.7	1.0
F	5.65	47.2	29.1	79 52	1.55	74.7	2.0
G	6.35	49.9	17.9	82 34	1.59	88.3	1.3
H	5.86	47.5	26.9	88 42	1.65	88.0	2.3
J	6.03	46.2	32.6	84 42	1.73	78.0	1.7
K	5.08	44.4	43.5	74 43	1.75	74.3	2.0
L	6.35	49.0	22.0	85 40	1.70	90.7	2.0
M	5.68	47.3	28.9	86 47	1.73	90.3	1.7
Sed	0.219	1.00	3.17	6 7	0.061	1.7	0.57

**Table 108 *Sunnybrae* treatment means**

	Yield in t/ha at 85% DM	TCW (g)	Screenings % <2.5mm	Germ Energy 5ml 8ml	Grain N%	Straw length cm	Mildew % 22 Jul	Brackling %
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Nitrogen (kg/ha)									
70	5.74	48.3	21.2	84	45	1.56	79.4	2.3	7.4
110	5.89	47.8	23.9	82	44	1.62	81.8	2.6	14.0
150	5.71	46.9	31.0	84	41	1.71	84.3	2.8	38.5
Sed	0.076	0.35	1.12	2	2.5	0.022	0.65	0.23	2.85
Growth regulator (Terpal)									
+	5.66	46.7	30.1	81	44	1.62	75.6	2.6	23.9
-	5.90	48.6	20.6	85	42	1.64	88.0	2.4	16.1
Sed	0.062	0.29	0.91	1.8	2	0.018	0.53	0.19	2.32
Late Fungicide (Tilt Turbo)									
+	6.04	48.3	21.7	83	41	1.62	81.8	2.4	14.0
-	5.52	47.1	29.0	83	45	1.64	81.9	2.7	26.0
Sed	0.062	0.29	0.91	1.8	2	0.018	0.53	0.19	2.32
Time of Sowing									
Barly	5.66	47.7	23.9	83	45	1.63	82.3	3.4	22.4
Late	5.90	47.6	26.8	82	42	1.63	81.4	1.7	17.5
Sed	0.062	0.29	0.91	1.8	2	0.018	0.53	0.19	2.32

**Table 109 ALDROUGHTY, ELGIN 1991**

Code	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Lodging %	Straw length cm	Mildew % 29 Jul	Rhyncho-sporium %
Early									
A	6.42	46.9	11.5	92	1.34	0	69.0	3.0	1.5
B	6.12	49.8	15.5	93	1.39	0	67.7	32.5	7.5
C	6.46	51.7	8.8	94	1.39	0	78.7	6.0	3.5
D	6.15	51.4	9.9	96	1.41	1.7	80.3	19.0	14.5
E	7.20	49.1	16.6	91	1.55	0	74.0	8.5	6.5
F	6.68	49.1	18.1	96	1.48	6.7	79.7	25.5	10.5
G	6.94	50.9	10.9	91	1.56	1.7	88.3	8.0	2.5
H	6.33	50.5	16.2	98	1.53	10.0	89.7	19.0	6.0
J	6.73	48.6	21.9	87	1.49	10.0	82.3	3.5	6.0
K	6.32	46.1	32.5	92	1.51	30.0	79.3	35.5	10.0
L	6.73	51.0	17.9	98	1.56	10.0	88.0	16.5	12.0
M	6.21	49.1	23.2	93	1.63	18.3	90.0	25.0	8.0
Late									
A	5.73	51.6	14.2	88	1.40	0	68.0	4.5	4.0
B	5.72	50.6	15.7	95	1.39	0	70.7	22.5	3.0
C	5.76	52.6	19.7	94	1.44	1.7	78.7	6.5	5.0
D	5.24	52.1	13.5	94	1.44	0.3	81.3	27.0	2.0
E	6.24	52.9	17.7	86	1.51	8.3	76.0	9.5	2.5
F	5.40	47.9	31.7	92	1.51	13.3	71.0	34.5	5.5
G	5.45	55.9	16.2	98	1.54	2.3	86.0	18.0	4.0
H	5.58	51.5	20.7	97	1.55	10.0	85.3	27.0	5.5
J	5.38	48.0	31.5	92	1.67	10.0	74.0	12.0	3.0
K	5.43	46.7	41.2	100	1.63	8.3	72.0	38.0	3.0
L	6.05	50.7	24.6	95	1.64	15.0	89.0	8.5	1.5
M	5.32	49.0	29.6	97	1.61	15.0	85.0	22.5	9.5
Sed	0.247	2.12	3.96	2.8	0.042	5.5	2.69	8.09	3.6

**Table 110 Aldroughty treatment means**

	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Lodging %	Straw length cm	Mildew %	Rhyncho- sporium %	
Nitrogen (kg/ha)										
80	5.79	50.9	13.6	94	63	1.40	0.5	74.5	15.1	5.13
120	6.10	51.0	18.6	94	54	1.53	6.5	81.5	18.8	5.38
160	5.94	48.7	27.8	95	52	1.60	14.6	82.7	20.2	6.63
Sed	0.087	0.75	1.40	1.0	3.6	0.015	1.9	0.92	2.86	1.29
Growth regulator (Terpal)										
+	5.96	48.9	22.3	92	57	1.50	7.2	73.9	19.1	5.25
-	5.92	51.4	17.6	96	56	1.52	7.2	85.3	16.9	6.17
Sed	0.071	0.61	1.14	0.8	3	0.012	1.55	0.75	2.34	1.05
Late Fungicide (Tilt Turbo)										
+	6.15	50.8	17.6	92	56	1.49	4.9	79.6	8.7	4.33
-	5.73	49.5	22.3	96	56	1.52	9.5	79.6	27.3	7.08
Sed	0.071	0.61	1.14	0.8	3	0.012	1.55	0.75	2.34	1.05
Time of sowing										
Barly	6.52	49.5	16.9	94	63	1.49	7.4	80.3	16.8	7.38
Late	5.36	50.8	23.0	94	49	1.53	7.0	78.3	19.2	4.04
Sed	0.34	0.61	1.14	0.8	3	0.012	1.8	1.24	1.71	0.25

Table 111 CROSSHALL 1992

Code	Yield t/ha at 85% DM	Straw length cm	TCW (g)	Screenings % <2.5mm	Germ Energy 5ml 8ml	Grain N%	Grain N kg/ha
<u>Early Sown</u>							
A	5.37	56.0	52.5	4.3	92.0	1.48	74.5
B	5.49	53.0	53.1	4.7	99.0	1.50	75.3
C	5.46	62.0	55.3	3.1	94.0	1.55	76.7
D	5.78	64.0	54.4	4.3	92.5	1.59	82.4
E	6.67	59.0	53.1	3.7	92.0	1.64	98.5
F	6.42	59.3	53.5	6.1	91.0	1.61	90.5
G	6.42	70.3	56.1	3.0	95.0	1.68	93.9
H	6.16	70.0	54.8	4.0	97.0	1.60	88.9
J	6.88	64.0	54.5	4.3	93.5	1.58	93.7
K	6.83	64.0	52.8	6.2	93.5	1.67	96.3
L	7.30	76.3	56.0	3.5	92.5	1.79	114.0
M	7.04	74.3	55.8	4.7	97.0	1.79	113.0
<u>Late sown</u>							
A	5.91	60.3	56.3	7.3	86.0	1.57	86.8
B	6.12	64.7	51.0	10.0	88.0	1.65	88.9
C	6.22	70.7	54.8	5.8	93.0	1.62	88.7
D	5.59	68.0	53.0	7.0	87.0	1.56	74.3
E	6.42	62.7	52.8	10.2	87.5	1.59	89.8
F	6.16	65.0	49.3	14.1	84.0	1.74	93.8
G	6.43	76.3	55.0	7.3	83.0	1.68	94.3
H	6.31	73.0	53.1	9.4	91.0	1.73	93.7
J	6.97	67.0	50.6	11.5	80.5	1.70	102.1
K	5.79	66.0	47.1	22.4	91.5	1.67	82.4
L	6.67	77.0	52.8	8.1	84.5	1.66	94.9
M	6.29	77.7	52.3	10.9	95.5	1.81	97.5
Sed	0.484	2.40	1.54	1.25	4.6	0.12	15.9

**Table 112 Crosshail Treatment means**

	Yield t/ha at 85% DM	Straw length cm	TCW (g)	Screenings % <2.5mm	Germ Energy		Grain N%	Grain N kg/ha
					5ml	8ml		
Nitrogen (kg/ha)								
60	5.74	62.3	53.7	5.8	91.4	22.0	1.56	81.0
100	6.37	67.0	53.5	7.2	90.0	21.4	1.66	92.9
140	6.72	70.8	52.8	8.9	91.0	21.6	1.71	99.2
Sed	0.171	1.70	0.55	0.44	1.6	2.3	0.04	5.6
Growth Regulator (Terpal)								
+	6.25	61.8	52.1	8.7	89.9	22.0	1.61	89.4
-	6.30	71.6	54.5	5.8	91.7	21.2	1.67	92.6
Sed	0.140	1.39	0.45	0.36	1.3	1.9	0.03	4.6
Late Fungicide (Tilt Turbo)								
+	6.39	66.8	54.2	6.0	89.4	21.0	1.63	92.3
-	6.16	66.6	52.4	8.6	92.2	22.2	1.66	89.8
Sed	0.140	1.39	0.45	0.36	1.3	1.9	0.03	4.6
Time of Sowing								
Early	6.32	64.4	54.3	4.3	94.1	24.3	1.62	91.5
Late	6.24	69.0	52.4	10.3	87.5	19.0	1.64	90.6
Sed	0.140	1.39	0.45	0.36	1.3	1.9	0.03	4.6

**Table 113 PANTATHY 1992**

Code	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	Grain N%	Grain N kg/ha
<u>Early Sown</u>						
A	5.95	52.7	6.6	98.0	1.45	73.2
B	6.08	52.4	7.6	97.0	1.49	79.7
C	6.01	52.4	6.6	97.0	1.54	81.9
D	5.95	54.4	5.7	97.0	1.55	77.8
E	6.38	50.2	8.5	96.5	1.59	90.5
F	6.30	52.8	6.6	95.5	1.55	84.9
G	6.30	54.5	7.4	97.0	1.58	87.9
H	6.60	53.0	7.5	98.5	1.57	91.1
J	6.68	51.2	8.3	98.0	1.59	92.7
K	6.46	48.8	9.4	96.5	1.62	91.6
L	7.03	51.6	8.9	98.0	1.68	102.7
M	6.92	50.2	10.8	98.0	1.64	100.7
<u>Late sown</u>						
A	6.10	54.6	9.2	92.5	1.56	84.9
B	5.74	49.9	9.2	95.5	1.53	74.0
C	5.76	49.4	5.8	93.0	1.60	79.3
D	5.90	55.0	7.4	98.0	1.58	81.3
E	6.17	51.0	10.0	95.0	1.67	90.4
F	6.00	50.4	11.0	98.0	1.63	85.5
G	5.95	54.2	7.3	93.5	1.74	89.0
H	6.15	49.0	8.3	98.5	1.75	93.8
J	5.77	51.3	12.3	93.0	1.77	87.5
K	5.96	48.6	18.2	92.5	1.76	90.4
L	6.07	50.7	10.3	96.5	1.87	96.0
M	5.95	51.9	10.5	92.0	1.82	93.1
Sed	0.279	2.33	2.65	1.7	0.05	7.3

**Table 114 Panlathy treatment means**

	Yield in t/ha at 85% DM	TCW (g)	Screenings % < 2.5mm	Germ Energy		Grain N%	Grain N kg/ha
				5ml	8ml		
Nitrogen (kg/ha)							
60	5.94	52.6	7.2	96.0	38.6	1.54	79.0
100	6.23	51.9	8.3	96.5	39.6	1.63	89.1
140	6.36	50.5	11.1	95.5	42.2	1.72	94.3
Sed	0.098	0.82	0.94	0.58	3.34	0.018	2.6
Growth Regulator (Terpal)							
+	6.13	51.1	9.7	95.6	42.0	1.60	85.4
-	6.22	52.2	8.0	96.4	38.3	1.66	89.6
Sed	0.080	0.67	0.77	0.48	2.72	0.015	2.1
Late Fungicide (Tilt Turbo)							
+	6.18	52.0	8.4	95.6	42.0	1.63	88.0
-	6.17	51.3	9.3	96.4	38.3	1.62	87.0
Sed	0.080	0.67	0.77	0.48	2.72	0.015	2.1
Time of Sowing							
Early	6.39	52.0	7.8	97.2	38.4	1.57	87.9
Late	5.96	51.3	9.9	94.8	41.9	1.69	87.1
Sed	0.080	0.67	0.77	0.48	2.72	0.015	2.1

**Table 115 WITHCALL 1992**

Code	Yield in t/ha at 85% DM	Straw length (cm)	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml	Germ Energy 8ml	Grain N%	Grain N kg/ha
Early								
A	5.23	58.7	46.7	15.5	62.5	31.5	1.35	60.3
B	4.85	57.3	45.2	16.6	62.0	37.0	1.42	60.5
C	5.03	60.7	47.9	12.7	60.0	36.0	1.43	61.4
D	4.87	65.3	47.8	13.3	54.0	33.0	1.48	62.4
E	5.71	62.0	46.4	18.8	60.5	46.0	1.48	71.7
F	5.26	61.3	44.3	26.3	61.0	33.0	1.49	67.3
G	5.50	64.3	48.0	14.7	57.5	40.5	1.46	68.5
H	5.44	65.3	46.1	16.9	46.5	41.5	1.43	68.5
J	6.08	62.3	46.9	20.4	54.5	35.5	1.50	78.9
K	5.46	62.3	43.8	35.9	64.0	36.5	1.59	76.3
L	5.93	67.3	48.3	19.5	50.5	29.5	1.55	79.6
M	5.26	68.0	43.3	39.1	57.0	42.0	1.59	72.8
Late								
A	4.92	58.0	49.8	12.8	59.0	36.0	1.35	57.7
B	4.48	57.3	46.7	21.2	68.0	35.0	1.44	57.9
C	4.95	63.3	48.5	14.7	68.0	47.0	1.40	57.9
D	4.55	60.7	47.0	16.6	63.0	39.0	1.44	58.7
E	5.27	59.7	47.4	20.8	66.5	40.0	1.49	70.4
F	4.89	60.3	45.0	29.0	67.0	39.0	1.44	63.3
G	5.10	67.7	49.2	19.1	64.0	39.0	1.42	65.1
H	4.70	66.0	45.5	31.5	63.0	44.0	1.52	65.6
J	5.47	64.0	45.9	27.2	60.5	39.0	1.50	72.1
K	4.80	61.0	48.5	44.5	63.0	34.0	1.60	68.2
L	5.37	67.7	45.3	27.9	64.0	43.5	1.59	77.2
M	5.11	69.0	46.6	30.8	57.0	41.0	1.57	73.5
Sed	0.304	1.70	2.15	7.05	22.2	16.7	0.05	5.0

**Table 116 Withcall treatment means**

	Yield in t/ha at 85% DM	Straw length (cm)	TCW (g)	Screenings % < 2.5mm	Germ Energy		Grain N%	Grain N kg/ha
					5ml	8ml		
Nitrogen (kg/ha)								
70	4.86	60.2	47.47	15.45	62.1	36.8	1.41	59.6
110	5.23	63.3	46.51	22.15	60.8	40.4	1.46	67.6
150	5.43	65.2	46.08	30.70	58.9	37.6	1.56	74.8
Sed	0.107	0.60	0.76	0.76	7.8	5.9	0.019	1.8
Growth regulator (Terpal)								
+	5.20	60.4	46.40	24.10	62.4	36.9	1.47	67.1
-	5.15	65.4	46.97	21.44	58.7	39.7	1.49	67.6
Sed	0.088	0.49	0.62	0.88	6.3	3.8	0.016	1.4
Late Fungicide (Tilt Turbo)								
+	5.38	63.0	47.55	18.70	60.6	38.6	1.46	68.4
-	4.97	62.8	45.83	26.85	60.5	37.9	1.50	66.3
Sed	0.088	0.49	0.62	0.88	6.3	3.8	0.016	1.4
Time of Sowing								
Early	5.39	62.9	46.24	20.84	57.5	36.8	1.48	69.0
Late	4.97	62.9	47.13	24.70	63.6	39.7	1.48	65.6
Sed	0.088	0.49	0.62	0.88	6.3	3.8	0.016	1.4

**Table 117 SUNNYBRAE, ABERDEEN 1992**

Code	Yield in t/ha at 85% DM	Straw length cm	Leaning %	Necking %	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	% Split grain	Grain N% N	Grain kg/ha
Early										
A	6.21	60.7	3.7	10.0	50.6	6.0	80.0 27.0	4.5	1.37	75.1
B	5.99	60.0	6.7	6.0	49.8	6.9	89.0 26.0	0.5	1.40	73.0
C	6.06	70.0	13.3	37.5	50.9	4.2	84.5 17.5	0.5	1.37	71.2
D	5.86	67.3	8.3	52.5	51.2	5.2	93.5 30.5	0.5	1.38	69.7
E	6.77	64.7	11.7	11.0	49.3	6.2	88.5 33.5	2.5	1.48	86.5
F	6.49	62.3	13.3	10.0	49.6	7.0	85.0 25.0	2.0	1.48	82.1
G	6.80	75.3	43.3	45.0	51.7	4.7	79.5 26.5	2.0	1.41	81.2
H	6.72	75.3	36.7	12.5	49.9	6.1	80.0 26.0	4.0	1.50	87.2
J	7.40	66.0	31.7	7.5	49.3	8.2	83.5 20.0	6.5	1.56	98.7
K	7.33	70.0	36.7	15.0	48.3	9.0	71.0 24.5	3.5	1.61	102.0
L	7.40	78.7	60.0	40.0	53.5	5.8	87.0 17.5	6.5	1.59	101.2
M	7.35	77.7	80.0	40.0	49.1	6.6	70.5 35.5	2.0	1.61	100.3
Late										
A	5.28	66.3	13.3	1.7	49.2	8.4	70.5 37.5	7.5	1.46	67.8
B	5.31	70.3	15.0	3.7	49.0	9.0	85.0 52.5	2.5	1.50	69.0
C	5.56	75.3	28.3	3.0	50.3	8.8	72.5 49.0	5.5	1.60	77.6
D	5.32	74.7	25.0	2.0	50.6	7.2	82.5 45.0	2.0	1.54	71.0
E	5.77	71.3	40.0	0.7	49.8	13.6	71.0 29.5	6.5	1.66	84.1
F	5.49	74.3	63.3	2.3	51.0	10.7	85.0 54.0	5.0	1.60	74.8
G	5.87	79.3	25.0	1.3	49.6	8.1	68.5 38.5	6.5	1.69	89.4
H	5.87	78.3	50.0	3.3	50.4	10.9	89.0 49.5	1.0	1.70	85.6
J	5.93	72.0	61.7	1.0	49.5	10.5	70.0 31.0	9.0	1.67	84.0
K	5.72	78.0	88.3	4.0	49.2	12.7	89.0 46.0	3.0	1.69	80.9
L	6.19	77.7	76.7	1.7	49.4	10.9	80.0 47.5	5.5	1.74	90.2
M	5.92	81.7	93.3	3.7	50.2	11.3	86.5 49.0	1.0	1.73	88.3
Sed	0.177	3.11	17.6		1.28	1.80	6.63 8.63	2.69	0.057	3.7

**Table 118 Sunnybrae treatment means**

	Yield in t/ha at 85% DM	Straw length cm	Leaning %	Necking %	TCW (g)	Screenings % <2.5mm	Germ Energy 5ml	Germ Energy 8ml	% Split grain	Grain N%	Grain N kg/ha
Nitrogen (kg/ha)											
70	5.70	68.1	14.2	14.6	50.2	6.9	82.2	35.6	2.94	1.45	71.8
110	6.22	72.6	35.4	10.8	50.2	8.4	80.8	35.3	3.69	1.56	83.9
150	6.66	75.2	66.1	14.1	49.8	9.3	79.7	33.8	4.63	1.65	93.2
Sed	0.063	1.12	6.24		0.44	0.63	2.34	3.04	0.95	0.020	1.3
Growth regulator (Terpal)											
+	6.14	68.0	32.1	6.1	49.6	9.0	80.5	33.8	4.42	1.54	81.5
-	6.24	75.9	45.0	20.2	50.6	7.4	81.2	36.0	3.08	1.57	84.4
Sed	0.051	0.91	5.10		0.5	0.73	2.70	3.51	0.78	0.016	1.1
Late Fungicide (Tilt Turbo)											
+	6.27	71.4	34.1	13.4	50.3	7.9	77.9	31.2	5.25	1.55	83.9
-	6.11	75.9	43.0	12.9	49.9	8.5	83.2	38.6	2.25	1.56	82.0
Sed	0.051	0.91	5.10		0.5	0.73	2.70	3.51	0.78	0.016	1.1
Time of Sowing											
Early	6.70	69.0	28.8	23.9	50.3	6.3	82.6	25.7	2.92	1.47	85.7
Late	5.69	74.9	48.3	2.4	49.9	10.1	79.1	44.0	4.58	1.63	80.2
Sed	0.051	0.91	5.10		0.51	0.73	2.70	3.51	0.78	0.016	1.1

**Table 119 ALDROUGHTRY, ELGIN 1992**

Code	Yield in t/ha at 85% DM	Leaning %	Straw length cm	Mildew % 9 Jul	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml 8ml	% Split grain	Grain N%	Grain N kg/ha
Earlyly										
A	6.11	0	56.7	1.50	54.4	6.7	77.5 15.5	4.5	1.81	95.9
B	5.61	0	54.2	11.67	52.2	9.7	79.5 21.5	1.0	1.76	84.8
C	6.24	0	68.3	0.67	55.1	4.6	72.0 17.0	2.0	1.72	89.2
D	6.01	0.3	71.2	13.33	55.0	14.3	92.0 21.0	1.0	1.97	101.4
E	6.44	0	59.7	1.17	52.1	7.9	79.0 14.5	5.0	1.90	102.3
F	5.82	0	54.2	18.33	49.9	13.2	77.5 15.5	1.0	1.86	91.4
G	6.36	0	71.5	1.67	55.2	5.4	80.5 19.0	3.5	1.96	104.4
H	6.08	1.7	71.0	9.33	55.0	7.7	91.0 25.5	2.0	2.04	107.3
J	6.57	0	58.0	1.67	52.2	11.0	72.0 19.5	4.0	2.03	111.6
K	6.01	3.7	56.2	25.00	50.6	9.6	77.5 19.0	3.5	2.05	101.7
L	6.65	0.7	68.8	1.17	54.5	6.5	83.0 13.0	3.0	2.02	113.6
M	6.12	7.3	71.5	15.00	53.4	8.2	92.0 15.0	1.5	2.08	110.8
Late										
A	4.84	0	55.3	11.67	53.0	8.9	72.5 19.5	8.5	1.82	74.0
B	4.62	0	54.3	26.67	50.3	10.9	87.5 39.5	4.0	1.74	68.8
C	5.09	0	70.0	4.67	55.7	4.9	79.0 21.0	8.5	1.78	77.9
D	4.94	0	69.3	15.67	54.9	4.8	88.0 28.5	5.0	1.75	73.8
E	5.09	0	56.5	5.00	51.6	9.5	69.0 25.5	10.0	1.92	82.2
F	4.50	0	55.5	31.67	50.0	13.5	77.5 31.0	3.5	1.88	72.2
G	5.00	0	70.0	5.67	55.6	6.3	74.0 20.0	7.5	2.00	86.1
H	4.99	0.3	72.0	33.33	52.4	8.1	80.0 28.5	6.5	1.97	81.8
J	4.93	0	57.2	11.67	51.9	10.6	77.0 22.0	5.5	2.12	88.8
K	4.43	0.7	57.3	35.00	48.5	18.5	71.0 36.0	4.0	2.05	77.6
L	5.49	0.3	71.3	9.00	54.2	6.6	76.0 19.5	7.5	2.00	95.7
M	4.93	0.7	74.0	28.33	52.2	9.0	81.5 37.0	2.0	2.00	85.1
Sed	0.205	0.85	2.26	4.7	1.13	3.5	8.90 6.93	2.69	0.150	5.3

**Table 120 Aldrougthy treatment means**

	Yield in t/ha at 85% DM	Leaning %	Straw length cm	Mildew %	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml	Germ Energy 8ml	% Split grain	Grain N%	Grain N kg/ha
Nitrogen (kg/ha)											
80	5.43	0	62.4	10.8	53.8	8.1	81.0	22.8	4.3	1.79	83.2
120	5.54	0.3	63.8	13.3	52.7	8.9	78.5	22.3	4.9	1.94	91.0
160	5.64	1.7	64.3	15.9	52.2	10.0	78.7	22.5	3.9	2.04	98.1
Sed	0.072	0.31	0.80	1.65	0.40	1.2	3.14	2.43	0.94	0.058	1.9
Growth regulator (Terpal)											
+	5.41	0.4	56.3	15.1	51.4	10.8	76.5	23.2	4.5	1.91	87.6
-	5.66	0.9	70.7	11.5	54.4	7.2	82.4	20.0	4.2	1.94	93.9
Sed	0.059	0.25	0.65	1.35	0.33	1.0	3.63	2.80	0.77	0.043	1.5
Late Fungicide (Tilt Turbo)											
+	5.73	0.1	63.6	4.7	53.8	7.4	76.0	18.8	5.79	1.92	93.5
-	5.34	1.2	63.4	21.9	52.0	10.6	82.8	26.5	2.92	1.93	88.1
Sed	0.059	0.25	0.65	1.35	0.33	1.0	3.63	2.80	0.77	0.043	1.5
Time of Sowing											
Early	6.17	1.14	63.4	8.38	53.3	8.7	81.2	18.0	2.67	1.93	101.2
Late	4.90	0.17	63.6	18.20	52.5	9.3	77.7	27.2	6.04	1.92	80.3
Sed	0.059	0.25	0.65	1.35	0.33	1.0	3.63	2.80	0.77	0.043	1.5

**Table 121 CROSSHALL 1993**

Code	Yield t/ha at 85% DM	Straw length cm	Mildew %	Rhynchosporium %	TCW (g)	Screenings % <2.5mm	Germ Energy		Grain N%	Grain N kg/ha
							5ml	8ml		
<u>Early Sown</u>										
A	7.61	76.0	0	0	54.5	6.20	91.5	45.5	1.50	98.5
B	7.60	75.3	0.33	0	55.6	6.50	86.0	53.0	1.51	97.8
C	7.31	82.7	0	0	56.5	5.10	89.0	50.0	1.53	97.9
D	7.33	87.3	0	0	55.8	6.10	89.5	52.0	1.54	98.6
E	8.21	83.0	0	0.03	55.1	5.80	83.0	62.0	1.60	112.2
F	8.33	83.0	0	0	54.8	6.30	85.5	46.5	1.56	109.3
G	8.18	88.7	0	0.03	55.5	5.15	85.0	41.5	1.58	109.8
H	7.65	88.0	0	0	55.9	4.55	90.0	54.5	1.60	104.9
J	8.56	86.3	0	0	53.8	8.95	85.5	41.5	1.59	115.9
K	8.60	88.7	0.33	0.70	54.7	6.25	81.5	48.5	1.67	123.1
L	8.82	92.0	0.03	0	56.0	5.75	85.5	46.0	1.67	125.2
M	8.43	93.0	0.03	0.03	55.1	5.25	82.5	46.0	1.67	118.4
<u>Late sown</u>										
A	7.59	74.0	0.40	0.37	54.7	6.95	91.5	26.5	1.72	111.2
B	7.37	75.0	1.73	0.07	54.5	7.00	92.5	35.0	1.71	109.6
C	7.46	80.0	0.70	0.20	55.9	4.70	91.5	37.0	1.76	109.1
D	7.07	81.7	0.80	0.03	55.9	5.05	91.0	48.0	1.76	106.9
E	7.82	74.7	0.70	0	54.4	6.60	82.5	31.0	1.73	116.6
F	7.78	77.7	2.67	0.03	53.0	6.75	94.0	35.5	1.77	117.5
G	7.54	85.7	0.83	0	56.4	4.65	89.0	34.5	1.83	117.5
H	7.45	87.0	2.73	0.03	55.4	5.00	96.5	41.5	1.79	113.7
J	8.24	80.3	0.40	0	55.1	5.35	94.5	35.5	1.84	127.6
K	7.82	78.0	4.00	0	52.5	9.35	94.0	36.0	1.82	121.6
L	8.05	89.0	4.67	0	55.1	4.35	95.0	32.5	1.87	128.2
M	7.98	88.3	2.77	0.20	55.3	5.55	94.5	31.5	1.91	129.7
Sed	0.201	1.98	1.05	0.21	0.88	1.56	4.8	7.1	0.075	5.86

**Table 122 Crosshail Treatment means**

	Yield t/ha at 85% DM	Straw length cm	Mildew % 16 Jul	Rhynchosporium % 16 Jul	TCW (g)	Screenings % <2.5mm	Germ Energy		Grain N%	Grain N kg/ha
							5ml	8ml		
Nitrogen (kg/ha)										
70	7.36	79.0	0.50	0.08	55.4	5.95	90.3	43.4	1.63	103.7
110	7.81	83.6	0.87	0.02	55.1	5.60	88.2	43.4	1.68	112.7
150	8.25	87.0	1.53	0.12	54.7	6.35	89.1	39.7	1.76	123.7
Sed	0.071	0.70	0.37	0.076	0.31	0.55	1.71	2.48	0.026	2.07
Growth Regulator (Terpal)										
+	7.90	79.4	0.88	0.10	54.4	6.83	88.5	41.4	1.67	113.4
-	7.71	87.0	1.05	0.04	55.7	5.10	89.9	42.9	1.71	113.3
Sed	0.058	0.57	0.30	0.062	0.25	0.45	1.39	2.02	0.022	1.69
Late Fungicide (Tilt Turbo)										
+	7.88	82.7	0.64	0.05	55.3	5.80	88.6	40.3	1.69	114.1
-	7.72	83.6	1.28	0.09	54.9	6.14	89.8	44.0	1.69	112.6
Sed	0.058	0.57	0.30	0.062	0.25	0.45	1.39	2.02	0.022	1.69
Time of Sowing										
Early	8.05	85.4	0.06	0.07	55.3	5.99	86.2	48.9	1.59	109.3
Late	7.55	81.0	1.86	0.08	54.9	5.94	92.2	35.4	1.79	117.5
Sed	0.058	0.57	0.30	0.062	0.25	0.45	1.39	2.02	0.022	1.69

**Table 123 BUSH 1993**

Code	Yield in t/ha at 85% DM	Mildew % 22 Jul	Straw Length (cm)	Rhynchosporium % 22 July	TCW (g)	Screenings % < 2.5mm	Germ		Grain N%	Grain N kg/ha
							5ml Energy	8ml		
A	4.59	0	65.0	0	49.7	10.1	88.0	51.0	1.16	45.2
B	4.43	0	69.0	0.03	50.2	9.3	91.0	60.0	1.14	42.8
C	4.56	0	71.3	0	49.9	10.2	87.5	53.5	1.17	45.1
D	4.76	0	71.3	0.33	51.0	9.3	86.0	54.5	1.21	48.8
E	5.67	0	73.0	0	51.0	9.5	94.0	61.0	1.23	59.2
F	5.09	0	73.0	0	50.8	9.5	72.5	47.5	1.21	52.6
G	5.54	0	79.0	0	52.0	7.4	90.5	59.5	1.23	57.9
H	5.43	0	79.0	0.07	51.4	8.5	88.0	52.0	1.30	59.8
J	5.59	0	79.0	0	51.8	8.5	90.0	44.5	1.26	59.6
K	5.71	0	78.0	0.20	51.6	9.6	85.5	62.5	1.33	64.2
L	5.65	0	81.7	0	52.6	8.7	90.0	56.0	1.30	62.5
M	5.96	0.03	82.3	0.10	52.0	7.0	89.5	56.5	1.34	67.6
<u>Late sown</u>										
A	4.00	0.07	68.0	0.03	50.4	16.5	75.5	19.0	1.33	45.4
B	3.91	2.00	66.0	0.03	49.5	15.2	85.5	28.0	1.29	42.9
C	3.83	0.03	71.7	0.03	52.5	13.1	83.0	20.0	1.31	42.8
D	3.76	2.33	69.3	0.03	50.7	14.2	87.5	34.0	1.34	42.8
E	4.36	0.10	71.0	0	48.6	15.9	74.0	21.0	1.32	49.2
F	4.53	4.67	72.0	0.17	50.5	14.4	75.5	34.5	1.40	54.0
G	4.37	0.23	72.3	0.03	52.4	14.0	81.0	28.0	1.39	51.6
H	4.49	3.67	73.3	0.07	52.1	14.0	80.0	28.0	1.45	55.4
J	4.85	0.73	75.0	0.03	50.7	15.7	89.0	23.5	1.39	57.2
K	4.66	0.67	75.3	0.07	50.7	17.0	77.5	23.5	1.42	56.6
L	5.01	0.23	82.0	0.03	53.9	12.9	88.0	23.0	1.51	64.2
M	4.70	7.00	79.3	0.20	52.5	13.6	84.5	21.5	1.49	59.5
SED	0.290	0.740	2.97	0.126	1.15	1.40	6.50	7.6	0.061	5.17

Table 124 Bush treatment means		Mildew		Straw length		Rhynchosporium		TCW		Screenings		Germ Energy		Grain	
Yield in t/ha at 85% DM		22 Jul		(cm)		22 July		(g)		% < 2.5mm		5ml		8ml	
Nitrogen (kg/ha)															
80	4.23	0.55	0.55	69.0	69.0	0.06	0.06	50.5	50.5	12.2	12.2	85.5	40.0	1.24	44.5
120	4.94	1.08	1.08	74.1	74.1	0.04	0.04	51.1	51.1	11.6	11.6	81.9	41.4	1.32	55.0
160	5.27	1.83	1.83	79.1	79.1	0.08	0.08	52.0	52.0	11.6	11.6	86.8	38.9	1.38	61.4
Sed	0.103	0.224	0.224	1.00	1.00	0.046	0.046	0.405	0.405	0.50	0.50	2.31	2.70	0.021	1.83
Growth Regulator (Terpal)															
+	4.78	1.19	1.19	72.0	72.0	0.08	0.08	50.5	50.5	12.6	12.6	83.2	39.7	1.29	52.4
-	4.84	1.13	1.13	76.1	76.1	0.05	0.05	51.9	51.9	11.1	11.1	86.3	40.5	1.34	54.8
Sed	0.084	0.183	0.183	0.81	0.81	0.038	0.038	0.33	0.33	0.40	0.40	1.88	2.20	0.017	1.49
Late Fungicide (Tilt Turbo)															
+	4.84	0.12	0.12	74.1	74.1	0.01	0.01	51.3	51.3	11.9	11.9	85.9	38.3	1.30	53.3
-	4.79	2.20	2.20	74.0	74.0	0.11	0.11	51.1	51.1	11.8	11.8	83.6	41.9	1.33	53.9
Sed	0.084	0.183	0.183	0.81	0.81	0.038	0.038	0.33	0.33	0.40	0.40	1.88	2.20	0.017	1.49
Time of Sowing															
Early	5.25	0	0	75.1	75.1	0.06	0.06	51.2	51.2	9.0	9.0	87.7	54.9	1.24	55.4
Late	4.37	2.31	2.31	72.9	72.9	0.06	0.06	51.2	51.2	14.7	14.7	81.8	25.3	1.39	51.8
Sed	0.084	0.183	0.183	0.81	0.81	0.038	0.038	0.33	0.33	0.40	0.40	1.88	2.20	0.017	1.49

**Table 125 WITHCALL 1993**

Code	Yield in t/ha at 85% DM	Straw length (cm)	TCW (g)	Screenings & < 2.5mm	Germ Energy		Grain N%	Grain N kg/ha
					5ml	8ml		
<b>Early</b>								
A	4.54	65.7	45.2	19.15	69.0	45.0	1.25	49.2
B	4.25	65.5	44.2	23.25	68.0	43.5	1.30	49.3
C	4.59	71.9	44.7	20.00	52.0	44.0	1.25	48.8
D	4.44	71.8	43.9	24.05	71.0	47.5	1.26	48.5
E	4.95	72.3	43.5	25.50	64.5	51.0	1.31	57.6
F	4.82	71.1	43.7	27.70	72.5	52.5	1.27	52.9
G	5.03	72.3	44.9	24.55	72.0	53.0	1.32	56.6
H	4.79	75.0	43.3	30.75	81.0	45.5	1.30	54.2
J	5.04	71.8	43.0	33.90	71.0	50.5	1.37	59.7
K	4.79	73.7	42.4	37.15	70.0	57.5	1.34	54.4
L	5.26	79.9	44.3	27.00	83.5	50.0	1.35	60.2
M	4.92	77.2	42.5	37.15	68.0	53.5	1.34	56.8
<b>Late</b>								
A	4.62	63.3	44.3	22.35	90.0	56.5	1.33	54.2
B	4.56	64.6	44.1	22.85	91.5	56.5	1.28	52.9
C	4.84	71.8	43.0	28.15	94.5	73.5	1.28	51.7
D	4.37	71.7	42.6	29.60	94.5	72.5	1.29	47.7
E	5.13	67.5	44.2	22.30	87.0	64.5	1.35	61.3
F	4.96	67.5	42.1	33.25	87.0	64.5	1.35	58.6
G	5.09	73.9	44.9	23.20	87.5	66.5	1.33	58.9
H	4.53	74.6	41.2	42.45	95.5	83.0	1.31	50.4
J	4.88	71.3	42.4	39.00	93.5	69.0	1.34	56.6
K	4.56	71.1	39.8	56.00	94.0	67.5	1.37	52.1
L	4.92	79.0	41.1	54.15	96.5	76.0	1.40	56.8
M	4.77	79.4	41.6	43.45	89.0	73.0	1.34	53.4
Sed	0.276	1.66	1.56	9.72	6.1	7.8	0.035	5.00

**Table 126 Withcall treatment means**

	Yield in t/ha at 85% DM	Straw length (cm)	TCW (g)	Screenings % < 2.5mm	Germ Energy		Grain N%	Grain N kg/ha
					5ml	8ml		
Nitrogen (kg/ha)								
60	4.53	68.3	44.0	23.68	78.8	54.9	1.28	50.3
100	4.91	71.8	43.5	28.71	80.9	60.1	1.32	56.3
140	4.68	75.4	42.1	40.98	83.2	62.1	1.36	56.3
Sed	0.097	0.59	0.45	3.44	1.77	2.7	0.013	1.77
Growth regulator (Terpal)								
+	4.76	68.8	43.2	30.20	79.8	56.5	1.32	54.9
-	4.80	74.9	43.2	32.04	82.1	61.5	1.31	53.7
Sed	0.080	0.48	0.37	2.81	1.44	2.2	0.010	1.44
Late Fungicide (Tilt Turbo)								
+	4.91	71.7	43.8	28.27	80.1	58.3	1.32	56.0
-	4.65	71.9	42.6	33.97	81.8	59.8	1.31	52.6
Sed	0.080	0.48	0.37	2.81	1.44	2.2	0.010	1.44
Time of Sowing								
Early	4.79	72.4	43.8	27.51	70.2	49.5	1.31	54.0
Late	4.77	71.3	42.6	34.73	91.7	68.6	1.33	54.6
Sed	0.080	0.48	0.37	2.81	1.44	2.2	0.010	1.44

Table 127 SUNNYBRAE, ABERDEEN 1993												
Code	Yield in t/ha at 85% DM	Straw length cm	Leaning %	TCW (g)	Screenings % < 2.5mm	Germ Energy 5ml	Mildew %	Rhynchosporium %	Grain N%	Grain N	Grain kg/ha	
Early Sown												
A	6.63	61.8	0.0	48.2	9.65	91.0	38.0	0	0.67	1.52	85.4	
B	6.72	64.0	1.7	48.1	11.00	91.5	41.0	0	1.33	1.55	87.4	
C	5.94	72.3	0.0	51.9	5.95	90.0	39.0	0	0.70	1.64	80.7	
D	5.68	74.3	0.0	52.2	5.30	90.5	47.5	0.03	0.67	1.63	75.4	
E	6.90	64.0	0.0	48.7	10.00	87.0	34.0	0	1.83	1.54	90.5	
F	7.20	69.0	0.0	48.0	11.55	95.0	56.5	0	1.33	1.60	96.8	
G	6.31	76.5	6.7	52.6	6.10	90.0	50.5	0	1.70	1.67	84.8	
H	6.31	78.7	6.7	52.2	5.50	89.5	50.5	0	1.03	1.75	89.7	
J	7.55	71.8	6.7	49.4	10.30	94.5	38.0	0	1.67	1.63	100.3	
K	6.97	67.3	3.3	48.3	11.45	87.0	55.5	0	0.87	1.58	91.5	
L	6.34	83.8	10.0	52.3	5.15	94.0	35.0	0	2.33	1.73	87.8	
M	6.41	82.5	8.3	52.5	6.25	89.5	38.5	0.03	1.50	1.78	91.7	
Late Sown												
A	5.94	78.7	43.3	49.9	12.60	62.0	38.0	2.00	0.20	1.73	84.1	
B	5.63	80.3	40.0	48.6	13.50	78.0	56.0	2.67	0.07	1.68	78.0	
C	5.55	80.3	53.3	50.0	10.20	72.0	40.0	1.00	0.03	1.61	73.3	
D	5.51	80.8	56.7	49.2	11.35	72.5	40.5	1.67	0.07	1.64	74.3	
E	5.90	82.7	75.0	48.3	15.75	69.0	42.5	2.33	0.03	1.74	83.8	
F	5.94	83.8	83.3	47.0	18.25	75.0	51.0	4.00	0.17	1.78	88.2	
G	6.18	84.7	73.3	48.8	13.15	59.0	48.0	3.33	0.10	1.74	89.0	
H	6.21	85.2	75.0	48.3	15.20	76.0	54.0	4.00	0.07	1.70	86.4	
J	6.07	85.7	80.0	46.6	21.15	67.0	47.0	2.67	0.03	1.92	95.7	
K	5.88	81.5	73.3	45.6	22.20	71.5	49.5	4.33	0.20	1.81	88.0	
L	6.07	90.0	83.3	47.8	15.15	65.0	42.0	3.67	0.23	1.82	93.9	
M	5.96	89.7	88.3	45.9	20.30	71.0	46.5	3.67	0.03	1.84	92.4	
Sed	0.307	2.50		1.41	3.22	4.5	7.9	0.85	0.49	0.096	9.8	

**Table 128 Sunnybrae treatment means**

	Yield in t/ha at 85% DM	Straw length cm	Leaning %	TCW (g)	Screenings % <2.5mm	Germ Energy 5ml	8ml	Mildew %	Rhynchosporium %	Grain N%	Grain N kg/ha
Nitrogen (kg/ha)											
70	5.95	74.1	24.4	49.8	9.94	80.9	42.5	0.92	0.47	1.63	79.8
110	6.37	78.1	40.0	49.2	11.93	80.1	48.4	1.71	0.78	1.69	88.7
150	6.41	81.5	44.2	48.6	13.99	79.9	44.0	1.80	0.86	1.76	92.7
Sed	0.109	0.89	5.26	0.50	1.14	1.58	2.82	0.30	0.17	0.034	3.5
Growth regulator (Terpal)											
+	6.44	74.2	33.9	48.1	13.95	80.7	45.6	1.25	0.79	1.67	89.1
-	6.04	81.6	38.1	50.3	9.97	79.9	44.3	1.70	0.61	1.71	85.0
Sed	0.089	0.72	4.29	0.41	0.93	1.29	2.30	0.24	0.14	0.028	2.8
Late Fungicide (Tilt Turbo)											
+	6.28	77.7	36.0	49.5	11.26	78.4	41.0	1.50	0.70	1.69	87.4
-	6.20	77.9	36.4	48.8	12.65	82.3	48.9	1.45	0.70	1.70	86.7
Sed	0.089	0.72	4.29	0.41	0.93	1.29	2.30	0.24	0.14	0.028	2.8
Time of Sowing											
Early	6.58	72.2	3.6	50.4	8.18	90.8	43.7	0.01	1.30	1.64	88.5
Late	5.90	83.6	68.7	48.0	15.73	69.8	46.3	2.95	0.10	1.75	85.6
Sed	0.089	0.72	4.29	0.41	0.93	1.29	2.30	0.24	0.14	0.028	2.8

**Table 129 ALDROUGHTY, ELGIN 1993**

Code	Yield in t/ha at 85% DM	Leaning %	Straw length cm	Mildew % 9 Jul	TCW (g)	Screenings % < 2.5mm	Germ		Grain N%	Grain N kg/ha
							5ml Energy	8ml Energy		
Early Sown										
A	5.52	0	67.2	10.0	50.0	8.8	84.5	27.5	1.40	64.7
B	5.84	0	70.2	15.0	49.8	10.6	89.5	30.0	1.52	74.9
C	5.44	0	80.2	8.0	51.5	7.5	92.0	38.5	1.49	69.5
D	5.51	0	78.8	15.0	50.8	8.5	86.5	41.0	1.51	70.3
E	6.13	0	73.3	4.0	50.0	9.7	90.5	42.0	1.51	79.9
F	5.74	5.0	76.2	16.7	48.5	14.9	94.5	36.5	1.53	75.9
G	5.89	3.3	85.1	4.0	50.0	10.0	96.0	41.0	1.52	76.0
H	6.19	10.0	85.5	20.0	50.0	9.7	90.5	35.0	1.53	81.8
J	6.57	1.7	77.2	2.0	50.1	10.5	93.0	37.5	1.58	89.5
K	6.25	8.3	76.2	25.0	48.6	15.4	92.0	39.0	1.56	81.4
L	6.01	3.3	86.7	2.0	50.1	11.5	96.0	39.5	1.64	80.6
M	6.11	13.3	87.7	13.3	48.4	16.5	90.0	36.5	1.60	81.0
Late Sown										
A	3.61	1.7	73.2	6.7	51.1	10.2	87.0	39.5	1.69	53.2
B	4.01	4.0	71.3	20.0	50.5	11.3	92.5	41.5	1.77	69.9
C	3.88	5.0	80.5	5.0	50.3	10.6	85.5	30.5	1.76	60.6
D	3.70	4.0	75.8	15.0	49.9	12.4	81.5	41.0	1.76	64.2
E	4.37	8.3	76.3	5.0	49.1	19.4	90.0	54.0	1.81	72.2
F	3.81	10.0	77.8	20.0	49.3	18.6	82.5	46.5	1.81	64.1
G	4.16	10.0	81.7	5.0	50.6	14.9	89.5	40.5	1.81	65.9
H	4.37	8.3	84.0	13.3	50.2	14.4	91.5	46.0	1.77	65.7
J	4.24	10.0	80.2	8.3	51.0	12.7	87.5	42.0	1.83	71.0
K	3.29	3.3	78.2	21.7	50.2	14.3	93.5	52.5	1.73	58.1
L	4.05	15.0	82.0	4.0	49.3	17.1	92.5	44.0	1.79	64.9
M	3.50	11.7	86.7	13.3	49.8	16.8	95.0	41.5	1.82	53.9
Sed	0.454	3.8	2.89	5.27	1.41	3.23	6.22	7.12	0.105	10.3

Table 130 Aldroughly treatment means												
Nitrogen (kg/ha)	Yield in t/ha at 85% DM	Leaning %	Straw length cm	Mildew %	TCW (g)	Screenings % < 2.5mm	Germ Energy		Grain N%	Grain N kg/ha	Growth regulator (Terpal)	Late Fungicide (Tilt Turbo)
							5ml	8ml				
70	4.69	1.8	74.7	11.8	50.5	10.0	87.4	36.2	1.61	65.9	+	4.99
110	5.08	6.9	80.0	11.0	49.7	14.0	90.6	42.7	1.66	72.7	-	4.86
150	5.00	8.3	81.9	11.2	49.7	14.4	92.4	41.6	1.69	72.6	Sed	0.13
Sed	0.16	1.34	1.02	1.86	0.41	0.93	1.78	1.90	0.037	3.7		
Growth regulator (Terpal)												
+	4.95	4.4	78.4	12.9	49.9	13.0	89.8	40.7	1.65	71.2		
-	4.90	7.0	82.9	9.8	50.1	12.5	90.5	39.6	1.66	69.5		
Sed	0.13	1.10	0.83	1.52	0.33	0.76	1.46	1.55	0.030	3.0		
Late Fungicide (Tilt Turbo)												
+	4.99	4.9	78.6	5.3	49.9	11.9	90.3	39.7	1.65	70.7		
-	4.86	6.5	79.0	17.4	50.1	13.6	90.0	40.6	1.66	70.1		
Sed	0.13	1.10	0.83	1.52	0.33	0.76	1.46	1.55	0.030	3.0		
Time of Sowing												
Early	5.93	3.7	78.7	11.3	49.8	11.1	91.3	37.0	1.53	77.1		
Late	3.92	7.6	79.0	11.4	50.1	14.4	89.0	43.3	1.78	63.6		
Sed	0.13	1.10	0.83	1.52	0.33	0.76	1.46	1.55	0.030	3.0		

**APPENDIX 4 SUMMARY OF RESULTS BY YEARS**

**Table 201 Summary of five 1991 sites**

Code	Yield t/ha at 85% DM	Grain N%	Screenings % <2.5mm
<u>Early sown</u>			
A	6.23	1.42	17.4
B	5.90	1.40	21.6
C	6.10	1.44	13.6
D	5.95	1.44	15.9
E	6.73	1.52	21.3
F	6.21	1.52	26.9
G	6.51	1.54	15.5
H	6.27	1.50	19.7
J	6.70	1.60	25.3
K	6.24	1.64	34.4
L	6.78	1.63	19.0
M	6.47	1.63	23.1
<u>Late sown</u>			
A	5.88	1.45	21.3
B	5.59	1.48	28.4
C	5.86	1.50	19.1
D	5.57	1.52	20.6
E	6.28	1.57	25.8
F	5.66	1.58	35.5
G	6.01	1.61	19.4
H	5.80	1.58	26.5
J	6.05	1.74	34.9
K	5.61	1.73	42.1
L	6.37	1.69	24.7
M	5.68	1.70	30.2
SeD	0.210	0.038	2.89

**Table 202 Summary of five 1991 site treatment means**

	Yield t/ha at 85% DM	Grain N%	Screenings % <2.5mm
<b>Nitrogen(kg/ha)</b>			
Low	5.88	1.46	19.8
Moderate	6.18	1.55	23.9
High	6.24	1.67	29.3
SeD	0.074	0.014	1.02
<b>Growth Regulator (Terpal)</b>			
+	6.09	1.55	27.9
-	6.11	1.56	20.6
SeD	0.061	0.011	0.83
<b>Late Fungicide</b>			
+	6.29	1.56	21.5
-	5.91	1.56	27.1
SeD	0.061	0.011	0.83
<b>Time of Sowing</b>			
Early	6.34	1.52	21.2
Late	5.86	1.59	27.4
SeD	0.061	0.011	0.83

**Table 203 Summary of five 1992 sites**

Code	Yield t/ha at 85% DM	Grain N%	Screenings % <2.5mm
<u>Early sown</u>			
A	5.77	1.49	7.8
B	5.60	1.51	9.1
C	5.76	1.52	6.2
D	5.69	1.59	8.6
E	6.39	1.62	9.0
F	6.06	1.60	11.8
G	6.28	1.62	7.0
H	6.20	1.63	8.4
J	6.72	1.65	10.4
K	6.42	1.71	14.0
L	6.86	1.73	8.8
M	6.54	1.74	13.9
<u>Late sown</u>			
A	5.41	1.55	9.3
B	5.25	1.57	12.1
C	5.52	1.60	8.0
D	5.26	1.57	8.6
E	5.74	1.67	12.8
F	5.41	1.66	15.7
G	5.67	1.71	9.6
H	5.60	1.73	13.6
J	5.81	1.75	14.4
K	5.34	1.75	23.3
L	5.96	1.77	12.8
M	5.64	1.79	14.5
SeD	0.211	0.039	2.29

**Table 204 Summary of five 1992 site treatment means**

	Yield t/ha at 85% DM	Grain N%	Screenings % <2.5mm
Nitrogen (kg/ha)			
Low	5.53	1.55	8.7
Moderate	5.92	1.66	11.0
High	6.16	1.74	14.0
SeD	0.076	0.014	0.81
Growth Regulator (Terpal)			
+	5.83	1.63	12.5
-	5.92	1.67	10.0
SeD	0.062	0.011	0.66
Late Fungicide			
+	5.99	1.64	9.7
-	5.75	1.66	12.8
SeD	0.062	0.011	0.66
Time of Sowing			
Early	6.19	1.62	9.6
Late	5.55	1.68	12.9
SeD	0.062	0.011	0.66

**Table 205 Summary of five 1993 sites**

Code	Yield t/ha at 85% DM	Grain N%	Screenings % <2.5mm
<u>Early sown</u>			
A	5.78	1.37	10.8
B	5.77	1.40	12.1
C	5.57	1.42	9.8
D	5.54	1.43	10.7
E	6.37	1.44	12.1
F	6.24	1.43	14.0
G	6.19	1.46	10.6
H	6.07	1.50	11.8
J	6.66	1.49	14.4
K	6.46	1.50	16.0
L	6.42	1.54	11.6
M	6.37	1.55	14.4
<u>Late sown</u>			
A	5.15	1.56	13.7
B	5.10	1.55	14.0
C	5.11	1.54	13.4
D	4.88	1.56	14.5
E	5.52	1.59	16.0
F	5.40	1.62	18.3
G	5.47	1.62	14.0
H	5.41	1.60	18.2
J	5.66	1.66	18.8
K	5.24	1.63	23.8
L	5.62	1.68	20.7
M	5.38	1.68	19.9
SeD	0.297	0.037	2.93

**Table 206 Summary of five 1993 site treatment means**

	Yield t/ha at 85% DM	Grain N%	Screenings % <2.5mm
Nitrogen (kg/ha)			
Low	5.36	1.48	12.4
Moderate	5.83	1.54	14.4
High	5.98	1.59	17.5
SeD	0.105	0.013	1.04
Growth Regulator (Terpal)			
+	5.78	1.52	15.3
-	5.67	1.55	14.1
SeD	0.086	0.011	0.84
Late Fungicide			
+	5.79	1.53	13.8
-	5.66	1.54	15.6
SeD	0.086	0.011	0.84
Time of Sowing			
Early	6.12	1.46	12.3
Late	5.33	1.61	17.1
SeD	0.086	0.011	0.84

**Table 207 Summary of 15 site treatment means**

	Yield t/ha at 85% DM	Grain N%	Screenings % <2.5mm
<b>Nitrogen (kg/ha)</b>			
Low	5.59	1.50	13.6
Moderate	5.98	1.58	16.4
High	6.13	1.67	20.3
SeD	0.05	0.008	0.56
<b>Growth Regulator (Terpal)</b>			
+	5.90	1.57	18.6
-	5.90	1.59	14.9
SeD	0.04	0.006	0.45
<b>Late Fungicide</b>			
+	6.02	1.58	15.0
-	5.77	1.59	18.5
SeD	0.04	0.006	0.45
<b>Time of Sowing</b>			
Early	6.22	1.53	14.4
Late	5.58	1.63	19.1
SeD	0.04	0.006	0.45

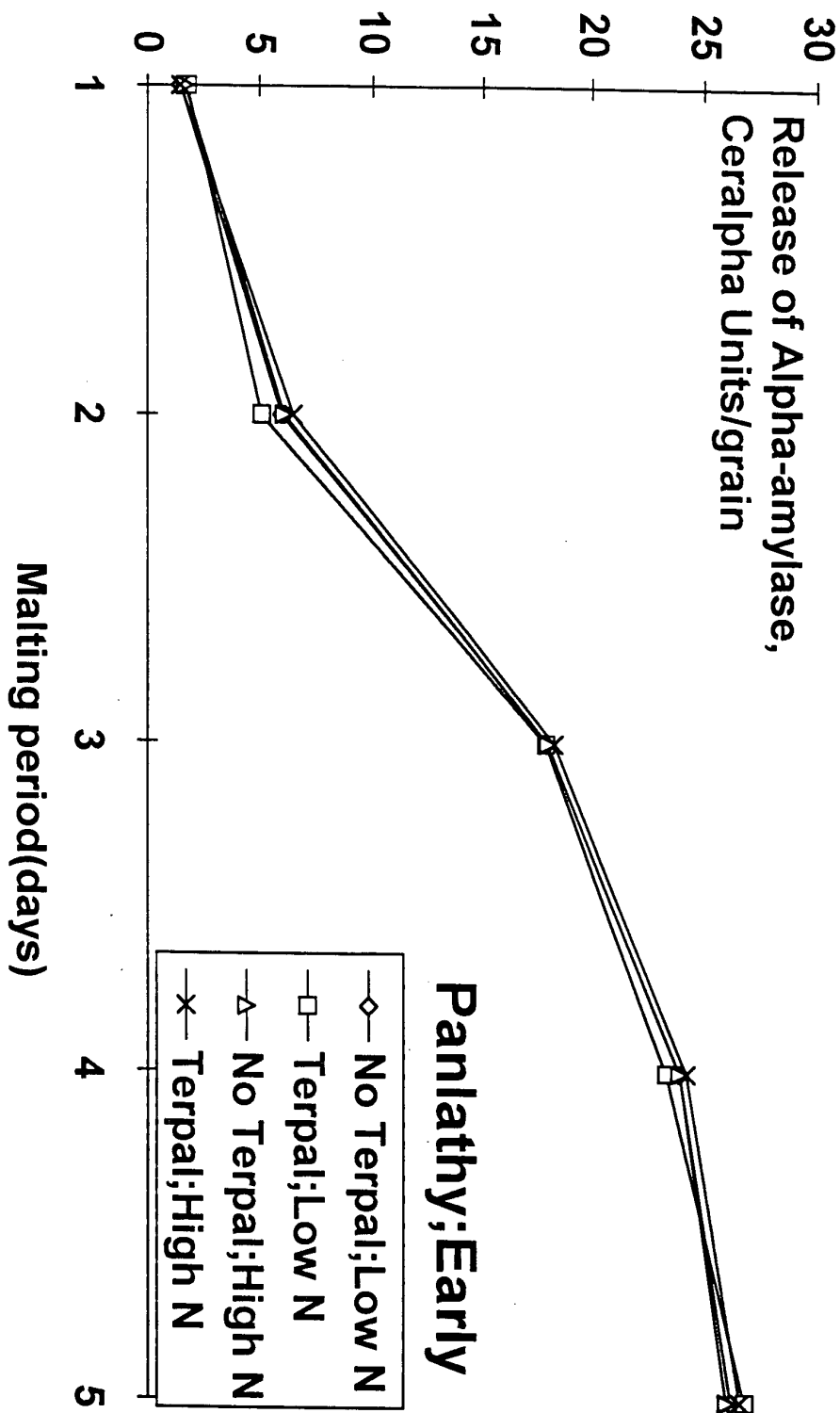
**APPENDIX 5**

**AMYLASE PRODUCTION**

**FIGURES 1-8**

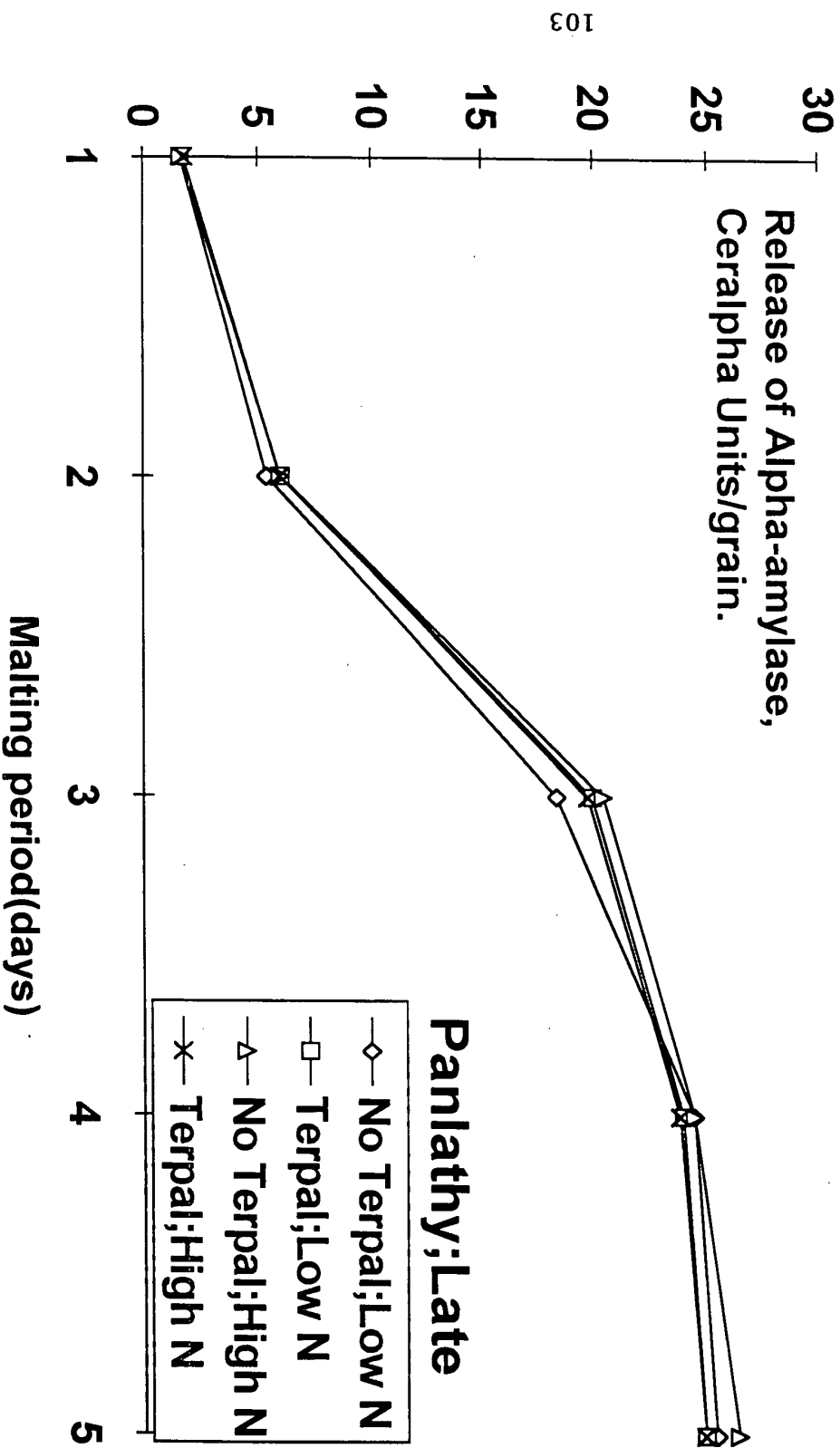
**Figure 1**

**Effect of Terpal on release of Alpha-amylase during malting.**



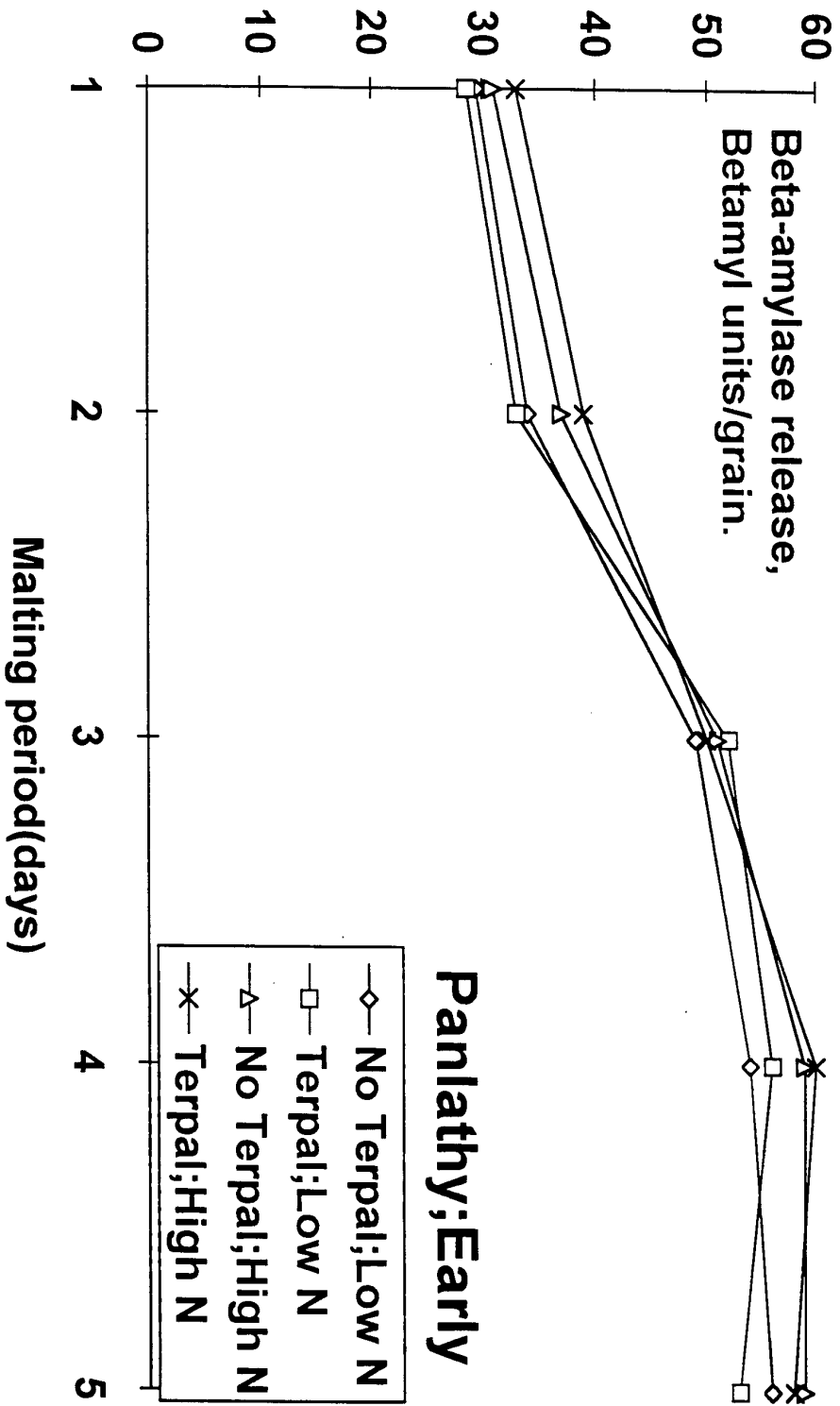
# Figure 2

## Effect of Terpal on release of Alpha-amylase during malting.



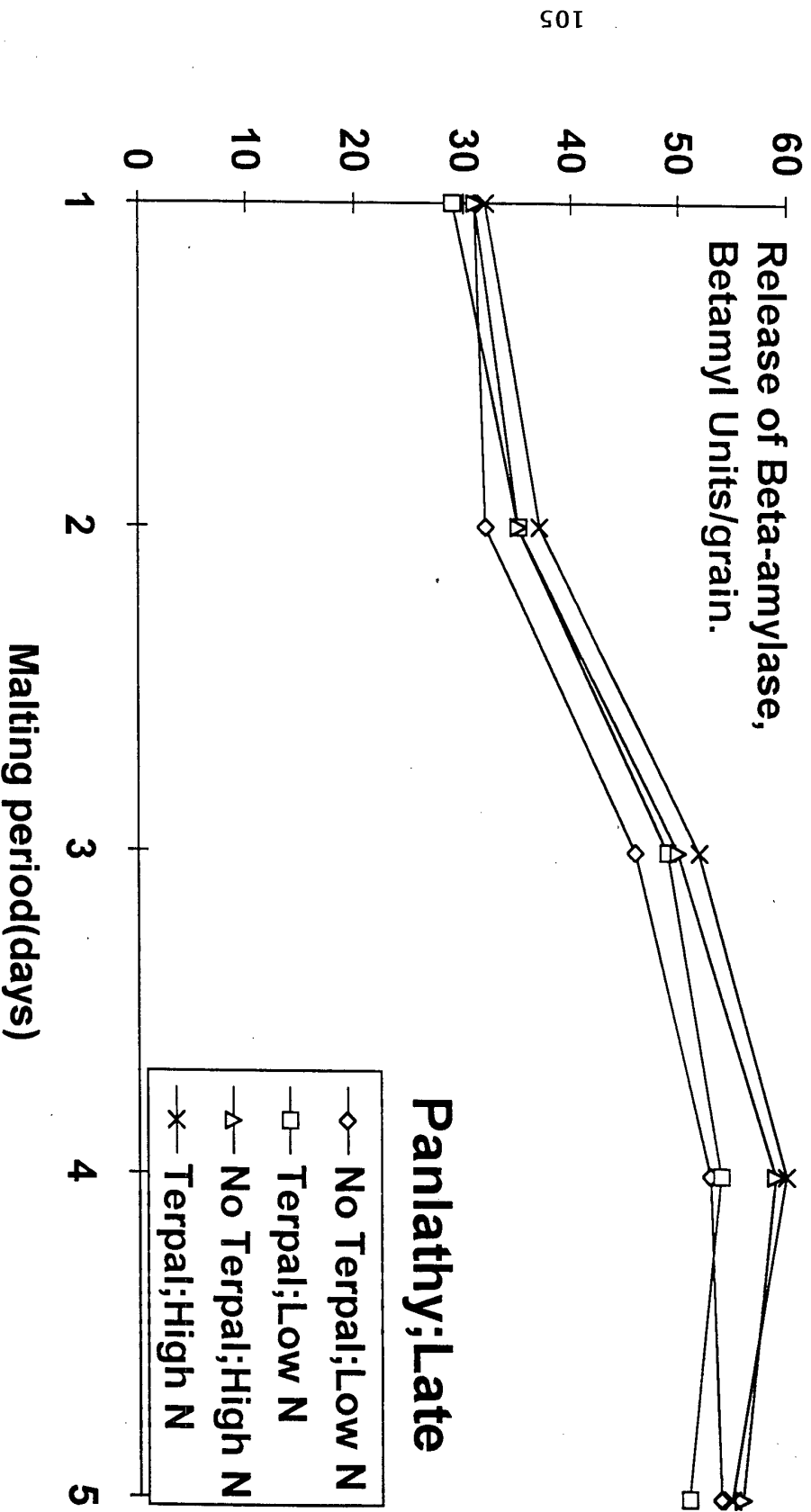
# Figure 3

## Effect of Terpal on release of Beta-amylase during malting.



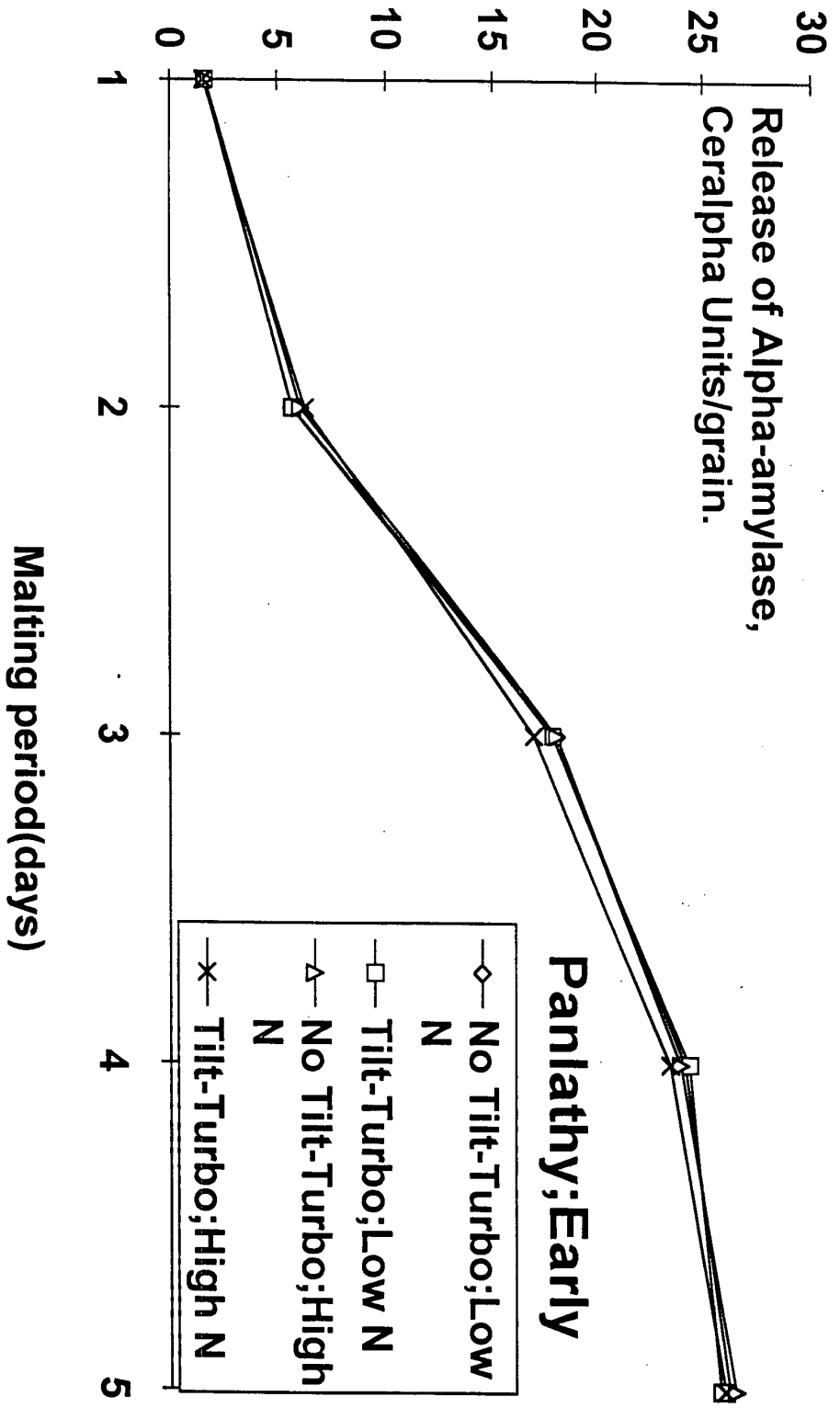
# Figure 4

## Effect of Terpal on release of Beta-amylase during malting.



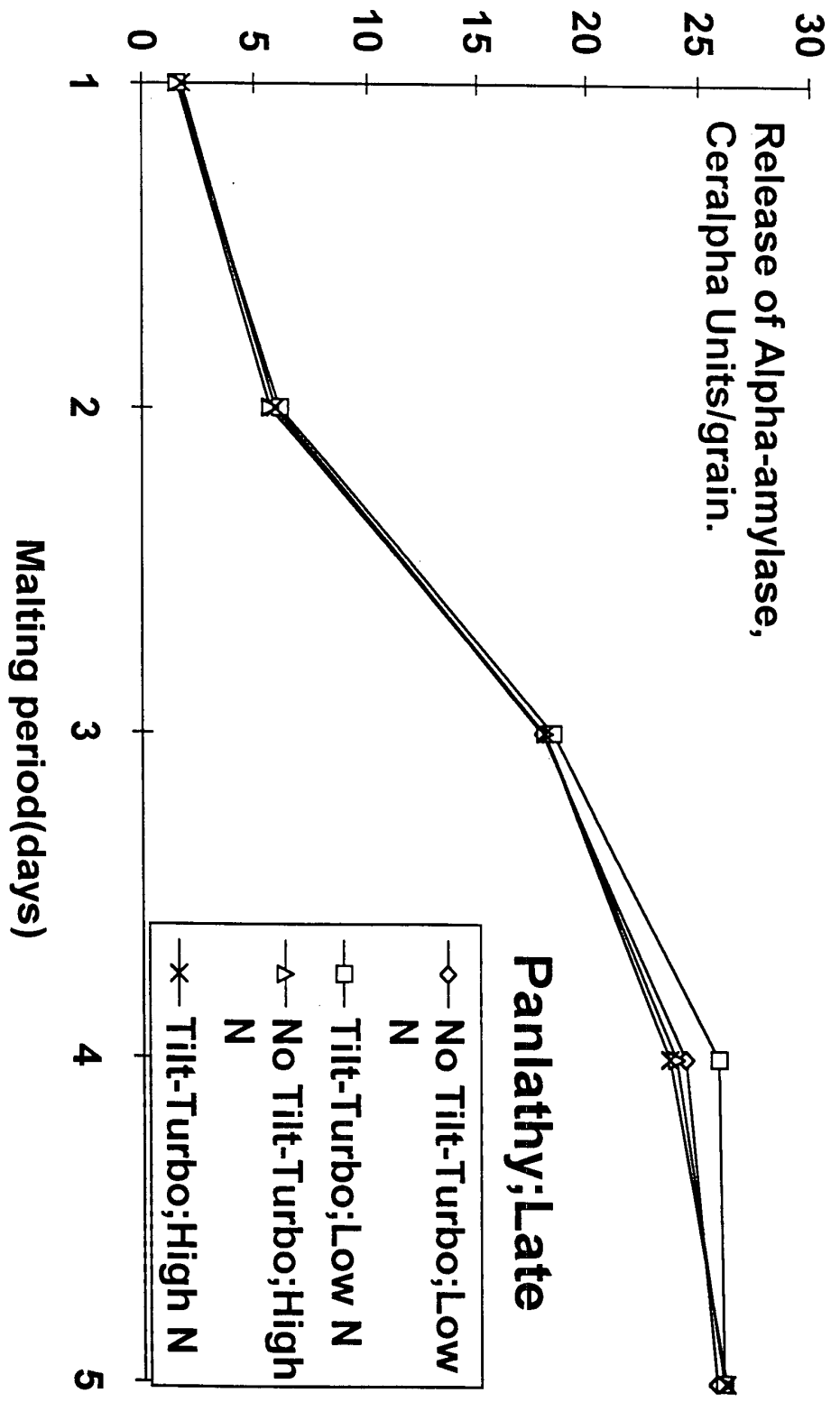
**Figure 5**

**Effect of Tilt-Turbo on release of Alpha-amylase during malting.**



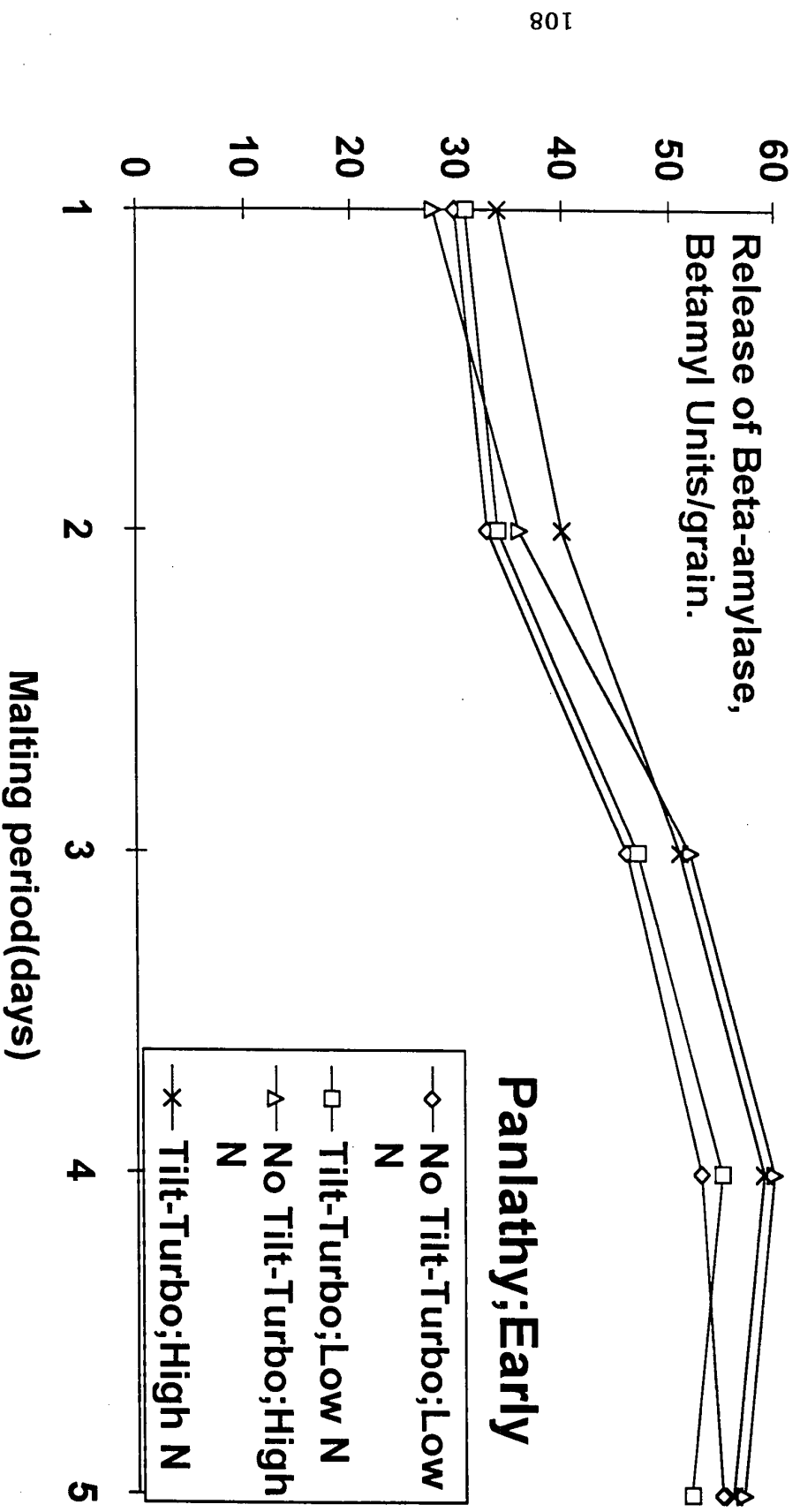
**Figure 6**

**Effect of Tilt-Turbo on release of Alpha-amylase during malting.**



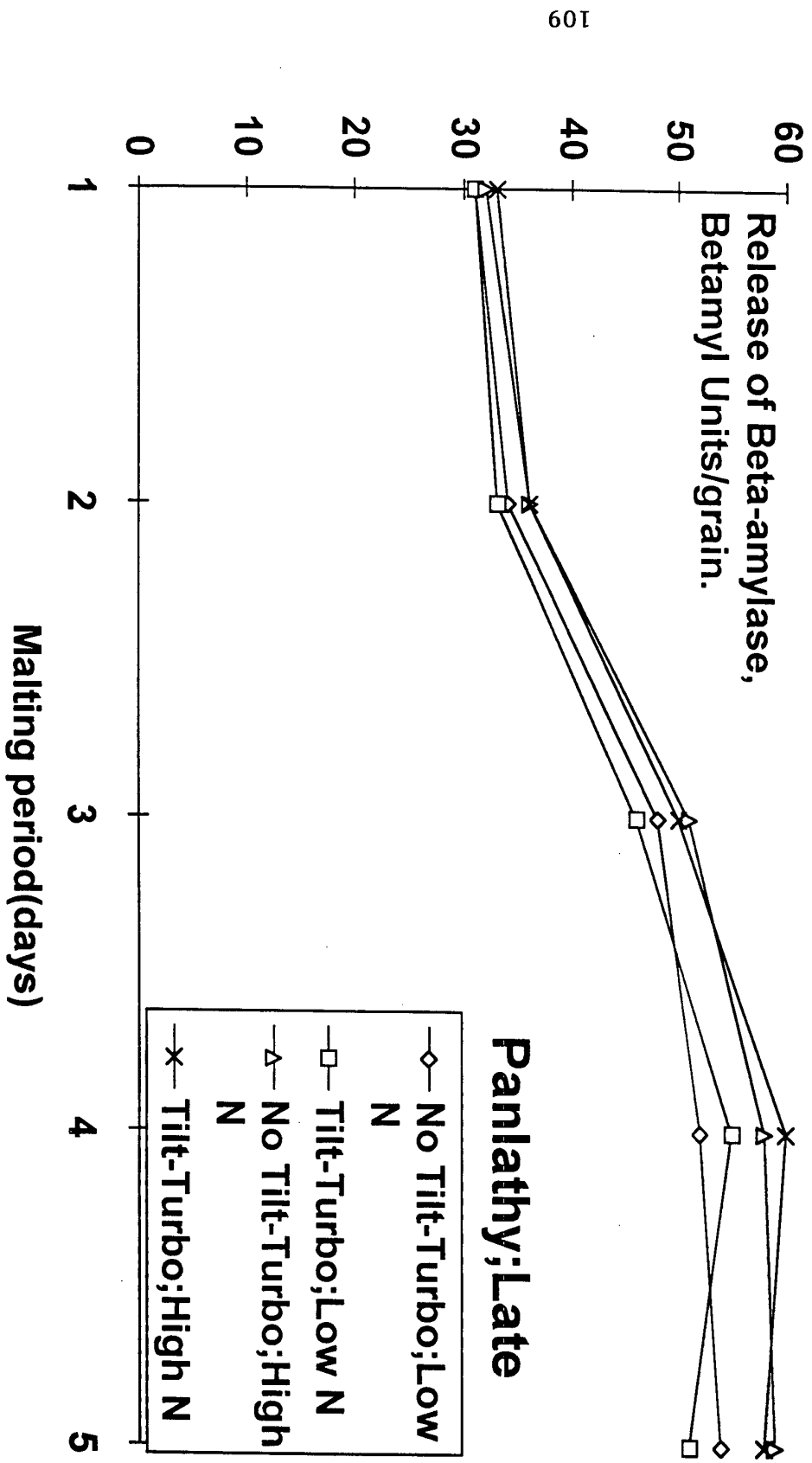
# Figure 7

## Effect of Tilt-Turbo on release of Beta-amylase during malting.



# Figure 8

## Effect of Tilt-Turbo on release of Beta-amylase during malting.



APPENDIX 6

FINANCIAL DATA

Table 301 Code	Price adjusted for premium (£/tonne)			Grain output (£/ha)		
	1991	1992	1993	1991	1992	1993
Early sown						
A	133.59	136.94	134.15	833	790	770
B	131.67	134.94	131.31	779	757	752
C	135.57	136.54	132.37	828	786	733
D	133.87	131.32	131.04	797	747	724
E	125.96	129.80	129.63	849	831	823
F	121.98	128.82	128.51	762	783	797
G	129.02	131.16	129.35	840	824	799
H	128.34	129.70	126.94	807	805	770
J	119.36	127.10	125.60	801	856	835
K	110.93	121.80	124.02	698	787	801
L	122.30	124.50	124.96	831	856	799
M	119.53	120.18	122.60	775	792	781
Late sown						
A	129.76	132.88	122.40	761	719	626
B	123.22	129.98	122.92	690	684	623
C	128.83	131.38	123.46	754	725	628
D	126.75	132.28	121.94	708	696	593
E	120.53	124.72	119.31	756	718	657
F	113.15	123.12	116.12	641	668	627
G	123.12	124.96	119.22	740	710	649
H	119.66	120.76	117.05	695	679	632
J	105.36	119.34	113.65	636	697	640
K	101.06	113.00	111.86	569	608	585
L	115.24	119.48	111.59	733	714	628
M	110.83	117.56	112.04	631	665	601
Sed	2.70	2.62	2.32	35	31	41

	Price adjusted for premium (£/tonne)				Grain output (£/ha)				
	1991	1992	1993	Mean	1991	1992	1993	Mean	
Nitrogen (kg/ha)									
Low	130.41	133.28	127.45	130.38	769	738	681	729	
Moderate	122.72	126.63	123.27	124.20	761	752	719	744	
High	113.08	120.37	118.29	117.25	709	747	709	722	
Sed	0.96	0.93	0.82		12	11	15		
Growth Regulator (Terpal)									
+	119.71	126.87	123.29	123.29	731	742	711	728	
-	124.42	126.65	122.71	124.59	762	750	695	736	
Sed	0.78	0.76	0.67		10	9	12		
Late Fungicide									
+	124.05	128.23	123.81	125.36	780	769	716	755	
-	120.08	125.29	122.20	122.52	713	722	691	709	
Sed	0.78	0.76	0.67		10	9	12		
Time of Sowing									
Early	126.01	129.40	128.37	127.93	800	801	782	794	
Late	118.13	124.12	117.63	119.96	693	690	624	669	
Sed	0.78	0.76	0.67		10	9	12		

N rate	Table 303 Grain Yield (t/ha)		Grain Output (£/ha) @ £100 per t		Grain Output (£/ha) adjusted for malting premium	
	Early sown	Late sown	Early sown	Late sown	Early sown	Late sown
Low	5.81	5.38	581	538	775	684
Moderate	6.29	5.66	629	566	808	681
High	6.55	5.69	655	569	801	642

N rate	Table 304 Grain Yield (t/ha)		Grain Output (£/ha) @ £100 per t less N costs @ 28p per kg N		Grain Output (£/ha) @ an average malting barley price of £130 per t adjusted for malting premium less N costs @ 28p per kg N	
	Early sown	Late sown	Early sown	Late sown	Early sown	Late sown
Low	5.81	5.18	561	518	755	664
Moderate	6.29	5.35	598	535	777	650
High	6.13	5.27	613	527	759	600
Mean	5.91	2.67	591	267	764	638

N rate	Table 305 Grain Yield (t/ha)		Grain Output (£/ha) @ £75 per t less N costs @ 35p per kg N		Grain Output (£/ha) @ an average malting barley price of £90 per t adjusted for malting premium less N costs @ 35p per kg N	
	Early sown	Late sown	Early sown	Late sown	Early sown	Late sown
Low	4.12	3.80	412	380	519	445
Moderate	4.34	3.87	434	387	518	417
High	4.39	3.75	439	375	487	362
Mean	4.28	3.81	428	381	508	408

N rate	Table 305 Grain Yield (t/ha)		Grain Output (£/ha) @ £75 per t less N costs @ 35p per kg N		Grain Output (£/ha) @ an average malting barley price of £90 per t adjusted for malting premium less N costs @ 35p per kg N	
	Early sown	Late sown	Early sown	Late sown	Early sown	Late sown
Low	4.12	3.80	412	380	519	445
Moderate	4.34	3.87	434	387	518	417
High	4.39	3.75	439	375	487	362
Mean	4.28	3.81	428	381	508	408

## APPENDIX 7 GLOSSARY OF MICRO-MALTING TERMS

**Extract** is a prediction of the maltster's yield; it measures the soluble extract obtained from a malt under controlled conditions. The traditional scale was in litre degrees/kg with a good extract exceeding 310; below 300, grain was likely to be treated as feed. Some extracts are now expressed as percentage soluble extract; above 80.5 is good, below 78 is feed.

**Coarse and fine** difference refers to settings on the MIAG mill. The difference between them is an estimate of the loss during malting; an average loss is about 1%, a higher loss indicates the malt is under-modified, a figure in the region of 0.1% indicates the malt is over-modified. An under-modified malt can give rise to a sticky mash with run-off problems and cause haze problems in beer. An over-modified malt adversely affects foam quality in beer.

**Total nitrogen** measures the nitrogen of the malted barley.

**Soluble Nitrogen Ratio (SNR)** is the ratio of the soluble nitrogen in the malt divided by the total nitrogen in the malt (x100). If the SNR is below 34 there is evidence of under-modification; above 42 the malt is likely to be over-modified. The SNR tends to vary according to the micro-malting process used and also between batches: for this work, the relative figures were more important than the absolute figures.

**Friability** is another measure of how well the barley has malted. A low figure indicates under-modification. The UK industry looks for a higher standard than continental users. Within the UK industry there are different requirements; a good distilling malt should exceed 90 whereas a lager malt might be acceptable at 80. Below 70, the malt is unacceptable. Variety and season are likely to have a major influence on friability.

**Fermentability**, a high % benefits distilling, it is an estimate of the percentage of the extract that will be fermented into alcohol. In general the differences in this character are small.

**Predicted Spirit Yield (PSY)** is widely used by distillers in setting the specification for a distilling malt and predicting the spirit yield from a malt. It is derived from the extract, fermentability and a constant. A high figure gives a high distillery yield. In some cases a large discount on a lower PSY malt can be more profitable if the distillery is not operating at full capacity. The threshold PSY is now about 405 with good malts achieving 415.

**Viscosity** predicts the ease of filtration in the brewery. An extract of brewing malt should have a viscosity of

1.4-1.6 milliPascal seconds.

**Diastatic power (DP)** is an estimate of the enzyme available in the malt to convert starch to sugars. Grain whisky requires some high DP malt. A good high DP malt is likely to have a DP above 150 degrees IOB and it is widely assumed that grain nitrogen in excess of 1.8% is also necessary.