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‘Canopy management’ and late nitrogen applications to improve yield of oilseed rape

by

P.M. Berry[1], J.H. Spink[2]

[1]ADAS High Mowthorpe, Duggleby, Malton, North Yorkshire YO17 8BP

[2]ADAS Rosemaund, Preston Wynne, Hereford HR1 3PG

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Contents

1. Abstract

Previous HGCA-funded work demonstrated that oilseed rape yield is reduced by the development of an over-large canopy. This project further developed and tested Canopy Management principles that will help growers achieve an optimum sized canopy through the correct timing and rate of nitrogen (N) fertiliser. Canopy Management involves measuring the amount of N in the soil and crop in February (soil N supply – SNS) and then applying sufficient N to build an optimum sized canopy with a green area index of 3.5 units by flowering followed by variable amounts of late N applied between yellow bud and early flowering depending on yield potential. When the SNS was moderate or high the first N application made to the Canopy Managed treatments was at the 2nd conventional split timing (start of stem extension, end March/early April). When the SNS was low a small proportion of N was applied at the 1st conventional split (end February/early March). During the project, methods were developed to calculate what proportion of N must be applied early for crops with a small SNS. Experiments were set up in 2005/6, 2006/7 and 2007/8 at ADAS Boxworth, High Mowthorpe and Rosemaund. Each experiment included two varieties (Winner and 'low biomass' variety Castille), grown at seven N rates (0 to 360 kg/ha) applied at Conventional timings (50% in late Feb/early March and 50% in late March) and Canopy Management timings, with and without Folicur applied at green bud.

The project showed that delaying N through using Canopy Management principles increased yield by up to 0.36 t/ha in situations where the crop would have produced an over-large and lodging-prone canopy. The yield increases were associated with reduced stem growth leading to shorter plants and less lodging, and possibly increased seed set. Methods of employing Canopy Management were developed so that they are applicable for all types of crop, including low biomass varieties and crops with a small SNS. The assumptions that underlie Canopy Management were validated within the study. Using the Canopy Management principles to calculate the N fertiliser requirement was shown to be accurate across sites and seasons, and more accurate than RB209 guidelines. The application of Folicur at green bud increased yield by up to 0.32 t/ha and resulted in average yield increases across the nine experiments of 0.15 t/ha for Winner and 0.10 t/ha for Castille, in the presence of minimal amounts of disease. Using Canopy Managed N timings did not affect the size of the yield response to Folicur. Results from this project have been used to develop the 'N-Calc' fertiliser recommendation system run by Growhow UK Ltd and to help revise the current RB209 guidelines.

2. Summary

2.1 Introduction

The current recommendations for N fertiliser applications to oilseed rape (RB209) were formulated in the late 1980s on varieties such as Rafal and Ariana. Since then the average yield of oilseed rape varieties in the Recommended List trials have increased from 3.7 t/ha to 4.8 t/ha, with the best varieties yielding more than 5 t/ha. Alterations in N management may be required to realise the high yield potential of new varieties. Conventional RB209 recommendations are for N to be applied in two splits at the end of February/early March and end of March/early April. N is sometimes applied as early as late January/early February. Previous HGCA-funded work demonstrated that yield is reduced by the development of an over-large canopy at flowering (Project Report OS49). This may arise from too much early N, from early or overly dense plant establishment or from mild autumn and winter conditions. The result of this is a thick flower layer reflecting much of the incoming light which causes few seeds to be set and a low yield potential. Canopy size can be optimised by adjusting the timing and rate of N to the size of the crop and the soil N supply. Nitrogen is a particularly valuable tool for avoiding the production of over-large canopies which may arise from uncontrollable factors such as mild autumn and winter conditions or high soil nitrogen supply.

2.2 Aim and objectives

2.2.1 Project Aim

Develop nitrogen management strategies that help to realise the high yield potential of modern oilseed rape varieties.

2.2.2 Specific Objectives

I. Understand the physiological mechanisms by which a canopy management approach to N use increases yield.

II. Understand how the canopy management approach may need adjusting for different types of crop.

2.3 Materials and Methods

2.3.1 Canopy Management approach

Previous HGCA-funded work has demonstrated that oilseed rape must achieve an optimum green area index (GAI) of 3.5 units at flowering and the crop must take up 50 kg N/ha to build each unit of GAI. This means that the crop must take up 175 kg N/ha to achieve the optimum GAI of 3.5. Canopy Management principles assume that any N that the crop has taken up by the end of winter remains in the crop until flowering and therefore contributes to the production of the optimum GAI. The principles also assume that oilseed rape takes up 100% of the soil mineral N measured in the soil in February and 60% of any fertiliser N applied (55% on shallow soils over chalk or limestone). These uptake efficiencies are similar to average figures that have been measured in wheat. The rate of crop N uptake is assumed to be 3 kg N per ha per day from the start of active spring growth until flowering. It was expected that crops with a higher than average yield potential will require additional N which should be applied between yellow bud and mid-flowering to avoid this additional N causing the optimum canopy size to be exceeded.

In early February, the amount of N in the soil and crop were measured and this was used to calculate how much fertiliser N was required for the crop to achieve a GAI of 3.5 using the assumptions described above.

Example: In February the amount of N in the soil was 50 kg N/ha and the amount of N in the crop was 50 kg N/ha. It is assumed that by flowering the crop will contain all of this soil and crop N (100 kg N/ha). This means it will be 75 kg N/ha short of the amount required for the optimum GAI. At 60% efficiency, 125 kg of fertiliser N must be applied to make up this shortfall.

In general the fertiliser N required to achieve the optimum sized canopy was applied at the 2nd conventional split timing at the start of stem extension (late March/early April). A small proportion of the N was applied at the 1st conventional split timing (late February/early March) when it was calculated that there would be insufficient time (assuming an uptake of 3 kg/ha/day) for the crop to take up all of the N required to achieve an optimum sized canopy by mid flowering if the first application was delayed. Additional N for high yield potential was applied at yellow bud to mid flowering.

2.3.2 Field experiments

2.3.2.1 Sites

Experiments were carried out in 2005/6, 2006/7 and 2007/8. Experiments were drilled at ADAS Boxworth in Cambridgeshire (Clay, Hanslope series), ADAS High Mowthorpe in N. Yorkshire (shallow silty clay loam over chalk, Andover series) and ADAS Rosemaund in Herefordshire (silty clay loam, Bromyard series).

2.3.2.2 Experimental factors and design

Four factors were investigated; variety, N rate, N timing and a growth regulatory fungicide Folicur. At each site the variety, N rate and N timing treatments were fully randomised within each of four replicate blocks, apart from Boxworth and High Mowthorpe in 2006 in which variety formed main plots within which the N rate and N timing were randomised. At each site Folicur was then applied across one half of each block and the position of the Folicur strip was randomised for each block. Each individual plot measured 18 m by 3.5 m.

The two varieties used were Winner and the 'low biomass' variety Castille. Seven N rates were used (0, 60, 120, 180, 240, 300, 360 kg/ha). All N was applied as ammonium nitrate (34.5% N) at either Conventional or Canopy Managed timings. Conventional timings were for 50% of the N applied in late February/early March and 50% applied at the start of stem extension (late March/early April). Canopy Management timings were for all, or the majority, of the N required to achieve the optimum sized canopy to be applied at the 2nd conventional split timing (start of stem extension) and the remaining N was applied between yellow bud and mid-flowering. The Folicur treatment was applied at green bud. The rate of Folicur was dependent on the size of the crop canopy measured in February. Crops with a GAI of less than 1 received 0.5 l/ha and crops with a GAI of 1 or more received a rate of 1.0 l/ha. Fungicides without growth regulatory activity were used to minimise disease. Adequate Sulphur was ensured by applying 75 kg/ha SO_3 as Magnesium Sulphate (Kieserite) to all treatments at the same time as the first N split was applied.

2.3.2 Measurements

Assessments included the amount of mineral N in the soil, together with the GAI and N content of the crop, in February. At flowering, the crop height, light interception/reflection, GAI, biomass and crop N content were measured. At crop maturity the biomass and N content of the stem, pod walls and seeds were measured.

Pod greenness and lodging were assessed at regular intervals. Yield was determined for all treatments using a small plot combine from an area of at least 30m^2 and the moisture content and oil content of the seed was measured.

2.3.3 Calculations and Statistics

Analysis of variance procedures within Genstat (8.1) (www.genstat.com) were used to calculate whether treatments were significantly different. Linear plus exponential N response curves were fitted to the seed yield data. The economically optimum N rate was calculated using a breakeven ratio of 2.5 because this has previously been used as a standard for fertiliser recommendations. The gross margin over N costs was calculated by assuming a seed yield price of £230/t (9% moisture), ammonium nitrate containing 34.5% N costing £200/t (which were typical average prices during the project and these give a breakeven ratio of 2.5). The oil premium was calculated as 1.5% of the basic oilseed rape price for each percentage point that the oil content was above 40%.

2.4 Results

2.4.1 Effects of Canopy Management on yield

The regression analyses showed that the Canopy Managed and Conventional N strategies did not result in significantly different N optima in any of the experiments. In the 2005/6 season the Canopy Management approach increased yield over the Conventionally-timed N treatments at the sites with a moderate or large combined supply of N in the soil and crop in February (soil N supply – SNS). The yield of Winner was increased by 0.36 t/ha at Boxworth and 0.15 t/ha at Rosemaund, and the yield of Castille was increased by 0.10 t/ha at Boxworth with no effect at Rosemaund (Table 2.1). The yield increases were associated with reduced lodging as a result of stem shortening. In later experiments measurements showed that Canopy Management reduced height by up to 10 cm. Canopy Management was also shown to reduce the size of the canopy at flowering. This will have helped the crops, which would otherwise have produced an over-large canopy, to achieve the optimum sized canopy and set more seeds/m^2. At High Mowthorpe the SNS was just 67 kg/ha and the Canopy Management approach had no effect on Winner and slightly reduced the yield of Castille. This result demonstrated that a greater proportion of N must be applied early to crops with a small SNS to give the crop sufficient time to take up enough N by flowering to achieve the optimum GAI. This was used to modify the Canopy

Management approach for later experiments. Although there was no significant interaction between Folicur and N management, the Folicur did appear to increase the yield of Conventionally-managed crops at Rosemaund and Boxworth more than the Canopy Managed crops. There was, however, no significant interaction between N rate and Folicur. Folicur did significantly increase the yield of both conventional and Canopy Managed treatments at High Mowthorpe, which was probably due to an effect on light leaf spot rather than a PGR effect.

Table 2.1. 2005/6 experiment summary.

	BX06		HM06		RM06	
†Jan/Feb soil mineral N (kg/ha)	50		35		60	
Jan/Feb crop N content (kg/ha)	72		32		33	
Jan/Feb GAI	1.40		0.57		0.63	
N timing strategy	Conv	CM	Conv	CM	Conv	CM
Optimum N rate (kg/ha)	70	70	239	239	224	224
N rate at 1st split (end Feb/early March)	35	0	120	40	112	0
N rate at 2nd split (early stem ext.)	35	70	119	140	112	140
N rate at 3rd split (yellow bud to mid flower)	0	0	0	59	0	84
Yield at opt N Winner (t/ha)	3.40	3.76	3.69	3.62	4.40	4.55
Yield at opt N Winner + Folicur (t/ha)	3.60	3.74	3.86	3.89	4.62	4.58
Yield at opt N Castille (t/ha)	4.04	4.12	4.56	4.43	4.90	4.91
Yield at opt N Castille + Folicur (t/ha)	4.19	4.31	4.84	4.74	4.99	4.92

†Measured to 90 cm at Boxworth and Rosemaund and 60 cm depth at High Mowthorpe.
Conv – conventional N timing strategy; CM – Canopy Managed N timing strategy.

In the 2006/7 season, the crops at each site had moderate to large canopies in February and in a typical season would have been expected to produce over-large canopies and to benefit from a Canopy Managed approach. However, negligible rainfall between the end of March and early May restricted canopy growth which resulted in moderate sized canopies at flowering. Across all the treatments at Boxworth, Canopy Management increased yield slightly by 0.08 t/ha (P=0.082). This advantage was greater at high N rates and for Winner, for example at 300 and 360 kg N/ha Canopy Manegement gave a 0.28 t/ha yield advantage. The yield increase was shown to result from less early lodging as a result of crop shortening and a small increase in seeds/m^2 which was probably caused by achieving a canopy size at flowering that was closer to the optimum. At Rosemaund Canopy Management did not affect yield despite the very dry spring. There was no effect on yield because Canopy Management reduced the

size of the canopy at flowering from above the optimum to slightly below the optimum, and because there was only slight lodging at this site. At High Mowthorpe Canopy Management reduced yield by 0.14 t/ha. The spring drought was most severe at this site which resulted in the development of a sub-optimal canopy at flowering. Canopy Management reduced the canopy size further and this resulted in slightly fewer seeds/m^2 set. Folicur significantly increased yield on Winner but not Castile at High Mowthorpe and Rosemaund but had no significant effect on yield at Boxworth.

Table 2.2. 2006/7 experiment summary.

	BX07		HM07		RM07	
†Jan/Feb soil mineral N (kg/ha)	43		58		54	
Jan/Feb crop N content (kg/ha)	92		54		61	
Jan/Feb GAI	2.37		1.21		2.08	
N timing strategy	Conv	CM	Conv	CM	Conv	CM
Optimum N rate (kg/ha)	54	54	156	156	165	165
N rate at 1st split (end Feb/early March)	0	27	78	0	83	0
N rate at 2nd split (early stem ext.)	54	27	78	120	83	100
N rate at 3rd split (yellow bud to mid flower)	0	0	0	36	0	65
Yield at opt N Winner (t/ha)	3.05	3.05	4.50	4.31	4.66	4.66
Yield at opt N Winner + Folicur (t/ha)	2.90	3.06	4.64	4.42	4.88	4.84
Yield at opt N Castille (t/ha)	3.66	3.63	5.20	5.12	5.04	4.99
Yield at opt N Castille + Folicur (t/ha)	3.51	3.63	5.17	5.10	5.09	5.11

†Measured to 90 cm at Boxworth and Rosemaund and 60 cm depth at High Mowthorpe.
Conv – conventional N timing strategy; CM – Canopy Managed N timing strategy.

In the 2007/8 season the crops at Boxworth and High Mowthorpe were very small in February following slow emergence during the dry autumn and had a modest amount of mineral N in the soil. After the first year the Canopy Management approach was further developed to be applicable for crops with a small SNS by including an estimate of the latest date when the N should start to be applied to give the crop sufficient time to build the optimum sized canopy. This assumed a rate of crop N uptake of 3 kg N/ha. Based on this 40 to 60 kg N/ha was applied at the first Conventional split timing (early March) at these sites compared with 118 to 128 kg N/ha for the Conventional strategy. Overall, there were no differences in yield between the two strategies at Boxworth and High Mowthorpe indicating that the Canopy Management strategy is appropriate for crops with a small SNS. The crop at Rosemaund also had a small SNS,

but with a moderate sized canopy and a very small amount of soil N. The original Canopy Management principles were tested at this site with all of the N required for the optimum canopy applied at the 2nd Conventional split timing (31 March). At this site Canopy Management did not affect the yield of Winner and reduced the yield of Castille by 0.29 t/ha. If the modified Canopy Management principles had been applied then 50 kg N/ha would have been applied in early March which is likely to have prevented any yield penalty and may have increased the yield of Winner. At Rosemaund, Folicur significantly increased the yield of Winner by 0.20 t/ha and had no effect on Castille. At High Mowthorpe, Folicur increased yield by 0.3 t/ha, although this was not statistically significant, and there was no significan effect at Boxworth.

Table 2.3. 2007/8 experiment summary.

	BX08		HM08		RM08	
†Jan/Feb soil mineral N (kg/ha)	58		38		12	
Jan/Feb crop N content (kg/ha)	8		10		50	
Jan/Feb GAI	0.19		0.10		1.36	
N timing strategy	Conv	CM	Conv	CM	Conv	CM
Optimum N rate (kg/ha)	256	256	236	236	128	128
N rate at 1st split (end Feb/early March)	128	40	118	60	64	0
N rate at 2nd split (early stem ext.)	128	180	118	170	64	128
N rate at 3rd split (yellow bud to mid flower)	0	36	0	6	0	0
Yield at opt N Winner (t/ha)	3.82	3.80	3.42	3.43	4.01	3.98
Yield at opt N Winner + Folicur (t/ha)	3.84	3.92	3.76	3.65	4.20	4.18
Yield at opt N Castille (t/ha)	4.00	3.99	3.78	3.78	4.49	4.21
Yield at opt N Castille + Folicur (t/ha)	4.06	4.10	4.04	4.16	4.45	4.14

†Measured to 90 cm at Boxworth and Rosemaund and 60 cm depth at High Mowthorpe.
Conv – conventional N timing strategy; CM – Canopy Managed N timing strategy.

2.4.2 Testing the Canopy Management principles

2.4.2.1 Soil N uptake efficiency

The efficiency with which the crop took up soil N was calculated by dividing the amount of N taken up by the unfertilised crop at harvest by the amount of mineral N measured in the soil (to 60 or 90cm) and the crop N in February. On average the efficiency with which soil N was taken up was estimated to be 107% (Figure 2.1) and there were no systematic differences between the sites or seasons. Several of the experiments had soil N uptake efficiency values of more than 100%, which may

simply be the result of sampling variation or may indicate that these crops took up some N which was mineralised after February. In 2008, it was possible to compare the two varieties and this showed that Castille had greater soil N uptake efficiency at each site with an average soil N uptake efficiency of 130% compared with 113% for Winner.

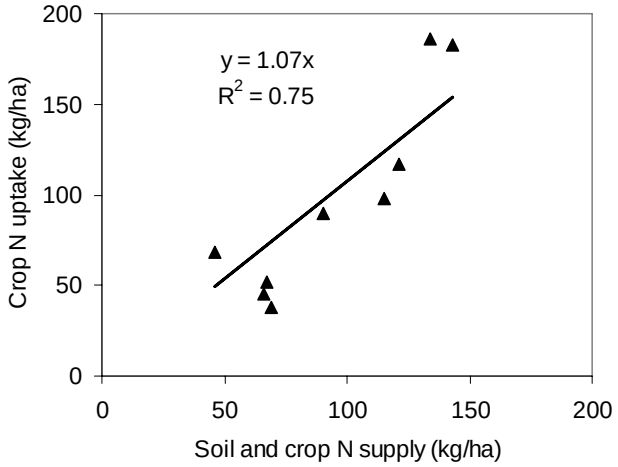

Figure 2.1. Relationship between the combined soil mineral N and crop N measured in February and the crop N uptake at harvest for crops grown at Boxworth, High Mowthorpe and Rosemaund in 2006, 2007 and 2008.

2.4.2.2 Fertiliser N uptake efficiency

The equivalent efficiency with which fertiliser N was taken up by the crop was calculated by subtracting the N taken up by the crop without fertiliser from the N taken up with fertiliser and dividing by the rate of fertiliser N applied. At the N rate that was closest to the economic optimum (167 kg N/ha on average) the fertiliser N uptake efficiency was calculated at 57%. The coefficient of variation of the fertiliser uptake efficiency across the 24 crops was 23%. Across the 3 sites, the fertiliser N uptake efficiency was lower in 2008 (47%) compared with 63% in 2006 and 63% in 2007. There were no systematic differences between sites or between the Canopy Managed and Conventional N timings. At a lower average fertiliser N rate of 100 kg N/ha the fertiliser N uptake efficiency was 67%. At 240 kg N/ha the average Fertiliser N uptake efficiency was 43%. These differences emphasise the importance of calculating the N uptake efficiency at the economically optimum N rate. The combined efficiency with which the soil N and optimum fertiliser N rate were taken up was 77% across all of the crops that were analysed in this study.

2.4.2.3 Relationship between GAI and crop N content

In February, crops with a GAI of between 0.1 and 1.5 contained 49 kg N per unit of GAI (Figure 2.2). Crops with GAIs of between 1.5 and 2.5, which were measured at Rosemaund and Boxworth in 2007 and Rosemaund in 2008, contained about 40 kg N per unit of GAI on average. These crops grew in seasons with a mild autumn and winter which increased the rate of over winter growth and it is possible that the tissue N concentration becomes diluted under these conditions. For crops measured at mid-flowering in 2007 and 2008 and the end of flowering in 2006, each unit of GAI up to the target GAI of 3.5 contained 43 kg N/ha (Figure 2.3). The slope of this regression line was not significantly different from a slope of 50 kg N per unit of GAI. There was no significant difference in the amount of N contained within each unit of GAI between N rate, variety, site or year. These results generally support the assumption that each unit of GAI contains 50 kg N/ha. However further work should test whether large canopies in February resulting from a mild autumn/winter contain less than 50 kg N/ha.

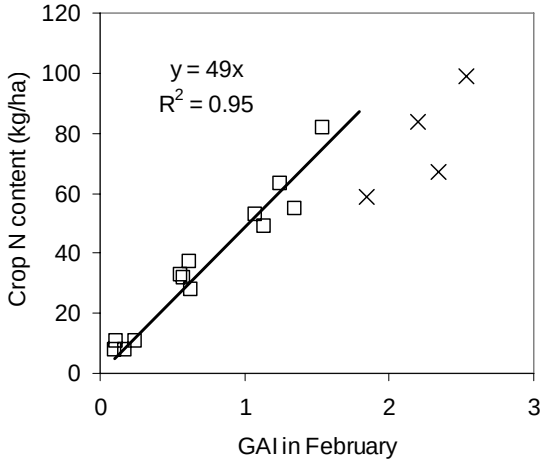

Figure 2.2. Relationship between GAI and crop N content measured in February Crops of GAI 1.5 or below (squares), crops above GAI 1.5 (crosses).

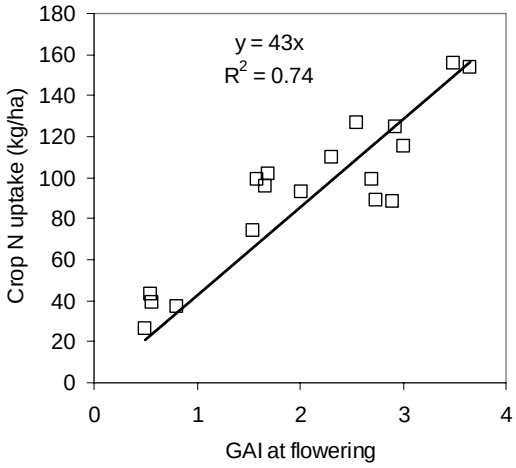

Figure 2.3. Relationship between GAI and crop N content at flowering.

2.4.2.4 Relationship between N requirement and yield

Whether or not the yield potential of each site affected the N supply required to achieve the yield potential was investigated by comparing the yield at the economic optimum (as calculated from the N response curves) with the supply of N available for crop uptake (100% of soil and crop N in February and 60% of the optimum fertiliser N) (Figure 2.4) to account for differences in residual soil N between sites. Data from an additional nine N response experiments from Growhow UK Ltd were also included

in the analysis. The regression analysis showed that each additional tonne of yield required an additional 36 kg/ha of crop available N. It is estimated that this would be equivalent to 36 kg/ha of soil mineral N or 60 kg/ha of fertiliser N for each additional tonne of yield.

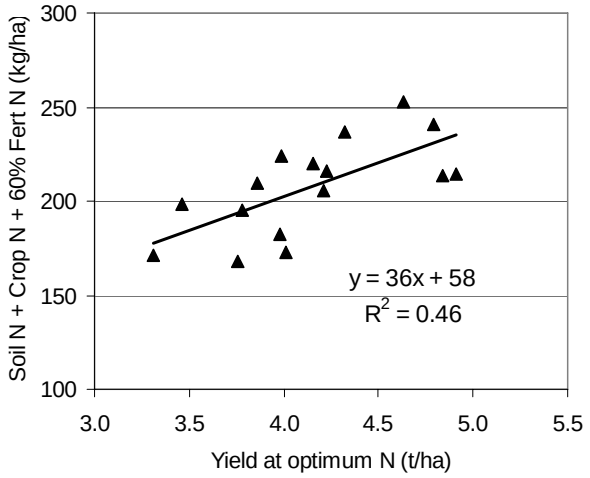

Figure 2.4. Relationship between the yield at the economic optimum N rate and the supply of N that is available for crop uptake. Each point represents data from an N response experiment.

2.4.3 Predicting fertiliser N requirement

The Canopy Management principles predict the optimum amount of fertiliser N based on measurements of the soil and crop N in February, a realistic estimate of the potential yield, together with assumptions about the efficiencies with which the crop takes up N from the soil and fertiliser. The accuracy of these principles for predicting N optima were tested retrospectively for each experiment described in this study and nine N response experiments from GrowHow. The accuracy of the RB209 guidelines; 1) using the book values to estimate the SNS and 2) using measured values of SNS were also tested. The tests showed that the Canopy Management principles were the most accurate method of predicting the optimum N rate with an average error of +/- 32 kg N/ha for yield (Table 2.4). RB209 guidelines with measurements of soil and crop N had an average error of 39 kg N/ha and 35 kg N/ha after accounting for the oil premia. Relying on RB209 look up tables to estimate the SNS, rather than taking a measurement, significantly increased the error to between 48 and 59 kg N/ha.

Table 2.4. Average error in the prediction of the fertiliser N requirement (kg N/ha).

	Optimum yield	Optimum yield after accounting for oil premia
RB209	+/- 48	+/- 59
RB209 with soil N measurements	+/- 39	+/- 35
Canopy Management	+/- 32	+/- 32

Based on 18 N response experiments between 2006 and 2008.

2.4.4 Folicur

Folicur applied at the green bud stage at a rate of 0.5 l/ha or 1.0 l/ha increased yield by up to 0.32 t/ha and did not cause any significant yield reductions. On average across all experiments Folicur increased the yield of Winner by 0.15 t/ha and Castille by 0.10 t/ha. Disease was minimised in all experiments using fungicides without growth regulatory activity. The effect of Folicur was generally the same for Canopy Managed or Conventional N timings. At the sites where Folicur significantly increased yield there was usually a significant reduction in lodging caused by Folicur. The reductions in lodging were at least partially caused by reductions in height of between 3 and 10 cm. There was no evidence of any differential height reduction between Canopy Management and Conventional N timings or between Winner and Castille. Greater height reductions occurred at higher N rates in only one experiment. It is possible that part of the yield increases were also caused by the Folicur treatment increasing the number of seeds set as a result of reducing the amount of light absorbed and reflected by the flowers.

2.5 Conclusions

- Delaying N through using Canopy Management principles increased yield by up to 0.36 t/ha in situations where the crop would have produced an over-large and lodging-prone canopy.
- Following modifications to account for the start date for N application the Canopy Management approach was shown to be robust both with backward crops and where dry conditions in the spring delayed N uptake.
- The yield increase has been shown to be associated with reduced stem growth leading to shorter plants and less lodging, and possibly increased seed set.
- Methods of employing the Canopy Management principles have been developed so that they are applicable for all types of crop including low biomass varieties and crops with small amounts of N in the crop and soil in February.

- The assumptions that underlie Canopy Management have been validated within the series of experiments carried out within this study.
- Using the Canopy Management principles to calculate the N fertiliser requirement based on the amount of N in the crop and soil in the spring, together with the yield potential, is accurate across sites and seasons, and more accurate that RB209 guidelines.
- The application of Folicur at green bud resulted in average yield increases across the 9 experiments in the presence of minimal amounts of disease of 0.15 t/ha for Winner and 0.10 t/ha for Castille. Using Canopy Managed N timings did not affect the size of the yield response to Folicur.
- Further work must investigate how much of the N that is mineralised after February is taken up by the crop.
- The results from this project have been used to develop the 'N-Calc' fertiliser recommendation system run by Growhow UK Ltd and to help to revise the relationship between N rate and potential yield in the new RB209 guidelines.

3. Introduction & Objectives

3.1 Introduction

The current recommendations for N fertiliser applications to oilseed rape (RB209) were formulated in the late 1980s on varieties such as Rafal and Ariana. Since then the average yield of oilseed rape varieties in the Recommended List trials have increased from 3.7 t/ha to 4.8 t/ha, with the best varieties yielding more than 5 t/ha. Alterations in N management may be required to realise the high yield potential of new varieties. Conventional RB209 recommendations are for N to be applied in two splits at the end of February/early March and end of March/early April. N is sometimes applied as early as late January/early February.

HGCA-funded work (Lunn *et al*., 2001; 2003) demonstrated that yield is reduced by the development of an over-large canopy up to flowering. An optimum pod number of 7000 pods/m^2 is required to maximise seeds/m^2 (Figure 3.1; Berry and Spink, 2006). This may arise from too much early N, from early plant establishment or from mild autumn and winter conditions. The result of this is a thick flower layer reflecting much of the incoming light which causes few seeds to be set and a low yield potential (Berry and Spink, 2006). An optimum sized canopy can be achieved by adjusting the timing and rate of N to the size of the crop and the soil N supply. Nitrogen is a particularly valuable tool for avoiding the production of over-large canopies which may arise from uncontrollable factors such as mild autumn and winter conditions.

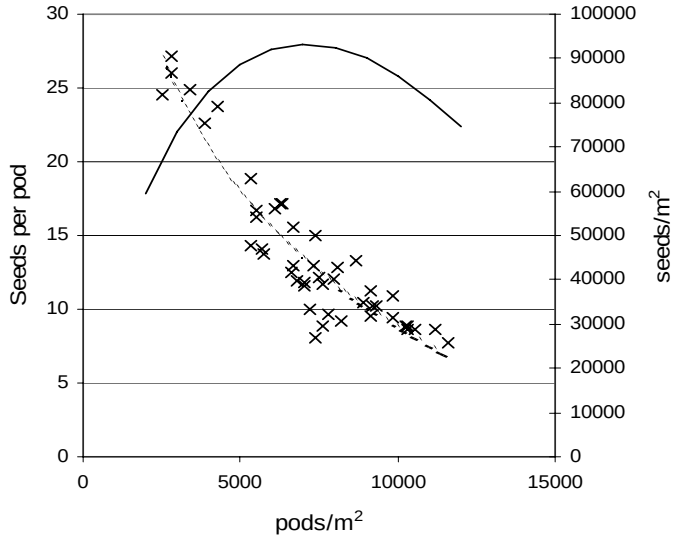

Figure 3.1. Seeds per pod plotted against pods per metre squared (crosses) Relationship between seeds/m^2 and pods/m^2 (solid line). From Berry & Spink (2003).

Another problem with crops that develop an over-large canopy is that they may take up their N supply early then risk running out of N resulting in early canopy death. This is a problem for crops with a high yield potential because they require a long canopy duration to fill all the seeds. The advantage of later N applications has been demonstrated by Lunn *et al*. (2001) which showed that delaying applications by 2-3 weeks after early March increased the yield of crops receiving 200 kg N/ha or more by 0.25 t/ha.

Winter oilseed rape crops receive on average about 200 kg N/ha, and less than half of this is removed in the seed. This means that the winter following oilseed rape is the most nitrate leaching prone phase of many rotations (Johnson *et al.*, 1997). Approximately 80% of green house gas emissions are associated with the production of oilseed rape result from the manufacture and application of N fertiliser (Mortimer *et al*., 2003). Therefore it is clear that any improvements in N management that improve its use efficiency will be valuable for reducing nitrate leaching and green house gases.

3.2 Aim and objectives

3.2.1 Project Aim

Develop nitrogen management strategies that help to realise the high yield potential of modern oilseed rape varieties.

3.2.1 Specific Objectives

I. Understand the physiological mechanism by which a canopy management approach to N use increases yield.

II. Understand how the canopy management approach may need adjusting for different types of crop.

4. Experimental design, materials and methods

4.1 Canopy Management approach

Previous work has demonstrated that oilseed rape must achieve an optimum green area index (GAI) of 3.5 units at flowering (Lunn *et al*., 2001). Larger canopies set fewer seeds/m^2 and are more prone to lodging, whilst smaller canopies do not intercept all of the available light. It has been shown that the crop must take up 50 kg N/ha to build each unit of GAI (Lunn *et al*., 2001), which means that the crop must take up 175 kg N/ha to achieve the optimum GAI of 3.5. It was assumed that any N that the crop had taken up by the end of winter remained in the crop until flowering and therefore contributed to the production of the optimum GAI. It was assumed that oilseed rape took up 100% of the soil mineral N measured in the soil in January/February and 60% of any fertiliser N applied (55% on shallow soils over chalk or limestone). These uptake efficiencies are similar to average figures that have been measured in wheat. The rate of crop N uptake was 3 kg N per day (Schjoerring *et al*., 1995). It was expected that crops with a higher than average yield potential will require additional N which should be applied between yellow bud and mid-flowering.

In late January or early February, the amount of N in the soil and crop were measured and this was used to calculate how much fertiliser N was required for the crop to achieve a GAI of 3.5 using the assumptions described above.

Example: In February the amount of N in the soil was 50 kg N/ha and the amount of N in the crop was 50 kg N/ha. It is assumed that by flowering the crop will contain all of this soil and crop N (100 kg N/ha). This means it will be 75 kg N/ha short of the amount required for the optimum GAI. 125 kg of fertiliser N must be applied to make up this shortfall assuming 60% of the fertiliser N applied is taken up by the crop.

The amount of fertiliser N required to achieve the optimum sized canopy was applied at the 2nd conventional split timing at the start of stem extension (late March/early April). A small proportion of the N was applied at the 1st conventional split timing (late February/early March) when it was calculated that there would be insufficient time for the crop to take up all of the N required to achieve an optimum sized canopy by mid flowering if the first application was made at the 2nd conventional split timing. Additional N for high yield potential was applied at yellow bud to mid flowering.

4.2 Field experiments

4.2.1 Sites

Experiments were carried out in 2005/6, 2006/7 and 2007/8. Experiments were drilled at ADAS Boxworth in Cambridgeshire (Clay, Hanslope series), ADAS High Mowthorpe in N. Yorkshire (shallow silty clay loam over chalk, Andover series) and ADAS Rosemaund in Herefordshire (silty clay loam, Bromyard series). Site codes used in this report are as follows Boxworth (BX06, BX07 and BX08), High Mowthorpe (HM06, HM07, HM08), and Rosemaund (RM06, RM07, RM08).

4.2.2 Experimental factors and design

Four factors were investigated; variety, N rate, N timing and a growth regulatory fungicide Folicur. At each site the variety, N rate and N timing treatments were fully randomised within each of four replicate blocks, apart from BX06 and HM06 in which variety formed main plots in which the N rate and N timing were randomised. At each site Folicur was then applied across one half of each block. The position of the Folicur strip was randomised for each block. This type of design is a special case of a split plot design where the sub-plot treatments are not randomised separately for each whole plot, but are randomly allocated to strips of subplots across each block. This is usually called a strip design or a criss-cross design. Each plot measured 18m by 3.5m.

The two varieties used were Winner and the 'low biomass' variety Castille. Seven N rates were used (0, 60, 120, 180, 240, 300, 360 kg/ha). All N was applied as ammonium nitrate (34.5% N). All N rates, apart from the nil, were applied at either conventional or canopy managed timings. Conventional timings were for 50% of the N applied in late February/March and 50% applied at the start of stem extension (late March/early April). Canopy management timings were for all, or the majority, of the N required to achieve the optimum sized canopy to be applied at the 2nd conventional split timing (start of stem extension) and the remaining N was applied between yellow bud and mid-flowering. The Folicur treatment was applied at green bud. The rate of Folicur was dependent on the size of the crop canopy measured in February. Crops with a GAI of less than 1 received 0.5 l/ha and crops with a GAI of 1 or more received a rate of 1.0 l/ha.

4.2.3 Husbandry

All crops were sown at 90 seeds/m^2. Adequate Sulphur was ensured by applying 75 kg/ha SO_3 as Magnesium Sulphate (Kieserite) to all treatments at the same time as the first N split was applied to the conventional N treatments. Fungicides without growth regulatory activity were used to minimise disease and to help ensure that any effects of the Folicur treatment resulted from growth regulation rather than disease control. Pests were minimised using molluscicides and insecticides. Desiccants were not used apart from High Mowthorpe in 2008. See appendices 1, 2 and 3 for further site details.

4.3 Measurements

Assessments included the amount of mineral N in the soil, together with the GAI and N content of the crop, in February. At flowering, the crop height, light interception/reflection, GAI, biomass and crop N content were measured. At crop maturity the biomass and N content of the stem, pod walls and seeds were measured. Pod greenness and lodging were assessed at regular intervals. Many of the physiological measurements were carried out on a subset of the treatments. Yield was determined for all treatments using a small plot combine from an area of at least 30m^2 and the moisture content and oil content of the seed was measured.

4.4 Calculations and Statistics

Analysis of variance procedures within Genstat (8.1) (www.genstat.com) were used to calculate whether treatments were significantly different. Linear plus exponential N response curves were fitted to the seed yield data for each treatment of the form

$$Y = A + BR^N + CN \qquad \text{Equation 1}$$

where *Y* is the seed yield (t/ha), *A, B, C* and *R* are constants. Each linear plus exponential function was fitted using a stepwise process within Genstat (8.1) involving the following steps: i) fitting a common curve to all fungicide treatments, ii) fitting separate parallel curves for each fungicide treatment, iii) fitting separate curves for each fungicide treatment by allowing parameters *A*, *B* and *C* all to vary, and iv) fitting separate curves for each fungicide treatments by allowing all parameters to vary. The sums of squares explained at each stage was calculated, and a test was made of the improvement in fit over the previous model. If there was no significant improvement between two stages, then the previous model was taken as the best description of the

data. In general, fitting at stage (ii) was most satisfactory and the economic N rate (N_{OPT}) was determined from the fitted linear plus exponential parameters as follows;

$$N_{OPT} = \frac{\left[\ln(k - C) - \ln(B(\ln R))\right]}{\ln R} \qquad \text{Equation 2}$$

where *k* is the breakeven price ratio between fertiliser N (p/kg) and grain (p/kg). A breakeven ratio of 2.5 was used in this study because this has previously been used as a standard for fertiliser recommendations (Anon., 2000). The yield at the optimum N rate (Y_{OPT}) was calculated from the fitted parameters using equation 1.

The gross margin over N costs was calculated by assuming a seed yield price of £230/t (9% moisture), ammonium nitrate containing 34.5% N costing £200/t (which were typical average prices during the project and these give a breakeven ratio of 2.5). The oil premium was calculated as 1.5% of the basic oilseed rape price for each percentage point that the oil content was above 40%. When the oil content was less than 40% the same formula was used to calculate the price penalty from the basic oilseed rape price of £230/t.

5. Results

5.1 Experiment Year 1 – 2005/6

5.1.1 Soil and crop N in February

Experiments were drilled at ADAS Boxworth (Cambridgeshire) on 8/9/05, ADAS High Mowthorpe (N. Yorkshire) on 28/8/05 and ADAS Rosemaund (Herefordshire) on 6/9/05. The soil mineral N and GAI of the experimental crops was measured in late January or early February. This showed that the crop N content and the soil mineral N of Winner and Castille were not significantly different. A summary of this information (Table 5.1) shows that the combined supply of N from the crop and soil in February was 123 kg N/ha at Boxworth, 93 kg N/ha at Rosemaund and 67 kg N/ha at High Mowthorpe.

Table 5.1. Fertiliser requirement for canopy managed treatments

	Boxworth	High Mowthorpe	Rosemaund
Feb SMN (kg/ha)	50	35	60
Feb GAI	1.40	0.57	0.63
SNS (kg/ha)	123	67	93
Fert N for GAI 3.5	90	180	140

SMN – soil mineral nitrogen
SNS – soil nitrogen supply - combined supply of nitrogen from the soil and crop

5.1.2 N treatments

The amount of fertiliser N required to achieve the optimum GAI of 3.5 by flowering was calculated at 90 kg/ha at Boxworth, 140 kg/ha at Rosemaund and 180 kg/ha at High Mowthorpe based on the measurements of soil and crop N. At Boxworth and Rosemaund, the first dose for the canopy managed treatment was applied at the 2nd conventional split timing. At High Mowthorpe it was estimated that the crop would not be able to take up all of the N required to acheve the optimum sized canopy by mid-flowering if the N applications were delayed until the 2nd conventional split timing. Therefore, 40 kg N/ha was applied at the 1st conventional split timing. After sufficient N had been applied to achieve the optimum GAI of 3.5 the remainder of the N was applied between yellow bud and early/mid flowering in late April/early May. The N applications in each split are described in Tables 5.2 to 5.4. The dates of the N applications and Folicur treatment are described in Table 5.5.

Table 5.2. Boxworth N applications (kg/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	0	60		60
9	Managed	0	90	30	120
10	Managed	0	90	90	180
11	Managed	0	90	150	240
12	Managed	0	90	210	300
13	Managed	0	90	270	360

Table 5.3. High Mowthorpe N applications (kg/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	40	20	0	60
9	Managed	40	80	0	120
10	Managed	40	140	0	180
11	Managed	40	140	60	240
12	Managed	40	140	120	300
13	Managed	40	140	180	360

Table 5.4. Rosemaund N applications (kg/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	0	60	0	60
9	Managed	0	120	0	120
10	Managed	0	140	40	180
11	Managed	0	140	100	240
12	Managed	0	140	160	300
13	Managed	0	140	220	360

Table 5.5. Timings of Nitrogen and Folicur treatments

	Boxworth	High Mowthorpe	Rosemaund
1st N timing	27 February	22 March	10 March
2nd N timing	4 April	12 April	12 April
3rd N timing	5 May	25 April	25 April
Folicur timing	4 April (1.0 l/ha)	24 April (0.5 l/ha)	7 April (0.5 l/ha)

5.1.3 Seed yield

At Boxworth, all of the main treatment factors affected seed yield. Castille averaged 4.27 t/ha compared with 3.72 t/ha for Winner ($P<0.01$; Table 5.6). Increasing N rate significantly increased yield ($P<0.01$). The greatest difference occurred between the nil N and 60 kg N/ha treatments. Across all treatments, the Managed N timing treatment significantly increased yield over the Conventional N timing treatment from 3.99 t/ha to 4.21 t/ha ($P<0.001$). The N rate and Managed N treatments interacted ($P = 0.086$) because the Managed N timing produced a greater yield advantage over the Conventional N timing at higher rates of N. Averaged across all treatments, Folicur (1.0 l/ha) increased yield from 3.93 t/ha to 4.06 t/ha ($P = 0.10$).

At High Mowthorpe, across all treatments N rate increased yield from 1.92 t/ha at nil N to 3.59 t/ha at 360 kg N/ha ($P<0.001$), and Folicur (0.5 l/ha) increased yield by on average 0.26 t/ha ($P<0.01$; Table 5.7). There was a lower order interaction between

N rate and Folicur ($P<0.05$) because Folicur tended to increase yield more at the higher N rates. There was a weak interaction between Variety, N rate and N management ($P=0.061$). This occurred because the Managed timing tended to reduce the yield of Castille at low rates of N (60 to 180 kg/ha) but had little affect on the yield Winner grown at low N rates. At higher N rates the Managed timing either had no effect or increased the yield of both varieties.

At Rosemaund, Castille averaged 4.42 t/ha compared with 4.03 t/ha for Winner ($P<0.001$; Table 5.8). Increasing N rate significantly increased yield ($P<0.001$). Across all treatments N rate increased yield from 2.58 t/ha at nil N to 4.22 t/ha at 360 kg N/ha ($P<0.001$). Variety and N rate interacted ($P<0.05$). This interaction appeared to be caused by different sized yield increases between 60 and 120 kg/ha for the two varieties (Table 5.8). There was a weak interaction between Folicur and N management ($P=0.072$) because Folicur increased yield by 0.17 t/ha when the N was applied at Conventional timings but had no effect when the N was applied at Managed timings (Table 5.8). This effect was strongest for Winner.

Table 5.6. Boxworth seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	3.18		3.18	2.97		2.97	3.08		3.08
Winner	60	3.65	3.64	3.64	4.01	3.55	3.78	3.83	3.59	3.71
Winner	120	3.33	3.85	3.59	3.91	4.17	4.04	3.62	4.01	3.82
Winner	180	3.55	3.71	3.63	3.71	3.86	3.79	3.63	3.79	3.71
Winner	240	3.56	4.18	3.87	3.84	4.20	4.02	3.70	4.19	3.95
Winner	300	3.36	4.01	3.69	3.86	4.09	3.97	3.61	4.05	3.83
Winner	360	3.80	4.44	4.12	3.54	3.99	3.76	3.67	4.21	3.94
Winner	Mean	3.54	3.97	3.68	3.81	3.98	3.76	3.68	3.97	3.72
Castille	0	3.51		3.51	3.70		3.70	3.60		3.60
Castille	60	4.11	3.89	4.00	3.97	3.84	3.91	4.04	3.87	3.96
Castille	120	4.26	4.18	4.22	4.34	4.61	4.47	4.30	4.39	4.34
Castille	180	4.05	4.54	4.29	4.16	4.82	4.49	4.10	4.68	4.39
Castille	240	4.38	4.36	4.37	4.72	4.68	4.70	4.55	4.52	4.53
Castille	300	4.18	4.72	4.45	4.35	4.57	4.46	4.26	4.65	4.46
Castille	360	4.41	4.52	4.46	4.73	4.73	4.73	4.57	4.62	4.60
Castille	Mean	4.23	4.37	4.19	4.38	4.54	4.35	4.30	4.46	4.27
Win+Cas	0	3.35		3.35	3.33		3.33	3.34		3.34
Win+Cas	60	3.88	3.77	3.82	3.99	3.70	3.84	3.93	3.73	3.83
Win+Cas	120	3.80	4.02	3.91	4.12	4.39	4.26	3.96	4.20	4.08
Win+Cas	180	3.80	4.13	3.96	3.93	4.34	4.14	3.87	4.23	4.05
Win+Cas	240	3.97	4.27	4.12	4.28	4.44	4.36	4.12	4.35	4.24
Win+Cas	300	3.77	4.37	4.07	4.10	4.33	4.22	3.94	4.35	4.14
Win+Cas	360	4.10	4.48	4.29	4.14	4.36	4.25	4.12	4.42	4.27
Win+Cas	Mean	3.89	4.17	3.93	4.09	4.26	4.06	3.99	4.21	3.99

Treatment	df	SED	P-Value
Folicur	3	0.602	0.10
Variety	3	0.707	<0.01
Folicur x Variety	6	0.093	NS
N rate	72	0.154	<0.01
N Management	72	0.154	<0.001
Var x Nrate	45	0.158	NS
Var x Man	10	0.096	NS
Nrate x Man	72	0.154	0.081
Var x Nrate x Man	68	0.221	NS
Fol x Nrate	113	0.203	NS
Fol x Man	137	0.153	NS
Fol x Var x Nrate	86	0.206	NS
Fol x Var x Man	19	0.126	NS
Fol x Nrate x Man	113	0.213	NS
Fol x Var x Nrate x Man	130	0.287	NS

Table 5.7. High Mowthorpe seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (0.5 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	1.25		1.25	1.14		1.14	1.19		1.19
Winner	60	2.32	1.86	2.09	2.65	2.18	2.42	2.49	2.02	2.25
Winner	120	3.05	3.39	3.22	3.09	3.21	3.15	3.07	3.3	3.18
Winner	180	3.55	3.35	3.45	3.9	3.59	3.74	3.72	3.47	3.6
Winner	240	3.56	3.53	3.55	3.62	4.11	3.87	3.59	3.82	3.71
Winner	300	3.85	3.74	3.79	4.07	4.45	4.26	3.96	4.09	4.03
Winner	360	3.94	3.92	3.93	4.22	4.20	4.21	4.08	4.06	4.07
Winner	Mean	3.38	3.30	3.04	3.59	3.62	3.26	3.49	3.46	3.15
Castille	0	2.56		2.56	2.73		2.73	2.64		2.64
Castille	60	3.22	3.14	3.18	3.38	3.50	3.44	3.30	3.32	3.31
Castille	120	4.34	3.45	3.89	4.46	3.72	4.09	4.40	3.59	3.99
Castille	180	4.56	4.37	4.47	4.83	4.40	4.61	4.69	4.39	4.54
Castille	240	4.45	4.33	4.39	4.86	4.53	4.70	4.65	4.43	4.54
Castille	300	4.02	4.31	4.17	4.89	4.89	4.89	4.45	4.60	4.53
Castille	360	4.45	4.54	4.49	4.65	5.10	4.87	4.55	4.82	4.68
Castille	Mean	4.17	4.02	3.88	4.51	4.36	4.19	4.34	4.19	4.03
Win+Cas	0	1.90		1.90	1.93		1.93	1.92		1.92
Win+Cas	60	2.77	2.50	2.63	3.02	2.84	2.93	2.89	2.67	2.78
Win+Cas	120	3.69	3.42	3.56	3.77	3.47	3.62	3.73	3.44	3.59
Win+Cas	180	4.05	3.86	3.96	4.36	3.99	4.18	4.21	3.93	4.07
Win+Cas	240	4.00	3.93	3.97	4.24	4.32	4.28	4.12	4.13	4.13
Win+Cas	300	3.93	4.03	3.98	4.48	4.67	4.58	4.21	4.35	4.28
Win+Cas	360	4.19	4.23	4.21	4.43	4.65	4.54	4.31	4.44	4.38
Win+Cas	Mean	3.77	3.66	3.46	4.05	3.99	3.72	3.91	3.83	3.59

Treatment	df	SED	P-Value
Folicur	3	0.027	<0.01
Variety	3	0.363	NS
Folicur x Variety	6	0.363	NS
N rate	72	0.187	<0.001
N Management	72	0.187	NS
Var x Nrate	45	0.402	NS
Var x Man	10	0.371	NS
Nrate x Man	72	0.187	NS
Var x Nrate x Man	68	0.443	0.061
Fol x Nrate	113	0.148	<0.05
Fol x Man	137	0.082	NS
Fol x Var x Nrate	86	0.413	NS
Fol x Var x Man	19	0.375	NS
Fol x Nrate x Man	113	0.211	NS
Fol x Var x Nrate x Man	130	0.465	NS

Table 5.8. Rosemaund seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (0.5 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	2.23		2.23	2.55		2.55	2.39		2.39
Winner	60	3.47	3.51	3.49	3.37	3.59	3.48	3.42	3.55	3.49
Winner	120	3.88	4.16	4.02	4.00	3.99	4.00	3.94	4.08	4.01
Winner	180	3.87	4.19	4.03	4.38	4.29	4.34	4.13	4.24	4.18
Winner	240	4.47	4.78	4.63	4.77	4.48	4.62	4.62	4.63	4.62
Winner	300	4.63	4.74	4.69	4.64	4.91	4.78	4.64	4.83	4.73
Winner	360	4.67	4.66	4.66	5.02	4.65	4.84	4.85	4.66	4.75
Winner	Mean	4.17	4.34	3.96	4.36	4.32	4.09	4.27	4.33	4.03
Castille	0	2.80		2.80	2.72		2.72	2.76		2.76
Castille	60	3.51	3.31	3.41	3.86	3.83	3.85	3.69	3.57	3.63
Castille	120	4.39	4.66	4.52	4.24	4.51	4.38	4.32	4.59	4.45
Castille	180	4.79	5.04	4.92	4.90	4.72	4.81	4.85	4.88	4.86
Castille	240	4.85	4.98	4.92	5.05	5.02	5.03	4.95	5.00	4.98
Castille	300	5.07	4.97	5.02	5.19	5.05	5.12	5.13	5.01	5.07
Castille	360	5.28	5.02	5.15	5.33	5.01	5.17	5.30	5.01	5.16
Castille	Mean	4.65	4.66	4.39	4.76	4.69	4.44	4.71	4.68	4.42
Win+Cas	0	2.51		2.51	2.64		2.64	2.58		2.58
Win+Cas	60	3.49	3.41	3.45	3.62	3.71	3.66	3.55	3.56	3.56
Win+Cas	120	4.14	4.41	4.27	4.12	4.25	4.19	4.13	4.33	4.23
Win+Cas	180	4.33	4.61	4.47	4.64	4.50	4.57	4.49	4.56	4.52
Win+Cas	240	4.66	4.88	4.77	4.91	4.75	4.83	4.78	4.82	4.80
Win+Cas	300	4.85	4.85	4.85	4.92	4.98	4.95	4.88	4.92	4.90
Win+Cas	360	4.97	4.84	4.91	5.18	4.83	5.00	5.08	4.84	4.96
Win+Cas	Mean	4.41	4.50	4.18	4.57	4.50	4.26	4.49	4.51	4.22

Treatment	df	SED	P-Value
Folicur	3	0.073	NS
Variety	75	0.044	<0.001
Folicur x Variety	6	0.085	NS
N rate	75	0.111	<0.001
N Management	75	0.111	NS
Var x Nrate	75	0.157	<0.05
Var x Man	75	0.157	NS
Nrate x Man	75	0.111	NS
Var x Nrate x Man	75	0.157	NS
Fol x Nrate	24	0.125	NS
Fol x Man	6	0.087	0.072
Fol x Var x Nrate	60	0.166	NS
Fol x Var x Man	14	0.107	NS
Fol x Nrate x Man	60	0.116	NS
Fol x Var x Nrate x Man	112	0.228	NS

5.1.4 Oil content

At Boxworth both N rate and N management significantly affected oil content (P<0.001; Table 5.9). Furthermore there was a significant interaction between N rate and N management (P<0.001). Delaying N applications reduced oil content at 120 and 240 kg N/ha and had no effect at 360 kg N/ha. It should be noted that at this site the late N was delayed until very late (mid flowering), which was later than in any of the other experiments. Variety did not significantly affect oil content. A linear regression for N rate against oil content which was grouped for N management accounted for 51% of the variation (P<0.001). Altering the intercept for the N management treatments increased the proportion of variation accounted for to 61% (P<0.001). Altering the slope or using different shaped curves did not improve the fit. Oil content decreased by 2.67 percentage points for each 100 kg/ha increase in N rate from a starting oil content of 44.2% at nil N for Conventional N timings and 41.0% at nil N for Managed N timings.

Table 5.9. Boxworth Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
Kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	43.2		43.2	42.5		42.5	42.9		42.9
120	43.0	34.3	38.7	40.9	35.9	38.4	42.0	35.1	38.6
240	41.3	32.7	37.0	41.1	33.8	37.5	41.2	33.3	37.3
360	32.0	33.3	32.7	31.1	34.1	32.6	31.6	33.7	32.7
Mean	38.8	33.4	37.9	37.7	34.6	36.2	38.3	33.5	35.9

Treatment	df	SED	P Value
Variety	3	1.17	NS
Nitrogen	36	0.84	<0.001
N management	36	0.69	<0.001
Variety x Nitrogen	36	1.06	NS
Variety x Management	28	0.81	NS
Nitrogen x Management	36	1.19	<0.001
Var x N x Man	36	1.68	NS

Without Folicur

At High Mowthorpe, increasing N rate from nil to 360 kg N/ha decreased oil content from 42.5% to 40.3% (P<0.001; Table 5.10). Neither variety nor N management significantly affected oil content. A linear regression for N rate against oil content accounted for just 19% of the variation (P<0.001). Altering the intercept or slope for the different treatment combinations did not significantly increase the amount of variation accounted for, nor did the use of different shaped curves. On average oil

content decreased by 0.67 percentage points for each 100 kg/ha increase in N rate from a starting oil content of 42.5% at nil N.

Table 5.10. High Mowthorpe Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
Kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	42.4		42.4	42.6		42.6	42.5		42.5
120	42.5	42.0	42.2	40.4	43.8	42.1	41.4	42.9	42.2
240	39.7	41.5	40.6	40.3	40.3	40.3	40.0	40.9	40.4
360	40.9	40.9	40.9	40.0	39.6	39.8	40.4	40.3	40.3
Mean	41.0	41.5	41.5	40.2	41.2	41.2	40.6	41.4	41.4

Treatment	df	SED	P Value
Variety	3	0.341	NS
Nitrogen	36	0.974	<0.05
N management	36	0.974	NS
Variety x Nitrogen	36	1.320	NS
Variety x Management	28	1.320	NS
Nitrogen x Management	36	0.974	NS
Var x N x Man	36	1.320	NS

Without Folicur

At Rosemaund, increasing N rate from nil to 360 kg N/ha decreased oil content from 47.3% to 43.1% ($P<0.001$; Table 5.11). A linear regression for N rate against oil content accounted for 77% of the variation ($P<0.001$). Altering the intercept or slope for the different treatment combinations did not significantly increase the amount of variation accounted for, nor did the use of different shaped curves. Oil content decreased by 1.19 percentage points for each 100 kg/ha increase in N rate from a starting oil content of 47.0% at nil N.

Table 5.11. Rosemaund Oil contents (% dry matter)

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0	47.3		47.3	47.3		47.3	47.3		47.3
120	46.8	44.7	45.7	45.0	44.7	44.8	45.9	44.7	45.3
240	44.0	44.0	44.0	43.9	43.6	43.7	44.0	43.8	43.9
360	43.1	43.3	43.2	42.9	43.0	42.9	43.0	43.1	43.1
Mean	44.6	44.0	45.1	43.9	43.8	44.7	44.3	43.9	44.9

Treatment	df	SED	P Value
Variety	3	0.262	NS
Nitrogen	36	0.312	<0.001
N management	36	0.208	0.051
Variety x Nitrogen	36	0.402	NS
Variety x Management	28	0.344	NS
Nitrogen x Management	36	0.360	<0.05
Var x N x Man	36	0.540	NS

Without Folicur

5.1.5 Optimum N rates

At Boxworth, regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (44%, $P<0.001$). The economically optimum N rate before taking account of oil premiums was 100 kg N/ha for all treatments and 70 kg N/ha after taking account of the oil content. At 70 kg N/ha the Managed N timing increased yield of Winner by 0.36 t/ha and increased the yield of Castille by 0.08 t/ha. At 70 kg N/ha with Conventional N timings Folicur increased the yield of Winner by 0.20 t/ha and increased the yield of Castille by 0.15 t/ha (Table 5.12). At optimum N rate with Managed N timings Folicur increased the yield of Castille by 0.19 t/ha and had no effect on Winner.

At High Mowthorpe regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (73%, $P<0.001$). The economically optimum N rate before taking account of oil premiums was 249 kg N/ha for all treatments, and this decreased to 239 kg N/ha after taking account the oil content. At 239 kg N/ha the Managed N timing did not affect the yield of Winner and reduced the yield of Castille by 0.13 t/ha. At optimum N rate Folicur increased the yield of Winner and Castille with Conventional or Managed N timings by 0.27 to 0.31 t/ha.

At Rosemaund regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (83%, P<0.001). The economically optimum N rate before taking account of oil premiums was 246 kg N/ha for all treatments, which decreased to 224 kg N/ha after accounting for oil content. At 224 kg N/ha rate the Managed N timing increased the yield of Winner by 0.15 t/ha and had no effect on the yield of Castille. At the optimum N rate with Conventional N timings Folicur increased the yield of Winner by 0.22 t/ha and had no effect on the yield of Castille. At optimum N rate with Managed N timings Folicur had no effect on the yield of Winner or Castille.

Table 5.12. Optimum N rate and yields at N opt.

	Boxworth	High Mowthorpe	Rosemaund
Economically optimum N rate (kg/ha)	70	239	224
Winner Conventional N timings	3.40	3.69	4.40
Winner Managed N timings	3.76	3.62	4.55
Winner Conventional N timings with Folicur	3.60	3.86	4.62
Winner Managed N timings with Folicur	3.74	3.89	4.58
Castille Conventional N timings	4.04	4.56	4.90
Castille Managed N timings	4.12	4.43	4.91
Castille Conventional N timings with Folicur	4.19	4.84	4.99
Castille Managed N timings with Folicur	4.31	4.74	4.92

5.1.6 Crop growth before stem extension

Crop assessments carried out before any N applications in February showed that the GAI, dry weight, tissue N concentration and N content of the crops did not differ between Winner and Castille at the 5% level of significance (Table 5.13). At Boxworth there was a trend for Winner to have a greater GAI, tissue N concentration and crop N content ($P<0.01$; Table 5.13). Regression analysis on the plot data for both varieties across all sites showed that a single linear best fit line accounted for 88% of the variation between GAI and the crop N content (Figure 5.1). This demonstrates that the canopy nitrogen requirement observed in previous studies of 50 kg per unit of GAI also holds for the modern high biomass variety Winner and low biomass variety Castille.

Table 5.13. February measurements.

Boxworth

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	1.54	1.99	4.11	82.1
Castille	1.25	1.74	3.66	63.1
Mean	1.40	1.86	3.89	72.6
SED (df)	0.123	0.170	0.174	7.99
P-Value	0.099	NS	0.079	0.098

High Mowthorpe

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	0.58	0.69	5.24	31.9
Castille	0.56	0.69	4.75	33.1
Mean	0.57	0.69	4.99	32.5
SED (df)	0.372	0.384	0.576	15.69
P-Value	NS	NS	NS	NS

Rosemaund

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	0.63	0.81	3.42	28.1
Castille	0.62	0.86	4.47	37.1
Mean	0.63	0.84	3.94	32.6
SED (df)	0.080	0.062	1.15	8.28
P-Value	NS	NS	NS	NS

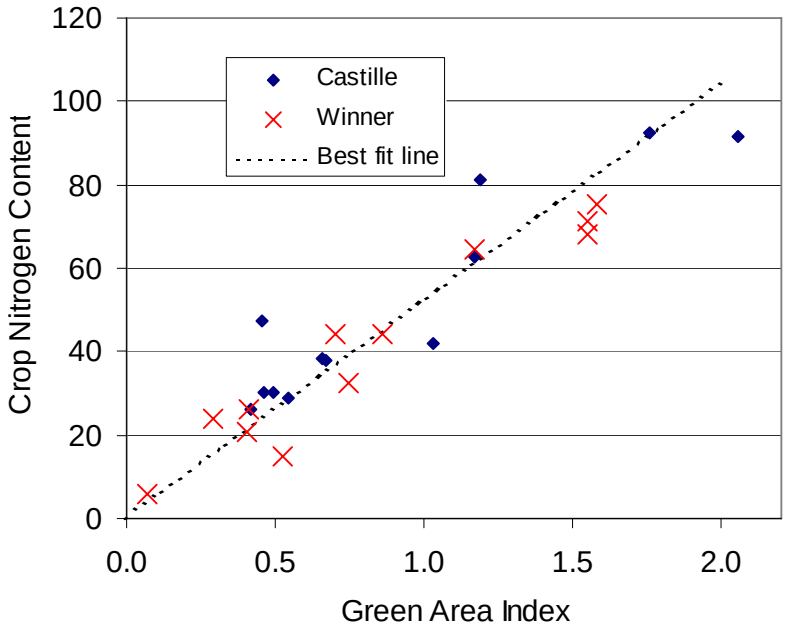

Figure 5.1. Relationship between green area index and crop nitrogen content measured in February at ADAS Boxworth, High Mowthorpe and Rosemaund. Best fit line: $y = 0.019x$; $R^2 = 0.88$; $P<0.001$).

5.1.7 GAI at end of flowering

Measurements of GAI were taken at the end of flowering on nitrogen Treatment 3 (120 kg N/ha) to assess whether the GAI achieved was similar to that predicted using the assumptions used for canopy management. GAI for each site was predicted from the soil and crop N measured in February and the amount of fertiliser N applied (120 kg/ha) (Table 5.14). The measurements of GAI at the end of flowering show that the predicted values of GAI were quite accurate. The GAI measurements were made at the end of May when no flowers were left. At this time the pod area represented about one third of the total GAI. Varietal differences were not observed for GAI (Tables 5.15 to 5.17). It is also interesting to note that there were no differences in total or stem biomass between Winner and Castille at this stage of development (Tables 5.15 to 5.17).

Table 5.14. Comparison of predicted and measured GAIs for Treatment 3.

	Boxworth	High Mowthorpe	Rosemaund
Predicted GAI	3.90	2.78	3.30
*Measured GAI	4.06	3.21	3.10

Mean of Winner and Castille

Table 5.15. Boxworth. End of flowering measurements on Treatment 3 (30th May).

	Green area indices				Dry weight (t/ha)				
	Leaf	Stem	Pod	Total	Leaf	Stem	Pod	Total	Crop N (kg/ha)
Winner	1.52	1.05	1.14	3.71	0.88	6.07	3.71	10.76	264
Castille	1.73	1.25	1.42	4.40	1.02	6.71	4.81	12.74	330
Mean	1.62	1.15	1.28	4.05	0.95	6.39	4.26	11.75	297
SED (df)	0.501	0.243	0.223	0.956	0.296	0.111	0.700	0.203	49.4
P-Value	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5.16. High Mowthorpe. End of flowering measurements on Treatment 3 (13 June).

	Green area indices			Dry weight (t/ha)					
	Leaf	Stem	Pod	Total	Leaf	Stem	Pod	Total	Crop N (kg/ha)
Winner	0.78	0.99	1.17	2.93	0.59	4.33	3.32	8.24	125
Castille	0.80	1.12	1.58	3.49	0.63	4.67	4.25	9.55	156
Mean	0.79	1.05	1.37	3.21	0.61	4.50	3.78	8.89	140
SED (df)	0.175	0.213	0.054	0.392	0.135	0.583	0.420	1.042	26.4
P-Value	NS	NS	0.078	NS	NS	NS	NS	NS	NS

Table 5.17. Rosemaund. End of flowering measurements on Treatment 3 (30th May).

	Green area indices			Dry weight (t/ha)					
	Leaf	Stem	Pod	Total	Leaf	Stem	Pod	Total	Crop N (kg/ha)
Winner	1.88	0.73	1.04	3.65	0.87	4.41	3.16	8.43	154
Castille	1.41	0.59	0.54	2.55	0.66	3.99	2.53	7.18	127
Mean	1.65	0.66	0.79	3.10	0.76	4.20	2.85	7.81	140
SED (df)	0.386	0.119	0.217	0.436	0.048	0.830	0.391	0.112	20.1
P-Value	NS	NS	NS	0.085	<0.05	NS	NS	NS	NS

5.1.8 Light interception at the end of flowering

At Boxworth, the crop canopy intercepted on average 97% of the incoming light (Table 5.18) of which 84% was intercepted by the pod layer (Table 5.19). Increasing the N rate applied at conventional timings from 120 kg/ha to 360 kg/ha increased the percentage of light intercepted by the whole canopy from 96.3% to 97.7% ($P<0.01$) and increased the light intercepted by the pod layer from 83.0% to 85.3% (NS). On average the canopy of Castille intercepted slightly more light than the canopy of Winner ($P = 0.054$). Folicur did not affect the amount of light intercepted.

At High Mowthorpe, the crop canopy intercepted on average 96% of the incoming light (Table 5.20) of which 84% was intercepted by the pod layer (Table 5.21). Increasing the N rate applied at conventional timings from 120 kg/ha to 360 kg/ha increased the percentage of light intercepted by the whole canopy from 94.4% to 97.7% ($P<0.001$) and increased the light intercepted by the pod layer from 81.0 to 86.2% ($P<0.01$). Neither variety nor Folicur affected the amount of light intercepted.

At Rosemaund, the crop canopy intercepted on average 88% of the incoming light (Table 5.22) of which almost all was intercepted by the pod layer (Table 5.23). Increasing the N rate applied at conventional timings from 120 kg/ha to 360 kg/ha increased the percentage of light intercepted by the whole canopy from 86.6% to 89.8% (NS) and increased the light intercepted by the pod layer from 86.4 to 89.3% ($P<0.05$). Neither variety nor Folicur affected the amount of light intercepted.

Table 5.18. Boxworth proportion of light intercepted by pod layer (31 May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	83.4	82.7	83.0	82.6	83.3	83.0	83.0	83.0	83.0
360	86.6	84.3	85.5	84.5	85.8	85.1	85.6	85.0	85.3
Mean	85.0	83.5	84.2	83.5	84.5	84.0	84.3	84.0	84.1

Treatment	df	SED	P Value
Variety	2	1.19	NS
N Rate	12	1.41	NS
Folicur	12	1.41	NS
Variety x N Rate	9	1.85	NS
Variety x Folicur	9	1.85	NS
N Rate x Folicur	12	1.99	NS
Variety x Folicur x N Rate	14	2.71	NS

Table 5.19. Boxworth proportion of light intercepted by whole canopy (31 May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	95.3	96.7	96.0	96.6	96.5	96.5	95.9	96.6	96.3
360	97.1	97.5	97.3	97.9	98.2	98.0	97.5	97.8	97.7
Mean	96.2	97.1	96.6	97.2	97.3	97.3	96.7	97.2	97.0

Treatment	df	SED	P Value
Variety	2	0.155	0.054
N Rate	12	0.452	<0.01
Folicur	12	0.452	NS
Variety x N Rate	9	0.478	NS
Variety x Folicur	9	0.478	NS
N Rate x Folicur	12	0.639	NS
Variety x Folicur x N Rate	14	0.798	NS

Table 5.20. High Mowthorpe proportion of light intercepted by pod layer (14 June 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	0.794	0.791	0.793	0.842	0.814	0.828	0.818	0.802	0.810
360	0.865	0.861	0.863	0.873	0.848	0.860	0.869	0.855	0.862
Mean	0.829	0.826	0.828	0.857	0.831	0.844	0.843	0.829	0.836

Treatment	df	SED	P Value
Variety	2	0.0200	NS
N Rate	12	0.0167	<0.01
Folicur	12	0.0167	NS
Variety x N Rate	9	0.0261	NS
Variety x Folicur	9	0.0261	NS
N Rate x Folicur	12	0.0236	NS
Variety x Folicur x N Rate	14	0.0351	NS

Table 5.21. High Mowthorpe proportion of light intercepted by whole canopy (14 June 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	0.947	0.944	0.946	0.932	0.947	0.939	0.940	0.945	0.943
360	0.984	0.974	0.979	0.969	0.979	0.974	0.977	0.977	0.977
Mean	0.966	0.959	0.963	0.950	0.963	0.957	0.958	0.961	0.960

Treatment	df	SED	P Value
Variety	2	0.0108	NS
N Rate	12	0.0066	<0.001
Folicur	12	0.0066	NS
Variety x N Rate	9	0.0126	NS
Variety x Folicur	9	0.0126	NS
N Rate x Folicur	12	0.0093	NS
Variety x Folicur x N Rate	14	0.0156	NS

Table 5.22. Rosemaund proportion of light intercepted by pod layer (30 May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	0.848	0.866	0.857	0.855	0.887	0.871	0.851	0.877	0.864
360	0.911	0.906	0.908	0.865	0.896	0.880	0.888	0.901	0.894
Mean	0.879	0.886	0.883	0.860	0.892	0.876	0.869	0.889	0.879

Treatment	df	SED	P Value
Variety	14	0.0129	NS
N Rate	14	0.0129	<0.05
Folicur	14	0.0129	NS
Variety x N Rate	14	0.0182	NS
Variety x Folicur	14	0.0182	NS
N Rate x Folicur	14	0.0182	NS
Variety x Folicur x N Rate	14	0.0258	NS

Table 5.23. Rosemaund proportion of light intercepted by whole canopy (30 May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	0.884	0.839	0.861	0.894	0.847	0.870	0.889	0.843	0.866
360	0.929	0.920	0.925	0.863	0.879	0.871	0.896	0.900	0.898
Mean	0.906	0.880	0.893	0.879	0.863	0.871	0.892	0.871	0.882

Treatment	df	SED	P Value
Variety	14	0.0199	NS
N Rate	14	0.0199	NS
Folicur	14	0.0199	NS
Variety x N Rate	14	0.0281	NS
Variety x Folicur	14	0.0281	NS
N Rate x Folicur	14	0.0281	NS
Variety x Folicur x N Rate	14	0.0397	NS

5.1.9 Depth of pod layer

Folicur reduced the depth of the pod layer from 70.7 cm to 67.7 cm at Boxworth (Table 5.24), from 59.3 cm to 57.9 cm at High Mowthorpe (Table 5.25) and from 67 cm to 62 cm at Rosemaund (Table 5.26). However none of these effects were statistically significant. There was no evidence that Folicur reduced pod depth more for Winner than for Castille. Winner tended to have a deeper pod layer than Castille, but again this effect was not statistically significant.

At Rosemaund additional measurements were carried out of the length of the stem from the ground to the base of the pod layer (Table 5.27) and of the overall crop height (Table 5.28). The stem length of Castille was 7 cm shorter than Winner ($P<0.05$). Folicur (0.5 l/ha) shortened the stems by 4 cm (NS). The overall crop height of Winner was 164 cm compared with 155 cm for Castille ($P<0.05$). Folicur reduced the overall crop height from 164 cm to 154 cm ($P<0.05$). Applying N at conventional timings at 120 kg/ha or 360 kg/ha did not affect the stem length or overall crop height.

Table 5.24. Boxworth depth of pod layer (cm) (31st May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	72.8	70.0	71.4	67.8	63.9	65.8	70.3	66.9	68.6
360	75.0	75.0	71.7	67.2	64.4	65.8	71.1	66.4	68.8
Mean	73.9	69.2	71.5	67.5	64.2	65.8	70.7	66.7	68.7

Treatment	df	SED	P Value
Variety	2	5.28	NS
N Rate	12	2.77	NS
Folicur	12	2.77	NS
Variety x N Rate	9	5.96	NS
Variety x Folicur	9	5.96	NS
N Rate x Folicur	12	3.92	NS
Variety x Folicur x N Rate	14	7.13	NS

Table 5.25. High Mowthorpe depth of pod layer (cm) (14 June 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	62.6	60.8	61.7	56.6	56.4	56.5	59.6	58.6	59.1
360	59.4	57.1	58.3	58.4	57.1	57.8	58.9	57.1	58.0
Mean	61.0	58.9	60.0	57.5	56.8	57.1	59.3	57.9	58.6

Treatment	df	SED	P Value
Variety	2	4.88	NS
N Rate	12	2.62	NS
Folicur	12	2.62	NS
Variety x N Rate	9	5.54	NS
Variety x Folicur	9	5.54	NS
N Rate x Folicur	12	3.10	NS
Variety x Folicur x N Rate	14	6.66	NS

Table 5.26. Rosemaund depth of pod layer (cm) (30 May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	68	62	65	70	60	65	69	61	65
360	63	66	65	67	58	63	65	62	64
Mean	66	64	65	69	59	64	67	62	64

Treatment	df	SED	P Value
Variety	14	3.60	NS
N Rate	14	3.60	NS
Folicur	14	3.60	NS
Variety x N Rate	14	5.09	NS
Variety x Folicur	14	5.09	NS
N Rate x Folicur	14	5.09	NS
Variety x Folicur x N Rate	14	7.21	NS

Table 5.27. Rosemaund stem length (cm) (30 May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	102	95	99	93	86	90	98	91	94
360	102	98	100	95	92	94	99	95	97
Mean	102	97	99	94	89	92	98	93	95

Treatment	df	SED	P Value
Variety	14	3.29	<0.05
N Rate	14	3.29	NS
Folicur	14	3.29	NS
Variety x N Rate	14	4.66	NS
Variety x Folicur	14	4.66	NS
N Rate x Folicur	14	4.66	NS
Variety x Folicur x N Rate	14	6.59	NS

Table 5.28. Rosemaund Overall crop height (cm) (30 May 2006)

N Rate	Winner			Castille			Nil	Folicur	Grand
Kg/ha	Nil	Folicur	Mean	Nil	Folicur	Mean	Mean	Mean	Mean
120	170	157	164	163	146	155	167	152	159
360	165	164	165	159	150	155	162	157	160
Mean	168	161	164	161	148	155	164	154	159

Treatment	df	SED	P Value
Variety	14	3.49	<0.05
N Rate	14	3.49	NS
Folicur	14	3.49	<0.05
Variety x N Rate	14	4.94	NS
Variety x Folicur	14	4.94	NS
N Rate x Folicur	14	4.94	NS
Variety x Folicur x N Rate	14	6.98	NS

5.1.10 Lodging

At Boxworth, lodging was observed in the Winner treatments from the 9th June (early seed filling) onwards and no lodging was observed in the Castille treatments. Throughout the seed filling period lodging was significantly increased in Winner by increasing N rate. For example on 30th June the nil N rate treatments had 6% area lodged and the 240 kg N/ha treatments had 51% area lodged (Table 5.29; $P<0.01$). Applying N at Managed timings also reduced lodging. This effect was most significant during late seed filling. On the 12th July the Managed N treatments averaged 35% area lodged compared with 53% for the Conventional N treatments (Table 5.30; $P<0.05$).

At High Mowthorpe, only leaning of the upper half of the canopy was observed. This is recognised as less serious than lodging in which the lower half of the stems are either severely bent or buckled. Castille had significantly less leaning than Winner between the 10th and 31st of July (Tables 5.31 to 5.34). On the 31st July, the Winner treatments averaged 25% area lodged compared with 16% area lodged for Castille ($P<0.01$; Table 5.34). Neither N rate nor N management affected the amount of leaning.

At Rosemaund, lodging was observed in Winner and none in Castille at harvest. Applying N at Managed timings reduced the percentage area lodged across all N treatments in Winner from 23% to 8% (Table 5.35).

Table 5.29. Boxworth percentage area lodged for Winner

N Rate Kg/ha	9th June Conv	CM	Mean	23 June Conv	CM	Mean	30 June Conv	CM	Mean
0			8			5			6
120	32	9	20	35	16	26	39	20	29
180	33	28	30	33	35	34	36	36	36
240	44	26	35	58	43	50	61	40	51
Mean	36	21	23	42	31	29	45	32	31
Treatment	df	SED	P Value		SED	P Value		SED	P Value
N Rate	18	10.59	0.064		9.17	<0.01		9.11	<0.01
N Management	18	8.01	0.074		6.93	NS		6.89	0.069
N Rate x N Man	18	13.87	NS		12.00	NS		11.93	NS

Table 5.30. Boxworth percentage area lodged for Winner

N Rate Kg/ha	6th July Conv	CM	Mean	12th July Conv	CM	Mean
0						5
120	41	21	31	40	24	32
180	40	36	38	46	40	43
240	65	40	53	71	41	56
Mean	49	32	32	52	35	34
Treatment	df	SED	P Value		SED	P Value
N Rate	18	9.63	<0.01		9.37	<0.001
N Management	18	7.28	<0.05		7.09	<0.05
N Rate x N Man	18	12.6	NS		12.27	NS

Table 5.31. High Mowthorpe percentage area lodged on 10th July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0			24			14	19		19
120	14	22	18	9	9	9	11	15	13
180	31	30	31	7	8	8	19	19	19
240	23	22	22	8	12	10	15	17	16
Mean	23	25	24	8	10	10	15	17	17

Treatment	df	SED	P Value
Variety	3	2.02	<0.01
N Rate	36	3.01	NS
N Management	36	2.27	NS
Variety x N Rate	37	3.89	<0.05
Variety x N Management	30	3.16	NS
N Rate x N Management	36	3.94	NS
Variety x N Rate x N Management	36	5.57	NS

Table 5.32. High Mowthorpe percentage area lodged on 17th July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0			27			13			20
120	17	19	18	14	14	14	15	16	16
180	22	21	22	12	13	12	17	17	17
240	17	20	19	12	11	11	14	16	15
Mean	19	20	21	13	13	12	15	16	17

Treatment	df	SED	P Value
Variety	3	1.17	<0.01
N Rate	36	2.31	0.076
N Management	36	1.75	NS
Variety x N Rate	37	2.82	NS
Variety x N Management	30	2.21	NS
N Rate x N Management	36	3.03	NS
Variety x N Rate x N Management	36	4.28	NS

Table 5.33. High Mowthorpe percentage area lodged on 25h July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0			28			15			21
120	19	22	21	16	16	16	17	19	18
180	24	25	25	16	18	17	20	21	21
240	21	25	23	14	14	14	17	19	18
Mean	21	24	24	15	16	15	18	20	20

Treatment	df	SED	P Value
Variety	3	0.728	<0.01
N Rate	36	2.278	NS
N Management	36	1.722	NS
Variety x N Rate	37	2.624	NS
Variety x N Management	30	1.980	NS
N Rate x N Management	36	2.982	NS
Variety x N Rate x N Management	36	4.218	NS

Table 5.34. High Mowthorpe percentage area lodged on 31st July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0			28			16			22
120	21	24	23	16	17	17	19	20	20
180	25	26	26	17	19	18	21	22	22
240	23	25	24	16	15	15	19	20	20
Mean	23	25	25	16	17	16	20	21	21

Treatment	df	SED	P Value
Variety	3	0.794	<0.01
N Rate	36	2.323	NS
N Management	36	1.756	NS
Variety x N Rate	37	2.690	NS
Variety x N Management	30	2.038	NS
N Rate x N Management	36	3.041	NS
Variety x N Rate x N Management	36	4.300	NS

Table 5.35. Rosemaund percentage area lodged at harvest for cv. Winner

N Rate Kg/ha	Winner Conv	CM	Mean
0			0
60	0	0	0
120	26	0	13
180	49	24	36
240	30	1	16
300	25	0	13
360	46	23	34
Mean	23	8	16

Treatment	SED	P-Value
N rate (36 df)	16.9	NS
N Management (36 df)	9.4	NS
N rate x Man (36 df)	22.9	<0.05

5.1.11 Pod greenness

At Boxworth, the percentage of green pods on Winner decreased from an average of 72% on the 9th June to 10% on 12th July (Tables 5.36 and 5.37). Increasing N rate from 0 to 120 kg N/ha and from 120 kg/ha to 240 kg/ha increased the percentage of green pods ($P<0.05$). On the 6th July, applying N at Managed timings reduced the percentage of green pods from 35% to 24% ($P<0.05$) compared to conventional timings. Canopy Management did not reduce the percentage of green pods at the other assessment dates.

At High Mowthorpe, the percentage of green pods was measured on both Winner and Castille. At this site the percentage of green pods decreased from on average 81% on the 10th July to 2% on 31st July (Tables 5.38 to 5.41). Increasing N rate from 0 to 120 kg N/ha and from 120 kg/ha to 240 kg/ha increased the percentage of green pods ($P<0.05$). Winner generally had a slightly greater percentage of green pods compared with Castille, but this difference was only statistically significant on the 10th July. Applying N at Managed timings did not affect the percentage of green pods at any of the assessment dates.

Table 5.36. Boxworth Pod greenness scores for Winner

N Rate	9th June			23 June			30 June		
Kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	48		48	33		33	23		23
120	70	70	70	63	65	64	50	46	48
180	88	76	82	73	74	73	58	58	58
240	85	91	88	79	84	81	70	66	68
Mean	81	79	72	72	74	63	59	57	49
Treatment	df	SED	P Value		SED	P Value		SED	P Value
N Rate	18	7.64	<0.001		2.99	<0.001		3.92	<0.001
N Management	18	5.78	NS		2.26	NS		2.96	NS
N Rate x N Man	18	10.01	NS		3.91	NS		5.13	NS

Table 5.37. Boxworth Pod greenness scores for Winner

N Rate	6th July			12th July		
Kg/ha	Conv	CM	Mean	Conv	CM	Mean
0	4		4	1		1
120	29	18	23	10	9	9
180	40	21	31	16	11	14
240	36	33	34	10	18	14
Mean	35	24	23	12	13	10
Treatment	df	SED	P Value		SED	P Value
N Rate	18	5.45	<0.001		4.95	<0.05
N Management	18	4.12	<0.05		3.74	NS
N Rate x N Man	18	7.13	NS		6.49	NS

Table 5.38. High Mowthorpe Pod greenness scores on 10th July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0	59		59	64		64	61		61
120	85	89	87	86	73	80	86	81	83
180	92	90	91	88	91	90	90	91	90
240	94	92	93	91	87	89	92	89	91
Mean	90	90	82	88	84	80	89	87	81

Treatment	df	SED	P Value
Variety	3	0.91	0.050
N Rate	36	2.12	<0.001
N Management	36	1.61	NS
Variety x N Rate	37	2.52	NS
Variety x N Management	30	1.94	NS
N Rate x N Management	36	2.78	NS
Variety x N Rate x N Management	36	3.93	<0.05

Table 5.39. High Mowthorpe Pod greenness scores on 17th July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0	38		38	37		37	37		37
120	71	66	69	70	63	66	70	65	67
180	76	67	72	79	80	80	78	74	76
240	81	85	83	79	82	80	80	84	82
Mean	76	73	65	76	75	66	76	74	66

Treatment	df	SED	P Value
Variety	3	1.93	NS
N Rate	36	4.14	<0.001
N Management	36	3.13	NS
Variety x N Rate	37	4.97	NS
Variety x N Management	30	3.86	NS
N Rate x N Management	36	5.42	NS
Variety x N Rate x N Management	36	7.67	NS

Table 5.40. High Mowthorpe Pod greenness scores on 25h July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0	10		10	10		10	10		10
120	38	41	39	24	25	24	31	33	32
180	41	40	41	36	44	40	39	42	40
240	44	45	44	37	32	35	40	39	39
Mean	41	42	34	32	34	27	37	38	30

Treatment	df	SED	P Value
Variety	3	15.72	NS
N Rate	36	3.51	<0.001
N Management	36	2.65	NS
Variety x N Rate	37	16.29	0.093
Variety x N Management	30	15.97	NS
N Rate x N Management	36	4.59	NS
Variety x N Rate x N Management	36	16.8	NS

Table 5.41. High Mowthorpe Pod greenness scores on 31st July 2006

N Rate Kg/ha	Winner Conv	CM	Mean	Castille Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
0	1		1	1		1	1		1
120	3	3	3	1	1	1	2	2	2
180	4	3	4	2	2	2	3	3	3
240	5	4	5	2	1	2	4	2	3
Mean	4	3	3	2	1	1	3	2	2

Treatment	df	SED	P Value
Variety	3	1.764	NS
N Rate	36	0.606	<0.001
N Management	36	0.458	NS
Variety x N Rate	37	1.880	NS
Variety x N Management	30	1.823	NS
N Rate x N Management	36	0.794	NS
Variety x N Rate x N Management	36	1.123	NS

5.1.12 Seed N concentration

The rate of N had the strongest effect on the seed N concentration at all three sites ($P<0.001$). Across all treatments, increasing the N rate from 0 kg/ha to 360 kg/ha increased the seed N concentration from 2.52% to 3.34% at Boxworth (Table 5.42), 2.40% to 3.06% at High Mowthorpe (Table 5.43) and from 2.71% to 3.62% at Rosemaund (Table 5.43). The timing of the N applications interacted with the N rate at Boxworth ($P<0.05$) because applying 120 kg N/ha at Managed timings increased seed N from 2.82% to 2.88%, but applying 360 kg at Managed timings decreased seed N from 3.44% to 3.24%. At Rosemaund, applying N at Managed timings increased the seed N of Castille from 3.29% to 3.37% ($P<0.05$) and had no effect on Winner. Applying N at Managed timings had no effect on seed N concentration at High Mowthorpe. Castille had a slightly greater seed N than Winner at Boxworth ($P = 0.089$). Variety did not affect seed N concentration at the other two sites.

Table 5.42. Boxworth seed N concentrations (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
Kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	2.63		2.63	2.41		2.41	2.52		2.52
120	2.82	2.95	2.88	2.81	2.81	2.81	2.82	2.88	2.85
180	3.18	3.06	3.12	3.06	2.99	3.03	3.12	3.03	3.07
240	3.25	3.25	3.25	3.07	3.08	3.07	3.16	3.16	3.16
360	3.45	3.28	3.36	3.43	3.19	3.31	3.44	3.24	3.34
Mean	3.14	3.12	3.13	3.09	3.03	3.06	3.12	3.07	3.10

Treatment	df	SED	P Value
Variety	4	0.046	0.089
Nitrogen	47	0.044	<0.001
N management	47	0.031	0.070
Variety x Nitrogen	45	0.072	NS
Variety x Management	45	0.057	NS
Nitrogen x Management	47	0.062	<0.05
Var x N x Man	45	0.088	NS

Without Folicur

Table 5.43. High Mowthorpe seed N concentrations (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
Kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	2.30		2.30	2.50		2.50	2.40		2.40
120	2.73	2.79	2.76	2.68	2.53	2.61	2.71	2.66	2.68
180	3.01	2.96	2.98	2.91	2.93	2.92	2.96	2.94	2.95
240	2.94	2.82	2.88	2.91	2.99	2.95	2.92	2.91	2.91
360	3.22	2.96	3.09	2.98	3.10	3.04	3.10	3.03	3.06
Mean	2.98	2.88	2.80	2.87	2.89	2.80	2.92	2.89	2.80

Treatment	df	SED	P Value
Variety	4	0.030	NS
Nitrogen	47	0.110	<0.001
N management	47	0.110	NS
Variety x Nitrogen	45	0.150	NS
Variety x Management	45	0.150	NS
Nitrogen x Management	47	0.110	NS
Var x N x Man	45	0.150	NS

Without Folicur

Table 5.44. Rosemaund seed N concentrations (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
Kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	2.75		2.75	2.68		2.68	2.71		2.71
120	2.99	3.23	3.11	2.98	3.21	3.10	2.98	3.22	3.10
180	2.96	3.33	3.15	3.23	3.35	3.29	3.10	3.34	3.22
240	3.65	3.36	3.50	3.44	3.36	3.40	3.54	3.36	3.45
360	3.86	3.59	3.73	3.51	3.54	3.52	3.68	3.57	3.62
Mean	3.37	3.38	3.25	3.29	3.37	3.20	3.33	3.37	3.22

Treatment	df	SED	P Value
Variety	4	0.071	NS
Nitrogen	47	0.132	<0.001
N management	47	0.132	NS
Variety x Nitrogen	45	0.132	NS
Variety x Management	45	0.189	<0.05
Nitrogen x Management	47	0.132	NS
Var x N x Man	45	0.189	NS

Without Folicur

5.1.13 Partitioning of dry matter and nitrogen for cv Winner

At Boxworth, increasing the N rate from 0 kg/ha to 120 kg/ha increased the overall crop biomass. The relative increase in biomass partitioned was greatest to the seeds then the pod walls and least to the stems (Table 5.45). However these effects were not statistically significant. N rates between 120 and 360 kg/ha and timing of N

applications did not produce any consistent effects on total dry matter and its partitioning. Increasing N rate increased the concentration of N in the stems, pod walls and seed (Table 5.46). This led to a greater amount of N per hectare in the stem, pod wall and seed components at the higher N rates. Delaying N applications did not significantly affect the concentration of N in the stem, pod walls or seed, nor did it affect the amount of N per hectare in these tissues.

At High Mowthorpe, increasing N rate increased the total crop biomass and the biomass of the stems, pod walls and seeds ($P<0.05$; Table 5.47). N rate and N Management interacted for their effect on the biomass of the stems, pods and seeds. Applying N at Managed timings increased biomass at low N rates and decreased biomass at high N rates. Increasing N rate increased the concentration of N in the stems, pod walls and seed (Table 5.48). This lead to greater amount of N per hectare in the stem, pod wall and seed components at the higher N rates. At Managed N timings more N per hectare was in the seed and total crop at low N rates than at high N rates.

At Rosemaund, increasing N rate increased the total crop biomass and the biomass of the stems, pod walls and seeds ($P<0.05$; Table 5.49). Applying N at Managed timings increased the harvest index from 0.319 to 0.353 across all treatments ($P<0.05$). This effect was caused by a reduction in stem biomass and an increase in seed biomass. Increasing N rate increased the concentration of N in the stems, pod walls and seed (Table 5.50). This led to a greater amount of N/ha in the stem, pod wall and seed components at the higher N rates. Applying N at Managed timings increased the N harvest index from 0.623 to 0.660 across all treatments ($P<0.05$). This was caused by an increase of N in the seed rather than a decrease of N in the stem and pod walls.

At the N rate closest to the economic optimum there was a trend for the treatments with Managed timings to have a lower stem biomass. The stem biomass resulting from Conventional and Managed N timings were 8.20 t/ha and 7.73 t/ha respectively at Boxworth, 4.06 t/ha and 3.86 t/ha at High Mowthorpe and 5.31 t/ha and 4.54 t/ha at Rosemaund.

Table 5.45. Boxworth dry matter components at harvest for cv. Winner.

N Rate kg/ha	Stem dry weight (t/ha)		Pod dry weight (t/ha)		Seed dry weight (t/ha)		Total dry weight (t/ha)		Harvest index	
	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM
0	7.31		2.66		4.34		14.32		0.309	
120	8.20	7.73	3.29	3.09	5.52	5.60	17.01	16.42	0.326	0.339
180	7.10	8.74	2.80	2.75	5.12	4.69	15.03	16.17	0.341	0.281
240	6.92	7.68	3.50	3.36	5.72	6.04	16.14	17.08	0.354	0.354
Mean	7.41	8.05	3.20	3.07	5.45	5.44	16.06	16.56	0.340	0.325
Treatment	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value
Nrate (18 df)	0.84	NS	0.350	NS	0.652	NS	1.64	NS	0.018	0.090
Management (18 df)	0.64	NS	0.264	NS	0.493	NS	1.24	NS	0.015	NS
Nrate x Man (18 df)	1.10	NS	0.458	NS	0.854	NS	2.15	NS	0.026	NS

Table 5.46. Boxworth crop N content at harvest for cv. Winner.

N Rate kg/ha	Stem+pod N concentration (%)		Seed N concentration (%)		Stem+Pod N content (kg N/ha)		Seed N content (kg N/ha)		Total crop N content (kg N/ha)		Nitrogen harvest index	
	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM
0	0.700		2.63		72		114		186		0.629	
120	0.820	0.943	2.82	2.95	96	109	156	165	252	275	0.624	0.621
180	1.010	1.283	2.99	3.06	102	146	162	144	264	290	0.619	0.485
240	1.055	0.948	3.25	3.25	109	107	186	196	295	302	0.634	0.655
Mean	0.962	1.058	3.02	3.09	102	121	168	168	270	289	0.626	0.587
Treatment	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value
Nrate (18 df)	0.096	<0.01	0.064	<0.001	16.1	<0.05	21.8	<0.05	29.6	<0.01	0.0320	<0.05
Management (18 df)	0.072	NS	0.052	NS	12.2	NS	16.4	NS	24.2	NS	0.0261	NS
Nrate x Man (18 df)	0.125	NS	0.091	NS	21.1	NS	28.5	NS	41.9	NS	0.0452	NS

Table 5.47. High Mowthorpe dry matter components at harvest for cv. Winner.

N Rate kg/ha	Stem dry weight (t/ha)		Pod dry weight (t/ha)		Seed dry weight (t/ha)		Total dry weight (t/ha)		Harvest index	
	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM
0	2.09		1.31		1.74		5.14		0.334	
120	2.81	4.60	1.90	2.73	2.64	4.10	7.35	11.42	0.352	0.359
180	3.71	4.11	2.40	3.32	3.15	4.21	9.26	11.64	0.338	0.359
240	4.06	3.86	3.37	2.53	4.53	3.75	11.96	10.14	0.379	0.364
Mean	3.53	4.19	2.56	2.86	3.44	4.02	9.52	11.07	0.356	0.361
Treatment	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value
Nrate (18 df)	0.563	<0.01	0.387	<0.01	0.436	<0.001	1.14	<0.001	0.0150	NS
Management (18 df)	0.425	NS	0.285	NS	0.329	NS	0.86	0.090	0.0114	NS
Nrate x Man (18 df)	0.737	NS	0.494	<0.05	0.571	<0.05	1.49	<0.05	0.0197	NS

Table 5.48. High Mowthorpe crop N content at harvest for cv. Winner.

N Rate kg/ha	Stem+pod N concentration (%)		Seed N concentration (%)		Stem+Pod N content (kg N/ha)		Seed N content (kg N/ha)		Total crop N content (kg N/ha)		Nitrogen harvest index	
	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM
0	0.465		2.30		15		37		52		0.702	
120	0.550	0.783	2.73	2.79	26	59	73	113	99	172	0.729	0.667
180	0.838	0.710	3.01	2.96	54	56	95	125	149	181	0.649	0.704
240	0.768	0.920	2.94	2.82	60	58	133	103	193	160	0.701	0.636
Mean	0.719	0.804	2.89	2.86	47	57	100	114	147	171	0.693	0.669
Treatment	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value
Nrate (18 df)	0.077	0.067	0.143	<0.001	10.2	<0.01	13.3	<0.001	21.1	<0.001	0.033	NS
Management (18 df)	0.058	NS	0.108	NS	7.7	NS	10.1	NS	16.0	NS	0.025	NS
Nrate x Man (18 df)	0.101	0.051	0.187	NS	13.4	NS	17.5	<0.05	27.7	<0.05	0.043	NS

Table 5.49. Rosemaund dry matter components at harvest for cv. Winner.

N Rate kg/ha	Stem dry weight (t/ha)		Pod dry weight (t/ha)		Seed dry weight (t/ha)		Total dry weight (t/ha)		Harvest index	
	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM
0	3.03		1.90		2.17		7.10		0.306	
120	4.74	4.35	3.54	3.34	4.18	4.08	12.45	11.78	0.336	0.347
180	5.15	4.47	2.97	3.19	3.51	3.95	11.62	11.62	0.302	0.340
240	5.31	4.54	3.42	3.73	4.12	4.91	12.85	13.19	0.320	0.372
Mean	5.07	4.45	3.31	3.42	3.94	4.31	12.31	12.20	0.319	0.353
Treatment	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value
Nrate (18 df)	0.653	<0.001	0.424	<0.001	0.523	<0.001	1.42	<0.001	0.020	NS
Management (18 df)	0.460	NS	0.320	NS	0.395	NS	1.07	NS	0.015	<0.05
Nrate x Man (18 df)	0.832	NS	0.555	NS	0.684	NS	1.86	NS	0.026	NS

Table 5.50. Rosemaund crop N content at harvest for cv. Winner.

N Rate kg/ha	Stem+pod N concentration (%)		Seed N concentration (%)		Stem+Pod N content (kg N/ha)		Seed N content (kg N/ha)		Total crop N content (kg N/ha)		Nitrogen harvest index	
	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM	Conv	CM
0	0.618		2.75		30		60		90		0.663	
120	0.760	0.825	2.99	3.23	63	64	125	132	188	196	0.665	0.675
180	0.988	0.910	2.96	3.33	82	70	105	132	187	202	0.562	0.655
240	0.990	1.070	3.65	3.36	84	88	151	164	235	253	0.642	0.650
Mean	0.913	0.935	3.20	3.31	76	74	127	143	203	217	0.623	0.660
Treatment	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value	SED	P value
Nrate (18 df)	0.077	<0.001	0.177	<0.001	10.7	<0.001	19.8	<0.001	27.5	<0.001	0.031	NS
Management (18 df)	0.058	NS	0.134	NS	8.1	NS	15.0	NS	20.8	NS	0.024	0.101
Nrate x Man (18 df)	0.100	NS	0.232	NS	14.1	NS	25.9	NS	36.0	NS	0.041	NS

5.2 Experiment year 2 – 2006/7

5.2.1 Soil and crop N in late January / early February

Experiments were drilled at ADAS Boxworth (Cambridgeshire) on 1/9/06, ADAS High Mowthorpe (N. Yorkshire) on 10/9/06 and ADAS Rosemaund (Herefordshire) on 28/8/06. The soil mineral N and GAI of the experimental crops was measured in February. This showed that the crop N content and the soil mineral N of Winner and Castille were not significantly different. A summary of this information (Table 5.51) shows that the combined supply of nitrogen from the crop and soil in February was 135 kg N/ha at Boxworth, 116 kg N/ha at Rosemaund and 112 kg N/ha at High Mowthorpe. The GAI was greater than 1 at all sites which meant that Folicur used used at a rate of 1.0 l/ha between early stem extension and green bud.

Table 5.51. Soil N, crop N and Fertiliser requirement for canopy managed treatments

	Boxworth	High Mowthorpe	Rosemaund
Feb SMN (kg/ha)	43 (29 Jan)	58 (13 Feb)	54 (14 Feb)
Feb GAI	2.37	1.21	2.08
Crop N (kg/ha)	92	54	61
SNS (kg/ha)	135	112	116
Fert N for GAI 3.5	67	115	100

SMN – soil mineral nitrogen
SNS – soil nitrogen supply - sum of SNS and crop N

5.2.2 N treatments

Based on the soil N supply the amount of fertiliser N required to achieve a GAI of 3.5 by flowering was 67 kg/ha at Boxworth, 100 kg/ha at Rosemaund and 115 kg/ha at High Mowthorpe. For managed treatments this dose was applied at the conventional 2nd split timing at all sites. After sufficient N had been applied to achieve the optimum GAI of 3.5 the remainder of the N was applied between late stem extension and early/mid flowering in late April/early May. The N applications in each split are described in Tables 5.52, 5.53 and 5.54. Timings of each N application are described in Table 5.55.

Table 5.52. Boxworth N applications (kg N/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	0	60	0	60
9	Managed	0	70	50	120
10	Managed	0	70	110	180
11	Managed	0	70	170	240
12	Managed	0	70	230	300
13	Managed	0	70	290	360

Table 5.53. High Mowthorpe N applications (kg N/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	0	60	0	60
9	Managed	0	120	0	120
10	Managed	0	120	60	180
11	Managed	0	120	120	240
12	Managed	0	120	180	300
13	Managed	0	120	240	360

Table 5.54. Rosemaund N applications (kg N/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	0	60	0	60
9	Managed	0	100	20	120
10	Managed	0	100	80	180
11	Managed	0	100	140	240
12	Managed	0	100	200	300
13	Managed	0	100	260	360

Table 5.55. Timings of Nitrogen and Folicur treatments

	Boxworth	High Mowthorpe	Rosemaund
1st N timing	26 February	7 March	2 March
2nd N timing	15 March	2 April	29 March
3rd N timing	4 April	16 April	19 April
Folicur timing	14 March (1.0 l/ha)	4 April (1.0 l/ha)	28 March (1.0 l/ha)

5.2.3 Seed yield

At Boxworth, variety had the largest effect on seed yield. Castille averaged 3.65 t/ha compared with 3.04 t/ha for Winner ($P<0.001$; Table 5.56). Across the two varieties, increasing N rate from 0 to 60 kg N/ha significantly increased yield from 2.89 t/ha to 3.31 t/ha ($P<0.001$). Further increases in N rate resulted in small and non-significant yield increases. Across all treatments, the Managed N timing treatment increased yield over the Conventional N timing treatment from 3.34 t/ha to 3.42 t/ha ($P=0.082$). The advantage of the Managed N tended to be greater at high N rates and with Winner. For example Winner at 300 and 360 kg N/ha the Managed timing gave a 0.28 t/ha yield advantage over the Conventional timing. The effect of the N Managed timings did not appear to be affected by the use of Folicur.

At High Mowthorpe, across all treatments N rate increased yield from 3.07 t/ha at nil N to 4.98 t/ha at 300 kg N/ha ($P<0.001$; Table 5.57). Castille averaged 4.96 t/ha compared with 4.28 t/ha for Winner ($P<0.001$). On average, the Managed N timings reduced yield by 0.14 t/ha compared with the Conventional N timings ($P<0.001$). There was an interaction between N timing and variety ($P = 0.069$). This was caused because the effect of N timing was strongest for Winner at 0.21 t/ha and negligible for Castille. Folicur (1.0 l/ha) increased yield of Winner by 0.13 t/ha ($P<0.01$) and had no effect on Castille.

At Rosemaund, Castille averaged 4.85 t/ha compared with 4.56 t/ha for Winner ($P<0.001$; Table 5.58). Increasing N rate significantly increased yield ($P<0.001$). Across all treatments N rate increased yield from 3.55 t/ha at nil N to 5.00 t/ha at 300 kg N/ha ($P<0.001$). Variety and Folicur interacted ($P=0.064$). This interaction was caused because Folicur increased the yield of Winner by 0.21 t/ha and only increased the yield of Castille by 0.08 t/ha. N timing did not affect yield. There was a significant interaction between N timing, N rate and Folicur ($P<0.05$), but it is difficult to identify what caused this interaction (Table 5.58).

Table 5.56. Boxworth seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	2.41		2.41	2.80		2.80	2.60		2.60
Winner	60	2.85	3.10	2.98	3.25	2.84	3.05	3.05	2.97	3.01
Winner	120	3.39	3.18	3.28	2.72	3.24	2.98	3.05	3.21	3.13
Winner	180	3.39	3.18	3.28	2.87	2.94	2.91	3.13	3.06	3.09
Winner	240	3.11	3.19	3.15	3.03	3.08	3.05	3.07	3.13	3.10
Winner	300	3.12	3.13	3.12	2.65	3.20	2.92	2.88	3.16	3.02
Winner	360	3.04	3.14	3.09	2.92	3.38	3.15	2.98	3.26	3.12
Winner	Mean	3.15	3.15	3.04	2.90	3.11	2.98	3.03	3.13	3.01
Castille	0	3.15		3.15	3.19		3.19	3.17		3.17
Castille	60	3.44	3.60	3.52	3.71	3.67	3.69	3.57	3.63	3.60
Castille	120	3.88	3.57	3.72	3.63	3.79	3.71	3.75	3.68	3.71
Castille	180	4.01	3.82	3.91	3.54	3.57	3.56	3.78	3.69	3.73
Castille	240	3.84	3.65	3.75	3.39	3.72	3.55	3.61	3.69	3.65
Castille	300	3.71	3.96	3.84	3.27	3.43	3.35	3.49	3.70	3.59
Castille	360	3.63	3.66	3.64	3.93	4.10	4.01	3.78	3.88	3.83
Castille	Mean	3.75	3.71	3.65	3.58	3.71	3.58	3.66	3.71	3.61
Win+Cas	0	2.78		2.78	2.99		2.99	2.89		2.89
Win+Cas	60	3.14	3.35	3.25	3.48	3.26	3.37	3.31	3.30	3.31
Win+Cas	120	3.63	3.37	3.50	3.17	3.51	3.34	3.40	3.44	3.42
Win+Cas	180	3.70	3.50	3.60	3.20	3.26	3.23	3.45	3.38	3.41
Win+Cas	240	3.47	3.42	3.45	3.21	3.40	3.30	3.34	3.41	3.37
Win+Cas	300	3.42	3.55	3.48	2.96	3.31	3.14	3.19	3.43	3.31
Win+Cas	360	3.33	3.40	3.37	3.42	3.74	3.58	3.38	3.57	3.47
Win+Cas	Mean	3.45	3.43	3.35	3.24	3.41	3.28	3.34	3.42	3.31

Treatment	df	SED	P-Value
Folicur	3	0.068	NS
Variety	75	0.042	<0.001
Folicur x Variety	75	0.080	NS
N rate	75	0.079	<0.001
N Management	75	0.082	0.082
Var x Nrate	75	0.131	NS
Var x Man	75	0.115	NS
Nrate x Man	75	0.107	NS
Var x Nrate x Man	75	0.151	NS
Fol x Nrate	75	0.160	<0.05
Fol x Man	75	0.142	0.108
Fol x Var x Nrate	75	0.223	NS
Fol x Var x Man	75	0.198	NS
Fol x Nrate x Man	75	0.180	NS
Fol x Var x Nrate x Man	75	0.254	NS

Table 5.57. High Mowthorpe seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	2.64		2.64	2.85		2.85	2.75		2.75
Winner	60	3.77	3.73	3.75	3.90	3.81	3.85	3.84	3.77	3.80
Winner	120	4.34	4.18	4.26	4.51	4.49	4.50	4.43	4.33	4.38
Winner	180	4.68	4.47	4.58	4.68	4.47	4.57	4.68	4.47	4.57
Winner	240	4.53	4.26	4.39	4.91	4.42	4.66	4.72	4.34	4.53
Winner	300	4.84	4.53	4.69	4.78	4.52	4.65	4.81	4.52	4.67
Winner	360	4.55	4.34	4.45	4.71	4.48	4.59	4.63	4.41	4.52
Winner	Mean	4.45	4.25	4.11	4.58	4.36	4.24	4.52	4.31	4.17
Castille	0	3.35		3.35	3.44		3.44	3.40		3.40
Castille	60	4.35	4.60	4.47	4.53	4.52	4.52	4.44	4.56	4.50
Castille	120	5.04	4.94	4.99	5.00	5.02	5.01	5.02	4.98	5.00
Castille	180	5.27	5.13	5.20	5.17	5.10	5.14	5.22	5.11	5.17
Castille	240	5.35	5.07	5.21	5.31	5.30	5.30	5.33	5.18	5.26
Castille	300	5.47	5.21	5.34	5.43	5.08	5.26	5.45	5.15	5.30
Castille	360	5.47	5.44	5.45	5.19	5.27	5.23	5.33	5.35	5.34
Castille	Mean	5.16	5.06	4.86	5.10	5.05	4.84	5.13	5.06	4.85
Win+Cas	0	3.00		3.00	3.15		3.15	3.07		3.07
Win+Cas	60	4.06	4.16	4.11	4.21	4.17	4.19	4.14	4.17	4.15
Win+Cas	120	4.69	4.56	4.62	4.76	4.75	4.75	4.72	4.66	4.69
Win+Cas	180	4.97	4.80	4.89	4.92	4.78	4.85	4.95	4.79	4.87
Win+Cas	240	4.94	4.67	4.80	5.11	4.86	4.98	5.02	4.76	4.89
Win+Cas	300	5.16	4.87	5.01	5.10	4.80	4.95	5.13	4.84	4.98
Win+Cas	360	5.01	4.89	4.95	4.95	4.88	4.91	4.98	4.88	4.93
Win+Cas	Mean	4.80	4.66	4.48	4.84	4.71	4.54	4.82	4.68	4.51

Treatment	df	SED	P-Value
Folicur	3	0.128	NS
Variety	75	0.035	<0.001
Folicur x Variety	75	0.133	<0.01
N rate	75	0.065	<0.001
N Management	75	0.068	<0.001
Var x Nrate	75	0.108	NS
Var x Man	75	0.096	0.069
Nrate x Man	75	0.089	0.104
Var x Nrate x Man	75	0.125	NS
Fol x Nrate	75	0.157	<0.05
Fol x Man	75	0.150	NS
Fol x Var x Nrate	75	0.182	NS
Fol x Var x Man	75	0.171	NS
Fol x Nrate x Man	75	0.108	NS
Fol x Var x Nrate x Man	75	0.152	NS

Table 5.58. Rosemaund seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	3.10		3.10	3.21		3.21	3.16		3.16
Winner	60	3.86	3.92	3.89	4.05	4.38	4.22	3.96	4.15	4.06
Winner	120	4.23	4.45	4.34	4.93	4.57	4.75	4.58	4.51	4.54
Winner	180	5.09	4.70	4.90	5.16	4.77	4.96	5.13	4.73	4.93
Winner	240	4.83	4.65	4.74	4.99	4.99	4.99	4.91	4.82	4.86
Winner	300	4.88	4.92	4.90	4.78	4.86	4.82	4.83	4.89	4.86
Winner	360	4.50	4.75	4.63	4.91	4.96	4.94	4.71	4.86	4.78
Winner	Mean	4.56	4.57	4.36	4.80	4.76	4.56	4.68	4.66	4.46
Castille	0	3.48		3.48	3.60		3.60	3.54		3.54
Castille	60	4.73	4.53	4.63	4.44	4.54	4.49	4.59	4.53	4.56
Castille	120	4.64	4.72	4.68	5.11	4.85	4.98	4.88	4.79	4.83
Castille	180	5.01	5.05	5.03	5.08	5.36	5.22	5.04	5.20	5.12
Castille	240	5.04	5.05	5.05	4.84	5.13	4.99	4.94	5.09	5.02
Castille	300	5.10	5.06	5.08	5.23	5.19	5.21	5.17	5.13	5.15
Castille	360	5.15	4.93	5.04	5.19	4.98	5.08	5.17	4.96	5.06
Castille	Mean	4.95	4.89	4.71	4.98	5.01	4.80	4.96	4.95	4.75
Win+Cas	0	3.29		3.29	3.41		3.41	3.35		3.35
Win+Cas	60	4.30	4.22	4.26	4.25	4.46	4.35	4.27	4.34	4.31
Win+Cas	120	4.44	4.59	4.51	5.02	4.71	4.86	4.73	4.65	4.69
Win+Cas	180	5.05	4.88	4.96	5.12	5.06	5.09	5.09	4.97	5.03
Win+Cas	240	4.93	4.85	4.89	4.91	5.06	4.99	4.92	4.96	4.94
Win+Cas	300	4.99	4.99	4.99	5.01	5.03	5.02	5.00	5.01	5.00
Win+Cas	360	4.83	4.84	4.83	5.05	4.97	5.01	4.94	4.91	4.92
Win+Cas	Mean	4.76	4.73	4.53	4.89	4.88	4.68	4.82	4.81	4.61

Treatment	df	SED	P-Value
Folicur	3	0.068	NS
Variety	75	0.063	<0.001
Folicur x Variety	75	0.093	0.064
N rate	75	0.118	<0.001
N Management	75	0.122	NS
Var x Nrate	75	0.196	NS
Var x Man	75	0.173	NS
Nrate x Man	75	0.160	NS
Var x Nrate x Man	75	0.226	NS
Fol x Nrate	75	0.168	NS
Fol x Man	75	0.151	NS
Fol x Var x Nrate	75	0.230	0.051
Fol x Var x Man	75	0.205	NS
Fol x Nrate x Man	75	0.181	<0.05
Fol x Var x Nrate x Man	75	0.257	NS

5.2.4 Oil content

At Boxworth, increasing N rate significantly reduced oil content (P<0.001; Table 5.59). Increasing N rate from nil to 360 kg N/ha reduced oil content from 40.1% to 37.5%. Linear regression showed that each 100 kg increase in N rate reduced oil content by 0.74% (P<0.001). Neither variety nor N timing affected oil content. Folicur at 1.0 l/ha increased oil content by 0.4%, but this effect was not statistically significant (Table 5.60).

At High Mowthorpe, increasing N rate significantly reduced oil content (P<0.001; Table 5.61). Increasing N rate from nil to 360 kg N/ha reduced oil content from 41.8% to 38.7%. Linear regression showed that each 100 kg increase in N rate reduced oil content by 0.75% (P<0.001). Castille had an average oil content of 40.5% which was significantly greater than Winner at 39.6% (P<0.05). Folicur at 1.0 l/ha had no effect on oil content (Table 6.62). N timing did not affect oil content.

At Rosemaund, increasing N rate from nil to 360 kg N/ha reduced oil content from 41.7% to 40.6%, but this effect was not statistically significant (Table 5.63). Neither variety, N timing, nor Folicur significantly affected oil content (Table 5.64).

Table 5.59. Boxworth Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	40.0			40.3			40.1		40.1
120	39.2	39.0	39.1	38.9	38.3	38.6	39.1	38.7	38.9
240	37.3	38.7	38.0	37.4	38.1	37.8	37.4	38.4	37.9
360	37.0	38.6	37.8	36.9	37.5	37.2	37.0	38.1	37.5
Mean	37.8	38.8	38.7	37.7	38.0	38.5	37.8	38.4	38.6

Treatment	df	SED	P Value
Variety	45	0.41	NS
Nitrogen	45	0.58	<0.001
N management	45	0.41	NS
Variety x Nitrogen	45	0.82	NS
Variety x Management	45	0.58	NS
Nitrogen x Management	45	0.82	NS
Var x N x Man	45	1.15	NS

Without Folicur

Table 5.60. Boxworth Oil contents (% dry matter) effects of Folicur

		Conventional		Managed timing		Mean	
	N rate	Nil	Folicur	Nil	Folicur	Nil	Folicur
Winner	120 kg/ha	39.2	38.3	39.0	39.8	39.1	39.0
Winner	240 kg/ha	37.3	38.5	38.7	39.0	38.0	38.8
Castille	120 kg/ha	38.9	38.6	38.3	38.8	38.6	38.7
Castille	240 kg/ha	37.4	38.6	38.1	38.9	37.8	38.7
Mean		38.2	38.5	38.6	39.1	38.4	38.8
		SED	P-Value				
Folicur		0.278	NS				
Folicur x Variety		0.393	NS				
Folicur x N rate		0.393	NS				
Folicur x N timing		0.393	NS				

Table 5.61. High Mowthorpe Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	40.9		40.9	42.7		42.7	41.8		41.8
120	39.5	38.8	39.2	40.7	39.2	40.0	40.1	39.0	39.5
240	38.5	40.5	39.5	40.2	40.2	40.2	39.3	40.3	39.8
360	37.6	39.6	38.6	38.3	39.5	38.9	38.0	39.5	38.7
Mean	38.5	39.6	39.6	39.7	39.6	40.5	39.8	40.2	40.0

Treatment	df	SED	P Value
Variety	45	0.43	0.043
Nitrogen	45	0.61	<0.001
N management	45	0.43	NS
Variety x Nitrogen	45	0.61	NS
Variety x Management	45	0.87	NS
Nitrogen x Management	45	0.87	NS
Var x N x Man	45	1.22	NS

Without Folicur

Table 5.62. High Mowthorpe Oil contents (% dry matter) effects of Folicur

		Conventional		Managed timing		Mean	
	N rate	Nil	Folicur	Nil	Folicur	Nil	Folicur
Winner	120 kg/ha	39.5	40.0	38.8	38.3	39.1	39.2
Winner	240 kg/ha	38.5	38.0	40.5	38.2	39.5	38.1
Castille	120 kg/ha	40.7	39.9	39.2	39.9	39.9	39.9
Castille	240 kg/ha	40.2	39.3	40.2	38.1	40.2	38.7
Mean		39.7	39.3	39.6	38.6	39.7	39.0

	SED	P-Value
Folicur	0.363	NS
Folicur x Variety	0.515	NS
Folicur x N rate	0.515	NS
Folicur x N timing	0.515	NS

Table 5.63. Rosemaund Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	42.2		42.2	41.1		41.8	41.7		41.7
120	40.9	41.1	41.0	40.7	39.4	40.1	40.8	40.3	40.5
240	41.6	41.6	41.6	39.8	40.1	40.0	40.7	40.9	40.8
360	39.1	40.9	40.0	41.6	40.7	41.2	40.4	40.8	40.6
Mean	40.5	41.2	41.2	40.7	40.1	40.6	40.6	40.6	40.9

Treatment	df	SED	P Value
Variety	45	0.39	NS
Nitrogen	45	0.55	NS
N management	45	0.39	NS
Variety x Nitrogen	45	0.78	0.062
Variety x Management	45	0.55	NS
Nitrogen x Management	45	0.78	NS
Var x N x Man	45	1.10	NS

Without Folicur

Table 5.64. Rosemaund Oil contents (% dry matter) effects of Folicur

		Conventional		Managed timing		Mean	
	N rate	Nil	Folicur	Nil	Folicur	Nil	Folicur
Winner	120 kg/ha	40.9	41.7	41.1	43.9	41.0	42.8
Winner	240 kg/ha	41.6	40.0	41.6	39.6	41.6	39.8
Castille	120 kg/ha	40.7	40.3	39.4	40.2	40.0	40.3
Castille	240 kg/ha	39.8	40.2	40.1	40.4	39.9	40.3
Mean		40.8	40.6	40.5	41.0	40.7	40.8
		SED	P-Value				
Folicur		0.443	NS				
Folicur x Variety		0.626	NS				
Folicur x N rate		0.626	<0.05				
Folicur x N timing		0.626	NS				
Folicur x Var x N rate		0.885	<0.05				

5.2.5 Optimum N rate

At Boxworth regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (30%, P<0.001). The economically optimum N rate before taking account of oil premiums was 61 kg N/ha for all treatments, and this decreased to 54 kg N/ha after accounting for oil content. At the optimum N rate Castille yielded 3.61 t/ha and Winner yielded 3.02 t/ha (Table 5.65). At the optimum N rate the Managed N timing increased yield of both varieties by 0.06 t/ha.

At High Mowthorpe regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (88%, P<0.001). The economically optimum N rate before taking account of oil premiums was 173 kg N/ha for all treatments, and this decreased to 156 kg N/ha after accounting for oil content. At the optimum N rate the yield of Castille 5.15 t/ha and the yield of Winner was 4.47 t/ha. At the optimum N rate the Managed N timing reduced the yield of Winner by 0.20 t/ha and had little effect on Castille. Folicur increased the yield of Winner by 0.12 t/ha at optimum N rate.

At Rosemaund regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (83%, P<0.001). The economically optimum N rate was 165 kg N/ha for all treatments irrespective of whether the oil content was included. At the optimum N rate the Castille yielded 5.06 t/ha and Winner yielded 4.76 t/ha. At optimum N rate

Folicur increased yield by 0.14 t/ha. There was no difference between the Managed and Conventional N timings.

Table 5.65. Optimum N rate and yields at N opt.

	Boxworth	High Mowthorpe	Rosemaund
Economically optimum N rate (kg/ha)	54	156	165
Winner Conventional N timings	3.05	4.50	4.66
Winner Managed N timings	3.05	4.31	4.66
Winner Conventional N timings with Folicur	2.90	4.64	4.88
Winner Managed N timings with Folicur	3.06	4.42	4.84
Castille Conventional N timings	3.66	5.20	5.04
Castille Managed N timings	3.63	5.12	4.99
Castille Conventional N timings with Folicur	3.51	5.17	5.09
Castille Managed N timings with Folicur	3.63	5.10	5.11

5.2.6 Crop growth before stem extension

Crop assessments carried out before any N applications in February showed that the GAI, dry weight, tissue N concentration and N content of the crops did not differ between Winner and Castille at the 5% level of significance (Table 5.66). Regression analysis on the plot data for both varieties across all sites showed that the Rosemaund data differed from the data at the other two sites (Figure 5.2). The slope of the regression line showed that each crop contained about 40 kg N/ha for each unit of GAI at Boxworth and High Mowthorpe. At Rosemaund the crop contained only 30 kg N/ha for each unit of GAI. Previous studies have shown that the crop contains about 50 kg N/ha per unit of GAI.

Table 5.67. February measurements.

Boxworth

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	2.53	2.80	3.55	99.4
Castille	2.20	2.37	3.68	84.4
Mean	2.37	2.59	3.61	91.9
SED (df)	0.296	0.425	0.374	11.02
P-Value	NS	NS	NS	NS

High Mowthorpe

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	1.35	1.67	3.30	54.5
Castille	1.07	1.63	3.25	53.1
Mean	1.21	1.65	3.27	53.8
SED (df)	0.170	0.173	0.177	4.86
P-Value	NS	NS	NS	NS

Rosemaund

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	2.34	1.71	3.88	66.5
Castille	1.84	1.58	3.71	59.2
Mean	2.09	1.64	3.79	62.8
SED (df)	0.240	0.097	0.314	8.51
P-Value	NS	NS	NS	NS

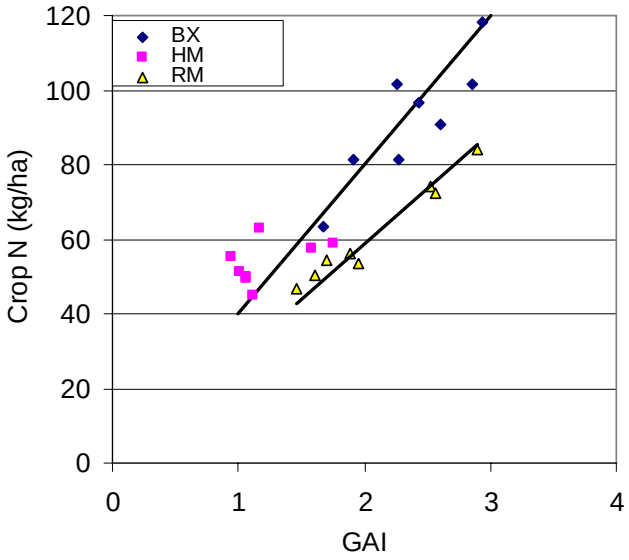

Figure 5.2. Relationship between green area index and crop nitrogen content measured in February at ADAS Boxworth, High Mowthorpe and Rosemaund. Best fit line for all sites: $y = 36x$; $R^2 = 0.61$; $P<0.001$. Best fit line for Boxworth and Mowthorpe: $y = 40x$; $R^2 = 0.80$; $P<0.001$. Best fit line for Rosemaund: $y = 30x$; $R^2 = 0.93$; $P<0.001$.

5.2.7 Rainfall patterns

At Boxworth, the 1st and 2nd N applications were followed by significant rainfall events within a few days of the applications (Figure 5.3). The 3rd application followed about 7 days of dry weather which was then followed by a further 30 days without significant rainfall. It is therefore likely that the 3rd split was taken up more slowly than normal.

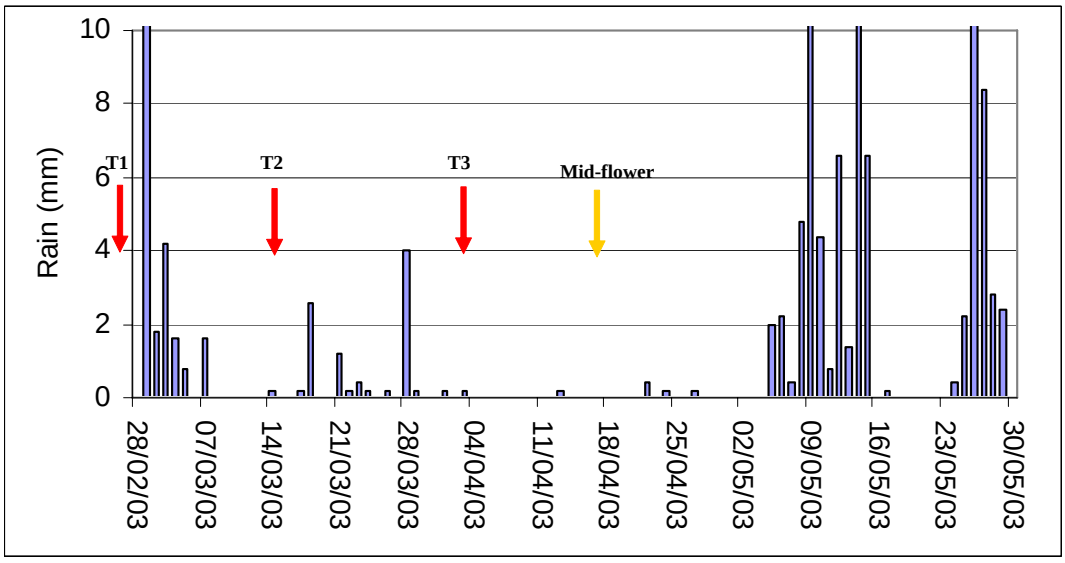

Figure 5.3. Boxworth rainfall, with dates of T1, T2 and T3 N applications.

At High Mowthorpe, rainfall around the time of the 1st application would have allowed the N from this split to be taken up normally. The 2nd split followed about 10 days of dry weather and was then followed by a further 36 days of dry weather when about 2mm of rain fell. The 3rd split followed about 24 days of dry weather and was then followed by a further 22 days in which about 2 mm fell. It is therefore probable that the N from both the 2nd and 3rd splits were taken up very slowly.

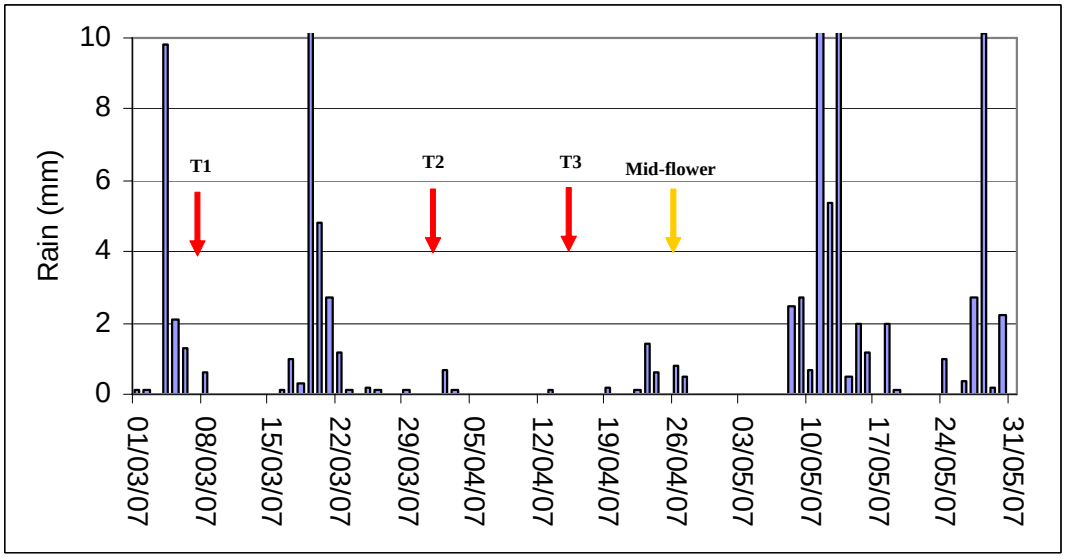

Figure 5.4. High Mowthorpe rainfall, with dates of T1, T2 and T3 N applications.

At Rosemaund, the 1st and 2nd N applications were close to significant rainfall events (Figure 5.5). The 3rd application followed about 19 days of dry weather which was then followed by a further 5 days before significant rainfall. It is therefore possible that the N from the 1st and 2nd splits would have been taken reasonably efficiently, but N uptake from the 3rd split would almost certainly have been delayed.

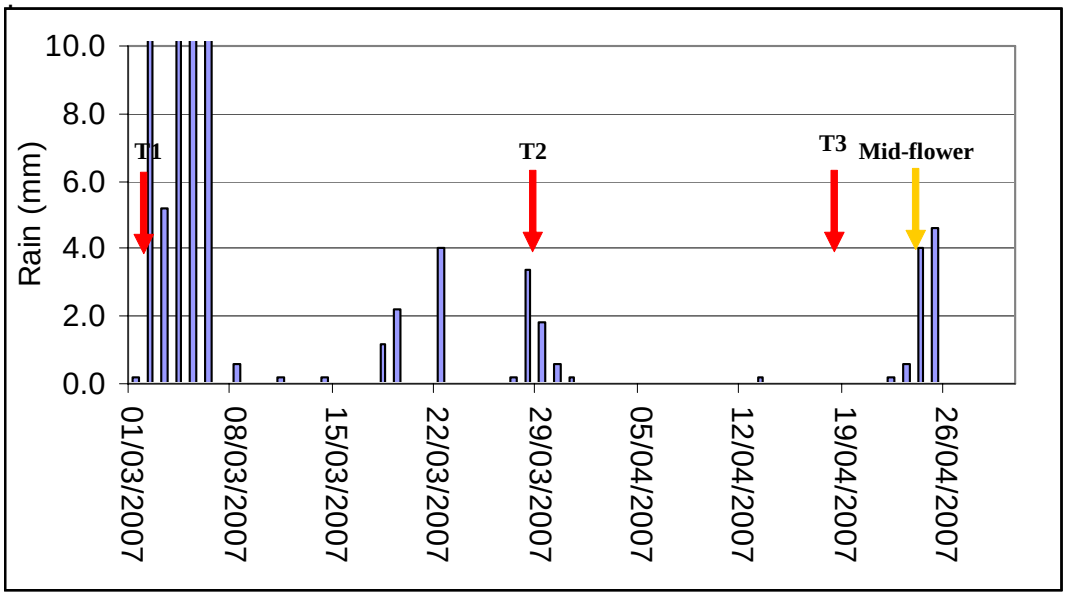

Figure 5.5. Rosemaund rainfall, with dates of T1, T2 and T3 N applications.

5.2.8 Mid-Flowering GAI and dry weight

At Boxworth, the nil N treatment had significantly lower GAI and dry weight than the 120 kg N/ha treatments ($P<0.001$; Table 5.67). At 120 kg N/ha, the Managed timings reduced the GAI from 5.12 to 4.49, and reduced stem dry weight, but these effects were not statistically significant. Castille had a smaller leaf GAI and flower dry weight than Winner ($P = 0.07$). The N content of the leaf and stem material for the Conventionally timed treatment at 120 kg N/ha averaged 3.7% and 1.5% respectively and there was no difference between Castille and Winner (Table 5.70). On average, the N uptake for this treatment was 178 kg N/ha.

At High Mowthorpe, the nil N treatment had lower GAI and dry weight than the 120 kg N/ha treatments (Table 5.68), but these effects were not statistically significant. At 120 kg N/ha, the Conventional and Managed timings had a similar GAI and dry weight. It is important to note that the GAI at 120 kg N/ha was 2.16 which was significantly below the GAI that would have been expected from this N rate. It seems likely that the dry weather between the end of March and early May restricted N uptake in both treatments. There was little difference between Castille and Winner for the GAI and dry matter. The N content of the leaf and stem material for the Conventionally timed treatment at 120 kg N/ha averaged 3.9% and 1.4% respectively and there was no difference between Castille and Winner (Table 5.71). On average N uptake of this treatment was 102 kg N/ha.

At Rosemaund, the nil N treatment had significantly lower GAI than the 120 kg N/ha treatments ($P<0.05$; Table 5.69). There was little difference in dry weight between the nil and 120 kg N/ha treatments. At 120 kg N/ha, the Managed timings significantly reduced the total GAI from 4.35 to 3.12 ($P<0.05$). This effect was mainly caused by reducing the leaf GAI from 3.30 to 2.27 ($P<0.05$). Castille had a significantly smaller leaf GAI, total GAI and pod dry weight compared with Winner ($P<0.05$). The variety effects on GAI were consistent with the variety effects at Boxworth. The N content of the leaf, stem and pod material for the Conventionally timed treatment at 120 kg N/ha averaged 3.8%, 1.3% and 4.4% respectively (Table 5.72). Castille had a significantly greater leaf N% and a significantly lower stem N% compared with Winner. On average, the N uptake of this treatment was 142 kg N/ha.

Table 5.67. Boxworth. Mid flowering green area indices and dry matter measurements.

		Green area indices			Dry weight (t/ha)			
	kg/ha N	Leaf	Stem	Total	Leaf	Stem	Flower	Total
Winner	0	2.53	0.69	3.23	1.79	5.28	0.73	7.80
	120 conv	4.05	0.92	5.00	2.51	6.42	1.11	10.05
	120 mngd	3.80	0.90	4.72	2.20	5.93	0.95	9.08
Castille	0	1.97	0.72	2.70	1.58	5.07	0.72	7.37
	120 conv	3.81	1.42	5.23	2.43	5.33	0.76	8.52
	120 mngd	3.41	0.85	4.27	2.17	5.06	0.86	8.09
Means								
Winner		3.46	0.84	4.32	2.17	5.88	0.93	8.98
Castille		3.06	1.00	4.06	2.06	5.15	0.78	7.99
Nil N		2.25	0.71	2.97	1.69	5.17	0.73	7.59
120 kg/ha N conventional		3.93	1.17	5.12	2.47	5.88	0.94	9.28
120 kg/ha N managed		3.61	0.88	4.49	2.19	5.49	0.91	8.58
P-Value								
Variety		0.07	NS	NS	NS	NS	0.07	NS
Nitrogen		<0.001	NS	<0.001	0.005	NS	NS	NS
Var x N		NS	NS	NS	NS	NS	NS	NS
SED (15 df)								
Variety		0.208	0.173	0.301	0.166	0.463	0.079	0.670
Nitrogen		0.254	0.212	0.369	0.203	0.566	0.096	0.821
Var x N		0.360	0.299	0.522	0.287	0.801	0.136	1.161

Table 5.68. High Mowthorpe. Mid flowering green area indices and dry matter measurements.

		Green area indices			Dry weight (t/ha)			
	kg/ha N	Leaf	Stem	Total	Leaf	Stem	Flower	Total
Winner	0	1.12	0.55	1.66	0.97	3.69	0.80	5.46
	120 conv	1.34	0.68	2.01	0.97	4.27	1.09	6.33
	120 mngd	1.45	0.62	2.07	1.09	4.06	1.01	6.16
Castille	0	1.29	0.68	1.97	0.93	4.30	1.10	6.32
	120 conv	1.69	0.63	2.31	1.27	4.04	1.06	6.37
	120 mngd	1.58	0.69	2.27	1.15	4.27	1.19	6.60
Means								
Winner		1.30	0.61	1.92	1.01	4.00	0.97	5.98
Castille		1.52	0.67	2.19	1.11	4.20	1.12	6.43
Nil N		1.21	0.61	1.82	0.95	3.99	0.95	5.89
120 kg/ha N conventional		1.51	0.65	2.16	1.12	4.15	1.08	6.35
120 kg/ha N managed		1.52	0.66	2.17	1.12	4.16	1.10	6.38
P-Value								
Variety		NS	NS	NS	NS	NS	NS	NS
Nitrogen		NS	NS	NS	NS	NS	NS	NS
Var x N		NS	NS	NS	NS	NS	NS	NS
SED (15 df)								
Variety		0.219	0.048	0.247	0.137	0.243	0.082	0.385
Nitrogen		0.268	0.059	0.302	0.167	0.298	0.100	0.472
Var x N		0.379	0.083	0.427	0.237	0.421	0.141	0.667

Table 5.69. Rosemaund. Mid flowering green area indices and dry matter measurements.

		Green area indices				Dry weight (t/ha)				
	kg/ha N	Leaf	Stem	Pod	Total	Leaf	Stem	Pod	Flower	Total
Winner	0	1.93	0.60	0.14	2.66	1.05	4.52	0.57	0.22	6.71
	120 conv	3.64	0.91	0.11	4.65	1.46	4.85	0.46	0.38	7.16
	120 mngd	2.75	0.84	0.12	3.71	1.20	4.60	0.44	0.29	6.53
Castille	0	1.11	0.64	0.20	1.94	0.76	4.25	0.36	0.22	6.21
	120 conv	2.96	0.99	0.10	4.05	1.30	4.92	0.42	0.37	6.33
	120 mngd	1.80	0.70	0.04	2.53	0.98	3.79	0.24	0.20	5.21
Means										
Winner		2.77	0.78	0.12	3.67	1.24	4.66	0.49	0.30	6.80
Castille		1.95	0.78	0.11	2.84	1.02	4.32	0.34	0.26	5.92
Nil N		1.52	0.62	0.17	2.30	0.91	4.39	0.47	0.22	6.46
120 kg/ha N conventional		3.30	0.95	0.10	4.35	1.38	4.89	0.44	0.37	6.75
120 kg/ha N managed		2.27	0.77	0.08	3.12	1.09	4.19	0.34	0.25	5.87
P-Value										
Variety		0.030	NS	NS	0.05	NS	NS	0.008	NS	NS
Nitrogen		0.003	0.001	NS	0.003	0.02	NS	NS	<0.001	NS
Var x N		NS	NS	NS	NS	NS	NS	NS	NS	NS
SED (10-14 df)										
Variety		0.339	0.056	0.033	0.387	0.120	0.407	0.048	0.021	0.508
Nitrogen		0.415	0.070	0.040	0.474	0.147	0.498	0.059	0.026	0.622
Var x N		0.587	0.098	0.056	0.670	0.207	0.705	0.083	0.037	0.880

Table 5.70. Boxworth. Mid flowering measurement of nitrogen concentration in dry plant material on Treatment 3 without Folicur.

	N% Leaf	N% Stem	Crop N (kg/ha)
Winner	3.67	1.43	184
Castille	3.69	1.53	171
Mean	3.68	1.48	178
SED (3 df)	0.351	0.182	10.31
P-Value	NS	NS	NS

Table 5.71. High Mowthorpe. Mid flowering measurement of nitrogen concentration in dry plant material on Treatment 3 without Folicur.

	N% Leaf	N% Stem	Crop N (kg/ha)
Winner	3.69	1.34	93
Castille	4.08	1.45	110
Mean	3.89	1.39	102
SED (3 df)	0.193	0.101	16.08
P-Value	NS	NS	NS

Table 5.72. Rosemaund. Mid flowering measurement of nitrogen concentration in dry plant material on Treatment 3 without Folicur.

	N% Leaf	N% Stem	N% Pod	Crop N (kg/ha)
Winner	3.54	1.07	4.31	142
Castille	4.01	1.45	4.40	142
Mean	3.77	1.26	4.36	142
SED (3 df)	0.128	0.088	0.113	15.54
P-Value	0.03	0.05	NS	NS

5.2.9 Light interception at flowering

At Boxworth across all treatments, the Managed timings significantly reduced the amount of light intercepted by the whole canopy from 87% to 81% ($P<0.05$; Table 5.74). Unexpectedly the Managed timings increased the amount of light intercepted by the flowering layer for Castille and had no effect on Winner (Table 5.73). The whole canopy of Winner intercepted 88% of light compared with 80% for Castille ($P<0.05$). The flower layer of Castille intercepted more light than the flower layer of Winner ($P<0.05$; Table 5.73). Folicur did not affect light interception.

At High Mowthorpe, the Managed timings reduced the amount of light reflected from the flowers from 12.5% to 11.4% ($P<0.001$; Table 5.73). The effects were greater at the higher N rates, e.g. at 360 kg N/ha the Management timing reduced the amount of light reflected from 13.2% to 11.9% for Castille. The Managed timings also reduced the amount of light intercepted by the flower layer from 79% to 73% ($P<0.001$; Table 5.74). These effects were greater for high N rates, e.g. at 240 kg N/ha the Managed

timing reduced the light intercepted by the flower layer from 88% to 77%. The Managed timings also reduced the amount of light intercepted by the whole canopy (P<0.001; Table 5.75). Increasing N rate significantly increased the amount of light reflected and intercepted by the flower layer and whole canopy (P<0.05). Winner reflected 11.4% light compared with 12.5% of light for Castille (P<0.001; Table 5.73). Variety had no effect on the amount of light intercepted by the flower layer and the whole canopy. Folicur reduced light reflection from 12.4% to 11.5% (NS) and did not affect the amount of light intercepted by the flower layer or the whole canopy.

Table 5.73**.** Boxworth. Fraction of light interception at base of flower canopy

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0.66		0.66	0.65		0.65	0.66		0.66
Winner	120	0.74	0.72	0.73	0.71	0.71	0.71	0.72	0.72	0.72
Winner	240	0.83	0.80	0.82	0.82	0.81	0.82	0.82	0.81	0.82
Winner	360	0.73	0.70	0.72	0.70	0.69	0.69	0.72	0.69	0.70
Winner	Mean	0.74	0.72	0.73	0.72	0.72	0.72	0.73	0.72	0.72
Castille	0	0.75		0.75	0.88		0.88	0.81		0.81
Castille	120	0.68	0.88	0.78	0.70	0.88	0.79	0.69	0.88	0.79
Castille	240	0.65	0.78	0.72	0.67	0.81	0.74	0.66	0.79	0.73
Castille	360	0.78	0.79	0.79	0.78	0.78	0.78	0.78	0.79	0.78
Castille	Mean	0.72	0.80	0.76	0.75	0.84	0.80	0.73	0.82	0.78
Win+Cas	0	0.70		0.70	0.76		0.76	0.73		0.73
Win+Cas	120	0.71	0.80	0.76	0.70	0.80	0.75	0.70	0.80	0.75
Win+Cas	240	0.74	0.79	0.77	0.74	0.81	0.78	0.74	0.80	0.77
Win+Cas	360	0.76	0.75	0.75	0.74	0.73	0.74	0.75	0.74	0.74
Win+Cas	Mean	0.73	0.76	0.74	0.74	0.78	0.76	0.73	0.77	0.75

Treatment	df	SED	P-Value
Folicur	3	0.010	NS
Variety	90	0.024	0.026
Folicur x Variety	62	0.026	NS
N rate	90	0.034	NS
N Management	90	0.024	NS
Var x Nrate	90	0.047	0.004
Var x Man	90	0.034	0.047
Nrate x Man	90	0.047	NS
Var x Nrate x Man	90	0.067	NS
Fol x Nrate	91	0.042	NS
Fol x Man	62	0.026	NS
Fol x Var x Nrate	93	0.064	NS
Fol x Var x Man	91	0.042	NS
Fol x Nrate x Man	93	0.064	NS
Fol x Var x Nrate x Man	92	0.092	NS

Table 5.74. Boxworth. Fraction of light interception at ground level.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0.88		0.88	0.85		0.85	0.86		0.86
Winner	120	0.92	0.91	0.91	0.89	0.90	0.90	0.91	0.90	0.90
Winner	240	0.84	0.82	0.83	0.82	0.80	0.81	0.83	0.81	0.82
Winner	360	0.95	0.90	0.93	0.93	0.92	0.92	0.94	0.91	0.92
Winner	Mean	0.90	0.88	0.89	0.87	0.87	0.87	0.88	0.87	0.88
Castille	0	0.70		0.70	0.78		0.78	0.74		0.74
Castille	120	0.92	0.68	0.80	0.91	0.69	0.80	0.92	0.68	0.80
Castille	240	0.91	0.77	0.84	0.92	0.76	0.84	0.91	0.77	0.84
Castille	360	0.81	0.81	0.81	0.83	0.80	0.81	0.82	0.80	0.81
Castille	Mean	0.84	0.74	0.79	0.86	0.76	0.81	0.85	0.75	0.80
Win+Cas	0	0.79		0.79	0.82		0.82	0.80		0.80
Win+Cas	120	0.92	0.79	0.86	0.90	0.79	0.85	0.91	0.79	0.85
Win+Cas	240	0.87	0.80	0.83	0.87	0.78	0.82	0.87	0.79	0.83
Win+Cas	360	0.88	0.86	0.87	0.88	0.86	0.87	0.88	0.86	0.87
Win+Cas	Mean	0.87	0.81	0.84	0.87	0.81	0.84	0.87	0.81	0.84

Treatment	df	SED	P-Value
Folicur	3	0.017	NS
Variety	90	0.026	0.003
Folicur x Variety	29	0.031	NS
N rate	90	0.037	NS
N Management	90	0.026	0.034
Var x Nrate	90	0.052	NS
Var x Man	90	0.037	0.097
Nrate x Man	90	0.052	NS
Var x Nrate x Man	90	0.074	NS
Fol x Nrate	74	0.048	NS
Fol x Man	29	0.031	NS
Fol x Var x Nrate	91	0.071	NS
Fol x Var x Man	74	0.048	NS
Fol x Nrate x Man	91	0.071	NS
Fol x Var x Nrate x Man	93	0.102	NS

Table 5.75. High Mowthorpe. Fraction of light reflected at mid flowering

Variety	N rate kg/ha	No Folicur Conv	No Folicur CM	No Folicur Mean	Folicur (1.0 l/ha) Conv	Folicur (1.0 l/ha) CM	Folicur (1.0 l/ha) Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0.111		0.111	0.104		0.104	0.108		0.108
Winner	120	0.120	0.112	0.116	0.116	0.109	0.112	0.118	0.110	0.114
Winner	240	0.123	0.114	0.119	0.123	0.107	0.115	0.123	0.110	0.117
Winner	360	0.129	0.121	0.125	0.118	0.103	0.110	0.123	0.112	0.118
Winner	Mean	0.121	0.114	0.118	0.115	0.106	0.110	0.118	0.110	0.114
Castille	0	0.129		0.129	0.119		0.119	0.124		0.124
Castille	120	0.137	0.125	0.131	0.125	0.114	0.120	0.131	0.120	0.125
Castille	240	0.136	0.120	0.128	0.130	0.113	0.121	0.133	0.117	0.125
Castille	360	0.144	0.124	0.134	0.132	0.104	0.118	0.138	0.114	0.126
Castille	Mean	0.137	0.125	0.131	0.127	0.113	0.120	0.132	0.119	0.125
Win+Cas	0	0.120		0.120	0.112		0.112	0.116		0.116
Win+Cas	120	0.128	0.118	0.123	0.121	0.112	0.116	0.124	0.115	0.120
Win+Cas	240	0.129	0.117	0.123	0.126	0.110	0.118	0.128	0.114	0.121
Win+Cas	360	0.136	0.122	0.129	0.125	0.104	0.114	0.131	0.113	0.122
Win+Cas	Mean	0.129	0.120	0.124	0.121	0.109	0.115	0.125	0.114	0.120

Treatment	df	SED	P-Value
Folicur	3	0.0048	NS
Variety	90	0.0013	<0.001
Folicur x Variety	3	0.0050	NS
N rate	90	0.0018	0.013
N Management	90	0.0013	<0.001
Var x Nrate	90	0.0026	0.076
Var x Man	90	0.0018	0.063
Nrate x Man	90	0.0026	<0.001
Var x Nrate x Man	90	0.0037	NS
Fol x Nrate	4	0.0053	0.062
Fol x Man	3	0.0050	NS
Fol x Var x Nrate	7	0.0059	NS
Fol x Var x Man	4	0.0053	NS
Fol x Nrate x Man	7	0.0059	NS
Fol x Var x Nrate x Man	13	0.0070	NS

Table 5.76. Mowthorpe. Fraction of light interception at base of flower canopy

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0.593		0.593	0.609		0.609	0.601		0.601
Winner	120	0.825	0.745	0.785	0.802	0.775	0.789	0.814	0.760	0.787
Winner	240	0.870	0.743	0.806	0.868	0.765	0.817	0.869	0.754	0.812
Winner	360	0.869	0.795	0.832	0.892	0.791	0.842	0.881	0.793	0.837
Winner	Mean	0.789	0.719	0.754	0.793	0.735	0.764	0.791	0.727	0.759
Castille	0	0.628		0.628	0.590		0.590	0.609		0.609
Castille	120	0.860	0.747	0.803	0.827	0.728	0.777	0.843	0.737	0.790
Castille	240	0.889	0.811	0.850	0.881	0.776	0.828	0.885	0.794	0.839
Castille	360	0.872	0.767	0.819	0.845	0.779	0.812	0.858	0.773	0.816
Castille	Mean	0.812	0.738	0.775	0.786	0.718	0.752	0.799	0.728	0.764
Win+Cas	0	0.610		0.610	0.600		0.600	0.605		0.605
Win+Cas	120	0.843	0.746	0.794	0.815	0.751	0.783	0.829	0.748	0.789
Win+Cas	240	0.880	0.777	0.828	0.875	0.771	0.823	0.877	0.774	0.825
Win+Cas	360	0.870	0.781	0.826	0.869	0.785	0.827	0.870	0.783	0.826
Win+Cas	Mean	0.801	0.729	0.765	0.789	0.727	0.758	0.795	0.728	0.761

Treatment	df	SED	P-Value
Folicur	3	0.0135	NS
Variety	90	0.0099	NS
Folicur x Variety	7	0.0168	0.096
N rate	90	0.0140	<0.001
N Management	90	0.0099	<0.001
Var x Nrate	90	0.0198	NS
Var x Man	90	0.0140	NS
Nrate x Man	90	0.0198	0.002
Var x Nrate x Man	90	0.0280	NS
Fol x Nrate	19	0.0218	NS
Fol x Man	7	0.0168	NS
Fol x Var x Nrate	46	0.0295	NS
Fol x Var x Man	19	0.0218	NS
Fol x Nrate x Man	46	0.0295	NS
Fol x Var x Nrate x Man	78	0.0406	NS

Table 5.77. Mowthorpe. Fraction of light interception at ground level

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0.831		0.831	0.847		0.847	0.839		0.839
Winner	120	0.955	0.932	0.944	0.951	0.955	0.953	0.953	0.944	0.948
Winner	240	0.970	0.927	0.948	0.974	0.937	0.955	0.972	0.932	0.952
Winner	360	0.979	0.949	0.964	0.973	0.949	0.961	0.976	0.949	0.963
Winner	Mean	0.934	0.910	0.922	0.936	0.922	0.929	0.935	0.916	0.925
Castille	0	0.818		0.818	0.816		0.816	0.817		0.817
Castille	120	0.956	0.923	0.940	0.946	0.921	0.933	0.951	0.922	0.937
Castille	240	0.979	0.949	0.964	0.969	0.939	0.954	0.974	0.944	0.959
Castille	360	0.977	0.926	0.952	0.976	0.916	0.946	0.976	0.921	0.949
Castille	Mean	0.933	0.904	0.918	0.927	0.898	0.912	0.930	0.901	0.915
Win+Cas	0	0.824		0.824	0.832		0.832	0.828		0.828
Win+Cas	120	0.956	0.928	0.942	0.948	0.938	0.943	0.952	0.933	0.943
Win+Cas	240	0.974	0.938	0.956	0.971	0.938	0.954	0.972	0.938	0.955
Win+Cas	360	0.978	0.938	0.958	0.974	0.932	0.953	0.976	0.935	0.956
Win+Cas	Mean	0.933	0.907	0.920	0.931	0.910	0.921	0.932	0.908	0.920

Treatment	df	SED	P-Value
Folicur	3	0.0106	NS
Variety	90	0.0055	0.070
Folicur x Variety	5	0.0119	NS
N rate	90	0.0078	<0.001
N Management	90	0.0055	<0.001
Var x Nrate	90	0.0110	NS
Var x Man	90	0.0078	NS
Nrate x Man	90	0.0110	0.045
Var x Nrate x Man	90	0.0156	NS
Fol x Nrate	10	0.0143	NS
Fol x Man	5	0.0119	NS
Fol x Var x Nrate	23	0.0180	NS
Fol x Var x Man	10	0.0143	NS
Fol x Nrate x Man	23	0.0180	NS
Fol x Var x Nrate x Man	50	0.0239	NS

5.2.10 Crop height at the end of flowering

At Boxworth, the Canopy Managed timings reduced the crop height of the 120 and 240 N rates by 4 cm and 6 cm respectively, and no effect was observed at 360 kg N/ha ($P<0.05$; Table 5.78). The Managed timings significantly reduced the height to the base of the flowers by 4 cm across all N rates ($P<0.001$; Table 5.79). Increasing N rate from 0 to 360 kg N/ha reduced crop height by about 2 cm ($P<0.001$). There was no evidence that this unexpected effect resulted from lodging. N rate did not affect the height to the base of the flower layer. The N rate and Folicur treatments interacted ($P<0.05$). Folicur reduced height by 4 cm at 0 kg/ha, 0 cm at 120 kg/ha, 3 cm at 240 kg/ha and 5 cm at 360 kg/ha. Castille was 21 cm shorter than Winner ($P<0.001$).

At High Mowthorpe, the Managed timings reduced the crop height by 4 cm ($P<0.001$; Table 5.80). Increasing N rate from 0 to 360 kg/ha increased height by 2.5 cm ($P<0.001$). The N rate and Folicur treatments interacted ($P<0.05$). Folicur reduced height by 0 cm at 0 kg/ha, 3 cm at 120 kg/ha, 5 cm at 240 kg/ha and 8 cm at 360 kg/ha (Table 5.80). Castille was 10 cm shorter than Winner ($P<0.001$).

At Rosemaund, the Managed timings reduced the crop height by 4 cm ($P<0.001$; Table 5.82). This effect was due to a reduction in the height to the base of the flowering layer (Table 5.83). N rate did not significantly affect crop height. Folicur shortened crop height by 3 cm (Table 5.82) and height to the base of the flowering layer by 5 cm (Table 5.83), but these effects were not statistically significant. Castille was 9 cm shorter than Winner ($P<0.001$). About half of the varietal effect came from shortening the height to the base of the flower layer (Table 5.83).

Table 5.78. Boxworth. Height (cm) to the top of the flowers.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	164.2		164.2	157.5		157.5	160.8		160.8
Winner	120	160.2	155.2	157.7	158.5	156.5	157.5	159.4	155.8	157.6
Winner	240	162.1	157.8	159.9	160.2	154.6	157.4	161.2	156.2	158.7
Winner	360	157.1	160.4	158.8	155.0	158.1	156.6	156.0	159.3	157.7
Winner	Mean	160.9	159.4	160.1	157.8	156.7	157.2	159.4	158.0	158.7
Castille	0	139.6		139.6	137.5		137.5	138.5		138.5
Castille	120	140.4	135.8	138.1	140.8	137.9	139.4	140.6	136.9	138.8
Castille	240	143.5	134.2	138.9	139.6	133.3	136.5	141.6	133.8	137.7
Castille	360	142.3	140.4	141.4	135.4	131.9	133.7	138.9	136.2	137.5
Castille	Mean	141.5	137.5	139.5	138.3	135.2	136.7	139.9	136.3	138.1
Win+Cas	0	151.9		151.9	147.5		147.5	149.7		149.7
Win+Cas	120	150.3	145.5	147.9	149.7	147.2	148.4	150.0	146.4	148.2
Win+Cas	240	152.8	146.0	149.4	149.9	144.0	146.9	151.4	145.0	148.2
Win+Cas	360	149.7	150.4	150.1	145.2	145.0	145.1	147.5	147.7	147.6
Win+Cas	Mean	151.2	148.4	149.8	148.1	145.9	147.0	149.6	147.2	148.4

Treatment	df	SED	P-Value
Folicur	3	2.20	NS
Variety	90	0.71	<0.001
Folicur x Variety	4	2.31	NS
N rate	90	1.00	<0.001
N Management	90	0.71	NS
Var x Nrate	90	1.42	NS
Var x Man	90	1.00	NS
Nrate x Man	90	1.42	0.003
Var x Nrate x Man	90	2.00	NS
Fol x Nrate	5	2.52	0.033
Fol x Man	4	2.31	NS
Fol x Var x Nrate	9	2.89	0.090
Fol x Var x Man	5	2.52	NS
Fol x Nrate x Man	9	2.89	NS
Fol x Var x Nrate x Man	18	3.52	NS

Table 5.79. Boxworth. Height (cm) to the base of the flowers.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	114.0		114.0	110.6		110.6	112.3		112.3
Winner	120	114.4	112.3	113.3	113.3	112.5	112.9	113.9	112.4	113.1
Winner	240	115.6	112.3	114.0	115.4	109.8	112.6	115.5	111.0	113.3
Winner	360	113.5	108.3	110.9	114.8	112.3	113.5	114.2	110.3	112.2
Winner	Mean	114.4	111.7	113.1	113.5	111.3	112.4	114.0	111.5	112.7
Castille	0	99.0		99.0	99.4		99.4	99.2		99.2
Castille	120	102.7	95.00	98.9	104.2	99.6	101.9	103.4	97.3	100.4
Castille	240	107.5	95.2	101.4	105.6	95.4	100.5	106.6	95.3	100.9
Castille	360	107.7	101.5	104.6	101.3	97.5	99.4	104.5	99.5	102.0
Castille	Mean	104.2	97.7	100.9	102.6	98.0	100.3	103.4	97.8	100.6
Win+Cas	0	106.5		106.5	105.0		105.0	105.7		105.7
Win+Cas	120	108.5	103.7	106.1	108.8	106.0	107.4	108.7	104.8	106.7
Win+Cas	240	111.6	103.8	107.7	110.5	102.6	106.6	111.0	103.2	107.1
Win+Cas	360	110.6	104.9	107.8	108.0	104.9	106.5	109.3	104.9	107.1
Win+Cas	Mean	109.3	104.7	107.0	108.1	104.6	106.4	108.7	104.7	106.7

Treatment	df	SED	P-Value
Folicur	3	1.70	NS
Variety	90	0.70	<0.001
Folicur x Variety	4	1.84	NS
N rate	90	0.99	NS
N Management	90	0.70	<0.001
Var x Nrate	90	1.40	NS
Var x Man	90	0.99	0.027
Nrate x Man	90	1.40	0.002
Var x Nrate x Man	90	1.98	NS
Fol x Nrate	7	2.09	NS
Fol x Man	4	1.84	NS
Fol x Var x Nrate	14	2.51	0.014
Fol x Var x Man	7	2.09	NS
Fol x Nrate x Man	14	2.51	NS
Fol x Var x Nrate x Man	31	3.20	NS

Table 5.80. High Mowthorpe. Height (cm) to the top of the flowers.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	135.0		135.0	135.7		135.7	135.4		135.4
Winner	120	138.8	134.0	136.4	137.5	131.5	134.5	138.2	132.8	135.5
Winner	240	141.4	135.7	138.5	139.1	129.6	134.3	140.2	132.6	136.4
Winner	360	142.6	136.8	139.7	136.8	131.7	134.3	139.7	134.3	137.0
Winner	Mean	139.5	135.4	137.4	137.3	132.1	134.7	138.4	133.7	136.1
Castille	0	124.0		124.0	124.6		124.6	124.3		124.3
Castille	120	131.6	123.8	127.7	125.2	121.8	123.5	128.4	122.8	125.6
Castille	240	136.3	131.2	133.7	126.0	121.7	123.9	131.2	126.4	128.8
Castille	360	133.4	131.5	132.4	126.7	118.8	122.8	130.0	125.2	127.6
Castille	Mean	131.3	127.6	129.5	125.6	121.7	123.7	128.5	124.7	126.6
Win+Cas	0	129.5		129.5	130.2		130.2	129.8		129.8
Win+Cas	120	135.2	128.9	132.1	131.4	126.7	129.0	133.3	127.8	130.5
Win+Cas	240	138.8	133.4	136.1	132.6	125.6	129.1	135.7	129.5	132.6
Win+Cas	360	138.0	134.2	136.1	131.8	125.3	128.5	134.9	129.7	132.3
Win+Cas	Mean	135.4	131.5	133.4	131.5	126.9	129.2	133.4	129.2	131.3

Treatment	df	SED	P-Value
Folicur	3	3.10	NS
Variety	90	0.99	<0.001
Folicur x Variety	4	3.25	NS
N rate	90	1.40	NS
N Management	90	0.99	<0.001
Var x Nrate	90	1.98	NS
Var x Man	90	1.40	NS
Nrate x Man	90	1.98	NS
Var x Nrate x Man	90	2.08	NS
Fol x Nrate	5	3.54	0.014
Fol x Man	4	3.25	NS
Fol x Var x Nrate	9	4.06	NS
Fol x Var x Man	5	3.54	NS
Fol x Nrate x Man	9	4.06	NS
Fol x Var x Nrate x Man	18	4.93	NS

Table 5.81. High Mowthorpe. Height (cm) to the base of the flowers.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	76.7		76.7	72.3		72.3	74.5		74.5
Winner	120	68.5	66.9	67.7	70.1	68.5	69.3	69.3	67.7	68.5
Winner	240	67.3	64.8	66.0	65.5	67.4	66.5	66.4	66.1	66.2
Winner	360	69.1	63.5	66.3	71.8	65.8	68.8	70.4	64.6	67.5
Winner	Mean	70.4	68.0	69.2	69.9	68.5	69.2	70.2	68.2	69.2
Castille	0	72.4		72.4	69.8		69.8	71.1		71.1
Castille	120	65.0	66.5	65.8	60.1	59.0	59.6	62.6	62.8	62.7
Castille	240	63.2	66.5	64.9	60.6	64.1	62.4	61.9	65.3	63.6
Castille	360	65.9	67.3	66.6	62.7	56.1	59.4	64.3	61.7	63.0
Castille	Mean	66.6	68.2	67.4	63.3	62.3	63.8	65.0	65.2	65.1
Win+Cas	0	74.5		74.5	71.0		71.0	72.8		72.8
Win+Cas	120	66.8	66.7	66.7	65.1	63.8	64.5	65.9	65.2	65.6
Win+Cas	240	65.2	65.7	65.4	63.1	65.8	64.4	64.2	65.7	64.9
Win+Cas	360	67.5	65.4	66.4	67.3	60.9	64.1	67.4	63.1	65.3
Win+Cas	Mean	68.5	68.1	68.3	66.6	65.4	66.0	67.6	66.7	67.1

Treatment	df	SED	P-Value
Folicur	3	1.60	NS
Variety	90	0.82	<0.001
Folicur x Variety	5	1.80	0.005
N rate	90	1.16	<0.001
N Management	90	0.82	NS
Var x Nrate	90	1.64	NS
Var x Man	90	1.16	NS
Nrate x Man	90	1.64	0.090
Var x Nrate x Man	90	2.32	NS
Fol x Nrate	9	2.14	NS
Fol x Man	5	1.80	NS
Fol x Var x Nrate	22	2.70	0.068
Fol x Var x Man	9	2.14	NS
Fol x Nrate x Man	22	2.70	NS
Fol x Var x Nrate x Man	48	3.56	NS

Table 5.82. Rosemaund. Height (cm) to the top of the flowers.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	154.5		154.5	148.8		148.8	151.6		151.6
Winner	120	154.3	149.8	152.0	149.9	138.7	144.3	152.1	144.3	148.2
Winner	240	153.5	149.4	151.5	156.5	145.6	151.0	155.0	147.5	151.3
Winner	360	152.2	143.8	148.0	148.8	147.5	148.1	150.5	145.7	148.1
Winner	Mean	153.6	149.4	151.5	151.0	145.1	148.1	152.3	147.3	149.8
Castille	0	140.7		140.7	140.7		140.7	140.7		140.7
Castille	120	142.5	140.1	141.3	142.3	135.3	138.8	142.4	137.7	140.0
Castille	240	142.3	137.8	140.0	140.3	136.4	138.4	141.3	137.1	139.2
Castille	360	147.8	147.3	147.5	142.8	138.8	140.8	145.3	143.0	144.2
Castille	Mean	143.3	141.5	142.4	141.5	137.8	139.6	142.4	139.6	141.0
Win+Cas	0	147.6		147.6	144.7		144.7	146.2		146.2
Win+Cas	120	148.4	145.0	146.7	146.1	137.0	141.5	147.2	141.0	144.1
Win+Cas	240	147.9	143.6	145.7	148.4	141.0	144.7	148.2	142.3	145.2
Win+Cas	360	150.0	145.6	147.8	145.8	143.1	144.4	147.9	144.4	146.1
Win+Cas	Mean	148.5	145.4	146.9	146.2	141.5	143.8	147.3	143.4	145.4

Treatment	df	SED	P-Value
Folicur	3	2.19	NS
Variety	30	1.10	<0.001
Folicur x Variety	2	2.45	NS
N rate	30	1.56	NS
N Management	30	1.10	0.001
Var x Nrate	30	2.20	0.062
Var x Man	30	1.56	NS
Nrate x Man	30	2.20	NS
Var x Nrate x Man	30	3.11	NS
Fol x Nrate	3	2.90	NS
Fol x Man	2	2.45	NS
Fol x Var x Nrate	7	3.64	NS
Fol x Var x Man	3	2.90	NS
Fol x Nrate x Man	7	3.64	NS
Fol x Var x Nrate x Man	16	4.79	NS

Table 5.83. Rosemaund. Height (cm) to the base of the flowers.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	94.4		94.4	90.0		90.0	92.2		92.2
Winner	120	99.7	91.2	95.4	93.7	85.0	89.3	96.7	88.1	92.4
Winner	240	91.7	93.7	92.7	96.8	91.6	94.2	94.3	92.6	93.4
Winner	360	98.3	93.5	95.9	95.4	92.8	94.1	96.8	93.2	95.0
Winner	Mean	96.0	93.2	94.6	94.0	89.9	91.9	95.0	91.5	93.3
Castille	0	93.8		93.8	90.1		90.1	91.9		91.9
Castille	120	92.8	91.7	92.2	89.9	87.8	88.8	91.3	89.7	90.5
Castille	240	90.6	83.8	87.2	86.8	80.8	83.8	88.7	82.3	85.5
Castille	360	97.6	87.7	82.6	92.5	75.3	83.9	95.0	81.5	88.3
Castille	Mean	93.7	89.2	91.4	89.8	83.5	86.7	91.7	86.3	89.0
Win+Cas	0	94.1		94.1	90.0		90.1	92.1		92.1
Win+Cas	120	96.2	91.4	93.8	91.8	86.4	89.1	94.0	88.9	91.5
Win+Cas	240	91.1	88.7	89.9	91.8	86.2	89.0	91.5	87.4	89.5
Win+Cas	360	97.9	90.6	94.3	94.0	84.1	89.0	95.9	87.3	91.6
Win+Cas	Mean	94.8	91.2	93.0	91.9	86.7	89.3	93.4	88.9	91.2

Treatment	df	SED	P-Value
Folicur	3	1.07	NS
Variety	30	1.14	<0.001
Folicur x Variety	4	1.56	NS
N rate	30	1.61	NS
N Management	30	1.14	<0.001
Var x Nrate	30	2.27	0.065
Var x Man	30	1.61	NS
Nrate x Man	30	2.27	0.085
Var x Nrate x Man	30	3.22	0.080
Fol x Nrate	14	2.24	NS
Fol x Man	4	1.56	NS
Fol x Var x Nrate	26	3.19	NS
Fol x Var x Man	14	2.24	NS
Fol x Nrate x Man	26	3.19	NS
Fol x Var x Nrate x Man	30	4.53	NS

5.2.11 Lodging during seed filling

At Boxworth, the Managed N timings reduced the lodging index from 42% to 36% ($P = 0.086$; Table 5.84). This effect was strongest for Winner for which the Managed timings reduced lodging from 60% to 49%. Increasing N rate from 0 to 360 kg/ha increased the lodging index from 0 to 60%. Folicur reduced the lodging index from 50% to 29% ($P<0.05$). There was a significant interaction between Folicur and Variety. Folicur reduced the lodging index of Castille from 39% to 9% and reduced the lodging index of Winner from 60% to 48%.

At High Mowthorpe there was very little lodging and the percentage area lodged ranged from 0% to 7% between the treatments (Table 5.85). Any lodging resulted from bending of the upper halves of the stems and the treatment differences were negligible.

At Rosemaund, the lodging resulted from bending of the upper halves of the stems. For Winner, the Managed N timings increased the percentage of plot for which the upper stems had bent over from 11 to 18% ($P<0.05$; Table 5.86). Field observations indicated that the Managed N treatments had a heavier weight of pods and the upper racemes were more flexible. Lodging was increased by increasing N rate and by Winner ($P<0.001$). Folicur reduced the lodging index from 12% to 7% ($P<0.05$). Effects were greatest for Winner grown at high N rates, e.g. Folicur reduced the lodging index of Winner at 360 kg N/ha from 32% to 12%.

Table 5.84. Boxworth. Early seed fill measurement of % lodging

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0.0		0.0	0.0		0.0	0.0		0.0
Winner	60	0.0	12.5	6.3	0.0	0.0	0.0	0.0	6.2	3.1
Winner	120	80.0	37.5	58.8	52.3	50.8	51.5	66.1	44.1	55.1
Winner	180	81.1	97.4	89.3	90.0	45.0	67.5	85.5	71.2	78.4
Winner	240	85.0	82.5	83.8	62.0	50.0	57.5	75.0	66.2	70.6
Winner	300	100.0	100.0	100.0	100.0	82.5	91.3	100.0	91.3	95.6
Winner	360	95.0	70.0	82.5	87.5	55.0	71.3	91.2	62.5	76.9
Winner	Mean	63.0	57.1	60.1	56.4	40.5	48.4	59.7	48.8	54.3
Castille	0	0.0		0.0	0.0		0.0	0.0		0.0
Castille	60	11.2	0.0	5.6	0.0	0.0	0.0	5.6	0.0	2.8
Castille	120	5.0	47.5	26.3	0.0	0.0	0.0	2.5	22.9	12.7
Castille	180	45.0	37.5	41.3	25.0	0.0	12.5	35.0	18.7	26.9
Castille	240	35.0	62.5	48.8	10.0	10.0	10.0	22.5	36.2	29.4
Castille	300	87.5	70.0	78.8	22.5	37.5	30.0	55.0	53.8	54.4
Castille	360	80.0	65.0	72.5	27.5	0.0	13.8	53.8	32.5	43.1
Castille	Mean	37.7	40.4	39.0	12.1	6.5	9.3	24.9	23.4	24.2
Win+Cas	0	0.0		0.0	0.0		0.0	0.0		0.0
Win+Cas	60	5.6	6.2	5.9	0.0	0.0	0.0	2.8	3.1	3.0
Win+Cas	120	42.5	42.5	42.5	26.1	24.5	25.3	34.3	33.5	33.9
Win+Cas	180	63.0	67.5	65.3	57.5	22.5	40.0	60.3	45.0	52.6
Win+Cas	240	60.0	72.5	66.2	37.5	30.0	33.8	48.7	51.2	50.0
Win+Cas	300	93.7	85.0	89.4	61.2	60.0	60.6	77.5	72.5	75.0
Win+Cas	360	87.5	67.5	77.5	57.5	27.5	42.5	72.5	47.5	60.0
Win+Cas	Mean	50.3	48.7	49.5	34.3	23.5	28.9	42.3	36.1	39.2

Treatment	df	SED	P-Value
Folicur	3	4.18	0.016
Variety	157	3.58	<0.001
Folicur x Variety	9	5.50	0.013
N rate	157	6.70	<0.001
N Management	157	3.58	0.086
Var x Nrate	157	9.47	<0.001
Var x Man	157	5.06	NS
Nrate x Man	157	9.47	NS
Var x Nrate x Man	157	13.40	NS
Fol x Nrate	64	9.71	0.066
Fol x Man	9	5.50	NS
Fol x Var x Nrate	122	13.57	NS
Fol x Var x Man	28	7.48	NS
Fol x Nrate x Man	122	13.57	NS
Fol x Var x Nrate x Man	153	19.07	NS

Table 5.85. High Mowthorpe. Early seed fill measurement of % lodging

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	1.5		1.5	1.0		1.0	1.3		1.3
Winner	60	0.5	2.8	1.6	1.0	1.0	1.0	0.8	1.9	1.3
Winner	120	3.5	3.0	3.3	1.0	1.3	1.1	2.3	2.1	2.2
Winner	180	1.3	1.8	1.5	0.8	1.0	0.9	1.0	1.4	1.2
Winner	240	0.8	6.8	3.8	0.8	1.8	1.3	0.8	4.3	2.5
Winner	300	1.3	1.8	1.5	0.8	1.3	1.0	1.0	1.5	1.3
Winner	360	2.0	4.3	3.1	1.0	1.8	1.4	1.5	3.0	2.3
Winner	Mean	1.5	3.1	2.3	0.9	1.3	1.1	1.2	2.2	1.7
Castille	0	0.0		0.0	0.3		0.3	0.1		0.1
Castille	60	0.0	0.0	0.0	0.5	0	0.3	0.3	0.0	0.1
Castille	120	0.0	2.8	1.4	0.5	0.8	0.6	0.3	1.8	1.0
Castille	180	0.5	0.8	0.6	0.3	0.5	0.4	0.4	0.6	0.5
Castille	240	0.3	2.8	1.5	0.8	0.5	0.6	0.5	1.6	1.1
Castille	300	0.5	0.5	0.5	0.5	0.8	0.6	0.5	0.6	0.6
Castille	360	0.0	2.8	1.4	0.8	0.5	0.6	0.4	1.6	1.0
Castille	Mean	0.2	1.4	0.8	0.5	0.5	0.5	0.3	0.9	0.6
Win+Cas	0	0.8		0.8	0.6		0.6	0.7		0.7
Win+Cas	60	0.3	1.4	0.8	0.8	0.5	0.6	0.5	0.9	0.7
Win+Cas	120	1.8	2.9	2.3	0.8	1.0	0.9	1.3	1.9	1.6
Win+Cas	180	0.9	1.3	1.1	0.5	0.8	0.6	0.7	1.0	0.8
Win+Cas	240	0.5	4.8	2.6	0.8	1.1	0.9	0.6	2.9	1.8
Win+Cas	300	0.9	1.1	1.0	0.6	1.0	0.8	0.8	1.1	0.9
Win+Cas	360	1.0	3.5	2.3	0.9	1.1	1.0	0.9	2.3	1.6
Win+Cas	Mean	0.9	2.2	0.8	0.7	0.9	1.5	0.8	1.6	1.2

Treatment	df	SED	P-Value
Folicur	3	0.56	NS
Variety	162	0.24	<0.001
Folicur x Variety	4	0.61	0.049
N rate	162	0.45	0.037
N Management	162	0.24	0.001
Var x Nrate	162	0.63	NS
Var x Man	162	0.34	NS
Nrate x Man	162	0.63	NS
Var x Nrate x Man	162	0.89	NS
Fol x Nrate	13	0.81	NS
Fol x Man	4	0.61	0.013
Fol x Var x Nrate	31	1.03	NS
Fol x Var x Man	7	0.70	NS
Fol x Nrate x Man	31	1.03	NS
Fol x Var x Nrate x Man	72	1.36	NS

Table 5.86. Rosemaund. Early seed fill measurement of % lodging as an index

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0.8		0.8	1.7		1.7	1.3		1.3
Winner	60	8.5	5.1	6.8	7.8	3.1	5.5	8.2	4.1	6.1
Winner	120	7.0	22.5	14.8	3.7	12.3	8.0	5.4	17.4	11.4
Winner	180	15.6	29.8	22.7	2.9	12.1	7.5	9.3	20.9	15.1
Winner	240	15.4	34.8	25.1	12.5	17.1	14.8	13.9	25.9	19.9
Winner	300	24.0	41.3	32.6	25.8	17.1	21.5	24.9	29.2	27.0
Winner	360	21.5	41.8	31.6	5.4	18.8	12.1	13.4	30.3	21.9
Winner	Mean	13.3	25.1	19.2	8.5	11.7	10.1	10.9	18.4	14.7
Castille	0	0.0		0.0	0.0		0.0	0.0		0.0
Castille	60	0.8	0.2	0.5	0.0	0.0	0.0	0.4	0.1	0.3
Castille	120	0.4	2.8	1.6	0.2	0.2	0.2	0.3	1.5	0.9
Castille	180	3.8	1.0	2.4	0.3	0.3	0.3	2.0	0.7	1.4
Castille	240	4.5	20.0	12.3	0.2	2.3	1.2	2.3	11.1	6.7
Castille	300	10.0	12.7	11.3	0.5	8.1	4.3	5.2	10.4	7.8
Castille	360	9.2	3.4	6.3	1.8	1.4	1.6	5.5	2.4	4.0
Castille	Mean	4.1	5.7	4.9	0.4	1.8	1.1	2.3	3.7	3.0
Win+Cas	0	0.4		0.4	0.8		0.8	0.6		0.6
Win+Cas	60	4.7	2.6	3.7	3.9	1.5	2.7	4.3	2.1	3.2
Win+Cas	120	3.7	12.6	8.2	1.9	6.2	4.1	2.8	9.4	6.1
Win+Cas	180	9.7	15.4	12.5	1.6	6.2	3.9	5.7	10.8	8.2
Win+Cas	240	10.0	27.4	18.7	6.3	9.7	8.0	8.1	18.5	13.3
Win+Cas	300	17.0	27.0	22.0	13.2	12.6	12.9	15.1	19.8	17.4
Win+Cas	360	15.3	22.6	19.0	3.6	10.1	6.9	9.5	16.3	12.9
Win+Cas	Mean	8.7	15.4	12.1	4.5	6.7	5.6	6.6	11.1	8.8

Treatment	df	SED	P-Value
Folicur	3	0.79	0.004
Variety	162	1.29	<0.001
Folicur x Variety	36	1.52	0.044
N rate	162	2.42	<0.001
N Management	162	1.29	<0.001
Var x Nrate	162	3.42	0.003
Var x Man	162	1.83	0.020
Nrate x Man	162	3.42	NS
Var x Nrate x Man	162	4.84	NS
Fol x Nrate	151	3.27	0.061
Fol x Man	36	1.52	0.083
Fol x Var x Nrate	164	4.73	NS
Fol x Var x Man	111	2.38	NS
Fol x Nrate x Man	164	4.73	NS
Fol x Var x Nrate x Man	164	6.77	NS

5.1.12 Pod greenness at mid seed filling

At Boxworth, increasing N rate from 0 to 360 kg N/ha increased the percentage of green pods from 38% to 59% (P<0.001; Table 5.87). The Managed N timings appeared to increase the percentage of green pods for the 60 kg N/ha N rate but this effect was not significant and there were no effect at the other N rates.

At High Mowthorpe, increasing N rate from 0 to 360 kg N/ha increased the percentage of green pods from 68% to 96% on 20 June, from 46% to 85% on 29 June and from 36% to 74% on 13 July (P<0.001; Table 5.88). There was no difference in the percentage of green pods between the Conventional and Managed N timings.

At Rosemaund, pod greenness was measured as an index, where 1 was not green and 5 was dark green, except on the 28 June when the percentage of green pods was also measured. Increasing N rate from 0 to 360 kg N/ha increased the percentage of green pods from 3.5 to 5.0 on 16 May, from 2.0 to 4.1 on 29 May and from 1.0 to 2.3 on 28 June (P<0.001; Table 41). Increasing N rate increased the percentage of green pods from 0% to 38% on 28 June (P<0.001). The Managed N timings increased the percentage of green pods from 15% to 21% (P=0.074; Table 5.90). There was no difference between the Conventional and Managed N timings for pod greenness on 16 May and 29 May.

Table 5.87. Boxworth. % pods that were green for Winner without Folicur.

	20 June		
kg/ha N	Conv	CM	Mean
0	19.2		
60	27.5	48.5	37.5
120	43.8	42.5	43.1
240	53.8	50.0	51.9
360	62.5	55.0	58.8
Mean	46.9	49.0	48.0
P-Value			
Timing	NS		
Nitrogen	<0.001		
Timing x N	NS		
SED (27 df)			
Timing	3.81		
Nitrogen	6.03		
Timing x N	8.53		

Table 5.88. High Mowthorpe. % pods that were green for Winner without Folicur.

kg/ha N	20 June Conv	CM	Mean	29 June Conv	CM	Mean	13 July Conv	CM	Mean
0	67.50			46.25			36.25		
60	76.25	78.75	77.50	60.00	62.50	61.25	48.75	50.00	49.38
120	86.25	87.50	86.88	71.25	75.00	73.12	60.00	62.50	61.25
240	97.50	93.75	95.62	87.50	82.50	85.00	75.00	68.75	71.88
360	93.75	98.75	96.25	82.50	87.50	85.00	71.25	77.50	74.38
	84.25	85.25	84.75	69.50	70.75	70.13	58.25	59.00	58.63
P-Value									
Timing	NS			NS			NS		
Nitrogen	<0.001			<0.001			<0.001		
Timing x N	NS			NS			NS		
SED (27 df)									
Timing	1.503			1.948			1.817		
Nitrogen	2.377			3.080			2.874		
Timing x N	3.361			4.355			4.064		

Table 5.89. Rosemaund. Pod greenness for Winner without Folicur. Index 1 to 5 where 1=not green and 5=dark green

	16 May Index 1 to 5			29 May Index 1 to 5			28 June Index 1 to 5			28 June % of pods green		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	3.50			2.00			1.00			0		
60	4.00	4.00	4.00	2.75	3.00	2.88	1.00	1.00	1.00	0	0	0
120	4.25	4.25	4.25	3.13	3.50	3.31	1.25	1.88	1.56	6.2	22.5	14.4
240	4.75	5.00	4.85	4.00	4.00	4.00	2.25	2.25	2.25	37.5	37.5	37.5
360	5.00	5.00	5.00	4.13	4.00	4.06	2.13	2.38	2.25	31.2	43.8	37.5
mean	4.30	4.35	4.33	3.20	3.30	3.25	1.53	1.70	1.61	15.0	20.8	18.0
P-Value												
Timing	NS			NS			NS			0.074		
Nitrogen	<0.001			<0.001			<0.001			<0.001		
Timing x N	NS			NS			NS			NS		
SED (27 df)												
Timing	0.105			0.081			0.082			3.10		
Nitrogen	0.166			0.128			0.129			4.90		
Timing x N	0.235			0.181			0.182			6.92		

5.2.13 Dry matter at harvest

At Boxworth for Winner without Folicur, the Managed N timings reduced seed weight from 5.19 t/ha to 4.53 t/ha ($P<0.05$; Table 5.89), reduced stem weight from 5.01 to 4.73 t/ha (NS), reduced pod weight from 3.68 t/ha to 3.28 t/ha ($P = 0.075$) and reduced total dry matter from 13.88 t/ha to 12.54 t/ha (NS). The effect on seed yield was unexpected as the combine yields showed that the Managed N timings increased seed yield for this treatment. The combine yields are more accurate due to the much larger crop area over which they are estimated. It is unlikely that seed was lost during sampling because the seed yields are greater than the combine yields. Therefore it must be concluded that unrepresentative areas of plot were quadrat sampled. The Managed N timings for Castille at 240 kg N/ha increased yield from 5.57 t/ha to 6.45 t/ha (NS; Table 5.92)

Increasing N rate increased the weight of the pod walls, seeds and total dry weight ($P<0.05$; Table 5.90). This effect mainly resulted from increasing N rate from 0 to 60 kg N/ha. Dry matter increases above 60 kg N/ha were small. At 240 kg N/ha, Castille had a greater stem, pod and seed dry weight than Winner ($P<0.1$; Table 5.93).

At High Mowthorpe for Winner without Folicur, the Managed N timings significantly reduced the stem biomass from 4.09 t/ha to 3.75 t/ha and had no significant effects on the dry weights of the pod walls and seed ($P<0.05$; Table 5.91). At 240 kg/ha, the Managed timings also reduced the stem weight of both Winner and Castille and had no effect of the weight of the pod walls and the seed ($P<0.05$; Table 5.94) compared to conventional timings. Increasing N rate increased the weight of the stems, pod walls and seed ($P<0.05$; Table 5.91). At 240 kg N/ha, there was no difference for the weight of the stems, pod walls and seeds between Winner and Castille (Table 5.94).

At Rosemaund, for Winner without Folicur, the Managed N timings did not affect the weight of the stems, pod walls, seed or total dry weight (Table 5.92). At 240 kg N/ha, the Managed timings reduced the weight of the stems for Castille ($P<0.05$; Table 5.95). Managed N timings also reduced the seed weight of Castille ($P<0.1$; Table 5.95). This effect was not consistent with the combine yields which may indicate that unrepresentative areas of plot were sampled for the Castille, Managed N at 240 kg N/ha treatment. Increasing N rate increased the weight of the pod walls and seed ($P<0.05$; Table 5.92). This effect mainly resulted from increasing N rate from 0 to 60 kg N/ha.

Table 5.89. Boxworth. Pre-harvest measurement of dry matter (t/ha) for Winner without Folicur.

	Stem dry matter (t/ha)			Pod dry matter (t/ha)			Seed dry matter (t/ha)			Total dry matter (t/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	4.31			2.65			3.87			10.82		
60	5.96	5.54	5.75	3.59	3.56	3.57	5.76	4.44	5.10	15.31	13.53	14.42
120	4.91	5.30	5.10	4.30	3.90	4.10	6.45	5.51	5.98	15.66	14.71	15.18
240	5.00	3.95	4.48	3.83	2.96	3.39	4.67	4.00	4.34	13.50	10.92	12.21
360	4.87	4.58	4.72	4.03	3.34	3.68	5.22	4.82	5.02	14.12	12.73	13.43
Mean	5.01	4.73	4.87	3.68	3.28	3.48	5.19	4.53	4.86	13.88	12.54	13.21
P-Value												
Timing	NS			0.075			0.05			NS		
Nitrogen	NS			0.005			0.004			0.016		
Timing x N	NS			NS			NS			NS		
SED (27 df)												
Timing	0.373			0.214			0.321			0.800		
Nitrogen	0.590			0.338			0.507			1.266		
Timing x N	0.834			0.479			0.717			1.790		

Table 5.90. High Mowthorpe. Pre-harvest measurement of dry matter (t/ha) for Winner without Folicur.

	Stem dry matter (t/ha)			Pod dry matter (t/ha)			Seed dry matter (t/ha)			Total dry matter (t/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	3.13			1.71			2.24			7.09		
60	4.06	3.86	3.96	2.63	2.75	2.67	3.61	3.35	3.48	10.30	9.92	10.11
120	4.09	3.96	4.02	2.81	3.11	2.96	3.89	3.95	3.92	10.80	11.02	10.91
240	4.47	3.97	4.22	3.22	3.08	3.15	4.03	3.55	3.79	11.72	10.61	11.16
360	4.69	3.84	4.27	3.45	3.00	3.23	4.80	4.17	4.49	12.95	11.01	11.98
Mean	4.09	3.75	3.92	2.77	2.73	2.75	3.72	3.45	3.59	10.57	9.93	10.25
P-Value												
Timing	0.04			NS			NS			NS		
Nitrogen	<0.001			<0.001			<0.001			<0.001		
Timing x N	NS			NS			NS			NS		
SED (27 df)												
Timing	0.158			0.109			0.236			0.402		
Nitrogen	0.249			0.172			0.373			0.635		
Timing x N	0.352			0.243			0.527			0.898		

Table 5.91. Rosemaund. Pre-harvest measurement of dry matter (t/ha) for Winner without Folicur.

	Stem dry matter (t/ha)			Pod dry matter (t/ha)			Seed dry matter (t/ha)			Total dry matter (t/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	3.89			2.29			2.86			9.06		
60	4.16	4.62	4.39	3.00	3.27	3.13	3.51	3.77	3.64	10.67	11.66	11.16
120	4.37	4.45	4.41	2.95	3.06	3.00	3.83	4.04	3.94	11.15	11.56	11.35
240	4.53	4.89	4.71	3.41	3.47	3.44	3.19	3.73	3.46	11.12	12.08	11.60
360	4.50	4.11	4.30	3.08	2.83	2.95	3.92	3.85	3.89	12.11	10.96	11.53
Mean	4.29	4.39	4.34	2.94	2.98	2.96	3.46	3.65	3.56	10.82	11.06	10.94
P-Value												
Timing	NS			NS			NS			NS		
Nitrogen	NS			0.018			0.037			0.078		
Timing x N	NS			NS			NS			NS		
SED (24 df)												
Timing	0.268			0.197			0.224			0.613		
Nitrogen	0.424			0.312			0.354			0.969		
Timing x N	0.600			0.441			0.501			1.370		

Table 5.92. Boxworth. Dry matter and N content for Winner and Castille without Folicur.

		Dry matter (t/ha)				Stem	Pod	Stem N	Pod N	Seed N	Total N
	kg/ha N	Stem	Pod	Seed	Total	N%	N%	kg/ha	kg/ha	(kg/ha)	(kg/ha)
Winner	240 conv	5.00	3.83	4.67	13.50	1.24	1.17	65.6	44.2	158.2	267.9
	240 CM	4.23	3.31	4.35	11.88	1.04	1.12	38.3	31.0	122.9	192.2
Castille	240 conv	5.73	4.85	5.57	16.15	0.90	0.92	46.3	40.9	178.3	265.5
	240 CM	5.81	5.45	6.45	17.71	1.08	1.03	61.9	55.6	214.4	331.9
Means											
Winner		4.62	3.57	4.51	12.69	1.14	1.14	51.9	37.6	140.5	230.1
Castille		5.77	5.15	6.01	16.93	0.99	0.97	54.1	48.3	196.3	298.7
240 kg/ha N conv		5.36	4.34	5.12	14.83	1.07	1.04	55.9	42.5	168.2	266.7
240 kg/ha N CM		5.02	4.38	5.40	14.80	1.06	1.07	50.1	43.3	168.6	262.1
P-Value											
Variety		0.099	0.006	0.017	0.017	NS	NS	NS	NS	0.02	0.07
Timing		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Var x N timing		NS	NS	NS	NS	NS	NS	NS	0.07	NS	NS
SED (9 df)											
Variety		0.608	0.406	0.479	1.352	0.117	0.095	11.9	7.2	20.2	33.6
Timing		0.608	0.406	0.479	1.362	0.117	0.095	11.9	7.2	20.2	33.6
Var x N timing		0.859	0.575	0.677	1.925	0.165	0.134	16.8	10.1	28.5	47.6

Table 5.93. High Mowthorpe. Dry matter and N content for Winner and Castille without Folicur.

		Dry matter (t/ha)				Stem	Pod	Stem N	Pod N	Seed N	Total N
	kg/ha N	Stem	Pod	Seed	Total	N%	N%	kg/ha	kg/ha	(kg/ha)	(kg/ha)
Winner	240 conv	4.47	3.22	4.03	11.72	1.16	1.07	51.8	34.8	123.9	210.4
	240 CM	3.97	3.08	3.55	10.61	1.04	1.08	42.9	33.8	110.3	187.0
Castille	240 conv	4.25	3.48	4.60	12.33	1.10	1.08	48.4	38.0	140.0	226.4
	240 CM	3.67	3.30	3.92	10.89	1.04	1.01	39.2	33.3	120.9	193.4
Means											
Winner		4.22	3.15	3.79	11.16	1.10	1.07	47.4	34.3	117.1	198.9
Castille		3.96	3.39	4.26	11.61	1.07	1.04	43.8	35.7	130.4	209.9
240 kg/ha N conv		4.36	3.35	4.31	12.03	1.13	1.07	50.1	36.4	131.9	218.4
240 kg/ha N CM		3.82	3.19	3.74	10.75	1.04	1.04	41.1	33.6	115.6	190.2
P-Value											
Variety		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Timing		0.03	NS	NS	NS	NS	NS	0.071	NS	NS	NS
Var x N timing		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SED (9 df)											
Variety		0.218	0.169	0.551	0.779	0.078	0.066	4.41	2.79	17.00	19.49
Timing		0.218	0.169	0.551	0.779	0.078	0.066	4.41	2.79	17.00	19.49
Var x N timing		0.308	0.239	0.779	1.102	0.110	0.094	6.23	3.75	24.01	27.57

Table 5.94. Rosemaund. Dry matter and N content for Winner and Castille without Folicur.

		Dry matter (t/ha)				Stem	Pod	Stem N	Pod N	Seed N	Total N
	kg/ha N	Stem	Pod	Seed	Total	N%	N%	kg/ha	kg/ha	(kg/ha)	(kg/ha)
Winner	240 conv	4.53	3.40	3.19	11.12	1.20	1.04	54.1	35.2	103.0	192.3
	240 CM	4.89	3.46	3.73	12.08	1.17	1.32	56.7	45.8	123.6	226.0
Castille	240 conv	4.78	3.71	4.07	12.56	1.06	1.03	50.7	38.1	126.5	215.3
	240 CM	3.00	3.28	3.24	9.52	1.10	1.30	32.3	43.2	108.9	184.4
Means											
Winner		4.71	3.43	3.46	11.60	1.19	1.18	55.4	40.5	113.3	209.2
Castille		3.89	3.49	3.65	11.04	1.08	1.17	42.8	40.3	118.9	202.0
240 kg/ha N conv		4.65	3.56	3.63	11.84	1.13	1.03	52.4	36.6	114.7	203.8
240 kg/ha N CM		3.94	3.37	3.48	10.80	1.14	1.31	44.5	44.5	116.2	205.2
P-Value											
Variety		0.019	NS	NS	NS	NS	NS	NS	NS	NS	NS
Timing		0.033	NS	NS	NS	NS	0.003	NS	NS	NS	NS
Var x N timing		0.005	NS	0.087	0.029	NS	NS	NS	NS	0.087	0.053
SED (9 df)											
Variety		0.278	0.350	0.353	0.756	0.063	0.065	4.78	6.02	10.66	14.45
Timing		0.278	0.350	0.353	0.756	0.063	0.065	4.76	6.02	10.66	14.45
Var x N timing		0.393	0.495	0.499	1.069	0.089	0.092	6.73	8.51	15.07	20.43

5.2.14 Crop N content

At Boxworth, increasing N rate from 0 to 360 kg N/ha increased the seed N concentration from 2.88% to 3.44% ($P<0.001$; Table 5.95), increased stem N concentration from 0.72% to 1.31% ($P<0.001$; Table 5.96) and increased pod wall N concentration from 0.73% to 1.14% ($P<0.001$; Table 5.96). There was an indication that Managed N timings increased pod wall N concentration, but this was not statistically significant. Managed N timings did not affect the stem N concentration. There was no difference in the concentration of N in the seed, pod wall or the stem between Winner and Castille (Table 5.92, Table 5.95).

Increasing N rate from 0 to 360 kg N/ha increased the seed N content from 124 to 173 kg/ha, increased stem N content from 38 to 62 kg/ha and increased pod wall N content from 21 to 52 kg/ha ($P<0.001$; Table 50). There was no indication that Managed N timings affected the N content of the stems, pods or seeds (Table 5.92 and 5.97). Castille had a greater N content in the pod wall than Winner (Table 5.92).

At High Mowthorpe, increasing N rate from 0 to 360 kg N/ha increased the seed N concentration from 2.69% to 3.10% ($P<0.001$; Table 5.95), increased stem N concentration from 0.70% to 1.19% ($P<0.001$; Table 5.98) and increased pod wall N concentration from 0.75% to 1.06% ($P<0.001$; Table 5.98). The Managed N timings increased seed N concentration from 2.87% to 2.94% ($P<0.05$; Table 5.95) and had no effect on the concentration of N in the pod walls (Table 5.98). There was an indication that Managed N timings reduced stem N concentration (Table 5.93), but this was not statistically significant and was not supported by data in Table 5.98. Winner had an average seed N concentration of 2.96% compared with 2.87% for Castille ($P<0.001$; Table 5.95). There was no difference in the concentration of N in the pod wall or the stem between Winner and Castille (Table 5.93).

Increasing N rate from 0 to 360 kg N/ha increased the seed N content from 63 to 140 kg/ha, increased stem N content from 22 to 47 kg/ha and increased pod wall N content from 13 to 34 kg/ha ($P<0.001$; Table 5.95). At 240 kg N/ha, the Managed timings reduced the amount of N in the stems by 10 kg N/ha (Table 5.93), but this effect did not occur at other N rates (Table 5.98). There was also an indication that the Managed timings reduced the amount of N in the seed (Table 5.93 and 5.99). There was no indication that Managed N timings affected the N content of the pods

(Table 5.93 and 5.99). Castille had a greater N content in the seed than Winner and a similar amount in the stems and pods (Table 5.92).

At Rosemaund, increasing N rate from 0 to 360 kg N/ha increased the seed N concentration from 2.58% to 3.66% ($P<0.001$; Table 5.95), increased stem N concentration from 0.66% to 1.27% ($P<0.001$; Table 5.100) and increased pod wall N concentration from 0.70% to 1.35% ($P<0.001$; Table 5.100). The Managed N timings increased seed N concentration from 2.95% to 3.05% ($P<0.001$; Table 5.95) and these effects were greater at the higher N rates. Managed timings increased pod wall N concentration ($P<0.05$; Table 5.100) and had no effect on the stem N concentration. There was no difference in the concentration of N in the seed, pod wall or the stem between Winner and Castille (Table 5.92, Table 5.95). Winner had an average seed N concentration of 3.03% compared with 2.97% for Castille ($P<0.01$; Table 5.95). There was no difference in the concentration of N in the pod wall or the stem between Winner and Castille (Table 5.94).

Increasing N rate from 0 to 360 kg N/ha increased the seed N content from 74 to 133 kg/ha, increased stem N content from 26 to 54 kg/ha and increased pod wall N content from 16 to 39 kg/ha ($P<0.001$; Table 5.99). There was an indication that Managed N timings increased the N content of the pods and seeds whilst having no effect on the stem N content (Table 5.99). Castille and Winner had similar amounts of N in their stems, pod walls and seeds (Table 5.94).

Table 5.95. Nitrogen concentration in the seed without Folicur.

Variety	N rate kg/ha	Boxworth seed Nitrogen % Conv	CM	Mean	High Mowthorpe seed Nitrogen % Conv	CM	Mean	Rosemaund seed Nitrogen % Conv	CM	Mean
Winner	0	2.94		2.94	2.82		2.82	2.56		2.56
Winner	60	2.91	2.99	2.95	2.73	2.87	2.80	2.85	2.80	2.83
Winner	120	3.23	3.25	3.24	2.91	3.05	2.98	2.98	3.14	3.06
Winner	240	3.40	3.38	3.39	3.08	3.11	3.09	3.23	3.31	3.27
Winner	360	3.42	3.50	3.46	3.10	3.15	3.12	3.32	3.49	3.41
Winner	Mean	3.18	3.21	3.19	2.93	3.00	2.96	2.99	3.06	3.03
Castille	0	2.82		2.82	2.55		2.55	2.60		2.60
Castille	60	2.93	2.95	2.94	2.80	2.69	2.74	2.75	2.86	2.81
Castille	120	3.07	3.27	3.17	2.91	2.93	2.92	2.82	3.02	2.92
Castille	240	3.37	3.32	3.34	3.05	3.08	3.06	3.11	3.31	3.21
Castille	360	3.41	3.43	3.42	3.03	3.15	3.09	3.22	3.42	3.32
Castille	Mean	3.12	3.16	3.14	2.87	2.88	2.87	2.90	3.04	2.97
Win+Cas	0	2.88		2.88	2.69		2.69	2.58		2.58
Win+Cas	60	2.92	2.97	2.94	2.76	2.78	2.77	2.80	2.83	2.82
Win+Cas	120	3.15	3.26	3.20	2.91	2.99	2.95	2.90	3.08	2.99
Win+Cas	240	3.38	3.35	3.36	3.06	3.09	3.08	3.17	3.31	3.24
Win+Cas	360	3.41	3.47	3.44	3.06	3.15	3.10	3.27	3.45	3.36
Win+Cas	Mean	3.15	3.18	3.17	2.87	2.94	2.92	2.95	3.05	3.00

Treatment	df	SED	P-Val	df	SED	P-Val	df	SED	P-Val
Variety	57	0.035	NS	57	0.020	<0.01	57	0.018	0.003
N rate	57	0.055	<0.01	57	0.032	<0.01	57	0.028	<0.01
N Management	57	0.035	NS	57	0.020	0.042	57	0.018	<0.01
Var x Nrate	57	0.078	NS	57	0.046	0.002	57	0.040	0.028
Var x Man	57	0.049	NS	57	0.029	NS	57	0.025	0.052
Nrate x Man	57	0.078	NS	57	0.046	NS	57	0.040	0.003
Var x Nrate x Man	57	0.111	NS	57	0.064	NS	57	0.057	NS

Table 5.96. Boxworth. Pre-harvest measurement of nitrogen concentration for Winner without Folicur.

	N % Stem			N % Pod		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean
0	0.72			0.73		
60	0.61	0.83	0.72	0.86	0.98	0.92
120	0.91	0.86	0.88	0.96	1.09	1.02
240	1.24	1.04	1.14	1.17	1.12	1.14
360	1.27	1.34	1.31	1.07	1.22	1.14
Mean	0.95	0.96	0.97	0.96	1.03	1.00
P-Value						
Timing	NS			NS		
Nitrogen	<0.001			<0.001		
Timing x N	NS			NS		
SED (27 df)						
Timing	0.064			0.052		
Nitrogen	0.101			0.082		
Timing x N	0.143			0.115		

Table 5.97. Boxworth. Pre-harvest measurement of N content for Winner without Folicur.

	Stem N (kg/ha)			Pod wall N (kg/ha)			Seed N (kg/ha)			Total Crop N (kg/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	Mngd	Mean
0	37.8			21.1			124.2			183.1		
60	36.1	45.7	40.9	30.7	34.6	32.7	166.6	132.1	149.3	233.4	212.4	222.9
120	45.9	46.8	46.3	41.2	43.9	42.5	208.7	179.6	194.2	295.8	270.2	283.0
240	65.6	38.3	51.9	44.2	31.0	37.6	158.2	122.9	140.5	267.9	192.2	230.1
360	62.4	61.6	62.0	42.9	40.7	41.8	177.8	169.0	173.4	283.1	271.3	277.2
Mean	52.5	48.1	50.3	39.8	37.5	38.6	177.8	150.9	164.4	270.1	236.5	253.3
P-Value												
Timing	NS			NS			0.053			NS		
Nitrogen	<0.05			<0.01			0.002			0.004		
Timing x N	NS			NS			NS			NS		
SED (27 df)												
Timing	6.61			3.19			10.62			16.52		
Nitrogen	10.46			5.04			16.79			26.12		
Timing x N	14.79			7.12			23.75			36.93		

Table 5.98. High Mowthorpe. Pre-harvest measurement of nitrogen concentration for Winner without Folicur.

	N % Stem			N % Pod		
kg/ha N	Conv	Mngd	Mean	Conv	Mngd	Mean
0	0.70			0.75		
60	0.70	0.85	0.77	0.87	0.89	0.88
120	0.82	0.84	0.83	0.94	0.92	0.93
240	1.16	1.04	1.10	1.07	1.08	1.07
360	1.04	1.19	1.11	1.07	1.04	1.06
Mean	0.88	0.92	0.90	0.94	0.94	0.94
P-Value						
Timing	NS			NS		
Nitrogen	<0.001			0.001		
Timing x N	NS			NS		
SED (27 df)						
Timing	0.056			0.049		
Nitrogen	0.089			0.078		
Timing x N	0.126			0.110		

Table 5.99. High Mowthorpe. Pre-harvest measurement of N content for Winner without Folicur.

	Stem N (kg/ha)			Pod wall N (kg/ha)			Seed N (kg/ha)			Total Crop N (kg/ha)		
kg/ha N	Conv	Mngd	Mean	Conv	Mngd	Mean	Conv	Mngd	Mean	Conv	Mngd	Mean
0	22.2			12.8			63.1			98.1		
60	28.1	32.3	30.2	22.9	25.0	23.9	98.9	96.0	97.4	149.8	153.3	151.5
120	33.2	32.8	33.0	26.6	28.8	27.7	113.3	120.4	116.9	173.1	182.0	177.6
240	51.8	42.9	47.4	34.8	33.8	34.3	123.9	110.3	117.1	210.4	187.0	198.7
360	48.6	46.1	47.3	37.6	31.0	34.3	148.5	130.8	139.7	234.7	207.9	221.3
Mean	40.4	38.5	39.5	30.5	29.7	30.1	121.2	114.4	117.8	192.0	182.5	187.3
P-Value												
Timing	NS			NS			NS			NS		
Nitrogen	<0.001			<0.001			<0.001			<0.001		
Timing x N	NS			NS			NS			NS		
SED (27 df)												
Timing	2.54			2.32			7.00			9.51		
Nitrogen	4.02			3.67			11.05			15.04		
Timing x N	5.69			5.19			15.62			21.27		

Table 5.100. Rosemaund. Pre-harvest measurement of nitrogen concentration for Winner without Folicur.

	N % Stem			N % Pod		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean
0	0.66			0.70		
60	0.70	0.70	0.70	0.82	0.81	0.82
120	0.82	0.78	0.80	0.91	1.01	0.96
240	1.20	1.17	1.19	1.04	1.32	1.18
360	1.26	1.28	1.27	1.14	1.56	1.35
Mean	0.93	0.92	0.92	0.92	1.08	1.00
P-Value						
Timing	NS			0.017		
Nitrogen	<0.001			<0.001		
Timing x N	NS			NS		
SED (27 df)						
Timing	0.046					
Nitrogen	0.073					
Timing x N	0.104					

Table 5.101. Rosemaund. Pre-harvest measurement of N content for Winner without Folicur.

	Stem N (kg/ha)			Pod wall N (kg/ha)			Seed N (kg/ha)			Total Crop N (kg/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	Mngd	Mean
0	25.7			15.8			73.6			117.0		
60	29.3	32.0	30.7	25.1	27.0	26.0	100.3	105.3	102.8	154.7	164.3	159.5
120	33.9	34.4	34.1	26.4	30.6	28.5	113.9	126.8	120.3	174.2	191.7	182.9
240	54.1	56.7	55.4	35.2	45.8	40.5	103.0	123.6	113.3	192.3	226.0	209.2
360	54.7	52.4	53.6	33.5	44.1	38.8	130.0	136.2	133.1	225.8	233.6	229.7
Mean	43.0	43.9	43.4	30.0	36.8	33.4	111.8	123.0	117.4	186.7	203.9	195.3
P-Value												
Timing	NS			0.043			NS			NS		
Nitrogen	<0.001			<0.001			<0.001			<0.001		
Timing x N	NS			NS			NS			NS		
SED (27 df)												
Timing	1.99			2.61			7.00			9.09		
Nitrogen	3.14			4.13			11.07			14.37		
Timing x N	4.44			5.85			15.65			20.32		

5.2.15 Seed size and seed number

At Boxworth, increasing N rate in Winner from 0 to 360 kg N/ha increased the thousand seed weight from 4.68 to 5.21g. Seed number/m^2 increased significantly from 52,923 at 0 kg N/ha to 66,531 at 120 kg N/ha then declined to 60,547 at 360 kg N/ha ($P<0.05$; Table 5.102). Managed N timings caused a slight, but non-significant, increase in seed number. There was no indication that Managed N timings affected seed size (Table 5.102 and 5.105). Castille had about 70,000 seeds/m^2 compared with about 61,000 for Winner and there was no difference in seed size between the varieties (Table 5.105).

At High Mowthorpe, increasing N rate from 0 to 360 kg N/ha increased the seeds/m^2 from 48,854 to 82,555 ($P<0.001$; Table 5.103) and had no effect on thousand seed weight. Managed N timings slightly reduced the number of seeds/m^2 and had no effect on seed size (Table 5.103 and 5.106). Castille had about 92,000 seeds/m^2 compared with about 81,000 for Winner and had slightly (but not significantly) heavier seeds (Table 5.106).

At Rosemaund, increasing N rate from 0 to 360 kg N/ha increased the thousand seed weight of the Conventionally timed N treatments from 5.15 to 5.43 g but there was no effect in the Managed N treatments ($P<0.05$; Table 5.104). Increasing N rate from 0 to 240 kg N/ha increased seeds/m^2 from 60,172 to 91,922 ($P<0.001$; Table 5.107). Increasing N rate from 240 to 360 kg N/ha reduced the seeds/m^2 to 89,778. At 240 and 360 kg N/ha, the Managed N timings increased seed number and reduced seed size ($P<0.05$; Table 5.104 and 5.105). At 240 kg N/ha, Castille and Winner had a similar seed size and seed number (Table 5.105).

Table 5.102. Boxworth. Thousand seed weight (TSW) and seeds/m^2 for Winner without Folicur.

	TSW (g)			† Seeds/m^2			Combine yield (t/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	4.68			51923			2.43		
60	4.63	4.68	4.65	61555	66239	64086	2.85	3.10	2.98
120	4.85	5.00	4.93	69897	63600	66531	3.39	3.18	3.28
240	5.18	5.15	5.16	60039	61942	61047	3.11	3.19	3.15
360	5.25	5.18	5.21	57905	61004	60547	3.04	3.16	3.10
Mean	4.98	5.00	4.99	63008	63968	63489	3.10	3.16	3.13
P-Value									
Timing	NS			NS			NS		
Nitrogen	<0.001			<0.05			0.001		
Timing x N	NS			NS			NS		
SED (27 df)									
Timing	0.067			3099			0.202		
Nitrogen	0.106			4900			0.128		
Timing x N	0.150			6930			0.285		

† calculated from combine seed yield

Table 5.103. High Mowthorpe. Thousand seed weight (TSW) and seeds/m^2 for Winner without Folicur.

	TSW (g)			† Seeds/m^2			Combine yield (t/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	5.42			48854			2.64		
60	5.30	5.32	5.31	71426	67381	69403	3.77	3.57	3.67
120	5.14	5.52	5.33	84526	75684	80105	4.34	4.18	4.26
240	5.56	5.28	5.42	81576	80763	81169	4.52	4.26	4.39
360	5.49	5.32	5.41	83254	81855	82555	4.55	4.34	4.45
Mean	5.37	5.36	5.37	80196	76421	78308	4.30	4.09	4.19
P-Value									
Timing	NS			NS			0.051		
Nitrogen	NS			<0.001			<0.001		
Timing x N	NS			NS			NS		
SED (27 df)									
Timing	0.080			2304			0.081		
Nitrogen	0.126			3643			0.128		
Timing x N	0.179			5151			0.181		

† calculated from combine seed yield

Table 5.104. Rosemaund. Thousand seed weight (TSW) and seeds/m^2 for Winner without Folicur

	TSW (g)			† Seeds/m^2			Combine yield (t/ha)		
kg/ha N	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
0	5.15			60172			3.10		
60	5.22	5.14	5.18	74142	76798	75470	3.86	3.92	3.89
120	4.92	5.25	5.09	86288	82604	84446	4.23	4.33	4.28
240	5.38	4.87	5.13	88063	95780	91922	4.74	4.65	4.70
360	5.43	4.97	5.23	83003	96553	89778	4.50	4.75	4.63
Mean	5.24	5.06	5.15	82874	87934	85404	4.33	4.41	4.37
P-Value									
Timing	0.075			0.084			NS		
Nitrogen	NS			<0.001			<0.001		
Timing x N	0.012			NS			NS		
SED (27 df)									
Timing	0.078			2164			0.078		
Nitrogen	0.123			3420			0.123		
Timing x N	0.174			4838			0.175		

† calculated from combine seed yield

Table 5.105. Thousand seed weight (TSW) and seeds/m^2 for Winner and Castille without Folicur.

		Boxworth			High Mowthorpe			Rosemaund		
	kg/ha N	TSW (g)	Seeds/m^2	Yield (t/ha)	TSW (g)	Seeds/m^2	Yield (t/ha)	TSW (g)	Seeds/m^2	Yield (t/ha)
Winner	240 conv	5.18	60463	3.11	5.56	81576	4.52	5.38	88063	4.74
	240 CM	5.15	61873	3.19	5.28	80763	4.26	4.87	95780	4.65
Castille	240 conv	5.48	70288	3.84	5.62	95342	5.34	5.43	91511	4.96
	240 CM	5.28	69512	3.65	5.73	89027	5.07	5.48	94143	5.21
Means										
Winner		5.16	61168	3.15	5.42	81169	4.39	5.13	91922	4.70
Castille		5.38	69900	3.75	5.68	92185	5.21	5.45	92639	5.09
240 kg/ha N conv		5.33	65376	3.48	5.59	88576	4.93	5.38	88063	4.74
240 kg/ha N CM		5.21	65693	3.42	5.51	84895	4.66	4.87	95780	4.65
P-Value										
Variety		NS	0.032	0.002	NS	0.018	<0.001	0.034	NS	0.013
Timing		NS	NS	NS	NS	NS	0.031	NS	NS	NS
Var x N timing		NS	NS	NS	NS	NS	NS	0.053	NS	NS
SED (9 df)										
Variety		0.134	3436	0.140	0.181	3831	0.104	0.128	3133	0.125
Timing		0.134	3436	0.140	0.181	3831	0.104	0.128	3133	0.125
Var x N timing		0.189	4860	0.198	0.256	5418	0.148	0.181	4431	0.176

5.3 Experimental year 3 – 2007/8

5.3.1 Soil and crop N in February

Experiments were drilled at ADAS Boxworth (Cambridgeshire) on 5/9/07, ADAS High Mowthorpe (N. Yorkshire) on 6/9/07 and ADAS Rosemaund (Herefordshire) on 3/9/07. The soil mineral N and GAI of the experimental crops was measured in late January or early February. This showed that the crop N content and the soil mineral N of Winner and Castille were not significantly different. A summary of this information (Table 5.106) shows that the combined supply of N from the crop and soil in February was 66 kg N/ha at Boxworth, 48 kg N/ha at Rosemaund and 62 kg N/ha at High Mowthorpe.

Table 5.106. Soil N, crop N and Fertiliser requirement for canopy managed treatments

	Boxworth	High Mowthorpe	Rosemaund
Feb SMN (kg/ha)	58	38	12
Feb GAI	0.19	0.10	1.36
Crop N (kg/ha)	8	10	50
SNS (kg/ha)	66	48	62
Fert N for GAI 3.5 (kg/ha)	182	231	188

SMN – soil mineral nitrogen
SNS – soil nitrogen supply - sum of SNS and crop N

5.3.2 N treatments

The amount of fertiliser N required to achieve the optimum GAI of 3.5 by flowering was calculated at 182 kg/ha at Boxworth, 231 kg/ha at High Mowthorpe and 188 kg/ha at Rosemaund based on the measurements of soil and crop N. At Rosemaund, the first dose for the Canopy Managed treatment was applied at the 2nd conventional split timing. This was designed to test the Canopy Management principals by investigating the effect of delaying N to a crop with a moderate sized canopy with a very low soil N supply. At Boxworth and High Mowthorpe it was estimated that the crop would not be able to take up all of the N required to acheve the optimum sized canopy by mid-flowering if the N applications were delayed until the 2nd conventional split timing. Therefore, 40 kg N/ha and 60 kg N/ha was applied at the 1st conventional split timing at Boxworth and High Mowthorpe respectively. After sufficient N had been applied to achieve the optimum GAI of 3.5 the remainder of the N was applied between yellow bud and early/mid flowering in late April/early May. The N applications in each split are described in Tables 5.107, 5.108 and 5.109. The dates of the N applications and Folicur treatment are described in Table 5.110.

Table 5.107. Boxworth N applications (kg N/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	40	20	0	60
9	Managed	40	80	0	120
10	Managed	40	140	0	180
11	Managed	40	140	60	240
12	Managed	40	140	120	300
13	Managed	40	140	180	360

Table 5.108. High Mowthorpe N applications (kg N/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	60	0	0	60
9	Managed	60	60	0	120
10	Managed	60	120	0	180
11	Managed	60	170	10	240
12	Managed	60	170	70	300
13	Managed	60	170	130	360

Table 5.109. Rosemaund N applications (kg N/ha)

N treatment	Management	1st split	2nd split	3rd split	Total
1		0	0	0	0
2	Conventional	30	30	0	60
3	Conventional	60	60	0	120
4	Conventional	90	90	0	180
5	Conventional	120	120	0	240
6	Conventional	150	150	0	300
7	Conventional	180	180	0	360
8	Managed	0	60	0	60
9	Managed	0	120	0	120
10	Managed	0	180	0	180
11	Managed	0	180	60	240
12	Managed	0	180	120	300
13	Managed	0	180	180	360

Table 5.110**.** Timings of Nitrogen and Folicur treatments

	Boxworth	High Mowthorpe	Rosemaund
1st N timing	27 Feb	6 March	4 March
2nd N timing	2nd April	9 April	31 March
3rd N timing	21 April	6 May	14 April
Folicur timing	14 April (0.5 l/ha)	29 April (0.5 l/ha)	4 April (1.0 l/ha)

5.3.3 Seed yield

At Boxworth, yields significantly ($P < 0.001$) differed with variety; Winner had a mean yield of 3.07 t/ha and Castille 3.26 t/ha (Table 5.111). Increasing N rates significantly ($P < 0.001$) increased yield. Averaged over all other treatments, yields significantly increased at each level of N from nil N (1.34 t/ha) to 180 kg/ha N (3.79 t/ha). Further increases were found up to the highest N rate of 360 kg/ha, where the average yield was 4.05 t/ha, although these differences were not significant (Table 5.111). N rate was also found to significantly ($P < 0.05$) interact with the Folicur treatment and N Management. Here, with increasing levels of N, yields increased more rapidly with a Folicur treatment or under canopy management.

At High Mowthorpe, overall, the variety Castillle yielded significantly ($P < 0.001$) higher than Winner, with yields of 3.31 and 2.94 t/ha, respectively (Table 5.112). Yields were significantly ($P < 0.001$) increased with higher N rates. With no N applied, average yields were 1.39 t/ha, but at the highest N rate (360 kg/ha), yields increased

to 3.88 t/ha. N management did not significantly affect yield. Folicur at 0.5 l/ha increased yield by 0.29 t/ha on average, although this effect was not significant.

At Rosemaund, significant ($P < 0.001$) differences were found between variety, N rate and N management treatments (Table 5.113). On average, Castille produced a yield of 4.18 t/ha compared to 3.95 t/ha produced by Winner. Higher N rates led to higher yields; yields ranged from 2.72 t/ha with nil N applied to 4.51 t/ha with 360 kg/ha N applied. For Winner the Conventionally N managed plots gave a higher yield (4.33 t/ha) than the Canopy Managed plots (4.03 t/ha). N management had no effect on Castille. Folicur increased the yield of Winner by 0.19 t/ha ($P<0.05$), with greater yield increases occurring at the higher N rates.

Table 5.111. Boxworth seed yields (t/ha @ 9% mc)

Variety	N rate	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	1.32		1.32	1.10		1.10	1.21		1.21
Winner	60	2.05	1.96	2.00	2.01	2.04	2.02	2.03	2.00	2.01
Winner	120	2.87	2.95	2.91	3.07	3.05	3.06	2.97	3.00	2.98
Winner	180	3.70	3.75	3.73	3.58	3.86	3.72	3.64	3.81	3.72
Winner	240	3.46	3.72	3.59	3.89	4.08	3.98	3.67	3.90	3.79
Winner	300	3.96	3.57	3.76	3.75	4.03	3.89	3.85	3.80	3.83
Winner	360	3.98	3.92	3.95	4.02	3.84	3.93	4.00	3.88	3.94
Winner	Mean	3.05	3.03	3.04	3.06	3.14	3.10	3.05	3.08	3.07
Castille	0	1.44		1.44	1.51		1.51	1.48		1.48
Castille	60	2.21	2.41	2.31	2.32	2.37	2.35	2.27	2.39	2.33
Castille	120	3.04	3.23	3.14	3.00	3.49	3.25	3.02	3.36	3.19
Castille	180	3.73	3.91	3.82	3.71	4.10	3.90	3.72	4.00	3.86
Castille	240	3.50	3.42	3.46	3.91	4.17	4.04	3.71	3.80	3.75
Castille	300	4.08	4.15	4.11	4.21	3.75	3.98	4.14	3.95	4.05
Castille	360	4.54	3.95	4.25	4.31	3.88	4.09	4.42	3.92	4.17
Castille	Mean	3.22	3.22	3.22	3.28	3.32	3.30	3.25	3.27	3.26
Win+Cas	0	1.38		1.38	1.31		1.31	1.34		1.34
Win+Cas	60	2.13	2.18	2.16	2.17	2.20	2.18	2.15	2.19	2.17
Win+Cas	120	2.95	3.09	3.02	3.04	3.27	3.15	3.00	3.18	3.09
Win+Cas	180	3.72	3.83	3.77	3.65	3.98	3.81	3.68	3.90	3.79
Win+Cas	240	3.48	3.57	3.53	3.90	4.12	4.01	3.69	3.85	3.77
Win+Cas	300	4.02	3.86	3.94	3.98	3.89	3.94	4.00	3.87	3.94
Win+Cas	360	4.26	3.93	4.10	4.16	3.86	4.01	4.21	3.90	4.05
Win+Cas	Mean	3.13	3.12	3.13	3.17	3.23	3.20	3.15	3.18	3.16

Treatment	df	SED	P-Value
Folicur	3	0.237	0.718
Variety	75	0.045	<.001
N rate	75	0.084	<.001
N management	75	0.045	0.588
Fol x Var	75	0.241	0.829
Fol x Nrate	75	0.261	0.017
Var x Nrate	75	0.119	0.485
Fol x Man	75	0.241	0.407
Var x Man	75	0.064	0.897
Nrate x Man	75	0.119	0.021
Fol x Var x Nrate	75	0.287	0.718
Fol x Var x Man	75	0.250	0.762
Fol x Nrate x Man	75	0.287	0.994
Var x Nrate x Man	75	0.168	0.466
Fol x Var x Nrate x Man	75	0.333	0.222

Table 5.112. High Mowthorpe seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	1.29		1.29	1.23		1.23	1.26		1.26
Winner	60	1.87	2.08	1.97	2.29	2.17	2.23	2.08	2.12	2.10
Winner	120	2.85	2.70	2.78	3.17	3.09	3.13	3.01	2.89	2.95
Winner	180	3.53	3.07	3.30	3.72	3.45	3.59	3.63	3.26	3.44
Winner	240	3.25	3.34	3.30	3.81	3.75	3.78	3.53	3.55	3.54
Winner	300	3.37	3.59	3.48	3.79	3.54	3.67	3.58	3.57	3.57
Winner	360	3.40	3.56	3.48	3.89	3.94	3.92	3.65	3.75	3.70
Winner	Mean	2.79	2.80	2.80	3.13	3.02	3.08	2.96	2.91	2.94
Castille	0	1.48		1.48	1.58		1.58	1.53		1.53
Castille	60	2.43	2.62	2.52	2.45	2.95	2.70	2.44	2.78	2.61
Castille	120	3.10	2.95	3.03	3.49	3.40	3.44	3.30	3.17	3.23
Castille	180	3.53	3.54	3.53	3.90	4.03	3.97	3.71	3.78	3.75
Castille	240	3.76	3.74	3.75	4.23	4.00	4.12	4.00	3.87	3.93
Castille	300	3.82	3.92	3.87	4.00	4.44	4.22	3.91	4.18	4.05
Castille	360	3.95	3.80	3.88	4.19	4.28	4.24	4.07	4.04	4.06
Castille	Mean	3.15	3.15	3.15	3.41	3.53	3.47	3.28	3.34	3.31
Win+Cas	0	1.38		1.38	1.41		1.41	1.39		1.39
Win+Cas	60	2.15	2.35	2.25	2.37	2.56	2.46	2.26	2.45	2.36
Win+Cas	120	2.98	2.82	2.90	3.33	3.24	3.29	3.15	3.03	3.09
Win+Cas	180	3.53	3.30	3.41	3.81	3.74	3.78	3.67	3.52	3.60
Win+Cas	240	3.51	3.54	3.53	4.02	3.88	3.95	3.76	3.71	3.74
Win+Cas	300	3.59	3.75	3.67	3.90	3.99	3.95	3.75	3.87	3.81
Win+Cas	360	3.68	3.68	3.68	4.04	4.11	4.08	3.86	3.90	3.88
Win+Cas	Mean	2.97	2.98	2.98	3.27	3.27	3.27	3.12	3.13	3.12

Treatment	df	SED	P-Value
Folicur	3	0.140	0.125
Variety	75	0.043	<.001
N rate	75	0.080	<.001
N management	75	0.043	0.911
Fol x Var	75	0.147	0.665
Fol x Nrate	75	0.175	0.158
Var x Nrate	75	0.113	0.66
Fol x Man	75	0.147	0.969
Var x Man	75	0.061	0.22
Nrate x Man	75	0.113	0.288
Fol x Var x Nrate	75	0.208	0.934
Fol x Var x Man	75	0.159	0.165
Fol x Nrate x Man	75	0.208	0.972
Var x Nrate x Man	75	0.160	0.403
Fol x Var x Nrate x Man	75	0.263	0.675

Table 5.113. Rosemaund seed yields (t/ha @ 9% mc)

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	2.63		2.63	2.56		2.56	2.60		2.60
Winner	60	3.675	3.605	3.64	3.789	3.769	3.78	3.73	3.69	3.71
Winner	120	3.702	3.865	3.78	4.008	4.186	4.10	3.86	4.03	3.94
Winner	180	4.366	3.816	4.09	4.287	4.492	4.39	4.33	4.15	4.24
Winner	240	4.019	4.115	4.07	4.509	4.302	4.41	4.26	4.21	4.24
Winner	300	4.373	4.438	4.41	4.46	4.586	4.52	4.42	4.51	4.46
Winner	360	4.307	4.404	4.36	4.767	4.336	4.55	4.54	4.37	4.45
Winner	Mean	3.87	3.84	3.85	4.05	4.03	4.04	3.96	3.94	3.95
Castille	0	3.00		3.00	2.69		2.69	2.85		2.85
Castille	60	4.345	3.981	4.16	3.859	3.603	3.73	4.10	3.79	3.95
Castille	120	4.251	4.147	4.20	4.556	4.354	4.46	4.40	4.25	4.33
Castille	180	4.805	4.447	4.63	4.59	4.129	4.36	4.70	4.29	4.49
Castille	240	4.571	4.271	4.42	4.768	4.596	4.68	4.67	4.43	4.55
Castille	300	4.81	4.111	4.46	4.853	4.291	4.57	4.83	4.20	4.52
Castille	360	4.632	4.511	4.57	4.843	4.288	4.57	4.74	4.40	4.57
Castille	Mean	4.34	4.07	4.21	4.31	3.99	4.15	4.33	4.03	4.18
Win+Cas	0	2.82		2.82	2.63		2.63	2.72		2.72
Win+Cas	60	4.01	3.79	3.90	3.82	3.69	3.76	3.92	3.74	3.83
Win+Cas	120	3.98	4.01	3.99	4.28	4.27	4.28	4.13	4.14	4.13
Win+Cas	180	4.59	4.13	4.36	4.44	4.31	4.37	4.51	4.22	4.37
Win+Cas	240	4.30	4.19	4.24	4.64	4.45	4.54	4.47	4.32	4.39
Win+Cas	300	4.59	4.27	4.43	4.66	4.44	4.55	4.62	4.36	4.49
Win+Cas	360	4.47	4.46	4.46	4.81	4.31	4.56	4.64	4.38	4.51
Win+Cas	Mean	4.11	3.95	4.03	4.18	4.01	4.10	4.14	3.98	4.06

Treatment	df	SED	P-Value
Folicur	3	0.170	0.717
Variety	75	0.043	<.001
N rate	75	0.081	<.001
N management	75	0.043	<.001
Fol x Var	75	0.175	0.005
Fol x Nrate	75	0.200	0.013
Var x Nrate	75	0.114	0.429
Fol x Man	75	0.175	0.859
Var x Man	75	0.061	0.002
Nrate x Man	75	0.114	0.321
Fol x Var x Nrate	75	0.230	0.39
Fol x Var x Man	75	0.185	0.797
Fol x Nrate x Man	75	0.230	0.33
Var x Nrate x Man	75	0.161	0.446
Fol x Var x Nrate x Man	75	0.281	0.61

5.3.4 Oil content

At Boxworth, oil content significantly (P = 0.016) decreased with an increase in the N rate applied (Table 5.115). Linear regression showed a 0.42 % decrease in oil content with every 100 kg increase in N applied; the relationship was significant (P = 0.003). Folicur did not affect oil content (Table 5.115), nor were there any significant interations between Folicur and any other factor.

A significant (P < 0.001) decrease in oil content with an increased N rate was also found at High Mowthorpe (Table 5.116); at this site, oil content decreased by 0.73 % with every 100 kg increase in N applied. Neither Canopy Management nor Folicur affected oil content (Table 5.117)

At Rosemaund, as well as a significant (P < 0.001) decrease in oil content with increasing N applications, significant effects of variety (P < 0.001) and Canopy Management (P = 0.037) were found (Table 5.118). Here, Castille had, on average, oil contents 1.7% higher than Winner, and Conventional N timings, on average, produced slightly (0.4%), but significantly, higher oil contents than Canopy Management. Regression analysis showed a 1.0% decrease in oil content with each 100 kg increase in N applications.

Table 5.114. Boxworth Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	41.5		41.5	40.5		40.5	41.0		41.0
120	40.5	42.6	41.5	42.6	40.9	41.8	41.6	41.8	41.7
240	41.6	39.1	40.3	40.3	41.1	40.7	40.9	40.1	40.5
360	40.1	41.2	40.7	39.0	39.1	39.1	39.5	40.2	39.9
Mean	40.9	41.1	41.0	40.6	40.4	40.5	40.8	40.8	40.8

Treatment	df	SED	P Value
Variety	30	0.38	0.195
Nitrogen	30	0.53	0.016
N management	30	0.38	0.999
Variety x Nitrogen	30	0.76	0.201
Variety x Management	30	0.53	0.615
Nitrogen x Management	30	0.76	0.579
Var x N x Man	30	1.07	0.021

Without Folicur

Table 5.115. Boxworth Oil contents (% dry matter) effects of Folicur

		Conventional		Managed timing		Mean	
	N rate	Nil	Folicur	Nil	Folicur	Nil	Folicur
Winner	120	40.5	41.5	42.6	42.4	41.5	41.9
Winner	240	41.6	41.4	39.1	40.2	40.3	40.8
Castille	120	42.6	42.1	40.9	41.2	41.8	41.6
Castille	240	40.3	40.7	41.1	40.3	40.7	40.5
Mean		41.2	41.4	40.9	41.0	41.1	41.2

	df	SED	P-Value
Folicur	2	0.51	0.842
Folicur x Variety	4.77	0.64	0.442
Folicur x N rate	4.77	0.64	0.981
Folicur x N timing	4.77	0.64	0.893

Table 5.116. High Mowthorpe Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	42.2		42.2	42.3		42.3	42.3		42.3
120	41.5	41.5	41.5	41.7	42.0	41.8	41.6	41.8	41.7
240	40.2	40.5	40.4	40.1	40.7	40.4	40.1	40.6	40.4
360	40.3	40.2	40.3	39.5	40.2	39.8	39.9	40.2	40.1
Mean	41.0	41.1	41.1	40.9	41.3	41.1	41.0	41.2	41.1

Treatment	df	SED	P Value
Variety	45	0.15	0.838
Nitrogen	45	0.22	<.001
N management	45	0.15	0.119
Variety x Nitrogen	45	0.31	0.357
Variety x Management	45	0.22	0.26
Nitrogen x Management	45	0.31	0.732
Var x N x Man	45	0.44	0.845

Without Folicur

Table 5.117. High Mowthorpe Oil contents (% dry matter) effects of Folicur

		Conventional		Managed timing		Mean	
	N rate	Nil	Folicur	Nil	Folicur	Nil	Folicur
Winner	120	41.5	41.6	41.5	41.2	41.5	41.4
Winner	240	40.2	39.8	40.5	39.9	40.4	39.9
Castille	120	41.7	42.0	42.0	41.7	41.8	41.9
Castille	240	40.1	40.5	40.7	39.5	40.4	40.0
Mean		40.8	41.0	41.2	40.6	41.0	40.8

	df	SED	P-Value
Folicur	3	0.35	0.572
Folicur x Variety	5.04	0.40	0.779
Folicur x N rate	5.04	0.40	0.278
Folicur x N timing	5.04	0.40	0.057

Table 5.118. Rosemaund Oil contents (% dry matter)

N Rate	Winner			Castille			Conv	CM	Grand
kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
0	39.5	39.5	39.5	37.6	37.6	37.6	38.6	38.6	38.6
120	37.9	38.0	37.9	37.1	36.2	36.7	37.5	37.1	37.3
240	37.5	35.8	36.7	35.2	34.6	34.9	36.3	35.2	35.8
360	36.4	36.0	36.2	34.4	34.2	34.3	35.4	35.1	35.2
Mean	37.8	37.3	37.6	36.1	35.7	35.9	36.9	36.5	36.7

Treatment	df	SED	P Value
Variety	45	0.21	<.001
Nitrogen	45	0.30	<.001
N management	45	0.21	0.037
Variety x Nitrogen	45	0.42	0.68
Variety x Management	45	0.30	0.748
Nitrogen x Management	45	0.42	0.278
Var x N x Man	45	0.60	0.364

Without Folicur

Table 5.119. Rosemaund Oil contents (% dry matter) effects of Folicur

		Conventional		Managed timing		Mean	
	N rate	Nil	Folicur	Nil	Folicur	Nil	Folicur
Winner	120	37.9	36.6	38.0	35.2	37.9	35.9
Winner	240	37.5	33.1	35.8	33.8	36.7	33.5
Castille	120	37.1	33.9	36.2	34.7	36.7	34.3
Castille	240	35.2	33.2	34.6	33.3	34.9	33.2
Mean		36.9	34.2	36.2	34.2	36.5	34.2

	df	SED	P-Value
Folicur	3	0.75	0.053
Folicur x Variety	4.69	0.84	0.402
Folicur x N rate	4.69	0.84	0.774
Folicur x N timing	4.69	0.84	0.305

5.3.5 Optimum N rate

At Boxworth, regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (85%, $P<0.001$). The economically optimum N rate before taking account of oil premiums was 262 kg N/ha for all treatments and 256 kg N/ha after taking account of the oil content. At 256 kg N/ha Winner yielded 3.87 t/ha compared with 4.07 t/ha for Castille (Table 5.120). At optimum N the Canopy Managed treatments yielded 0.02 t/ha more than the Conventional treatments and Folicur increased yield by 0.08 t/ha.

At High Mowthorpe regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (85%, $P<0.001$). The economically optimum N rate before taking account of oil premiums was 245 kg N/ha for all treatments, and this decreased to 236 kg N/ha after taking account the oil content. At 236 kg N/ha Winner yielded 3.59 t/ha and Castille yielded 3.96 t/ha. At 236 kg N/ha the Canopy Managed and Conventional treatments had similar yields at 3.78 t/ha. Folicur at 0.5 l/ha increased yield by 0.3 t/ha.

At Rosemaund regression analysis showed that fitting parallel curves for each treatment combination accounted for the most variation between N rate and yield (70%, $P<0.001$). The economically optimum N rate before taking account of oil premiums was 146 kg N/ha for all treatments, which decreased to 128 kg N/ha after

accounting for oil content. At 128 kg N/ha Winner yielded 4.14 t/ha and Castille yielded 4.37 t/ha. At 128 kg N/ha the Canopy Managed N timing reduced yield of Castille by 0.29 t/ha and had no effect on Winner. Folicur increased the yield of Winner by 0.19 t/ha.

Table 5.120. Optimum N rate and yields at N opt.

	Boxworth	High Mowthorpe	Rosemaund
Economically optimum N rate (kg/ha)	256	236	128
Winner Conventional N timings	3.82	3.42	4.01
Winner Managed N timings	3.80	3.43	3.98
Winner Conventional N timings with Folicur	3.84	3.76	4.20
Winner Managed N timings with Folicur	3.92	3.65	4.18
Castille Conventional N timings	4.00	3.78	4.49
Castille Managed N timings	3.99	3.78	4.21
Castille Conventional N timings with Folicur	4.06	4.04	4.45
Castille Managed N timings with Folicur	4.10	4.16	4.14

5.3.6 Growth analysis before stem extension

Crop assessments carried out before any N applications in February showed that the GAI, dry weight, tissue N concentration and N content of the crops did not differ between Winner and Castille at the 5% level of significance (Table 5.121). Each unit of GAI contained 46 kg N/ha at Boxworth and 37 kg N/ha at Rosemaund. At High Mowthorpe the crop was too small to calculate the relationship between GAI and crop N content. Previous studies have shown that the crop contains about 50 kg N/ha per unit of GAI.

Table 5.121. February measurements.

Boxworth

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	0.238	0.297	3.65	10.83
Castille	0.168	0.209	3.68	7.60
Mean	0.203	0.253	3.66	9.21
SED (df)	0.0376	0.0474	0.187	1.798
P-Value	0.16	0.159	0.873	0.17

High Mowthorpe

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	0.095	0.187	4.51	8.4
Castille	0.107	0.229	4.75	10.94
Mean	0.101	0.208	4.63	9.67
SED (df)	0.018	0.0176	0.366	1.22
P-Value	0.577	0.096	0.555	0.129

Rosemaund

	GAI	Dry matter (t/ha)	N content (% of dry matter)	Crop N (kg/ha)
Winner	1.59	1.78	2.87	51.1
Castille	1.14	1.66	2.95	49.0
Mean	1.36	1.72	2.91	50.0
SED (df)	0.293	0.15	0.0256	4.64
P-Value	0.222	0.481	0.049	0.678

5.3.7 GAI, dry weight and N content at mid-flowering

At Boxworth, increased N rates significantly ($P < 0.01$) increased the GAI and biomass of leaves and the total biomass at Boxworth (Table 5.122 and 5.123), and increased the biomass of stems and flowers/pods, although not significantly ($P = 0.066$ and 0.102 for stems and flowers, respectively). Stem, flowers/pods and total biomass data also showed significant ($P < 0.05$) interactions between N rate and variety (Table 5.123). With the stem and flowers/pods results, biomass increased with higher N rates in Castille, but decreased with higher N rates in Winner (Table 5.123). When total biomass data was studied, an increase in biomass was found with increased N in Winner, but this was very small compared to the increase found in Castille (Table 5.123).

The soil mineral N + crop N in February amounted to 66 kg N/ha. In theory this would have been expected to be taken up into the crop by mid-flowering and to produce a GAI of 1.3. The measurements at Nil N showed that the crop had taken up 41 kg N/ha and achieved a GAI of 0.56. It is possible that the very low plant population meant that the roots had not grown to a sufficient density to take up all of the soil N by flowering, or some soil N may have been leached. Applying 120 kg N/ha would be expected to increase N uptake by 72 kg N/ha and increase the GAI by 1.4 units. The measured increases were 52 kg N/ha and 1.1 GAI units.

At High Mowthorpe, GAIs of leaves, stems and whole plants were significantly ($P < 0.001$) increased with higher N rates (Table 5.124). The stem GAI data also showed a significant ($P = 0.027$) interaction between variety and N rate; the stems of Castille showed a greater increase in GAI with an increased N rate than Winner (Table 5.124). Increased N rates led to increased biomass in all parts of the plant, plus the total biomass, and there was a significant ($P = 0.007$) interaction between N rate and variety in the stems, with the data showing the same effects as the GAI data. There was also a significant ($P = 0.025$) variety x N rate interaction in the total biomass data, which again showed the same effects i.e. a greater increase with increased N in Castille (4.02 t/ha of total biomass) than Winner (2.84 t/ha of total biomass). However, despite the greater increase, the overall biomass for Winner was slightly higher than Castille because the biomass at 0 N was higher for Winner than Castille (Table 5.125).

The soil mineral N + crop N in February amounted to 48 kg N/ha. In theory this would have been expected to be taken up into the crop by mid-flowering and to produce a GAI of 0.96. The measurements at Nil N showed that the crop had taken up 31 kg N/ha and achieved a GAI of 0.65. The crop at this site grew very slowly during February and March and it is possible that some of the soil N leached before the crop had time to take it up. Applying 120 kg N/ha would be expected to increase N uptake by 66 kg N/ha and increase the GAI by 1.3 units. The measured increases were 67 kg N/ha and 2.2 GAI units.

At Rosemaund the GAIs of leaves, stems and the whole plant were significantly ($P < 0.001$) increased with increased N (Table 5.126). No interactions were found for GAI at this site. Leaf and flower/pod biomass was significantly ($P < 0.01$) increased with increased N at Rosemaund (Table 5.127).

The soil mineral N + crop N in February amounted to 62 kg N/ha. In theory this would have been expected to be taken up into the crop by mid-flowering and to produce a GAI of 1.24. The measurements at nil N showed that the crop had achieved a GAI of 1.04. Applying 120 kg N/ha would be expected to increase the GAI by 1.4 units. The measured increases averaged across Winner and Castille was 1.4 GAI units.

Table 5.122. Boxworth. Mid flowering green area indices

Variety	N rate kg/ha	GAI leaves			GAI stems			Total GAI		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.415		0.415	0.136		0.136	0.55		0.55
Winner	120	1.437	1.485	1.461	0.107	0.173	0.140	1.54	1.66	1.6
Winner	Mean	0.926	0.950	0.938	0.121	0.154	0.138	1.05	1.1	1.08
Castille	0	0.474		0.474	0.101		0.101	0.57		0.57
Castille	120	1.394	1.521	1.457	0.190	0.165	0.177	1.58	1.69	1.63
Castille	Mean	0.934	0.997	0.965	0.145	0.133	0.139	1.08	1.13	1.1
Win+Cas	0	0.444		0.444	0.118		0.118	0.56		0.56
Win+Cas	120	1.415	1.503	1.459	0.148	0.169	0.158	1.58	1.67	1.62
Win+Cas	Mean	0.930	0.974	0.952	0.133	0.144	0.138	1.06	1.12	1.09
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		14	0.1879	0.886	14	0.0262	0.961	14	0.209	0.893
N management		14	0.1879	0.819	14	0.0262	0.705	14	0.209	0.8
N_rate		14	0.1879	<.001	14	0.0262	0.15	14	0.209	<.001
Var x Man		14	0.2658	0.917	14	0.0371	0.401	14	0.296	0.99
Var x Nrate		14	0.2658	0.872	14	0.0371	0.189	14	0.296	0.98
Man x Nrate		14	0.2658	0.819	14	0.0371	0.705	14	0.296	0.8
Var x Man x Nrate		14	0.3759	0.917	14	0.0525	0.401	14	0.419	0.99

Table 5.123. Boxworth. Mid flowering dry matter measurements

Variety	N rate kg/ha	Leaf biomass (t/ha)			Stem biomass (t/ha)			Flower biomass (t/ha)			Total biomass (t/ha)		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.376		0.376	1.95		1.95	0.487		0.487	2.81		2.81
Winner	120	0.839	0.938	0.888	1.37	2.02	1.70	0.307	0.475	0.391	2.52	3.43	2.97
Winner	Mean	0.608	0.657	0.632	1.66	1.98	1.82	0.397	0.481	0.439	2.67	3.12	2.89
Castille	0	0.382		0.382	1.28		1.28	0.265		0.265	1.93		1.93
Castille	120	0.972	0.946	0.959	2.58	2.22	2.40	0.662	0.464	0.563	4.21	3.63	3.92
Castille	Mean	0.677	0.664	0.670	1.93	1.75	1.84	0.464	0.365	0.414	3.07	2.78	2.93
Win+Cas	0	0.379		0.379	1.62		1.62	0.376		0.376	2.37		2.37
Win+Cas	120	0.906	0.942	0.924	1.98	2.12	2.05	0.485	0.470	0.477	3.37	3.53	3.45
Win+Cas	Mean	0.642	0.660	0.651	1.80	1.87	1.83	0.430	0.423	0.427	2.87	2.95	2.91
Treatment		df	SED	F prob	df	SED	F prob	df	SED	F prob	df	SED	F prob
Variety		14	0.0868	0.666	14	0.217	0.925	14	0.0578	0.675	14	0.332	0.92
N management		14	0.0868	0.839	14	0.217	0.742	14	0.0578	0.898	14	0.332	0.806
N_rate		14	0.0868	<.001	14	0.217	0.066	14	0.0578	0.102	14	0.332	0.006
Var x Man		14	0.1227	0.723	14	0.306	0.268	14	0.0818	0.135	14	0.47	0.281
Var x Nrate		14	0.1227	0.713	14	0.306	0.007	14	0.0818	0.004	14	0.47	0.016
Man x Nrate		14	0.1227	0.839	14	0.306	0.742	14	0.0818	0.898	14	0.47	0.806
Var x Man x Nrate		14	0.1736	0.723	14	0.433	0.268	14	0.1157	0.135	14	0.665	0.281

Table 5.124. High Mowthorpe. Mid flowering green area indices

Variety	N rate kg/ha	GAI leaves			GAI stems			Total GAI		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.461		0.461	0.345		0.345	0.81		0.81
Winner	120	2.010	2.257	2.134	0.694	0.744	0.719	2.70	3.00	2.85
Winner	Mean	1.236	1.359	1.297	0.519	0.544	0.532	1.76	1.90	1.83
Castille	0	0.263		0.263	0.227		0.227	0.49		0.49
Castille	120	1.779	2.079	1.929	0.963	0.820	0.892	2.74	2.90	2.82
Castille	Mean	1.021	1.171	1.096	0.595	0.524	0.560	1.62	1.70	1.66
Win+Cas	0	0.362		0.362	0.286		0.286	0.65		0.65
Win+Cas	120	1.894	2.168	2.031	0.828	0.782	0.805	2.72	2.95	2.84
Win+Cas	Mean	1.128	1.265	1.197	0.557	0.534	0.546	1.69	1.80	1.74
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		21	0.1525	0.201	21	0.0612	0.654	21	0.158	0.284
N management		21	0.1525	0.379	21	0.0612	0.71	21	0.158	0.478
N_rate		21	0.1525	<.001	21	0.0612	<.001	21	0.158	<.001
Var x Man		21	0.2157	0.931	21	0.0865	0.438	21	0.223	0.826
Var x Nrate		21	0.2157	0.984	21	0.0865	0.027	21	0.223	0.379
Man x Nrate		21	0.2157	0.379	21	0.0865	0.71	21	0.223	0.478
Var x Man x Nrate		21	0.305	0.931	21	0.1223	0.438	21	0.316	0.826

Table 5.125. High Mowthorpe. Mid flowering dry matter measurements

Variety	N rate kg/ha	Leaf biomass (t/ha)			Stem biomass (t/ha)			Flower biomass (t/ha)			Total biomass (t/ha)		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.311		0.311	2.12		2.12	0.633		0.633	3.06		3.06
Winner	120	0.953	1.034	0.993	4.07	3.65	3.86	1.083	1.016	1.049	6.1	5.7	5.9
Winner	Mean	0.632	0.673	0.652	3.09	2.89	2.99	0.858	0.824	0.841	4.58	4.38	4.48
Castille	0	0.217		0.217	1.55		1.55	0.509		0.509	2.27		2.27
Castille	120	0.872	0.876	0.874	4.45	4.20	4.33	1.282	0.896	1.089	6.61	5.97	6.29
Castille	Mean	0.544	0.546	0.545	3.00	2.87	2.94	0.895	0.702	0.799	4.44	4.12	4.28
Win+Cas	0	0.264		0.264	1.84		1.84	0.571		0.571	2.67		2.67
Win+Cas	120	0.913	0.955	0.934	4.26	3.93	4.09	1.182	0.956	1.069	6.35	5.84	6.1
Win+Cas	Mean	0.588	0.610	0.599	3.05	2.88	2.96	0.877	0.763	0.820	4.51	4.25	4.38
Treatment		df	SED	F prob	df	SED	F prob	df	SED	F prob	df	SED	. F prob
Variety		21	0.074	0.163	21	0.174	0.772	21	0.0682	0.54	21	0.244	0.421
N management		21	0.074	0.777	21	0.174	0.348	21	0.0682	0.111	21	0.244	0.301
N_rate		21	0.074	<.001	21	0.174	<.001	21	0.0682	<.001	21	0.244	<.001
Var x Man		21	0.1046	0.797	21	0.246	0.823	21	0.0965	0.256	21	0.346	0.81
Var x Nrate		21	0.1046	0.871	21	0.246	0.007	21	0.0965	0.244	21	0.346	0.025
Man x Nrate		21	0.1046	0.777	21	0.246	0.348	21	0.0965	0.111	21	0.346	0.301
Var x Man x Nrate		21	0.1479	0.797	21	0.348	0.823	21	0.1364	0.256	21	0.489	0.81

Table 5.126. Rosemaund. Mid flowering green area indices

Variety	N rate kg/ha	GAI leaves			GAI stems			Total GAI		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.760		0.760	0.242		0.242	1.00		1.00
Winner	120	2.066	2.202	2.134	0.436	0.367	0.401	2.50	2.57	2.54
Winner	Mean	1.413	1.481	1.447	0.339	0.304	0.321	1.75	1.79	1.77
Castille	0	0.786		0.786	0.282		0.282	1.07		1.07
Castille	120	1.918	1.938	1.928	0.411	0.333	0.372	2.33	2.27	2.30
Castille	Mean	1.352	1.362	1.357	0.346	0.307	0.327	1.70	1.67	1.68
Win+Cas	0	0.773		0.773	0.262		0.262	1.04		1.04
Win+Cas	120	1.992	2.070	2.031	0.423	0.350	0.387	2.42	2.42	2.42
Win+Cas	Mean	1.383	1.422	1.402	0.342	0.306	0.324	1.73	1.73	1.73
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		21	0.1069	0.409	21	0.024	0.826	21	0.123	0.498
N management		21	0.1069	0.721	21	0.024	0.142	21	0.123	0.987
N_rate		21	0.1069	<.001	21	0.024	<.001	21	0.123	<.001
Var x Man		21	0.1512	0.789	21	0.034	0.927	21	0.174	0.802
Var x Nrate		21	0.1512	0.29	21	0.034	0.166	21	0.174	0.234
Man x Nrate		21	0.1512	0.721	21	0.034	0.142	21	0.174	0.987
Var x Man x Nrate		21	0.2138	0.789	21	0.048	0.927	21	0.245	0.802

Table 5.127. Rosemaund. Mid flowering dry matter measurements

Variety	N rate kg/ha	Leaf biomass (t/ha)			Stem biomass (t/ha)			Flower biomass (t/ha)			Total biomass (t/ha)		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.682		0.682	†			0.435		0.435	†		
Winner	120	1.572	1.729	1.651				0.497	0.553	0.525			
Winner	Mean	1.127	1.205	1.166				0.466	0.494	0.480			
Castille	0	0.676		0.676				0.472		0.472			
Castille	120	1.441	1.600	1.520				0.588	0.510	0.549			
Castille	Mean	1.058	1.138	1.098				0.530	0.491	0.511			
Win+Cas	0	0.679		0.679				0.454		0.454			
Win+Cas	120	1.506	1.664	1.585				0.542	0.531	0.537			
Win+Cas	Mean	1.093	1.172	1.132				0.498	0.493	0.495			
Treatment		df	SED	F prob	df	SED	F prob	df	SED	F prob	df	SED	F prob
Variety		21	0.0748	0.374				21	0.0274	0.275			
N management		21	0.0748	0.303				21	0.0274	0.842			
N_rate		21	0.0748	<.001				21	0.0274	0.006			
Var x Man		21	0.1058	0.994				21	0.0387	0.236			
Var x Nrate		21	0.1058	0.413				21	0.0387	0.82			
Man x Nrate		21	0.1058	0.303				21	0.0387	0.842			
Var x Man x Nrate		21	0.1497	0.994				21	0.0547	0.236			

† error occurred during dry matter determination

Table 5.128. Boxworth. Mid flowering measurement of nitrogen concentration in dry plant material on Treatments 1, 3 and 9 without Folicur.

Variety	N rate kg/ha	Leaf N%			Other plant material N %			Total crop N (kg/ha)		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	2.77		2.77	1.35		1.35	43		43
Winner	120	4.23	4.24	4.24	2.29	2.27	2.28	74	96	85
Winner	Mean	3.50	3.51	3.50	1.82	1.81	1.81	59	68	63
Castille	0	3.34		3.34	1.67		1.67	39		39
Castille	120	3.73	4.23	3.98	1.94	2.31	2.12	99	102	101
Castille	Mean	3.54	3.78	3.66	1.80	1.99	1.90	67	67	67
Win+Cas	0	3.06		3.06	1.51		1.51	41		41
Win+Cas	120	3.98	4.23	4.11	2.11	2.29	2.20	87	99	93
Win+Cas	Mean	3.52	3.64	3.58	1.81	1.90	1.86	63	67	65
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		14	0.157	0.34	14	0.085	0.347	14	23.4	0.611
N management		14	0.157	0.439	14	0.085	0.319	14	23.4	0.57
N_rate		14	0.157	<.001	14	0.085	<.001	14	23.4	<.001
Var x Man		14	0.222	0.445	14	0.120	0.269	14	33.1	0.561
Var x Nrate		14	0.222	0.021	14	0.120	0.013	14	33.1	0.188
Man x Nrate		14	0.222	0.439	14	0.120	0.319	14	33.1	0.57
Var x Man x Nrate		14	0.314	0.445	14	0.170	0.269	14	46.8	0.561

Table 5.129. High Mowthorpe. Mid flowering measurement of nitrogen concentration in dry plant material on Treatments 1, 3 and 9 without Folicur.

Variety	N rate kg/ha	Leaf N%			Other plant material N %			Total crop N (kg/ha)		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	2.47		2.47	1.06		1.06	37		37
Winner	120	3.07	3.15	3.11	1.36	1.77	1.56	99	115	107
Winner	Mean	2.77	2.81	2.79	1.21	1.41	1.31	65	71	68
Castille	0	2.27		2.27	1.00		1.00	26		26
Castille	120	3.03	2.80	2.91	1.09	1.24	1.16	89	88	88
Castille	Mean	2.65	2.54	2.59	1.04	1.12	1.08	55	54	54
Win+Cas	0	2.37		2.37	1.03		1.03	31		31
Win+Cas	120	3.05	2.97	3.01	1.22	1.50	1.36	94	101	98
Win+Cas	Mean	2.71	2.67	2.69	1.13	1.27	1.20	60	63	61
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		21	0.095	0.054	14	0.071	0.004	21	10.4	0.017
N management		21	0.095	0.696	14	0.071	0.063	21	10.4	0.7
N_rate		21	0.095	<.001	14	0.071	<.001	21	10.4	<.001
Var x Man		21	0.134	0.438	14	0.101	0.376	21	14.7	0.314
Var x Nrate		21	0.134	0.99	14	0.101	0.026	21	14.7	0.548
Man x Nrate		21	0.134	0.696	14	0.101	0.063	21	14.7	0.7
Var x Man x Nrate		21	0.190	0.438	14	0.142	0.376	21	20.8	0.314

Table 5.130. Rosemaund. Mid flowering measurement of nitrogen concentration in dry plant material on Treatments 1, 3 and 9 without Folicur.

Variety	N rate kg/ha	Leaf N%			Other plant material N %			Total crop N (kg/ha)		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	2.40		2.40	1.65		1.65	†		
Winner	120	4.03	4.11	4.07	2.57	2.26	2.41			
Winner	Mean	3.21	3.25	3.23	2.11	1.96	2.03			
Castille	0	2.40		2.40	1.52		1.52			
Castille	120	3.70	4.61	4.16	2.40	2.53	2.47			
Castille	Mean	3.05	3.51	3.28	1.96	2.03	1.99			
Win+Cas	0	2.40		2.40	1.59		1.59			
Win+Cas	120	3.87	4.36	4.11	2.48	2.40	2.44			
Win+Cas	Mean	3.13	3.38	3.26	2.04	1.99	2.01			
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		21	0.102	0.649	21	0.142	0.778			
N management		21	0.102	0.025	21	0.142	0.763			
N_rate		21	0.102	<.001	21	0.142	<.001			
Var x Man		21	0.145	0.055	21	0.201	0.453			
Var x Nrate		21	0.145	0.684	21	0.201	0.522			
Man x Nrate		21	0.145	0.025	21	0.201	0.763			
Var x Man x Nrate		21	0.204	0.055	21	0.284	0.453			

† error occurred during dry matter determination

5.3.8 Light interception at mid-flowering

At Boxworth, the amount of light reflected by the flowers was significantly reduced by the Canopy Management treatment (Table 5.131), which indicates that this treatment reduced the size of the flowering layer. This was supported by the observation that Canopy Management also resulted in more light penetrating through the flower layer to the green leaves, and did not affect the amount of light reaching the ground (Table 5.132). Castille reflected more light than Winner ($P<0.001$) and Folicur caused a reduction in the amount of light reflected for Conventionally managed Winner and Canopy Managed Castille. Increasing N rate increased the amount of light reflected and intercepted by the flowers.

At High Mowthorpe, Canopy Management also reduced the amount of light reflected by the flowers (Table 5.134) and reduced the amount of light intercepted by the flowering layer. However Canopy Management was not observed to affect the amount of light transmitted to the ground (Table 5.135). Increasing N rate increased the amount of light reflected and intercepted by the flowers. Variety did not affect the amount of light reflected or intercepted.

At Rosemaund, Canopy management significantly reduced the amount of light reflected and intercepted by the flowers (Table 5.137 and 5.138). Canopy Management reduced the amount of light reflected from the flowers more at higher N rates. Increasing N rate increased the amount of light reflected and intercepted by the flowers. Variety did not significantly affect the amount of light reflected or intercepted.

Table 5.131. Boxworth. Percentage of light reflected from flowers

Variety	N rate kg/ha	No Folicur Conv	No Folicur CM	No Folicur Mean	Folicur (0.5 l/ha) Conv	Folicur (0.5 l/ha) CM	Folicur (0.5 l/ha) Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	9.1		9.1	8.4		8.4	8.7		8.7
Winner	60	10.4	10.8	10.6	9.5	10.3	9.9	9.9	10.5	10.2
Winner	180	12.1	11.5	11.8	11.0	11.4	11.2	11.5	11.5	11.5
Winner	300	12.3	11.2	11.8	11.1	10.5	10.8	11.7	10.8	11.3
Winner	Mean	11.0	10.6	10.8	10.0	10.1	10.1	10.5	10.4	10.4
Castille	0	10.1		10.1	8.7		8.7	9.4		9.4
Castille	60	11.1	11.1	11.1	11.1	10.1	10.6	11.1	10.6	10.8
Castille	180	12.2	12.3	12.3	11.8	11.4	11.6	12.0	11.8	11.9
Castille	300	12.9	12.0	12.4	13.9	10.3	12.1	13.4	11.2	12.3
Castille	Mean	11.6	11.4	11.5	11.4	10.1	10.7	11.5	10.7	11.1
Win+Cas	0	9.6		9.6	8.5		8.5	9.1		9.1
Win+Cas	60	10.8	11.0	10.9	10.3	10.2	10.2	10.5	10.6	10.5
Win+Cas	180	12.1	11.9	12.0	11.4	11.4	11.4	11.8	11.7	11.7
Win+Cas	300	12.6	11.6	12.1	12.5	10.4	11.4	12.6	11.0	11.8
Win+Cas	Mean	11.3	11.0	11.1	10.7	10.1	10.4	11.0	10.6	10.8

Treatment	df	SED	P-Value
Folicur	2	0.5771	0.329
Variety	60	0.1739	<.001
N management	60	0.1739	0.024
Nrate	60	0.2459	<.001
Fol x Var	2.38	0.6027	0.936
Fol x Man	2.38	0.6027	0.414
Var x Man	60	0.2459	0.073
Fol x Nrate	3.23	0.651	0.81
Var x Nrate	60	0.3477	0.717
Man x Nrate	60	0.3477	0.004
Fol x Var x Man	3.23	0.651	0.029
Fol x Var x Nrate	5.28	0.738	0.595
Fol x Man x Nrate	5.28	0.738	0.621
Var x Man x Nrate	60	0.4918	0.429
Fol x Var x Man x Nrate	10.5	0.8868	0.495

Table 5.132. Boxworth. Fraction of light interception at base of flower canopy

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv Mean	CM Mean	Grand Mean
		Conv	CM	Mean	Conv	CM	Mean			
Winner	0	32.2		32.2	24.5		24.5	28.3		28.3
Winner	60	42.6	47.5	45.0	43.1	38.3	40.7	42.9	42.9	42.9
Winner	180	53.8	55.8	54.8	60.0	55.4	57.7	56.9	55.6	56.3
Winner	300	65.0	56.9	61.0	67.2	63.9	65.5	66.1	60.4	63.2
Winner	Mean	48.4	48.1	48.2	48.7	45.5	47.1	48.6	46.8	47.7
Castille	0	29.0		29.0	30.3		30.3	29.7		29.7
Castille	60	45.3	42.7	44.0	45.3	46.0	45.6	45.3	44.3	44.8
Castille	180	55.5	57.5	56.5	63.1	59.9	61.5	59.3	58.7	59.0
Castille	300	63.3	56.6	59.9	67.8	58.3	63.0	65.5	57.4	61.5
Castille	Mean	48.3	46.5	47.4	51.6	48.6	50.1	49.9	47.5	48.7
Win+Cas	0	30.6		30.6	27.4		27.4	29.0		29.0
Win+Cas	60	43.9	45.1	44.5	44.2	42.1	43.2	44.1	43.6	43.8
Win+Cas	180	54.7	56.6	55.7	61.5	57.7	59.6	58.1	57.2	57.6
Win+Cas	300	64.1	56.7	60.4	67.5	61.1	64.3	65.8	58.9	62.4
Win+Cas	Mean	48.3	47.3	47.8	50.2	47.1	48.6	49.2	47.2	48.2

Treatment	df	SED	P-Value
Folicur	2	3.568	0.843
Variety	60	1.21	0.384
N management	60	1.21	0.091
Nrate	60	1.712	<.001
Fol x Var	2.49	3.767	0.115
Fol x Man	2.49	3.767	0.406
Var x Man	60	1.712	0.79
Fol x Nrate	3.61	4.138	0.09
Var x Nrate	60	2.421	0.576
Man x Nrate	60	2.421	0.156
Fol x Var x Man	3.61	4.138	0.722
Fol x Var x Nrate	6.38	4.794	0.458
Fol x Man x Nrate	6.38	4.794	0.744
Var x Man x Nrate	60	3.423	0.972
Fol x Var x Man x Nrate	13.52	5.891	0.51

Table 5.133. Boxworth. Fraction of light interception at ground level.

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	60.2		60.2	53.0		53.0	56.6		56.6
Winner	60	76.8	74.9	75.8	67.6	72.2	69.9	72.2	73.5	72.9
Winner	180	91.3	92.8	92.1	90.5	91.0	90.7	90.9	91.9	91.4
Winner	300	93.8	94.4	94.1	94.4	91.9	93.1	94.1	93.2	93.6
Winner	Mean	80.5	80.6	80.6	76.4	77.0	76.7	78.5	78.8	78.6
Castille	0	56.1		56.1	48.7		48.7	52.4		52.4
Castille	60	72.5	73.2	72.9	72.7	73.2	73.0	72.6	73.2	72.9
Castille	180	90.8	90.6	90.7	89.6	90.6	90.1	90.2	90.6	90.4
Castille	300	92.1	91.7	91.9	93.1	89.6	91.3	92.6	90.7	91.6
Castille	Mean	77.9	77.9	77.9	76.0	75.5	75.8	76.9	76.7	76.8
Win+Cas	0	58.1		58.1	50.8		50.8	54.5		54.5
Win+Cas	60	74.6	74.1	74.3	70.2	72.7	71.4	72.4	73.4	72.9
Win+Cas	180	91.1	91.7	91.4	90.1	90.8	90.4	90.6	91.2	90.9
Win+Cas	300	92.9	93.1	93.0	93.7	90.8	92.2	93.3	91.9	92.6
Win+Cas	Mean	79.2	79.2	79.2	76.2	76.3	76.2	77.7	77.8	77.7

Treatment	df	SED	P-Value
Folicur	2	2.352	0.332
Variety	60	1.024	0.082
N management	60	1.024	0.96
Nrate	60	1.448	<.001
Fol x Var	2.83	2.565	0.394
Fol x Man	2.83	2.565	0.991
Var x Man	60	1.448	0.78
Fol x Nrate	4.87	2.945	0.097
Var x Nrate	60	2.048	0.498
Man x Nrate	60	2.048	0.849
Fol x Var x Man	4.87	2.945	0.792
Fol x Var x Nrate	10.23	3.587	0.682
Fol x Man x Nrate	10.23	3.587	0.766
Var x Man x Nrate	60	2.896	0.999
Fol x Var x Man x Nrate	23.26	4.61	0.875

Table 5.134. Mowthorpe. Percentage of light reflected from flowers

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	19.3		19.3	22.9		22.9	21.1		21.1
Winner	60	19.7	20.1	19.9	23.6	16.1	19.9	21.6	18.1	19.9
Winner	180	23.5	19.9	21.7	22.0	21.5	21.7	22.8	20.7	21.7
Winner	300	22.3	22.2	22.3	20.9	26.0	23.4	21.6	24.1	22.8
Winner	Mean	21.2	20.4	20.8	22.4	21.6	22.0	21.8	21.0	21.4
Castille	0	18.5		18.5	14.2		14.2	16.3		16.3
Castille	60	21.7	13.4	17.5	26.9	24.1	25.5	24.3	18.7	21.5
Castille	180	22.3	19.8	21.1	27.6	20.1	23.9	25.0	20.0	22.5
Castille	300	21.5	22.0	21.8	22.9	18.1	20.5	22.2	20.1	21.1
Castille	Mean	21.0	18.4	19.7	22.9	19.1	21.0	22.0	18.8	20.4
Win+Cas	0	18.9		18.9	18.6		18.6	18.7		18.7
Win+Cas	60	20.7	16.7	18.7	25.3	20.1	22.7	23.0	18.4	20.7
Win+Cas	180	22.9	19.8	21.4	24.8	20.8	22.8	23.9	20.3	22.1
Win+Cas	300	21.9	22.1	22.0	21.9	22.0	22.0	21.9	22.1	22.0
Win+Cas	Mean	21.1	19.4	20.2	22.6	20.4	21.5	21.9	19.9	20.9

Treatment	df	SED	P-Value
Folicur	3	7.519	0.877
Variety	90	1.021	0.315
N management	90	1.021	0.056
Nrate	90	1.444	0.077
Fol x Var	3.11	7.588	0.953
Fol x Man	3.11	7.588	0.787
Var x Man	90	1.444	0.242
Fol x Nrate	3.34	7.724	0.436
Var x Nrate	90	2.042	0.124
Man x Nrate	90	2.042	0.243
Fol x Var x Man	3.34	7.724	0.761
Fol x Var x Nrate	3.82	7.99	0.045
Fol x Man x Nrate	3.82	7.99	0.995
Var x Man x Nrate	90	2.888	0.881
Fol x Var x Man x Nrate	4.88	8.495	0.167

Table 5.135. High Mowthorpe. Percentage of light intercepted at base of canopy

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	16.5		16.5	18.6		18.6	17.6		17.6
Winner	60	37.1	35.8	36.4	44.3	34.4	39.3	40.7	35.1	37.9
Winner	180	52.1	51.7	51.9	60.4	63.1	61.8	56.3	57.4	56.8
Winner	300	58.5	61.0	59.7	64.8	62.5	63.7	61.6	61.8	61.7
Winner	Mean	41.0	41.3	41.2	47.0	44.6	45.8	44.0	43.0	43.5
Castille	0	14.0		14.0	19.4		19.4	16.7		16.7
Castille	60	42.2	40.5	41.4	44.0	41.1	42.6	43.1	40.8	42.0
Castille	180	58.7	58.2	58.5	63.6	64.6	64.1	61.2	61.4	61.3
Castille	300	58.8	64.0	61.4	62.9	70.9	66.9	60.9	67.5	64.2
Castille	Mean	43.4	44.2	43.8	47.5	49.0	48.2	45.5	46.6	46.0
Win+Cas	0	15.3		15.3	19.0		19.0	17.1		17.1
Win+Cas	60	39.6	38.1	38.9	44.2	37.7	40.9	41.9	37.9	39.9
Win+Cas	180	55.4	54.9	55.2	62.0	63.8	62.9	58.7	59.4	59.1
Win+Cas	300	58.6	62.5	60.6	63.9	66.7	65.3	61.3	64.6	62.9
Win+Cas	Mean	42.2	42.7	42.5	47.3	46.8	47.0	44.8	44.8	44.8

Treatment	df	SED	P-Value
Folicur	3	2.578	0.175
Variety	90	1.248	0.046
N management	90	1.248	0.989
Nrate	90	1.765	<.001
Fol x Var	4.56	2.864	0.916
Fol x Man	4.56	2.864	0.715
Var x Man	90	1.765	0.38
Fol x Nrate	8.56	3.364	0.434
Var x Nrate	90	2.495	0.415
Man x Nrate	90	2.495	0.228
Fol x Var x Man	8.56	3.364	0.496
Fol x Var x Nrate	19.19	4.188	0.716
Fol x Man x Nrate	19.19	4.188	0.781
Var x Man x Nrate	90	3.529	0.717
Fol x Var x Man x Nrate	43.3	5.477	0.87

Table 5.136. Mowthorpe. Percentage of light intercepted at ground level

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	43.1		43.1	42.7		42.7	42.9		42.9
Winner	60	67.9	67.9	67.9	73.5	68.3	70.9	70.7	68.1	69.4
Winner	180	83.1	86.5	84.8	88.9	86.6	87.8	86.0	86.6	86.3
Winner	300	84.1	87.0	85.5	90.5	85.9	88.2	87.3	86.5	86.9
Winner	Mean	69.5	71.1	70.3	73.9	70.9	72.4	71.7	71.0	71.4
Castille	0	42.2		42.2	42.7		42.7	42.5		42.5
Castille	60	72.4	73.5	72.9	66.2	67.1	66.6	69.3	70.3	69.8
Castille	180	86.2	86.9	86.5	84.0	88.2	86.1	85.1	87.5	86.3
Castille	300	86.8	88.7	87.7	86.6	91.3	88.9	86.7	90.0	88.3
Castille	Mean	71.9	72.8	72.4	69.9	72.3	71.1	70.9	72.6	71.7
Win+Cas	0	42.6		42.6	42.7		42.7	42.7		42.7
Win+Cas	60	70.1	70.7	70.4	69.8	67.7	68.8	70.0	69.2	69.6
Win+Cas	180	84.6	86.7	85.7	86.5	87.4	86.9	85.5	87.1	86.3
Win+Cas	300	85.4	87.9	86.6	88.6	88.6	88.6	87.0	88.2	87.6
Win+Cas	Mean	70.7	72.0	71.3	71.9	71.6	71.7	71.3	71.8	71.5

Treatment	df	SED	P-Value
Folicur	3	4.139	0.928
Variety	90	1.31	0.782
N management	90	1.31	0.71
Nrate	90	1.852	<.001
Fol x Var	3.63	4.341	0.206
Fol x Man	3.63	4.341	0.551
Var x Man	90	1.852	0.356
Fol x Nrate	5.06	4.72	0.784
Var x Nrate	90	2.62	0.964
Man x Nrate	90	2.62	0.918
Fol x Var x Man	5.06	4.72	0.246
Fol x Var x Nrate	8.54	5.398	0.553
Fol x Man x Nrate	8.54	5.398	0.983
Var x Man x Nrate	90	3.705	0.942
Fol x Var x Man x Nrate	17.47	6.547	0.897

Table 5.137. Rosemaund. Percentage of light reflected

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	12.4		12.4	12.8		12.8	12.6		12.6
Winner	60	14.1	14.0	14.1	13.8	14.2	14.0	13.9	14.1	14.0
Winner	180	15.1	12.9	14.0	15.0	13.2	14.1	15.0	13.1	14.1
Winner	300	16.0	12.1	14.0	15.2	11.2	13.2	15.6	11.7	13.6
Winner	Mean	14.4	12.8	13.6	14.2	12.8	13.5	14.3	12.8	13.6
Castille	0	11.2		11.2	11.0		11.0	11.1		11.1
Castille	60	15.3	13.3	14.3	15.3	13.3	14.3	15.3	13.3	14.3
Castille	180	14.9	12.0	13.5	14.8	10.6	12.7	14.9	11.3	13.1
Castille	300	14.4	13.0	13.7	13.9	13.2	13.6	14.1	13.1	13.6
Castille	Mean	14.0	12.4	13.2	13.8	12.0	12.9	13.9	12.2	13.0
Win+Cas	0	11.8		11.8	11.9		11.9	11.9		11.9
Win+Cas	60	14.7	13.7	14.2	14.5	13.7	14.1	14.6	13.7	14.2
Win+Cas	180	15.0	12.5	13.7	14.9	11.9	13.4	14.9	12.2	13.6
Win+Cas	300	15.2	12.6	13.9	14.6	12.2	13.4	14.9	12.4	13.6
Win+Cas	Mean	14.2	12.6	13.4	14.0	12.4	13.2	14.1	12.5	13.3

Treatment	df	SED	P-Value
Folicur	3	0.12	0.218
Variety	90	0.31	0.095
N management	90	0.31	<.001
Nrate	90	0.439	<.001
Fol x Var	71.38	0.333	0.75
Fol x Man	71.38	0.333	0.989
Var x Man	90	0.439	0.771
Fol x Nrate	92.34	0.551	0.913
Var x Nrate	90	0.621	0.176
Man x Nrate	90	0.621	0.007
Fol x Var x Man	92.34	0.551	0.774
Fol x Var x Nrate	92.61	0.83	0.819
Fol x Man x Nrate	92.61	0.83	0.97
Var x Man x Nrate	90	0.878	0.022
Fol x Var x Man x Nrate	91.52	1.208	0.916

Table 5.138. Rosemaund. Percentage of light intercepted at base of flowers

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	36.3		36.3	36.7		36.7	36.5		36.5
Winner	60	58.6	34.6	46.6	60.6	41	50.8	59.6	37.8	48.7
Winner	180	81.8	62.4	72.1	70.9	66.3	68.6	76.4	64.3	70.4
Winner	300	66.4	67.4	66.9	61.1	63.7	62.4	63.8	65.6	64.7
Winner	Mean	60.8	50.2	55.5	57.3	51.9	54.6	59.1	51.1	55.1
Castille	0	42.2		42.2	40.1		40.1	41.1		41.1
Castille	60	66.4	50.1	58.2	56.5	55.5	56	61.5	52.8	57.1
Castille	180	74.5	63.4	68.9	77.3	67.2	72.2	75.9	65.3	70.6
Castille	300	74.2	50.1	62.1	75.1	53.6	64.3	74.6	51.8	63.2
Castille	Mean	64.3	51.4	57.9	62.2	54.1	58.2	63.3	52.8	58
Win+Cas	0	39.3		39.3	38.4		38.4	38.8		38.8
Win+Cas	60	62.5	42.3	52.4	58.6	48.3	53.4	60.5	45.3	52.9
Win+Cas	180	78.1	62.9	70.5	74.1	66.8	70.4	76.1	64.8	70.5
Win+Cas	300	70.3	58.8	64.5	68.1	58.6	63.4	69.2	58.7	64
Win+Cas	Mean	62.5	50.8	56.7	59.8	53	56.4	61.2	51.9	56.5

Treatment	df	SED	P-Value
Folicur	3	1.3	0.848
Variety	90	2.97	0.321
N management	90	2.97	0.002
Nrate	90	4.2	<.001
Fol x Var	60.88	3.24	0.845
Fol x Man	60.88	3.24	0.404
Var x Man	90	4.2	0.673
Fol x Nrate	90.77	5.3	0.994
Var x Nrate	90	5.93	0.639
Man x Nrate	90	5.93	0.314
Fol x Var x Man	90.77	5.3	0.967
Fol x Var x Nrate	92.9	7.96	0.815
Fol x Man x Nrate	92.9	7.96	0.926
Var x Man x Nrate	90	8.39	0.155
Fol x Var x Man x Nrate	91.86	11.56	0.909

Table 5.139. Rosemaund. Percentage of light intercepted at ground level

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	57.14		57.14	56.6		56.6	56.87		56.87
Winner	60	78.4	73.46	75.93	77.91	73.65	75.78	78.15	73.56	75.85
Winner	180	90.12	90.98	90.55	92.44	90.69	91.56	91.28	90.83	91.06
Winner	300	91.11	91.99	91.55	92.87	89.62	91.25	91.99	90.81	91.4
Winner	Mean	79.19	78.39	78.79	79.95	77.64	78.8	79.57	78.02	78.79
Castille	0	59.61		59.61	56.39		56.39	58		58
Castille	60	77.41	76.02	76.72	75.06	74.41	74.74	76.24	75.22	75.73
Castille	180	88.46	89.1	88.78	87.28	87.68	87.48	87.87	88.39	88.13
Castille	300	92.15	90.73	91.44	91.64	88.95	90.29	91.89	89.84	90.87
Castille	Mean	79.41	78.87	79.14	77.59	76.86	77.23	78.5	77.86	78.18
Win+Cas	0	58.38		58.38	56.49		56.49	57.44		57.44
Win+Cas	60	77.91	74.74	76.32	76.48	74.03	75.26	77.2	74.39	75.79
Win+Cas	180	89.29	90.04	89.66	89.86	89.19	89.52	89.57	89.61	89.59
Win+Cas	300	91.63	91.36	91.49	92.25	89.29	90.77	91.94	90.32	91.13
Win+Cas	Mean	79.3	78.63	78.96	78.77	77.25	78.01	79.04	77.94	78.49

Treatment	df	SED	P-Value
Folicur	3	1.028	0.422
Variety	314	1.396	0.661
N management	314	1.396	0.433
Nrate	314	1.974	<.001
Fol x Var	23.48	1.733	0.493
Fol x Man	23.48	1.733	0.76
Var x Man	314	1.974	0.742
Fol x Nrate	98.96	2.627	0.977
Var x Nrate	314	2.791	0.775
Man x Nrate	314	2.791	0.866
Fol x Var x Man	98.96	2.627	0.813
Fol x Var x Nrate	223.8	3.833	0.996
Fol x Man x Nrate	223.8	3.833	0.974
Var x Man x Nrate	314	3.947	0.949
Fol x Var x Man x Nrate	296.51	5.502	0.997

5.3.9 Crop height

At Boxworth, Winner was 12 cm taller than Castille ($P<0.001$) and increasing N rate from nil to 360 kg N/ha increased crop height by 10 cm (Table 5.140). Canopy Management appeared to reduce the height of Castille at high N rates, but had little effect on other treatments. Folicur did not significantly affect height.

At High Mowthorpe, Winner was 2 cm taller than Castille ($P<0.1$) and increasing N rate from nil to 360 kg N/ha increased the height of Winner by 15 cm and Castille by 28 cm (Table 5.141). Canopy Management did not affect height. Folicur reduced height by 7 cm.

At Rosemaund, Winner was 17 cm taller than Castille ($P<0.001$) and increasing N rate from nil to 360 kg N/ha increased crop height by 3 cm (Table 5.142). Canopy Management reduced height by 4 cm at 60 kg N/ha and by 9 cm at 300 kg N/ha. Folicur did not significantly affect height.

Table 5.140. Boxworth. Height (cm) to the top of terminal receme

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (0.5 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	130.9		130.9	127.0		127.0	128.9		128.9
Winner	60	126.1	131.6	128.9	126.3	135.2	130.8	126.2	133.4	129.8
Winner	180	133.1	130.5	131.8	138.7	134.3	136.5	135.9	132.4	134.1
Winner	300	134.1	140.4	137.3	138.0	138.2	138.1	136.1	139.3	137.7
Winner	Mean	131.0	133.4	132.2	132.5	133.7	133.1	131.8	133.5	132.7
Castille	0	111.5		111.5	115.2		115.2	113.3		113.3
Castille	60	117.3	119.1	118.2	120.3	120.0	120.1	118.8	119.5	119.2
Castille	180	125.6	126.7	126.1	127.2	125.1	126.1	126.4	125.9	126.1
Castille	300	130.1	121.2	125.6	130.1	120.3	125.2	130.1	120.8	125.4
Castille	Mean	121.1	119.6	120.4	123.2	120.2	121.7	122.2	119.9	121.0
Win+Cas	0	121.2		121.2	121.1		121.1	121.1		121.1
Win+Cas	60	121.7	125.3	123.5	123.3	127.6	125.4	122.5	126.5	124.5
Win+Cas	180	129.3	128.6	128.9	132.9	129.7	131.3	131.1	129.2	130.1
Win+Cas	300	132.1	130.8	131.5	134.1	129.3	131.7	133.1	130.0	131.6
Win+Cas	Mean	126.1	126.5	126.3	127.8	126.9	127.4	127.0	126.7	126.8

Treatment	df	SED	P-Value
Folicur	2	2.14	0.658
Variety	60	1.10	<.001
N management	60	1.10	0.814
Nrate	60	1.56	<.001
Fol x Var	3.2	2.41	0.848
Fol x Man	3.2	2.41	0.55
Var x Man	60	1.56	0.073
Fol x Nrate	6.34	2.87	0.816
Var x Nrate	60	2.21	0.113
Man x Nrate	60	2.21	0.131
Fol x Var x Man	6.34	2.87	0.933
Fol x Var x Nrate	14.7	3.62	0.261
Fol x Man x Nrate	14.7	3.62	0.898
Var x Man x Nrate	60	3.12	0.07
Fol x Var x Man x Nrate	32.56	4.78	0.862

Table 5.141. High Mowthorpe. Height (cm) to the top of terminal raceme

Variety	N rate kg/ha	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	114.7		114.7	104.1		104.1	109.4		109.4
Winner	60	123.0	121.1	122.0	118.8	117.8	118.3	120.9	119.4	120.2
Winner	180	127.8	125.8	126.8	117.6	117.3	117.4	122.7	121.5	122.1
Winner	300	127.3	128.7	128.0	120.7	119.6	120.1	124.0	124.1	124.1
Winner	Mean	123.2	122.5	122.9	115.3	114.7	115.0	119.3	118.6	118.9
Castille	0	99.5		99.5	97.7		97.7	98.6		98.6
Castille	60	117.8	123.8	120.8	115.1	121.2	118.1	116.4	122.5	119.5
Castille	180	127.3	127.7	127.5	122.9	119.9	121.4	125.1	123.8	124.5
Castille	300	130.8	131.4	131.1	120.6	121.8	121.2	125.7	126.6	126.2
Castille	Mean	118.9	120.6	119.8	114.1	115.1	114.6	116.5	117.9	117.2
Win+Cas	0	107.1		107.1	100.9		100.9	104.0		104.0
Win+Cas	60	120.4	122.4	121.4	116.9	119.5	118.2	118.7	121.0	119.8
Win+Cas	180	127.6	126.7	127.2	120.2	118.6	119.4	123.9	122.6	123.3
Win+Cas	300	129.1	130.1	129.6	120.6	120.7	120.7	124.9	125.4	125.1
Win+Cas	Mean	121.1	121.6	121.3	114.7	114.9	114.8	117.9	118.2	118.1

Treatment	df	SED	P-Value
Folicur	3	2.30	0.066
Variety	90	1.04	0.095
N management	90	1.04	0.714
Nrate	90	1.47	<.001
Fol x Var	4.35	2.53	0.19
Fol x Man	4.35	2.53	0.887
Var x Man	90	1.47	0.331
Fol x Nrate	7.72	2.93	0.246
Var x Nrate	90	2.08	<.001
Man x Nrate	90	2.08	0.682
Fol x Var x Man	7.72	2.93	0.855
Fol x Var x Nrate	16.63	3.59	0.313
Fol x Man x Nrate	16.63	3.59	0.994
Var x Man x Nrate	90	2.95	0.508
Fol x Var x Man x Nrate	37.85	4.65	0.923

Table 5.142. Rosemaund. Height to the top of terminal raceme

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv	CM	Grand
		Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	137.0		137.0	140.2		140.2	138.6		138.6
Winner	60	143.3	138.4	140.9	141.9	139.7	140.8	142.6	139.0	140.8
Winner	180	144.9	133.6	139.3	144.8	143.1	144.0	144.9	138.3	141.6
Winner	300	141.8	139.9	140.8	151.2	136.4	143.8	146.5	138.2	142.3
Winner	Mean	141.8	137.2	139.5	144.5	139.8	142.2	143.1	138.5	140.8
Castille	0	117.3		117.3	125.1		125.1	121.2		121.2
Castille	60	126.9	122.4	124.7	126.1	122.8	124.4	126.5	122.6	124.5
Castille	180	132.1	123.7	127.9	127.9	121.2	124.5	130.0	122.4	126.2
Castille	300	131.0	121.3	126.1	126.8	115.8	121.3	128.9	118.5	123.7
Castille	Mean	126.8	121.2	124.0	126.5	121.2	123.8	126.6	121.2	123.9
Win+Cas	0	127.1		127.1	132.6		132.6	129.9		129.9
Win+Cas	60	135.1	130.4	132.8	134.0	131.2	132.6	134.6	130.8	132.7
Win+Cas	180	138.5	128.6	133.6	136.4	132.1	134.3	137.4	130.4	133.9
Win+Cas	300	136.4	130.6	133.5	139.0	126.1	132.5	137.7	128.3	133.0
Win+Cas	Mean	134.3	129.2	131.7	135.5	130.5	133.0	134.9	129.9	132.4

Treatment	df	SED	P-Value
Folicur	3	1.40	0.434
Variety	90	1.13	<.001
N management	90	1.13	<.001
Nrate	90	1.60	0.075
Fol x Var	8.01	1.80	0.211
Fol x Man	8.01	1.80	0.96
Var x Man	90	1.60	0.702
Fol x Nrate	22.98	2.41	0.182
Var x Nrate	90	2.26	0.764
Man x Nrate	90	2.26	0.025
Fol x Var x Man	22.98	2.41	0.901
Fol x Var x Nrate	54.34	3.30	0.137
Fol x Man x Nrate	54.34	3.30	0.248
Var x Man x Nrate	90	3.19	0.989
Fol x Var x Man x Nrate	82.98	4.59	0.487

5.3.10 Lodging

At Boxworth there was very little lodging with only the highest N rates experiencing slight leaning (Table 5.143). At High Mowthorpe, Winner experienced more stem leaning (43%) compared with 29% for Castille at flowering (Table 5.145). Increasing N rate from 0 to 360 kg N/ha increased the area of plot that was leaning from 25% to 48% (Table 5.145). Folicur reduced the area lodged of Winner grown at Conventional N timings from 48% to 36% (Table 5.145). At harvest, Winner and higher N rates had significantly more lodging (Table 5.146). At Rosemaund Winner experienced significantly less lodging at flowering (Table 5.147 and 5.148). Folicur reduced the area of crop that was leaning between 10 and 45 degrees from 43 to 27% (Table 5.146). At harvest, the amount of severe lodging (46 to 90 degrees) was significantly reduced by Castille, reduced N rate and Folicur (Table 5.150). Without Folicur the Canopy Managed N timings reduced the amount of severe lodging from 32% to 19% (Table 5.150).

Table 5.143. Boxworth. Percent of plot lodged at 10-45 degrees at harvest

Variety	N rate	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	0		0	0		0	0		0
Winner	60	0	0	0	0	0	0	0	0	0
Winner	120	0	0	0	0	0	0	0	0	0
Winner	180	0	0	0	0	3.33	1.67	0	1.67	0.83
Winner	240	0	0	0	0	5.00	2.50	0	2.50	1.25
Winner	300	3.33	0	1.67	0	0	0	1.67	0	0.83
Winner	360	0	0	0	5.00	1.67	3.33	2.50	0.83	1.67
Winner	Mean	0.48	0	0.24	0.71	1.43	1.07	0.60	0.71	0.65
Castille	0	0		0	0		0	0		0
Castille	60	0	0	0	0	0	0	0	0	0
Castille	120	0	0	0	0	0	0	0	0	0
Castille	180	0	0	0	3.33	0	1.67	1.67	0	0.83
Castille	240	0	0	0	0	0	0	0	0	0
Castille	300	0	0	0	0	0	0	0	0	0
Castille	360	0	0	0	6.67	3.33	5.00	3.33	1.67	2.50
Castille	Mean	0	0	0	1.43	0.48	0.95	0.71	0.24	0.48
Win+Cas	0	0		0	0		0	0		0
Win+Cas	60	0	0	0	0	0	0	0	0	0
Win+Cas	120	0	0	0	0	0	0	0	0	0
Win+Cas	180	0	0	0	1.67	1.67	1.67	0.83	0.83	0.83
Win+Cas	240	0	0	0	0	2.50	1.25	0	1.25	0.63
Win+Cas	300	1.67	0	0.83	0	0	0	0.83	0	0.42
Win+Cas	360	0	0	0	5.83	2.50	4.17	2.92	1.25	2.08
Win+Cas	Mean	0.24	0	0.12	1.07	0.95	1.01	0.65	0.48	0.57

Treatment	df	SED	P-Value
Folicur	2	0.372	0.138
Variety	108	0.367	0.628
N rate	108	0.687	0.034
N Management	108	0.367	0.628
Fol x Var	7.67	0.522	0.871
Fol x Nrate	57.46	0.973	0.01
Var x Nrate	108	0.971	0.821
Fol x Man	7.67	0.522	0.871
Var x Man	108	0.519	0.419
Nrate x man	108	0.971	0.534
Fol x Var x	94.1	1.375	0.794
Fol x Var x man	26.61	0.737	0.147
Fol x Nrate x Man	94.1	1.375	0.509
Var x Nrate x man	108	1.374	0.587
Fol x Var x Nrate x Man	108	1.943	0.781

Table 5.144. High Mowthorpe lower stem leaning (degrees) at end of flowering

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv Mean	CM Mean	Grand Mean
		Conv	CM	Mean	Conv	CM	Mean			
Winner	0	22.5		22.5	18.8		18.8	20.6		20.6
Winner	60	11.3	15.0	13.1	15.0	15.0	15.0	13.1	15.0	14.1
Winner	120	15.0	15.0	15.0	7.5	11.3	9.4	11.3	13.1	12.2
Winner	180	11.3	15.0	13.1	3.8	7.5	5.6	7.5	11.3	9.4
Winner	240	15.0	11.3	13.1	7.5	3.8	5.6	11.3	7.5	9.4
Winner	300	11.3	11.3	11.3	15.0	11.3	13.1	13.1	11.3	12.2
Winner	360	11.3	11.3	11.3	15.0	0.0	7.5	13.1	5.6	9.4
Winner	Mean	13.9	14.5	14.2	11.8	9.6	10.7	12.9	12.1	12.5
Castille	0	18.8		18.8	15.0		15.0	16.9		16.9
Castille	60	11.3	15.0	13.1	11.3	7.5	9.4	11.3	11.3	11.3
Castille	120	18.8	11.3	15.0	3.8	11.3	7.5	11.3	11.3	11.3
Castille	180	11.3	11.3	11.3	11.3	7.5	9.4	11.3	9.4	10.3
Castille	240	18.8	11.3	15.0	3.8	11.3	7.5	11.3	11.3	11.3
Castille	300	11.3	11.3	11.3	3.8	11.3	7.5	7.5	11.3	9.4
Castille	360	3.8	15.0	9.4	3.8	7.5	5.6	3.8	11.3	7.5
Castille	Mean	13.4	13.4	13.4	7.5	10.2	8.8	10.4	11.8	11.1
Win+Cas	0	20.6		20.6	16.9		16.9	18.8		18.8
Win+Cas	60	11.3	15.0	13.1	13.1	11.3	12.2	12.2	13.1	12.7
Win+Cas	120	16.9	13.1	15.0	5.6	11.3	8.4	11.3	12.2	11.7
Win+Cas	180	11.3	13.1	12.2	7.5	7.5	7.5	9.4	10.3	9.8
Win+Cas	240	16.9	11.3	14.1	5.6	7.5	6.6	11.3	9.4	10.3
Win+Cas	300	11.3	11.3	11.3	9.4	11.3	10.3	10.3	11.3	10.8
Win+Cas	360	7.5	13.1	10.3	9.4	3.8	6.6	8.4	8.4	8.4
Win+Cas	Mean	13.7	13.9	13.8	9.6	9.9	9.8	11.7	11.9	11.8

Treatment	df	SED	P-Value
Folicur	3	2.32	0.182
Variety	162	0.902	0.14
N rate	162	1.687	<.001
N Management	162	0.902	0.767
Fol x Var	3.97	2.489	0.553
Fol x Nrate	10.75	3.204	0.355
Var x Nrate	162	2.386	0.599
Fol x Man	3.97	2.489	1
Var x Man	162	1.276	0.237
Nrate x man	162	2.386	0.979
Fol x Var x Nrate	24.62	3.995	0.681
Fol x Var x man	6.31	2.797	0.14
Fol x Nrate x Man	24.62	3.995	0.04
Var x Nrate x man	162	3.375	0.065
Fol x Var x Nrate x Man	59.21	5.23	0.681

Table 5.145. High Mowthorpe pod layer leaning (degrees) at end of flowering

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv Mean	CM Mean	Grand Mean
		Conv	CM	Mean	Conv	CM	Mean			
Winner	0	30.0		30.0	30.0		30.0	30.0		30.0
Winner	60	30.0	30.0	30.0	26.3	30.0	28.1	28.1	30.0	29.1
Winner	120	52.5	45.0	48.8	37.5	33.8	35.6	45.0	39.4	42.2
Winner	180	52.5	37.5	45.0	37.5	45.0	41.3	45.0	41.3	43.1
Winner	240	60.0	60.0	60.0	37.5	45.0	41.3	48.8	52.5	50.6
Winner	300	60.0	52.5	56.3	37.5	60.0	48.8	48.8	56.3	52.5
Winner	360	52.5	60.0	56.3	45.0	60.0	52.5	48.8	60.0	54.4
Winner	Mean	48.2	45.0	46.6	35.9	43.4	39.6	42.1	44.2	43.1
Castille	0	22.5		22.5	18.8		18.8	20.6		20.6
Castille	60	18.8	26.3	22.5	18.8	18.8	18.8	18.8	22.5	20.6
Castille	120	22.5	26.3	24.4	26.3	22.5	24.4	24.4	24.4	24.4
Castille	180	26.3	30.0	28.1	33.8	22.5	28.1	30.0	26.3	28.1
Castille	240	45.0	45.0	45.0	26.3	30.0	28.1	35.6	37.5	36.6
Castille	300	37.5	30.0	33.8	37.5	30.0	33.8	37.5	30.0	33.8
Castille	360	45.0	45.0	45.0	37.5	37.5	37.5	41.3	41.3	41.3
Castille	Mean	31.1	32.1	31.6	28.4	25.7	27.1	29.7	28.9	29.3
Win+Cas	0	26.3		26.3	24.4		24.4	25.3		25.3
Win+Cas	60	24.4	28.1	26.3	22.5	24.4	23.4	23.4	26.3	24.8
Win+Cas	120	37.5	35.6	36.6	31.9	28.1	30.0	34.7	31.9	33.3
Win+Cas	180	39.4	33.8	36.6	35.6	33.8	34.7	37.5	33.8	35.6
Win+Cas	240	52.5	52.5	52.5	31.9	37.5	34.7	42.2	45.0	43.6
Win+Cas	300	48.8	41.3	45.0	37.5	45.0	41.3	43.1	43.1	43.1
Win+Cas	360	48.8	52.5	50.6	41.3	48.8	45.0	45.0	50.6	47.8
Win+Cas	Mean	39.6	38.6	39.1	32.1	34.6	33.3	35.9	36.6	36.2

Treatment	df	SED	P-Value
Folicur	3	5.089	0.34
Variety	162	1.388	<.001
N rate	162	2.597	<.001
N Management	162	1.388	0.63
Fol x Var	3.46	5.275	0.387
Fol x Nrate	6.26	6.121	0.035
Var x Nrate	162	3.673	0.351
Fol x Man	3.46	5.275	0.212
Var x Man	162	1.963	0.29
Nrate x man	162	3.673	0.557
Fol x Var x Nrate	11.42	7.138	0.625
Fol x Var x man	4.49	5.628	0.01
Fol x Nrate x Man	11.42	7.138	0.699
Var x Nrate x man	162	5.195	0.416
Fol x Var x Nrate x Man	25.29	8.828	0.497

Table 5.146. High Mowthorpe lodging score (1 = whole plot flat; 9 = whole plot upright) at harvest.

Variety	N	No Folicur			Folicur (1.0 l/ha)			Conv	CM	Grand
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	8.25		8.25	8.75		8.75	8.50		8.50
Winner	60	8.50	8.75	8.63	9.00	8.75	8.88	8.75	8.75	8.75
Winner	120	8.00	8.50	8.25	8.50	8.75	8.63	8.25	8.63	8.44
Winner	180	8.50	8.50	8.50	8.25	8.50	8.38	8.38	8.50	8.44
Winner	240	7.75	7.50	7.63	8.25	8.25	8.25	8.00	7.88	7.94
Winner	300	7.25	7.25	7.25	8.25	7.50	7.88	7.75	7.38	7.56
Winner	360	7.25	7.25	7.25	7.75	7.00	7.38	7.50	7.13	7.31
Winner	Mean	7.93	8.00	7.96	8.39	8.21	8.30	8.16	8.11	8.13
Castille	0	8.75		8.75	9.00		9.00	8.88		8.88
Castille	60	8.75	9.00	8.88	9.00	9.00	9.00	8.88	9.00	8.94
Castille	120	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Castille	180	9.00	8.50	8.75	8.50	8.50	8.50	8.75	8.50	8.63
Castille	240	7.75	8.50	8.13	8.75	8.75	8.75	8.25	8.63	8.44
Castille	300	7.75	7.75	7.75	8.25	8.50	8.38	8.00	8.13	8.06
Castille	360	8.50	8.00	8.25	8.50	8.25	8.38	8.50	8.13	8.31
Castille	Mean	8.50	8.50	8.50	8.71	8.71	8.71	8.61	8.61	8.61
Win+Cas	0	8.50		8.50	8.88		8.88	8.69		8.69
Win+Cas	60	8.63	8.88	8.75	9.00	8.88	8.94	8.81	8.88	8.84
Win+Cas	120	8.50	8.75	8.63	8.75	8.88	8.81	8.63	8.81	8.72
Win+Cas	180	8.75	8.50	8.63	8.38	8.50	8.44	8.56	8.50	8.53
Win+Cas	240	7.75	8.00	7.88	8.50	8.50	8.50	8.13	8.25	8.19
Win+Cas	300	7.50	7.50	7.50	8.25	8.00	8.13	7.88	7.75	7.81
Win+Cas	360	7.88	7.63	7.75	8.13	7.63	7.88	8.00	7.63	7.81
Win+Cas	Mean	8.21	8.25	8.23	8.55	8.46	8.51	8.38	8.36	8.37

Treatment	df	SED	P-Value
Folicur	3	0.183	0.227
Variety	162	0.088	<.001
N rate	162	0.165	<.001
N Management	162	0.088	0.762
Fol x Var	4.56	0.203	0.48
Fol x Nrate	16.66	0.283	0.166
Var x Nrate	162	0.234	0.216
Fol x Man	4.56	0.203	0.48
Var x Man	162	0.125	0.762
Nrate x man	162	0.234	0.698
Fol x Var x	41.66	0.367	0.997
Fol x Var x man	8.59	0.238	0.48
Fol x Nrate x Man	41.66	0.367	0.943
Var x Nrate x man	162	0.33	0.736
Fol x Var x Nrate x Man	92.08	0.494	0.789

Table 5.147. Rosemaund – percent of plot lodged at 10-45 degrees at end of flowering

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv Mean	CM Mean	Grand Mean
		Conv	CM	Mean	Conv	CM	Mean			
Winner	0	50.0		50.0	51.3		51.3	50.6		50.6
Winner	60	49.5	50.8	50.1	58.8	53.3	56.0	54.1	52.0	53.1
Winner	120	49.3	51.3	50.3	52.5	24.3	38.4	50.9	37.8	44.3
Winner	180	63.8	51.3	57.5	64.5	52.5	58.5	64.1	51.9	58.0
Winner	240	54.0	48.8	51.4	58.8	26.8	42.8	56.4	37.8	47.1
Winner	300	53.8	51.8	52.8	63.8	55.5	59.6	58.8	53.6	56.2
Winner	360	50.0	52.0	51.0	24.3	50.0	37.1	37.1	51.0	44.1
Winner	Mean	52.9	50.8	51.9	53.4	44.8	49.1	53.1	47.8	50.5
Castille	0	1.3		1.3	0		0	0.6		0.6
Castille	60	41.3	45.5	43.4	0	0	0	20.6	22.8	21.7
Castille	120	35.0	20.0	27.5	25.8	0	12.9	30.4	10.0	20.2
Castille	180	33.8	40.0	36.9	1.3	3.8	2.5	17.5	21.9	19.7
Castille	240	36.3	40.0	38.1	0	3.8	1.9	18.1	21.9	20.0
Castille	300	52.5	47.5	50.0	1.3	24.5	12.9	26.9	36.0	31.4
Castille	360	48.8	45.0	46.9	2.5	7.5	5.0	25.6	26.3	25.9
Castille	Mean	35.5	34.2	34.9	4.4	5.6	5.0	20.0	19.9	19.9
Win+Cas	0	25.6		25.6	25.6		25.6	25.6		25.6
Win+Cas	60	45.4	48.1	46.8	29.4	26.6	28.0	37.4	37.4	37.4
Win+Cas	120	42.1	35.6	38.9	39.1	12.1	25.6	40.6	23.9	32.3
Win+Cas	180	48.8	45.6	47.2	32.9	28.1	30.5	40.8	36.9	38.8
Win+Cas	240	45.1	44.4	44.8	29.4	15.3	22.3	37.3	29.8	33.5
Win+Cas	300	53.1	49.6	51.4	32.5	40.0	36.3	42.8	44.8	43.8
Win+Cas	360	49.4	48.5	48.9	13.4	28.8	21.1	31.4	38.6	35.0
Win+Cas	Mean	44.2	42.5	43.4	28.9	25.2	27.1	36.6	33.9	35.2

Treatment	df	SED	P-Value
Folicur	3	3.25	0.015
Variety	162	4.83	<.001
N rate	162	9.04	0.573
N Management	162	4.83	0.577
Fol x Var	28.33	5.82	0.006
Fol x Nrate	143.3	12.27	0.835
Var x Nrate	162	12.78	0.654
Fol x Man	28.33	5.82	0.839
Var x Man	162	6.83	0.585
Nrate x man	162	12.78	0.901
Fol x Var x Nrate	162.8	17.72	0.792
Fol x Var x man	96.23	8.98	0.637
Fol x Nrate x Man	162.8	17.72	0.958
Var x Nrate x man	162	18.07	0.953
Fol x Var x Nrate x Man	165	25.31	0.993

Table 5.148. Rosemaund – percent of plot lodged at 45-90 degrees at end of flowering

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv Mean	CM Mean	Grand Mean
		Conv	CM	Mean	Conv	CM	Mean			
Winner	0	45.0		45.0	42.5		42.5	43.8		43.8
Winner	60	47.5	47.0	47.3	35.0	41.3	38.1	41.3	44.1	42.7
Winner	120	49.5	48.3	48.9	42.5	24.0	33.3	46.0	36.1	41.1
Winner	180	36.3	46.3	41.3	26.3	41.3	33.8	31.3	43.8	37.5
Winner	240	45.0	48.5	46.8	25.0	44.0	34.5	35.0	46.3	40.6
Winner	300	45.0	47.0	46.0	27.5	41.5	34.5	36.3	44.3	40.3
Winner	360	48.8	47.5	48.1	47.8	45.0	46.4	48.3	46.3	47.3
Winner	Mean	45.3	47.1	46.2	35.2	39.9	37.6	40.3	43.5	41.9
Castille	0	0		0	0		0	0		0
Castille	60	0	0	0	0	0	0	0	0	0
Castille	120	5.0	3.8	4.4	0	0	0	2.5	1.9	2.2
Castille	180	12.5	7.5	10.0	0	0	0	6.3	3.8	5.0
Castille	240	12.5	2.5	7.5	0	0	0	6.3	1.3	3.8
Castille	300	10.0	2.5	6.3	0	0	0	5.0	1.3	3.1
Castille	360	18.8	7.5	13.1	0	0	0	9.4	3.8	6.6
Castille	Mean	8.4	3.4	5.9	0	0	0	4.2	1.7	2.9
Win+Cas	0	22.5		22.5	21.3		21.3	21.9		21.9
Win+Cas	60	23.8	23.5	23.6	17.5	20.6	19.1	20.6	22.1	21.3
Win+Cas	120	27.3	26.0	26.6	21.3	12.0	16.6	24.3	19.0	21.6
Win+Cas	180	24.4	26.9	25.6	13.1	20.6	16.9	18.8	23.8	21.3
Win+Cas	240	28.8	25.5	27.1	12.5	22.0	17.3	20.6	23.8	22.2
Win+Cas	300	27.5	24.8	26.1	13.8	20.8	17.3	20.6	22.8	21.7
Win+Cas	360	33.8	27.5	30.6	23.9	22.5	23.2	28.8	25.0	26.9
Win+Cas	Mean	26.8	25.2	26.0	17.6	20.0	18.8	22.2	22.6	22.4

Treatment	df	SED	P-Value
Folicur	3	4.19	0.182
Variety	162	3.4	<.001
N rate	162	6.36	0.977
N Management	162	3.4	0.912
Fol x Var	8.19	5.39	0.69
Fol x Nrate	57.07	9.32	0.993
Var x Nrate	162	8.99	0.981
Fol x Man	8.19	5.39	0.56
Var x Man	162	4.81	0.399
Nrate x man	162	8.99	0.984
Fol x Var x Nrate	116.4	12.95	0.982
Fol x Var x man	24.78	7.22	0.879
Fol x Nrate x Man	116.4	12.95	0.991
Var x Nrate x man	162	12.71	0.955
Fol x Var x Nrate x Man	154.4	18.14	0.998

Table 5.149. Rosemaund – percent of plot lodged at 10-45 degrees at harvest

Variety	N rate kg/ha	No Folicur			Folicur (1.0 l/ha)			Conv Mean	CM Mean	Grand Mean
		Conv	CM	Mean	Conv	CM	Mean			
Winner	0	8.8		8.8	5.0		5.0	6.9		6.9
Winner	60	26.3	17.5	21.9	0.0	6.3	3.1	13.1	11.9	12.5
Winner	120	10.0	32.5	21.3	17.5	10.0	13.8	13.8	21.3	17.5
Winner	180	11.3	42.5	26.9	45.0	23.8	34.4	28.1	33.1	30.6
Winner	240	15.0	32.5	23.8	23.8	10.0	16.9	19.4	21.3	20.3
Winner	300	12.5	13.8	13.1	38.8	25.0	31.9	25.6	19.4	22.5
Winner	360	25.0	7.5	16.3	42.5	50.0	46.3	33.8	28.8	31.3
Winner	Mean	15.5	22.1	18.8	24.6	18.6	21.6	20.1	20.4	20.2
Castille	0	0.0		0.0	0.0		0.0	0.0		0.0
Castille	60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Castille	120	20.0	12.5	16.3	0.0	0.0	0.0	10.0	6.3	8.1
Castille	180	3.8	12.5	8.1	6.3	0.0	3.1	5.0	6.3	5.6
Castille	240	5.0	10.0	7.5	0.0	0.0	0.0	2.5	5.0	3.8
Castille	300	16.3	15.0	15.6	0.0	0.0	0.0	8.1	7.5	7.8
Castille	360	7.5	15.0	11.3	0.0	0.0	0.0	3.8	7.5	5.6
Castille	Mean	7.5	9.3	8.4	0.9	0.0	0.4	4.2	4.6	4.4
Win+Cas	0	4.4		4.4	2.5		2.5	3.4		3.4
Win+Cas	60	13.1	8.8	10.9	0.0	3.1	1.6	6.6	5.9	6.3
Win+Cas	120	15.0	22.5	18.8	8.8	5.0	6.9	11.9	13.8	12.8
Win+Cas	180	7.5	27.5	17.5	25.6	11.9	18.8	16.6	19.7	18.1
Win+Cas	240	10.0	21.3	15.6	11.9	5.0	8.4	10.9	13.1	12.0
Win+Cas	300	14.4	14.4	14.4	19.4	12.5	15.9	16.9	13.4	15.2
Win+Cas	360	16.3	11.3	13.8	21.3	25.0	23.1	18.8	18.1	18.4
Win+Cas	Mean	11.5	15.7	13.6	12.8	9.3	11.0	12.1	12.5	12.3

Treatment	df	SED	P-Value
Folicur	3	2.844	0.43
Variety	162	1.653	<.001
N rate	162	3.092	<.001
N Management	162	1.653	0.829
Fol x Var	5.36	3.289	0.001
Fol x Nrate	25.55	4.948	0.011
Var x Nrate	162	4.373	0.014
Fol x Man	5.36	3.289	0.021
Var x Man	162	2.338	0.957
Nrate x man	162	4.373	0.955
Fol x Var x Nrate	64.27	6.603	<.001
Fol x Var x man	11.94	4.035	0.132
Fol x Nrate x Man	64.27	6.603	0.009
Var x Nrate x man	162	6.184	0.773
Fol x Var x Nrate x Man	121	9.047	0.032

Table 5.150. Rosemaund – percent of plot lodged at 45-90 degrees at harvest.

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	0		0	0		0	0		0
Winner	60	0	6.3	3.1	0	0	0	0	3.1	1.6
Winner	120	50.0	7.5	28.8	11.3	0	5.6	30.6	3.8	17.2
Winner	180	56.3	25.0	40.6	7.5	1.3	4.4	31.9	13.1	22.5
Winner	240	52.5	27.5	40.0	12.5	23.8	18.1	32.5	25.6	29.1
Winner	300	62.5	52.5	57.5	15.0	7.5	11.3	38.8	30.0	34.4
Winner	360	42.5	60.0	51.3	12.5	7.5	10.0	27.5	33.8	30.6
Winner	Mean	37.7	25.5	31.6	8.4	5.7	7.1	23.0	15.6	19.3
Castille	0	10.0		10.0	0		0	5.0		5.0
Castille	60	0	0	0	0	0	0	0	0	0
Castille	120	22.5	0	11.3	0	0	0	11.3	0	5.6
Castille	180	25.0	17.5	21.3	0	0	0	12.5	8.8	10.6
Castille	240	33.8	23.8	28.8	0	0	0	16.9	11.9	14.4
Castille	300	27.5	22.5	25.0	0	0	0	13.8	11.3	12.5
Castille	360	58.8	15.0	36.9	0	0	0	29.4	7.5	18.4
Castille	Mean	25.4	12.7	19.0	0	0	0	12.7	6.3	9.5
Win+Cas	0	5.0		5.0	0		0	2.5		2.5
Win+Cas	60	0	3.1	1.6	0	0	0	0	1.6	0.8
Win+Cas	120	36.3	3.8	20.0	5.6	0	2.8	20.9	1.9	11.4
Win+Cas	180	40.6	21.3	30.9	3.8	0.6	2.2	22.2	10.9	16.6
Win+Cas	240	43.1	25.6	34.4	6.3	11.9	9.1	24.7	18.8	21.7
Win+Cas	300	45.0	37.5	41.3	7.5	3.8	5.6	26.3	20.6	23.4
Win+Cas	360	50.6	37.5	44.1	6.3	3.8	5.0	28.4	20.6	24.5
Win+Cas	Mean	31.5	19.1	25.3	4.2	2.9	3.5	17.9	11.0	14.4

Treatment	df	SED	P-Value
Folicur	3	4.449	0.016
Variety	162	1.99	<.001
N rate	162	3.722	<.001
N Management	162	1.99	<.001
Fol x Var	4.32	4.874	0.166
Fol x Nrate	14.14	6.599	<.001
Var x Nrate	162	5.264	0.012
Fol x Man	4.32	4.874	0.006
Var x Man	162	2.814	0.788
Nrate x man	162	5.264	0.115
Fol x Var x Nrate	34.55	8.442	0.324
Fol x Var x man	7.63	5.628	0.687
Fol x Nrate x Man	34.55	8.442	0.308
Var x Nrate x man	162	7.445	0.074
Fol x Var x Nrate x Man	79.78	11.25	0.063

5.3.11 Pod greenness at mid seed filling

At Boxworth the Canopy Managed Treatments significantly increased pod greenness at 300 kg N/ha on 19 June and 2 July (Table 5.151). At High Mowthorpe, pod greenness was increased by greater N rates, but Canopy Management had no effect (Table 5.152). At Rosemaund pod greenness was increased by greater N rates, but Canopy Management had little effect (Table 5.153).

Table 5.151. Boxworth. Pod greenness (1= brown and brittle; 5= green and flexible) at two assessment dates for Winner without Folicur.

Variety	N rate	19th June			2nd July		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean
Winner	0	1.00		1.00	1.00		1.00
Winner	60	1.33	2.00	1.67	1.33	1.67	1.50
Winner	180	3.00	3.00	3.00	3.33	2.67	3.00
Winner	300	3.33	4.67	4.00	3.33	5.00	4.17
Winner	Mean	2.17	2.67	2.42	2.25	2.58	2.42
Treatment		df	SED	P-Value	df	SED	P-Value
Nrate		14	0.1992	<.001	14	0.2559	<.001
Management		14	0.1409	0.003	14	0.1809	0.087
Nrate x Man		14	0.2817	0.013	14	0.3619	0.003

Table 5.152. High Mowthorpe. Pod greenness (1= brown and brittle; 5= green and flexible) at three assessment dates for Winner without Folicur.

Variety	N rate	1st July			11th July			23rd July		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	2.50		2.50	2.00		2.00	2.00		2.00
Winner	60	3.00	3.25	3.12	2.00	2.00	2.00	2.50	2.50	2.50
Winner	180	3.75	4.25	4.00	3.25	3.00	3.13	3.50	3.00	3.25
Winner	300	4.25	4.75	4.50	3.75	4.00	3.88	3.75	3.75	3.75
Winner	Mean	3.38	3.69	3.53	2.75	2.75	2.75	2.94	2.81	2.88
Treatment		df	SED	P-Value	df	SED	P-Value	df	SED	P-Value
Nrate		21	0.33	<.001	21	0.122	<.001	21	0.2113	<.001
Management		21	0.233	0.195	21	0.0863	1	21	0.1494	0.412
Nrate x Man		21	0.467	0.851	21	0.1725	0.271	21	0.2988	0.563

Table 5.153. Rosemaund. Pod greenness (1= brown and brittle; 5= green and flexible) at three assessment dates for Winner without Folicur.

Variety	N rate	28th May			19th June			2nd July		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	3.00		3.00	3.00		3.00	1.25		1.25
Winner	60	4.00	4.25	4.13	3.00	4.00	3.50	3.00	2.69	2.84
Winner	180	4.25	5.00	4.63	4.00	4.00	4.00	3.19	2.94	3.06
Winner	300	5.00	4.75	4.88	5.00	4.00	4.50	3.50	2.94	3.22
Winner	Mean	4.06	4.25	4.16	3.75	3.75	3.75	2.73	2.45	2.59
Treatment		df	SED	P-Value	df	SED	P-Value	df	SED	P-Value
Nrate		21	0.1778	<.001	Unable to calculate errors			21	0.67	0.028
Management		21	0.1257	0.151				21	0.474	0.559
Nrate x Man		21	0.2515	0.06				21	0.948	0.98

5.3.12 Biomass at harvest

At Boxworth, increasing N rate from 0 to 240 kg N/ha increased the total biomass from 4.05 t/ha to 9.10 t/ha (Table 5.154). Increasing N rate also significantly increased the biomass in the seed, stems and pod walls. Canopy Managed N timings reduced biomass of the pod walls at 240 kg N/ha. Canopy Managed N timings reduced the stem biomass by 0.2 t/ha, but this effect was not statistically significant. There were no differences in overall biomass between Winner and Castille.

At High Mowthorpe, increasing N rate from 0 to 240 kg N/ha increased the total biomass from 5.55 t/ha to 14.89 t/ha (Table 5.155). Increasing N rate also significantly increased the biomass in the seed, stems and pod walls. Castille had a significantly greater biomass of the stems, seed, pod walls and overall biomass (Table 5.155).

At Rosemaund, increasing N rate from 0 to 240 kg N/ha increased the stem biomass from 2.56 t/ha to 3.86 t/ha, but had no significant effect on the biomass of the pod wall, seed and the overall biomass (Table 5.156). Castille had a significantly greater biomass of the stems and pod walls (Table 5.156). The overall biomass of Castille was 2 t/ha greater than Winner, but this effect was not significant.

Table 5.154. Boxworth. Pre-harvest measurement of dry matter (t/ha) for plots without Folicur.

Variety	N rate	Total plant dry matter (t/ha)			Seed dry matter (t/ha)			Stem dry matter (t/ha)			Pod wall dry matter (t/ha)		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	3.63		3.63	1.20		1.20	1.40		1.40	1.03		1.03
Winner	120	7.26	7.80	7.53	2.61	2.68	2.64	2.56	2.60	2.58	2.10	2.52	2.31
Winner	240	9.80	8.99	9.39	3.15	3.39	3.27	3.47	2.99	3.23	3.18	2.61	2.89
Winner	Mean	6.89	6.80	6.85	2.32	2.42	2.37	2.48	2.33	2.40	2.10	2.05	2.08
Castille	0	4.47		4.47	1.31		1.31	1.74		1.74	1.41		1.41
Castille	120	7.69	7.65	7.67	2.77	2.94	2.85	2.55	2.29	2.42	2.37	2.42	2.40
Castille	240	9.36	8.25	8.80	3.18	3.12	3.15	3.06	2.53	2.79	3.11	2.61	2.86
Castille	Mean	7.17	6.79	6.98	2.42	2.46	2.44	2.45	2.19	2.32	2.30	2.15	2.22
Win+Cas	0	4.05		4.05	1.26		1.26	1.57		1.57	1.22		1.22
Win+Cas	120	7.47	7.72	7.60	2.69	2.81	2.75	2.55	2.44	2.50	2.24	2.47	2.35
Win+Cas	240	9.58	8.62	9.10	3.16	3.25	3.21	3.27	2.76	3.01	3.15	2.61	2.88
Win+Cas	Mean	7.03	6.80	6.91	2.37	2.44	2.41	2.46	2.26	2.36	2.20	2.10	2.15
Treatment		df	SED	F Prob.	df	SED	F Prob.	df	SED	F Prob.	df	SED	F Prob.
Variety		22	0.324	0.688	22	0.0979	0.491	22	0.1312	0.532	22	0.1184	0.229
N management		22	0.324	0.474	22	0.0979	0.483	22	0.1312	0.133	22	0.1184	0.401
N_rate		22	0.397	<.001	22	0.1199	<.001	22	0.1606	<.001	22	0.145	<.001
Var x Man		22	0.458	0.658	22	0.1384	0.721	22	0.1855	0.661	22	0.1675	0.667
Var x Nrate		22	0.561	0.22	22	0.1696	0.393	22	0.2272	0.068	22	0.2051	0.349
Man x Nrate		22	0.561	0.297	22	0.1696	0.872	22	0.2272	0.276	22	0.2051	0.04
Var x Man x Nrate		22	0.794	0.936	22	0.2398	0.677	22	0.3213	0.885	22	0.2901	0.713

Table 5.155. High Mowthorpe. Pre-harvest measurement of dry matter (t/ha) for plots without Folicur.

Variety	N rate	Total plant dry matter (t/ha)			Seed dry matter (t/ha)			Stem dry matter (t/ha)			Pod wall dry matter (t/ha)		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	4.94		4.94	1.18		1.18	1.84		1.84	1.92		1.92
Winner	120	12.41	12.27	12.34	2.60	2.46	2.53	4.58	4.44	4.51	5.23	5.37	5.30
Winner	240	13.97	14.06	14.02	2.96	3.04	3.00	4.89	4.88	4.88	6.13	6.14	6.13
Winner	Mean	10.44	10.42	10.43	2.24	2.22	2.23	3.77	3.72	3.74	4.43	4.48	4.45
Castille	0	6.16		6.16	1.35		1.35	2.10		2.10	2.72		2.72
Castille	120	15.57	14.79	15.18	2.82	2.68	2.75	6.04	5.57	5.80	6.71	6.54	6.62
Castille	240	15.09	16.43	15.76	3.43	3.40	3.41	5.16	5.59	5.38	6.51	7.44	6.97
Castille	Mean	12.27	12.46	12.37	2.53	2.48	2.50	4.43	4.42	4.43	5.31	5.57	5.44
Win+Cas	0	5.55		5.55	1.26		1.26	1.97		1.97	2.32		2.32
Win+Cas	120	13.99	13.53	13.76	2.71	2.57	2.64	5.31	5.00	5.16	5.97	5.95	5.96
Win+Cas	240	14.53	15.25	14.89	3.19	3.22	3.21	5.02	5.23	5.13	6.32	6.79	6.55
Win+Cas	Mean	11.36	11.44	11.40	2.39	2.35	2.37	4.10	4.07	4.08	4.87	5.02	4.95
Treatment		df	SED	F Prob.	df	SED	F Prob.	df	SED	F Prob.	df	SED	F Prob.
Variety		33	0.755	0.015	33	0.0855	0.003	33	0.295	0.027	33	0.416	0.024
N management		33	0.755	0.913	33	0.0855	0.673	33	0.295	0.915	33	0.416	0.718
N_rate		33	0.925	<.001	33	0.1047	<.001	33	0.361	<.001	33	0.51	<.001
Var x Man		33	1.068	0.892	33	0.121	0.846	33	0.417	0.949	33	0.589	0.809
Var x Nrate		33	1.308	0.676	33	0.1481	0.489	33	0.511	0.339	33	0.721	0.851
Man x Nrate		33	1.308	0.815	33	0.1481	0.697	33	0.511	0.773	33	0.721	0.861
Var x Man x Nrate		33	1.85	0.873	33	0.2095	0.958	33	0.723	0.866	33	1.02	0.823

Table 5.156. Rosemaund. Pre-harvest measurement of dry matter (t/ha) for plots without Folicur.

Variety	N rate	Total plant dry matter (t/ha)			Seed dry matter (t/ha)			Stem dry matter (t/ha)			Pod wall dry matter (t/ha)		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	8.70		8.70	2.39		2.39	4.22		4.22	1.89		1.89
Winner	120	10.47	10.52	10.50	3.37	3.52	3.44	4.49	4.28	4.39	2.61	2.72	2.66
Winner	240	12.52	11.72	12.12	3.66	3.75	3.70	5.62	4.57	5.10	3.36	3.40	3.38
Winner	Mean	10.57	10.32	10.44	3.14	3.22	3.18	4.78	4.36	4.57	2.62	2.67	2.64
Castille	0	12.55		12.55	2.73		2.73	5.84		5.84	3.97		3.97
Castille	120	11.04	14.20	12.62	3.87	3.77	3.82	3.92	5.39	4.66	3.25	5.04	4.14
Castille	240	13.15	11.38	12.27	4.16	3.89	4.02	5.46	4.04	4.75	3.53	3.47	3.50
Castille	Mean	12.25	12.71	12.48	3.59	3.46	3.53	5.08	5.09	5.08	3.58	4.16	3.87
Win+Cas	0	10.63		10.63	2.56		2.56	5.03		5.03	2.93		2.93
Win+Cas	120	10.75	12.36	11.56	3.62	3.65	3.63	4.21	4.84	4.52	2.93	3.88	3.40
Win+Cas	240	12.84	11.55	12.19	3.91	3.82	3.86	5.54	4.31	4.92	3.44	3.44	3.44
Win+Cas	Mean	11.41	11.51	11.46	3.36	3.34	3.35	4.93	4.73	4.83	3.10	3.42	3.26
Treatment		df	SED	F Prob.	df	SED	F Prob.	df	SED	F Prob.	df	SED	F Prob.
Variety		29	1.361	0.145	33	0.1012	0.002	29	0.774	0.511	29	0.579	0.042
N management		29	1.361	0.937	33	0.1012	0.83	29	0.774	0.798	29	0.579	0.591
N_rate		29	1.666	0.644	33	0.124	<.001	29	0.948	0.853	29	0.709	0.727
Var x Man		29	1.924	0.794	33	0.1432	0.328	29	1.094	0.782	29	0.819	0.653
Var x Nrate		29	2.357	0.547	33	0.1754	0.974	29	1.34	0.574	29	1.003	0.378
Man x Nrate		29	2.357	0.688	33	0.1754	0.882	29	1.34	0.611	29	1.003	0.741
Var x Man x Nrate		29	3.333	0.817	33	0.248	0.762	29	1.896	0.847	29	1.418	0.784

5.3.13 Crop N content

At Boxworth, increasing N rate from 0 to 240 kg N/ha increased the total N uptake from 42 to 146 kg N/ha (Table 5.158). Increasing N rate also significantly increased the amount of N in the seed, stems and pod walls. These effects were caused by a combination of greater biomass and greater tissue N concentration (Table 5.157). Canopy Managed N timings increased the total N taken up by 5 kg N/ha, but this effect was not significant. There were no differences between Winner and Castille in total N uptake or the N content of the stems, pod walls and seed.

At High Mowthorpe, increasing N rate from 0 to 240 kg N/ha increased the total N uptake from 70 to 209 kg N/ha (Table 5.160). Increasing N rate also significantly increased the amount of N in the seed, stems and pod walls. These effects were caused by a combination of greater biomass and tissue N concentration (Table 5.159). Canopy Managed N timings increased the total N taken up by 5 kg N/ha, but this effect was not significant. There were no differences between Winner and Castille in total N uptake or the N content of the stems, pod walls and seed. Winner had a greater concentration of N in the pod walls, stems and seeds than Castille ($P<0.1$) (Table 5.159).

At Rosemaund, increasing N rate from 0 to 240 kg N/ha increased the total N uptake from 96 to 194 kg N/ha (Table 5.162). Increasing N rate also significantly increased the amount of N in the seed, stems and pod walls. These effects were caused by a combination of greater biomass and tissue N concentration (Table 5.162). Castille took up 14 kg N/ha more than Winner into the seed. Castille had a greater N concentration in the stem and a smaller N concentration in the pod walls compared with Winner (Table 5.162). Canopy Managed N timings increased the amount of N in the seed by 10 kg N/ha ($P<0.1$) and significantly increased the concentration of N in the stems (Table 5.162).

Table 5.157. Boxworth. Pre-harvest measurement of nitrogen concentration for plots without Folicur.

Variety	N rate kg/ha	Stem N %			Seed N %			Pod wall N %		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.416		0.416	2.31		2.31	0.474		0.474
Winner	120	0.458	0.5	0.479	2.35	2.52	2.43	0.501	0.778	0.64
Winner	240	0.785	0.826	0.805	2.98	3.13	3.05	0.865	0.773	0.819
Winner	Mean	0.553	0.58	0.567	2.55	2.65	2.60	0.613	0.675	0.644
Castille	0	0.493		0.493	2.29		2.29	0.479		0.479
Castille	120	0.471	0.555	0.513	2.36	2.58	2.47	0.464	0.481	0.473
Castille	240	0.788	0.847	0.817	2.91	3.12	3.02	0.685	0.686	0.686
Castille	Mean	0.584	0.631	0.608	2.52	2.67	2.59	0.543	0.549	0.546
Win+Cas	0	0.454		0.454	2.30		2.30	0.477		0.477
Win+Cas	120	0.464	0.527	0.496	2.36	2.55	2.45	0.483	0.63	0.556
Win+Cas	240	0.786	0.836	0.811	2.95	3.12	3.03	0.775	0.73	0.752
Win+Cas	Mean	0.568	0.606	0.587	2.53	2.66	2.60	0.578	0.612	0.595
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		22	0.051	0.43	22	0.067	0.939	21	0.038	0.017
N management		22	0.051	0.468	22	0.067	0.075	21	0.038	0.381
N_rate		22	0.062	<.001	22	0.082	<.001	21	0.047	<.001
Var x Man		22	0.072	0.846	22	0.094	0.791	21	0.054	0.471
Var x Nrate		22	0.088	0.868	22	0.116	0.893	21	0.066	0.17
Man x Nrate		22	0.088	0.869	22	0.116	0.43	21	0.066	0.122
Var x Man x Nrate		22	0.125	0.986	22	0.164	0.98	21	0.093	0.172

Table 5.158. Boxworth. Pre-harvest measurement of N content for plots without Folicur.

Variety	N rate	Seed N yield (kg/ha)			Stem N yield (kg/ha)			Pod wall N yield (kg/ha)			Total N yield (kg/ha)		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	27.7		27.7	5.8		5.8	4.9		4.9	38.4		38.4
Winner	120	61.9	67.5	64.7	11.7	12.9	12.3	10.5	20.0	15.3	84.1	100.4	92.3
Winner	240	94.1	105.8	99.9	28.2	24.8	26.5	28.1	20.4	24.2	150.4	154.3	152.4
Winner	Mean	61.2	67.0	64.1	15.2	14.5	14.9	14.5	15.1	14.8	91.0	97.7	94.3
Castille	0	29.4		29.4	8.7		8.7	7.0		7.0	45.1		45.1
Castille	120	65.4	76.0	70.7	12.0	12.7	12.3	11.1	11.7	11.4	88.4	100.5	94.4
Castille	240	93.9	97.6	95.8	25.3	21.5	23.4	21.5	17.8	19.7	140.8	136.9	138.9
Castille	Mean	62.9	67.7	65.3	15.3	14.3	14.8	13.2	12.2	12.7	91.4	94.2	92.8
Win+Cas	0	28.6		28.6	7.2		7.2	5.9		5.9	41.7		41.7
Win+Cas	120	63.6	71.8	67.7	11.8	12.8	12.3	10.8	15.9	13.3	86.3	100.4	93.3
Win+Cas	240	94.0	101.7	97.9	26.8	23.1	25.0	24.8	19.1	22.0	145.6	145.6	145.6
Win+Cas	Mean	62.1	67.3	64.7	15.3	14.4	14.8	13.8	13.6	13.7	91.2	95.9	93.6

Treatment	df	SED	P value	df	SED	P value	df	SED	P value	df	SED	P value
Variety	22	3.3	0.723	22	2.15	0.981	21	1.556	0.189	21	6.01	0.799
N management	22	3.3	0.125	22	2.15	0.681	21	1.556	0.904	21	6.01	0.439
N_rate	22	4.04	<.001	22	2.63	<.001	21	1.906	<.001	21	7.37	<.001
Var x Man	22	4.67	0.883	22	3.04	0.952	21	2.201	0.606	21	8.51	0.743
Var x Nrate	22	5.71	0.463	22	3.72	0.529	21	2.696	0.183	21	10.42	0.371
Man x Nrate	22	5.71	0.538	22	3.72	0.655	21	2.696	0.034	21	10.42	0.549
Var x Man x Nrate	22	8.08	0.722	22	5.26	0.999	21	3.812	0.25	21	14.73	0.966

Table 5.159. High Mowthorpe. Pre-harvest measurement of nitrogen concentration for plots without Folicur.

Variety	N rate	Stem N %			Seed N %			Pod wall N %		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.42		0.42	2.97		2.97	1.344		1.344
Winner	120	0.512	0.486	0.499	2.31	2.43	2.37	1.049	1.204	1.126
Winner	240	0.694	0.622	0.658	2.58	2.71	2.64	1.419	1.539	1.479
Winner	Mean	0.542	0.509	0.525	2.62	2.70	2.66	1.271	1.362	1.316
Castille	0	0.44		0.44	2.30		2.30	1.167		1.167
Castille	120	0.428	0.443	0.436	2.31	2.15	2.23	1.168	1.052	1.11
Castille	240	0.536	0.591	0.564	2.69	2.69	2.69	1.272	1.353	1.312
Castille	Mean	0.468	0.491	0.48	2.43	2.38	2.41	1.202	1.191	1.197
Win+Cas	0	0.43		0.43	2.63		2.63	1.255		1.255
Win+Cas	120	0.47	0.464	0.467	2.31	2.29	2.30	1.108	1.128	1.118
Win+Cas	240	0.615	0.606	0.611	2.64	2.70	2.67	1.346	1.446	1.396
Win+Cas	Mean	0.505	0.5	0.503	2.53	2.54	2.53	1.236	1.276	1.256
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		32	0.024	0.066	33	0.148	0.094	33	0.062	0.06
N management		32	0.024	0.84	33	0.148	0.923	33	0.062	0.521
N_rate		32	0.029	<.001	33	0.181	0.093	33	0.075	0.003
Var x Man		32	0.034	0.251	33	0.209	0.641	33	0.087	0.408
Var x Nrate		32	0.041	0.143	33	0.255	0.137	33	0.107	0.499
Man x Nrate		32	0.041	0.988	33	0.255	0.968	33	0.107	0.782
Var x Man x Nrate		32	0.058	0.549	33	0.361	0.928	33	0.151	0.629

Table 5.160. High Mowthorpe. Pre-harvest measurement of N content for plots without Folicur.

Variety	N rate	Seed N yield (kg/ha)			Stem N yield (kg/ha)			Pod wall N yield (kg/ha)			Total N yield (kg/ha)		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	35.5		35.5	7.7		7.7	25.2		25.2	68.4		68.4
Winner	120	60.1	59.6	59.8	23.4	21.4	22.4	54.1	65.2	59.7	137.6	146.2	141.9
Winner	240	76.6	83.2	79.9	34.8	31.8	33.3	85.6	95.1	90.4	196.9	210.2	203.6
Winner	Mean	57.4	59.4	58.4	22.0	20.3	21.1	55.0	61.9	58.4	134.3	141.6	138.0
Castille	0	30.9		30.9	9.3		9.3	31.7		31.7	71.9		71.9
Castille	120	65.2	57.5	61.4	26.7	24.3	25.5	79.9	70.1	75.0	168.8	151.9	160.3
Castille	240	92.1	91.8	91.9	27.3	34.0	30.7	81.4	101.4	91.4	200.8	227.2	214.0
Castille	Mean	62.7	60.1	61.4	21.1	22.5	21.8	64.3	67.7	66.0	147.2	150.3	148.7
Win+Cas	0	33.2		33.2	8.5		8.5	28.5		28.5	70.2		70.2
Win+Cas	120	62.6	58.6	60.6	25.0	22.9	23.9	67.0	67.6	67.3	153.2	149.1	151.1
Win+Cas	240	84.3	87.5	85.9	31.0	32.9	32.0	83.5	98.3	90.9	198.9	218.7	208.8
Win+Cas	Mean	60.1	59.8	59.9	21.5	21.4	21.5	59.7	64.8	62.2	140.7	146.0	143.4

Treatment	df	SED	P value	df	SED	P value	df	SED	P value	df	SED	P value
Variety	33	3.07	0.338	32	2.23	0.768	33	6.11	0.221	32	10.07	0.293
N management	33	3.07	0.925	32	2.23	0.964	33	6.11	0.406	32	10.07	0.606
N_rate	33	3.76	<.001	32	2.74	<.001	33	7.49	<.001	32	12.33	<.001
Var x Man	33	4.34	0.447	32	3.16	0.496	33	8.64	0.778	32	14.24	0.839
Var x Nrate	33	5.32	0.098	32	3.87	0.562	33	10.59	0.634	32	17.44	0.833
Man x Nrate	33	5.32	0.635	32	3.87	0.758	33	10.59	0.541	32	17.44	0.588
Var x Man x Nrate	33	7.52	0.863	32	5.47	0.591	33	14.97	0.572	32	24.66	0.731

Table 5.161. Rosemaund. Pre-harvest measurement of nitrogen concentration for plots without Folicur.

Variety	N rate kg/ha	Stem N %			Seed N %			Pod wall N %		
		Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	0.347		0.347	2.30		2.30	0.48		0.48
Winner	120	0.429	0.568	0.498	2.52	2.85	2.69	0.675	0.653	0.664
Winner	240	0.717	0.878	0.798	2.92	3.17	3.04	0.87	1.051	0.96
Winner	Mean	0.498	0.597	0.548	2.58	2.77	2.68	0.675	0.728	0.701
Castille	0	0.379		0.379	2.36		2.36	0.421		0.421
Castille	120	0.506	0.526	0.516	2.68	2.84	2.76	0.603	0.633	0.618
Castille	240	1.004	0.819	0.912	3.14	3.33	3.24	0.792	0.912	0.852
Castille	Mean	0.63	0.575	0.602	2.72	2.84	2.78	0.605	0.655	0.630
Win+Cas	0	0.363		0.363	2.33		2.33	0.451		0.451
Win+Cas	120	0.467	0.547	0.507	2.60	2.84	2.72	0.639	0.643	0.641
Win+Cas	240	0.861	0.849	0.855	3.03	3.25	3.14	0.831	0.981	0.906
Win+Cas	Mean	0.564	0.586	0.575	2.65	2.81	2.73	0.640	0.692	0.666
Treatment		df	SED	P value	df	SED	P value	df	SED	P value
Variety		29	0.046	0.246	31	0.045	0.026	31	0.035	0.053
N management		29	0.046	0.63	31	0.045	0.002	31	0.035	0.154
N_rate		29	0.057	<.001	31	0.055	<.001	31	0.043	<.001
Var x Man		29	0.065	0.105	31	0.063	0.431	31	0.05	0.966
Var x Nrate		29	0.08	0.659	31	0.077	0.39	31	0.061	0.753
Man x Nrate		29	0.08	0.681	31	0.077	0.063	31	0.061	0.159
Var x Man x Nrate		29	0.113	0.316	31	0.109	0.738	31	0.087	0.811

Table 5.162. Rosemaund. Pre-harvest measurement of N content for plots without Folicur.

Variety	N rate	Seed N yield (kg/ha)			Stem N yield (kg/ha)			Pod wall N yield (kg/ha)			Total N yield (kg/ha)		
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean	Conv	CM	Mean
Winner	0	55.5		55.5	14.0		14.0	10.4		10.4	85.4		85.4
Winner	120	84.8	100.3	92.6	19.1	23.8	21.5	18.6	17.7	18.2	122.6	141.9	132.3
Winner	240	103.1	118.8	110.9	37.5	40.4	39.0	29.7	36.1	32.9	171.3	195.2	183.3
Winner	Mean	81.1	91.5	86.3	23.6	26.1	24.8	19.6	21.4	20.5	126.4	140.8	133.6
Castille	0	65.3		65.3	22.8		22.8	18.2		18.2	106.3		106.3
Castille	120	103.4	107.4	105.4	18.2	28.0	23.1	19.6	34.1	26.8	141.3	169.4	155.4
Castille	240	130.6	129.4	130.0	55.4	33.0	44.2	28.4	32.8	30.6	214.4	194.8	204.6
Castille	Mean	99.8	100.7	100.2	32.1	27.9	30.0	22.1	28.4	25.2	154.0	156.8	155.4
Win+Cas	0	60.4		60.4	18.4		18.4	14.3		14.3	95.9		95.9
Win+Cas	120	94.1	103.9	99.0	18.7	25.9	22.3	19.1	25.9	22.5	131.9	155.7	143.8
Win+Cas	240	116.8	124.1	120.4	46.5	36.7	41.6	29.1	34.4	31.7	192.8	195.0	193.9
Win+Cas	Mean	90.5	96.1	93.3	27.8	27.0	27.4	20.8	24.9	22.9	140.2	148.8	144.5

Treatment	df	SED	P value	df	SED	P value	df	SED	P value	df	SED	P value
Variety	31	3.05	<.001	29	3.73	0.173	29	3.87	0.229	29	8.56	0.017
N management	31	3.05	0.073	29	3.73	0.825	29	3.87	0.305	29	8.56	0.322
N_rate	31	3.74	<.001	29	4.56	<.001	29	4.74	0.004	29	10.49	<.001
Var x Man	31	4.32	0.131	29	5.27	0.375	29	5.47	0.57	29	12.11	0.506
Var x Nrate	31	5.29	0.461	29	6.45	0.741	29	6.7	0.448	29	14.83	0.994
Man x Nrate	31	5.29	0.412	29	6.45	0.191	29	6.7	0.756	29	14.83	0.466
Var x Man x Nrate	31	7.47	0.521	29	9.13	0.223	29	9.48	0.61	29	20.97	0.421

5.3.14 Seed size and seed number

At Boxworth, Canopy Management increased seed weight by 0.11 g, but this effect was not statistically significant (Table 5.163). None of the other treatments affected seed size. As a result the differences in yield were mainly caused by differences in seeds/m^2. Castille and increasing N rate both significantly increased seed number (Table 5.164).

At High Mowthorpe, there was no evidence for Canopy Management to affect seed size. The 300 kg N/ha treatment consistently had a greater seed weight than the 60 and 180 N rates. Castille had significantly heavier seeds than Winner ($P<0.01$). Castille and increasing N rate both significantly increased seed number (Table 5.166). Canopy Management increased the number of seeds for Castille ($P<0.1$).

At Rosemaund, Canopy Management, Castille, Folicur and greater N rates all resulted in significantly heavier seeds (Table 5.167). The seed number was significantly increased by the Conventional N timings, Winner and greater N rates (Table 5.168).

Table 5.163. Boxworth. Thousand seed weight

Variety	N rate	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	5.84		5.84	5.51		5.51	5.68		5.68
Winner	60	5.59	5.87	5.73	5.81	5.50	5.66	5.70	5.68	5.69
Winner	180	5.76	5.72	5.74	5.58	6.44	6.01	5.67	6.08	5.87
Winner	300	5.60	5.87	5.73	5.82	5.77	5.79	5.71	5.82	5.76
Winner	Mean	5.70	5.82	5.76	5.68	5.80	5.74	5.69	5.81	5.75
Castille	0	5.91		5.91	5.93		5.93	5.92		5.92
Castille	60	5.76	5.81	5.78	5.67	6.12	5.89	5.71	5.96	5.84
Castille	180	5.71	5.74	5.72	5.52	5.65	5.59	5.62	5.69	5.65
Castille	300	5.87	5.97	5.92	5.89	5.75	5.82	5.88	5.86	5.87
Castille	Mean	5.81	5.86	5.83	5.75	5.86	5.81	5.78	5.86	5.82
Win+Cas	0	5.87		5.87	5.72		5.72	5.80		5.80
Win+Cas	60	5.67	5.84	5.76	5.74	5.81	5.77	5.71	5.82	5.77
Win+Cas	180	5.73	5.73	5.73	5.55	6.04	5.80	5.64	5.88	5.76
Win+Cas	300	5.73	5.92	5.83	5.85	5.76	5.81	5.79	5.84	5.82
Win+Cas	Mean	5.75	5.84	5.80	5.72	5.83	5.77	5.73	5.84	5.79

Treatment	df	SED	P-Value
Folicur	2	0.119	0.871
Variety	60	0.072	0.339
N management	60	0.072	0.164
Nrate	60	0.102	0.945
Fol x Var	3.72	0.139	0.938
Fol x Man	3.72	0.139	0.835
Var x Man	60	0.102	0.747
Fol x Nrate	8.47	0.172	0.740
Var x Nrate	60	0.144	0.131
Man x Nrate	60	0.144	0.662
Fol x Var x Man	8.47	0.172	0.811
Fol x Var x Nrate	20.83	0.225	0.260
Fol x Man x Nrate	20.83	0.225	0.279
Var x Man x Nrate	60	0.204	0.518
Fol x Var x Man x Nrate	42.03	0.303	0.190

Table 5.164. Boxworth. Seeds per m^2

Variety	N rate kg/ha	No Folicur Conv	No Folicur CM	No Folicur Mean	Folicur (0.5 l/ha) Conv	Folicur (0.5 l/ha) CM	Folicur (0.5 l/ha) Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	20398		20398	18236		18236	19317		19317
Winner	60	33391	30701	32046	31480	33723	32602	32436	32212	32324
Winner	180	58534	59837	59186	58277	56294	57285	58406	58066	58236
Winner	300	64159	55298	59728	58674	63661	61167	61417	59479	60448
Winner	Mean	44121	41558	42840	41667	42979	42323	42894	42269	42581
Castille	0	22397		22397	23267		23267	22832		22832
Castille	60	35103	37887	36495	37271	35416	36344	36187	36652	36419
Castille	180	59406	62018	60712	61481	66120	63801	60443	64069	62256
Castille	300	63114	63332	63223	65020	59454	62237	64067	61393	62730
Castille	Mean	45005	46408	45707	46760	46064	46412	45882	46236	46059
Win+Cas	0	21397		21397	20752		20752	21075		21075
Win+Cas	60	34247	34294	34271	34376	34570	34473	34311	34432	34372
Win+Cas	180	58970	60927	59949	59879	61207	60543	59424	61067	60246
Win+Cas	300	63637	59315	61476	61847	61557	61702	62742	60436	61589
Win+Cas	Mean	44563	43983	44273	44213	44522	44367	44388	44252	44320

Treatment	df	SED	P-Value
Folicur	2	3025.5	0.978
Variety	60	1174.8	0.004
N management	60	1174.8	0.908
Nrate	60	1661.4	<.001
Fol x Var	2.65	3245.6	0.605
Fol x Man	2.65	3245.6	0.707
Var x Man	60	1661.4	0.678
Fol x Nrate	4.19	3646.1	0.985
Var x Nrate	60	2349.6	0.944
Man x Nrate	60	2349.6	0.697
Fol x Var x Man	4.19	3646.1	0.209
Fol x Var x Nrate	8.15	4337.6	0.670
Fol x Man x Nrate	8.15	4337.6	0.893
Var x Man x Nrate	60	3322.9	0.9
Fol x Var x Man x Nrate	18.18	5464.1	0.261

† calculated from combine seed yield

Table 5.165. High Mowthorpe. Thousand seed weight

Variety	N rate	No Folicur			Folicur (0.5 l/ha)			Conv	CM	Grand
	kg/ha	Conv	CM	Mean	Conv	CM	Mean	Mean	Mean	Mean
Winner	0	5.12		5.12	5.16		5.16	5.14	5.14	5.14
Winner	60	5.05	5.12	5.08	5.22	5.13	5.17	5.13	5.12	5.13
Winner	180	5.25	5.20	5.23	5.12	4.99	5.05	5.18	5.10	5.14
Winner	300	5.43	5.27	5.35	5.13	5.18	5.16	5.28	5.22	5.25
Winner	Mean	5.21	5.18	5.19	5.16	5.12	5.14	5.18	5.15	5.16
Castille	0	5.46		5.46	5.38		5.38	5.42	5.42	5.42
Castille	60	5.20	5.15	5.17	5.08	5.21	5.14	5.14	5.18	5.16
Castille	180	5.07	5.15	5.11	5.18	5.28	5.23	5.12	5.21	5.17
Castille	300	5.44	5.33	5.38	5.44	5.44	5.44	5.44	5.39	5.41
Castille	Mean	5.29	5.27	5.28	5.27	5.33	5.30	5.28	5.30	5.29
Win+Cas	0	5.29		5.29	5.27		5.27	5.28		5.28
Win+Cas	60	5.12	5.13	5.13	5.15	5.17	5.16	5.13	5.15	5.14
Win+Cas	180	5.16	5.17	5.17	5.15	5.13	5.14	5.15	5.15	5.15
Win+Cas	300	5.44	5.30	5.37	5.28	5.31	5.30	5.36	5.30	5.33
Win+Cas	Mean	5.25	5.22	5.24	5.21	5.22	5.22	5.23	5.22	5.23

Treatment	df	SED	P-Value
Folicur	3	0.016	0.277
Variety	90	0.041	0.003
N management	90	0.041	0.815
Nrate	90	0.058	0.003
Fol x Var	70.96	0.044	0.391
Fol x Man	70.96	0.044	0.646
Var x Man	90	0.058	0.503
Fol x Nrate	92.29	0.073	0.873
Var x Nrate	90	0.083	0.099
Man x Nrate	90	0.083	0.936
Fol x Var x Man	92.29	0.073	0.582
Fol x Var x Nrate	92.63	0.111	0.133
Fol x Man x Nrate	92.63	0.111	0.845
Var x Man x Nrate	90	0.117	0.865
Fol x Var x Man x Nrate	91.54	0.161	0.809

Table 5.166. High Mowthorpe. Seeds/m^2

Variety	N rate kg/ha	No Folicur Conv	No Folicur CM	No Folicur Mean	Folicur (0.5 l/ha) Conv	Folicur (0.5 l/ha) CM	Folicur (0.5 l/ha) Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	22731		22731	21668		21668	22200		22200
Winner	60	33577	37020	35298	39994	38384	39189	36786	37702	37244
Winner	180	61252	53637	57445	66331	63243	64787	63791	5844	61116
Winner	300	56573	62149	59361	67903	62779	65341	62238	62464	62351
Winner	Mean	43533	43884	43709	48974	46518	47746	46254	45201	45728
Castille	0	24744		24744	26646		26646	25695		25695
Castille	60	42629	46254	44441	43759	51326	47542	43194	48790	45992
Castille	180	63124	62668	62896	68940	69539	69239	66032	66103	66068
Castille	300	63803	67007	65405	67195	74408	70801	65499	70708	68103
Castille	Mean	48575	50168	49372	51635	55480	53557	50105	52824	51464
Win+Cas	0	23738		23738	24157		24157	23947		23947
Win+Cas	60	38103	41637	39870	41876	44855	43366	39990	43246	41618
Win+Cas	180	62188	58153	60170	67636	66391	67013	64912	62272	63592
Win+Cas	300	60188	64578	62383	67549	68594	68071	63869	66586	65227
Win+Cas	Mean	46054	47026	46540	50304	50999	50652	48179	49013	48596

Treatment	df	SED	P-Value
Folicur	3	1994.3	0.131
Variety	90	1064.5	<.001
N management	90	1064.5	0.436
Nrate	90	1505.5	<.001
Fol x Var	4.94	2260.6	0.945
Fol x Man	4.94	2260.6	0.897
Var x Man	90	1505.5	0.080
Fol x Nrate	10.08	2716.1	0.160
Var x Nrate	90	2129.1	0.361
Man x Nrate	90	2129.1	0.188
Fol x Var x Man	10.08	2716.1	0.238
Fol x Var x Nrate	23.75	3451.1	0.899
Fol x Man x Nrate	23.75	3451.1	0.790
Var x Man x Nrate	90	3010.9	0.787
Fol x Var x Man x Nrate	51.86	4579.9	0.419

† calculated from combine seed yield

Table 5.167. Rosemaund. Thousand seed weight

Variety	N rate kg/ha	No Folicur Conv	CM	Mean	Folicur (1.0 l/ha) Conv	CM	Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	5.26		5.26	5.31		5.31	5.28		5.28
Winner	60	5.01	5.28	5.15	5.03	5.68	5.35	5.02	5.48	5.25
Winner	180	5.25	5.56	5.40	5.29	5.71	5.50	5.27	5.63	5.45
Winner	300	5.35	5.82	5.59	5.54	5.83	5.69	5.45	5.83	5.64
Winner	Mean	5.22	5.48	5.35	5.29	5.63	5.46	5.25	5.56	5.41
Castille	0	6.15		6.15	6.43		6.43	6.29		6.29
Castille	60	5.74	6.07	5.90	5.94	6.20	6.07	5.84	6.13	5.99
Castille	180	5.92	6.28	6.10	6.06	6.31	6.18	5.99	6.30	6.14
Castille	300	6.33	6.64	6.48	6.17	6.56	6.36	6.25	6.60	6.42
Castille	Mean	6.04	6.29	6.16	6.15	6.37	6.26	6.09	6.33	6.21
Win+Cas	0	5.71		5.71	5.87		5.87	5.79		5.79
Win+Cas	60	5.38	5.67	5.53	5.49	5.94	5.71	5.43	5.81	5.62
Win+Cas	180	5.59	5.92	5.75	5.67	6.01	5.84	5.63	5.96	5.80
Win+Cas	300	5.84	6.23	6.04	5.85	6.20	6.02	5.85	6.21	6.03
Win+Cas	Mean	5.63	5.88	5.76	5.72	6.00	5.86	5.67	5.94	5.81

Treatment	df	SED	P-Value
Folicur	3	0.028	0.031
Variety	90	0.044	<.001
N management	90	0.044	<.001
Nrate	90	0.062	<.001
Fol x Var	30.78	0.052	0.898
Fol x Man	30.78	0.052	0.759
Var x Man	90	0.062	0.456
Fol x Nrate	75.78	0.081	0.384
Var x Nrate	90	0.088	0.057
Man x Nrate	90	0.088	0.008
Fol x Var x Man	75.78	0.081	0.539
Fol x Var x Nrate	91.68	0.119	0.355
Fol x Man x Nrate	91.68	0.119	0.859
Var x Man x Nrate	90	0.124	0.913
Fol x Var x Man x Nrate	92.87	0.172	0.529

Table 5.168. Rosemaund. Seeds/m^2

Variety	N rate kg/ha	No Folicur Conv	No Folicur CM	No Folicur Mean	Folicur (1.0 l/ha) Conv	Folicur (1.0 l/ha) CM	Folicur (1.0 l/ha) Mean	Conv Mean	CM Mean	Grand Mean
Winner	0	45801		45801	43932		43932	44867		44867
Winner	60	66827	62172	64499	68610	60783	64696	67719	61477	64598
Winner	180	75676	62474	69075	74075	71619	72847	74876	67047	70961
Winner	300	74289	69512	71901	73615	71718	72666	73952	70615	72283
Winner	Mean	65648	59990	62819	65058	62013	63536	65353	61001	63177
Castille	0	44411		44411	38248		38248	41330		41330
Castille	60	68842	59748	64295	59203	53017	56110	64023	56382	60202
Castille	180	73827	64526	69176	69195	59681	64438	71511	62104	66807
Castille	300	69256	56393	62824	71550	59611	65580	70403	58002	64202
Castille	Mean	64084	56270	60177	59549	52639	56094	61816	54454	58135
Win+Cas	0	45106		45106	41090		41090	43098		43098
Win+Cas	60	67835	60960	64397	63907	56900	60403	65871	58930	62400
Win+Cas	180	74751	63500	69126	71635	65650	68643	73193	64575	68884
Win+Cas	300	71772	62953	67363	72582	65664	69123	72177	64309	68243
Win+Cas	Mean	64866	58130	61498	62304	57326	59815	63585	57728	60656

Treatment	df	SED	P-Value
Folicur	3	3117	0.627
Variety	90	1080.2	<.001
N management	90	1080.2	<.001
Nrate	90	1527.6	<.001
Fol x Var	3.76	3298.8	0.029
Fol x Man	3.76	3298.8	0.418
Var x Man	90	1527.6	0.167
Fol x Nrate	5.53	3635.3	0.169
Var x Nrate	90	2160.3	0.441
Man x Nrate	90	2160.3	0.022
Fol x Var x Man	5.53	3635.3	0.693
Fol x Var x Nrate	9.93	4228.8	0.278
Fol x Man x Nrate	9.93	4228.8	0.797
Var x Man x Nrate	90	3055.2	0.445
Fol x Var x Man x Nrate	21.25	5217	0.575

† calculated from combine seed yield

6. Discussion

6.1 Effects of Canopy Management on yield

The regression analyses showed that the Canopy Managed and Conventional N strategies did not result in significantly different N optima in any of the experiments. In the 2005/6 season the Canopy Management approach increased yield over the Conventionally timed N treatments at the sites with a moderate or large combined supply of N in the soil and crop in February (soil N supply – SNS). The yield of Winner was increased by 0.36 t/ha at Boxworth and 0.15 t/ha at Rosemaund, and the yield of Castille was increased by 0.10 t/ha at Boxworth with no effect at Rosemaund (Table 6.1). The yield increases were associated with reduced lodging as a result of stem shortening. Measurements in later experiments showed that Canopy Management reduced height by up to 10 cm. Canopy Management was also shown to reduce the size of the canopy at flowering. This will have helped the crops, which would otherwise have produced an over-large canopy, to achieve the optimum sized canopy and set more seeds/m^2. At High Mowthorpe the SNS was just 67 kg/ha and the Canopy Management approach had no effect on Winner and slightly reduced the yield of Castille. This result demonstrated that a greater proportion of N must be applied early to crops with a small SNS to give the crop sufficient time to take up enough N by flowering to achieve the optimum GAI. This was used to modify the Canopy Management approach for later experiments.

Table 6.1. 2005/6 experiment summary.

	BX06		HM06		RM06	
†Jan/Feb soil mineral N (kg/ha)	50		35		60	
Jan/Feb crop N content (kg/ha)	72		32		33	
Jan/Feb GAI	1.40		0.57		0.63	
N timing strategy	Conv	CM	Conv	CM	Conv	CM
Optimum N rate (kg/ha)	70	70	239	239	224	224
N rate at 1st split (end Feb/early March)	35	0	120	40	112	0
N rate at 2nd split (early stem ext.)	35	70	119	140	112	140
N rate at 3rd split (yellow bud to mid flower)	0	0	0	59	0	84
Yield at opt N Winner (t/ha)	3.40	3.76	3.69	3.62	4.40	4.55
Yield at opt N Winner + Folicur (t/ha)	3.60	3.74	3.86	3.89	4.62	4.58
Yield at opt N Castille (t/ha)	4.04	4.12	4.56	4.43	4.90	4.91
Yield at opt N Castille + Folicur (t/ha)	4.19	4.31	4.84	4.74	4.99	4.92

†Measured to 90 cm at Boxworth and Rosemaund and 60 cm depth at High Mowthorpe.

Conv – conventional N timing strategy; CM – Canopy Managed N timing strategy.

In the 2006/7 season, the crops at each site had moderate to large canopies in February and in a typical season would have been expected to produce over-large canopies and to benefit from a Canopy Managed approach. However, negligible rainfall between the end of March and early May restricted canopy growth which resulted in moderate sized canopies at flowering. Across all the treatments at Boxworth, Canopy Management increased yield slightly by 0.08 t/ha (Table 6.2; P=0.082). This advantage was greater at high N rates and for Winner, for example at 300 and 360 kg N/ha Canopy Manegement gave a 0.28 t/ha yield advantage. The yield increase was shown to result from less early lodging as a result of crop shortening and a small increase in seeds/m^2 which was probably caused by achieving a canopy size at flowering that was closer to the optimum. At Rosemaund Canopy Management did not affect yield despite the very dry spring. There was no effect on yield because Canopy Management reduced the size of the canopy at flowering from above the optimum to slightly below the optimum, and because there was only slight lodging at this site. At High Mowthorpe Canopy Management reduced yield by 0.14 t/ha. The spring drought was most severe at this site which resulted in the development of a sub-optimal canopy at flowering. Canopy Management reduced the canopy size further and this resulted in slightly fewer seeds/m^2 set.

Table 6.2. 2006/7 experiment summary.

	BX07		HM07		RM07	
†Jan/Feb soil mineral N (kg/ha)	43		58		54	
Jan/Feb crop N content (kg/ha)	92		54		61	
Jan/Feb GAI	2.37		1.21		2.08	
N timing strategy	Conv	CM	Conv	CM	Conv	CM
Optimum N rate (kg/ha)	54	54	156	156	165	165
N rate at 1st split (end Feb/early March)	0	27	78	0	83	0
N rate at 2nd split (early stem ext.)	54	27	78	120	83	100
N rate at 3rd split (yellow bud to mid flower)	0	0	0	36	0	65
Yield at opt N Winner (t/ha)	3.05	3.05	4.50	4.31	4.66	4.66
Yield at opt N Winner + Folicur (t/ha)	2.90	3.06	4.64	4.42	4.88	4.84
Yield at opt N Castille (t/ha)	3.66	3.63	5.20	5.12	5.04	4.99
Yield at opt N Castille + Folicur (t/ha)	3.51	3.63	5.17	5.10	5.09	5.11

†Measured to 90 cm at Boxworth and Rosemaund and 60 cm depth at High Mowthorpe.

Conv – conventional N timing strategy; CM – Canopy Managed N timing strategy.

In the 2007/8 season the crops at Boxworth and High Mowthorpe were very small in February following slow emergence during the dry autumn and had a modest amount of mineral N in the soil (Table 6.3). After the first year the Canopy Management approach was further developed to be applicable for crops with a small SNS by

including an estimate of the latest date when the N should be applied to give the crop sufficient time to build the optimum sized canopy. This assumed a rate of crop N uptake of 3 kg N/ha. Based on this 40 to 60 kg N/ha was applied at the first Conventional split timing (early March) at these sites compared with 118 to 128 kg N/ha for the Conventional strategy. Overall, there were no differences in yield between the two strategies at Boxworth and High Mowthorpe indicating that the Canopy Management strategy is appropriate for crops with a small SNS. The crop at Rosemaund also had a small SNS, but with a moderate sized canopy and a very small amount of soil N. The original Canopy Management principles were tested at this site with all of the N required for the optimum canopy applied at the 2nd Conventional split timing (31 March). At this site Canopy Management did not affect the yield of Winner and reduced the yield of Castille by 0.29 t/ha. If the modified Canopy Management principles had been applied then 50 kg N/ha would have been applied in early March which is likely to have prevented any yield penalty and may have increased the yield of Winner.

Table 6.3. 2007/8 experiment summary.

	BX08		HM08		RM08	
†Jan/Feb soil mineral N (kg/ha)	58		38		12	
Jan/Feb crop N content (kg/ha)	8		10		50	
Jan/Feb GAI	0.19		0.10		1.36	
N timing strategy	Conv	CM	Conv	CM	Conv	CM
Optimum N rate (kg/ha)	256	256	236	236	128	128
N rate at 1st split (end Feb/early March)	128	40	118	60	64	0
N rate at 2nd split (early stem ext.)	128	180	118	170	64	128
N rate at 3rd split (yellow bud to mid flower)	0	36	0	6	0	0
Yield at opt N Winner (t/ha)	3.82	3.80	3.42	3.43	4.01	3.98
Yield at opt N Winner + Folicur (t/ha)	3.84	3.92	3.76	3.65	4.20	4.18
Yield at opt N Castille (t/ha)	4.00	3.99	3.78	3.78	4.49	4.21
Yield at opt N Castille + Folicur (t/ha)	4.06	4.10	4.04	4.16	4.45	4.14

†Measured to 90 cm at Boxworth and Rosemaund and 60 cm depth at High Mowthorpe.

Conv – conventional N timing strategy; CM – Canopy Managed N timing strategy.

6.2 Testing the Canopy Management principles

6.2.1 Soil N uptake efficiency

The efficiency with which the crop took up soil N was calculated by dividing the amount of N taken up by the crop at harvest by the amount of mineral N measured in the soil and the crop N in February. Soil mineral N was measured to 90 cm at Rosemaund and Boxworth and to 60 cm at High Mowthorpe. Overall 9 site/seasons were tested including cv Winner from each of the three sites in 2006 and 2007, and

an average of Winner and Castille in 2008. On average the efficiency with which soil N was taken up was estimated to be 107% (Figure 6.1) and there were no systematic differences between the sites or seasons. The data in Figure 6.1 indicates that crops took up on average an additional 4 to 11 kg N/ha compared with the amount of mineral N measured in the soil in February. The uptake efficiency ranged from 63% at Boxworth in 2008 to between 139% and 149% at Boxworth 2006, High Mowthorpe 2008 and Rosemaund 2008. Boxworth 2008 had a very low plant population which may have resulted in a sub-optimal root length density and a lower soil N uptake efficiency. Soil N uptake efficiency values of significantly more than 100% were observed in some crops, which may simply be the result of sampling variation, or may indicate that these crops took up some N which was mineralised after February. In 2008, it was possible to compare the two varieties and this showed that Castille had a greater soil N uptake efficiency at each site with an average soil N uptake efficiency of 130% compared with 113% for Winner. This increase was similar in size to the greater amount of yield taken into the seed of higher yielding Castille.

No other studies can be found which have measured soil N uptake efficiency in oilseed rape. In wheat, studies have generally found the crop takes up 20 to 50 kg N/ha more than amount of N measured in the soil in spring (Stokes *et al*., 1997; Webb and Sylvester-Bradley, 1995; Sylvester-Bradley *et al*., 2008). This study only includes nine sites, but indicates that oilseed rape may take up less N that is mineralised after February compared with wheat. This may be because oilseed rape stops taking N up earlier than wheat and therefore has less time to take up N that is mineralised as the soil warms up in the spring. Differences in rooting between wheat and oilseed rape may also be a factor. Further work must investigate how much N that is mineralised after after February is taken up by oilseed rape, and this must also take account of any N that is deposited from the atmosphere during the growth period.

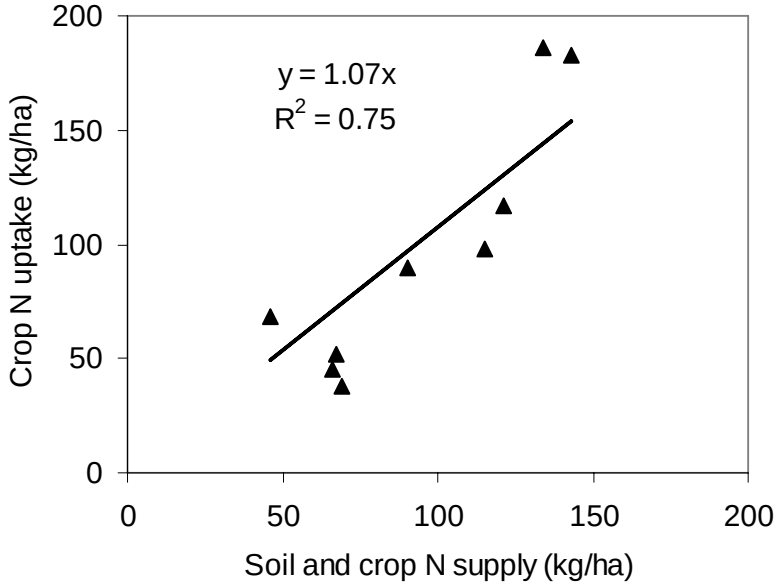

Figure 6.1. Relationship between the combibed soil mineral N and crop N measured in February and the crop N uptake at harvest for crops grown at Boxworth, High Mowthorpe and Rosemaund in 2006, 2007 and 2008.

6.2.2 Fertiliser N uptake efficiency

The equivalent efficiency with which fertiliser N was taken up by the crop was calculated by subtracting the N taken up by the crop without fertiliser from the N taken up with fertiliser and dividing by the rate of fertiliser N applied. This was carried out for 24 crops across the three sites and three seasons. At the N rate that was closest to the economic optimum (which was 167 kg N/ha on average) the fertiliser N uptake efficiency was calculated at 57%. The coefficient of variation of this calculation across the 24 crops was 23%. Across the 3 sites, the fertiliser N uptake efficiency was lower in 2008 (47%) compared with 63% in 2006 and 63% in 2007. There were no systematic differences between sites or between the Canopy Managed and Conventional N timings. At the lowest fertiliser N rate that fertiliser N uptake efficiency could be calculated (which averaged 100 kg N/ha across the trials) the fertiliser N uptake efficiency was 67%. At 240 kg N/ha the average Fertiliser N uptake efficiency was 43%. These differences emphasise the importance of calculating the N uptake efficiency at the economically optimum N rate. Few other studies can be found which have measured the fertiliser N uptake efficiency in oilseed rape. Schjoerring *et al.* (1995) measured a fertiliser uptake efficiency of 50% on a sandy loam, but it is not known if the N rate used was the economic optimum. In wheat Gryllis *et al.* (1987) observed that shallow soils over chalk had a slightly lower fertiliser uptake efficiency compared with other soil types. This current study found no evidence for this in

oilseed rape, although it should be recognised that insufficient experiments have been performed to make anything other than a cursory comparison of soil types. In 2008, there was little difference between the fertiliser uptake efficiency of Castille and Winner. The combined efficiency with which the soil N and optimum fertiliser N rate were taken up was 77% across all of the crops that were analysed in this study.

6.2.3 Relationship between GAI and crop N content

In February, crops with a GAI of between 0.1 and 1.5 contained 49 kg N per unit of GAI (Figure 6.2). Crops with GAIs of between 1.5 and 2.5, which were measured at Rosemaund and Boxworth in 2007 and Rosemaund in 2008, contained about 40 kg N per unit of GAI on average. These crops grew in seasons with a mild autumn and winter which increased the rate of over winter growth and it is possible that the tissue N concentration becomes diluted under these conditions.

For crops measured at mid-flowering on 2007 and 2008 and the end of flowering in 2006, each unit of GAI up to the target GAI of 3.5 contained 43 kg N/ha (Figure 6.3). The slope of this regression line was not significantly different from a slope of 50 kg N per unit of GAI. The crops tested had either received no fertiliser or 120 kg N/ha and included Winner and Castille. There was no significant difference in the amount of N contained within each unit of GAI between N rate, variety, site or year.

The Canopy Management principles assume that each unit of GAI contains 50 kg N/ha. This assumption was made following work by Stokes *et al.* (1998) who demonstrated that each unit of GAI contains 50 kg N/ha using cv Apex grown with different management and sampled at a range of developmental stages and the GAIs ranged from 1 to 6. The work of this present study largely supports the assumption that each unit of GAI contains 50 kg N/ha. However further work should test whether large canopies in February resulting from a mild autumn/winter contain less than 50 kg N/ha and a wider range of varieties and conditions should be used to confirm that each unit of GAI contains 50 kg N at flowering.

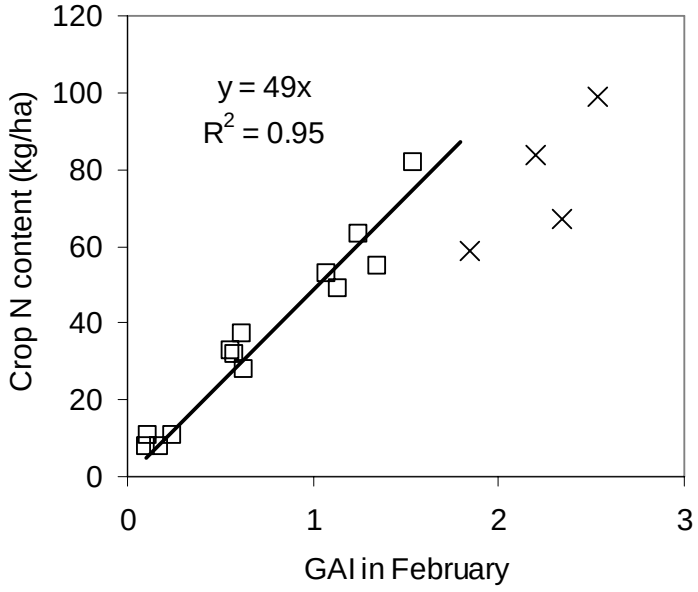

Figure 6.2. Relationship between GAI and crop N content measured in February for cvs Winner and Castille grown at Boxworth, High Mowthorpe and Rosemaund in 2006, 2007 and 2008. Crops of GAI 1.5 or below (squares), crops above GAI 1.5 (crosses).

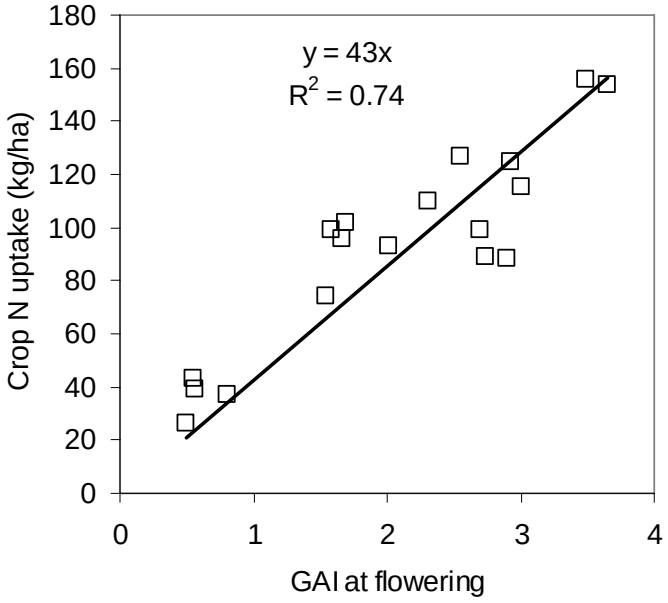

Figure 6.3. Relationship between GAI and crop N content at flowering for cvs Winner and Castille grown at 0 and 120 kg N/ha at Boxworth, High Mowthorpe and Rosemaund in 2006, 2007 and 2008.

6.2.4 Duration of N uptake

In 2006, there was no net N uptake after the end of flowering on average across the sites. In 2007 and 2008 the amount of N taken up after mid flowering was 74 kg N/ha and 27 kg N/ha respectively across all sites. Differences between sites were small (25 kg N/ha) compared with the differences between seasons. The large amount of N taken up after mid flowering in 2007 may have been related to the dry period between the end of March and early May in this season. This observation indicates that oilseed rape has the capacity to take up N after flowering under certain conditions and further work must investigate what determines the amount of N that is taken up after flowering and whether this varies between varieties.

6.2.5 Relationship between N requirement and yield

Whether or not the yield potential of each site affected the N supply required to achieve the yield potential was investigated by comparing the yield at the economic optimum (as calculated from the N response curves) with the supply of N available for crop uptake (100% of soil and crop N in February and 60% of the optimum fertiliser N) (Figure 6.4) to account for differences in soil residual N between sites. At each of the nine sites carried out within this study the average optimum yield across all treatments was used. In each experiment the optimum N rate was the same for all treatments. Data from an additional nine N response experiments from GrowHow UK Ltd were also included in the analysis. The regression analysis showed that each additional tonne of yield required an additional 36 kg/ha of crop available N. It is estimated that this would be equivalent to 36 kg/ha of soil mineral N or 60 kg/ha of fertiliser N for each additional tonne of yield.

These findings are consistent with two other datasets. Between 1988 and 1991, 28 N response experiments were carried out for the development of the RB209 Guidelines. Analysis of this data showed that the optimum N rate (calculated using a BER of 2.5 rose by 60 kg N/ha for each additional tonne of yield. Holmes and Ainsley (1979) analysed 41 N response experiments and showed that crops with an optimum yield of less than 2.5 t/ha had an N opt of 158 kg N/ha. Crops with an optimum yield of 2.5 to 3.5 t/ha had an N opt of 206 kg N/ha. Crops with an optimum yield of more than 3.5 t/ha had an N opt of 251 kg N/ha. This indicates that about an additional 50 kg N/ha is required for each additional tonne of yield.

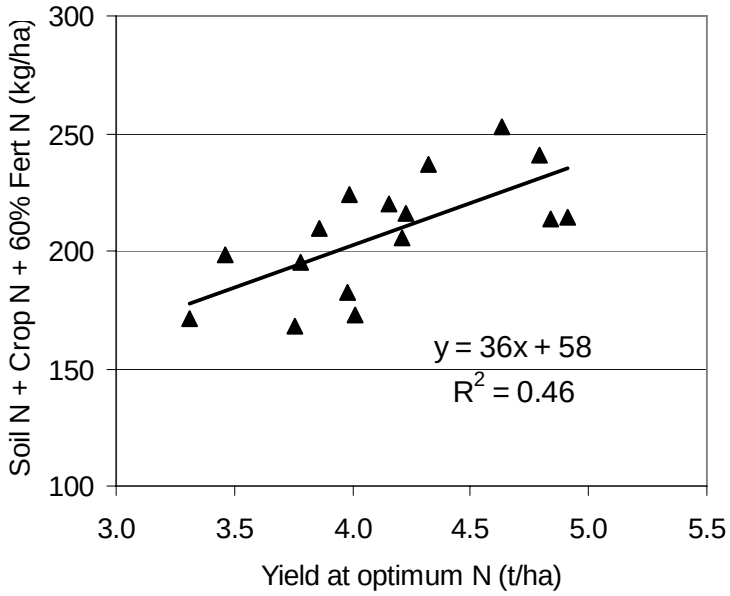

Figure 6.4. Relationship between the yield at the economic optimum N rate and the supply of N that is available for crop uptake. Each point represents data from an N response experiment.

6.3 Predicting fertiliser N requirement

The Canopy Management principles predict the optimum amount of fertiliser N based on measurements of the soil and crop N in February, a realistic estimate of the potential yield, together with assumptions about the efficiencies with which the crop takes up N from the soil and fertiliser. These principles were tested at each of the nine experimental sites described in this study and nine N response experiments from GrowHow. Each test was done retrospectively against the economic optimum calculated from the fitted linear plus exponential response curves (using a break even ratio of 2.5). The accuracy of the Canopy Management principles to predict optimum N rate was compared against RB209 guidelines; 1) using the book values to estimate the SNS and 2) using measured values of SNS. Each RB209 test included adding 30 kg N/ha for the sites which achieved a yield of more than 4 t/ha. The tests showed that the Canopy Management principles were the most accurate method of predicting the optimum N rate with an average error of +/- 32 kg N/ha for yield (Table 6.4). The second most accurate method that was tested was RB209 guidelines using measurements of soil and crop N which had an average error of 39 kg N/ha and 35 kg N/ha after accounting for the oil premia. Relying on RB209 look up tables to estimate the SNS, rather than taking a measurement, significantly increased the error to between 48 and 59 kg N/ha.

Table 6.4. Average error in the prediction of the fertiliser N requirement (kg N/ha).

	Optimum yield	Optimum yield after accounting for oil premia
RB209	+/- 48	+/- 59
RB209 with soil N measurements	+/- 39	+/- 35
Canopy Management	+/- 32	+/- 32

Based on 18 N response experiments between 2006 and 2008.

6.4 Folicur

Folicur applied at the green bud stage at a rate of 0.5 l/ha or 1.0 l/ha increased yield by up to 0.32 t/ha and did not cause any significant yield reductions. On average across all experiments Folicur increased the yield of Winner by 0.15 t/ha and Castille by 0.10 t/ha. Disease was minimised in all experiments using fungicides without growth regulatory activity. At Rosemaund in 2006, Folicur increased yield more for the Conventionally timed N treatments than for the Canopy Managed N treatments ($P<0.1$). There was no statistical evidence that Canopy Management affected the response to Folicur at any of the other sites. Folicur significantly increased the yield of Winner more than Castille at three sites. At least part of this effect resulted from the greater scope for lodging control in the more lodging prone variety Winner compared with Castille. Folicur increased yield more at high N rates at Rosemaund in 2008, but no other statistically significant interations between Folicur and N rate were observed in the other experiments. Numerically Folicur had a smaller effect when nil N was applied compared with higher rates. On average across all of the trials the yield response at nil N was 0.04 t/ha compared with 0.12 t/ha across the 60 to 360 kg N/ha treatments.

At the sites where Folicur significantly increased yield there was usually a significant reduction in lodging caused by Folicur. The reductions in lodging were at least partially caused by reductions in height of between 3 and 10 cm. There was no evidence of any differential height reduction between Canopy Management and Conventional N timings or between Winner and Castille. Greater height reductions occurred at higher N rates in only one experiment. Surprisingly large reductions in lodging were observed in response to relatively modest reductions in height in two experiments and further work should investigate whether Folicur reduces lodging by affecting other plant traits such as stem strength. It is possible that part of the yield increases were also caused by the Folicur treatment increasing the number of seeds set as a result of reducing

the amount of light absorbed and reflected by the flowers. Reduced light reflection from the flowers in response to Folicur was observed at 2 of the 5 sites where it was tested. At High Mowthorpe in 2007 the positive yield effect was unexpected because there was negligible lodging and the canopy at flowering was small. Although fungicides without growth regulatory activity were used in all of the experiments to minimise disease, it is possible that some yield response to Folicur resulting from disease control occurred at this site.

7. Conclusions

- Delaying N through using Canopy Management principles increased yield by up to 0.36 t/ha in situations where the crop would have produced an over-large and lodging-prone canopy.
- Following modifications to account for the start date for N application the Canopy Management approach was shown to be robust both with backward crops and where dry conditions in the spring delayed N uptake.
- The yield increase has been shown to be associated with reduced stem growth leading to shorter plants and less lodging, and possibly increased seed set.
- Methods of employing the Canopy Management principles have been developed so that they are applicable for all types of crop including low biomass varieties and crops with small amounts of N in the crop and soil in February.
- The assumptions that underlie Canopy Management have been validated within the series of experiments carried out within this study.
- Using the Canopy Management principles to calculate the N fertiliser requirement based on the amount of N in the crop and soil in the spring, together with the yield potential, is accurate across sites and seasons, and more accurate that RB209 guidelines.
- The application of Folicur at green bud increased yield by up to 0.32 t/ha and resulted in average yield increases across the 9 experiments in the presence of minimal amounts of disease of 0.15 t/ha for Winner and 0.10 t/ha for Castille. Using Canopy Managed N timings did not affect the size of the yield response.
- Further work must investigate how much of the N that is mineralised after February is taken up by the crop.
- The results from this project have been used to develop the ‘N-Calc’ fertiliser recommendation system run by Growhow UK Ltd and to revise the relationship between N rate and potential yield in the new RB209 guidelines.

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Appendix 1. Site details 2005/6

Site	**ADAS Boxworth**
Field name:	Top Pavements
Soil texture:	Clay, Hanslope series
Sowing date	08/09/05
Harvest date:	21/07/06
Previous cropping	
Harvest year	
2005	W Wheat
2004	W Wheat
2003	WOSR
Soil analyses 16/01/2006	
pH	8.4
P	Index 2
K	Index 3
Mg	Index 2
Fertilisers (N, P, K, S)	
14/09/05	12:18:0:0 @ 400L/ha
06/03/06	Keiserite @ 150 kg/ha & TSP @ 326 kg/ha
Crop Protection	
Herbicides	
27/10/05	Aramo @ 1 L/ha
Insect/molluscicides	
15/09/05	Draza @ 5 kg/ha
29/09/06	Mini pellets @ 15 kg/ha
Fungicides	
27/10/06	Punch C @ 0.398 L/ha
07/02/06	Plover @ 0.249 L/ha
04/04/06	Folicur @ 1 L/ha (half trial)

Site	**High Mowthorpe**
Field name:	Warren
Soil texture:	Silty loam over chalk, Andover series
Sowing date	28/08/05
Harvest date:	05/08/06
Previous cropping	
Harvest year	
2005	Winter barley
2004	Winter wheat
2003	Winter wheat
Soil analyses	
	pH 8.0 P index 2 K index 2- Mg index 1 OM% 4.13
Fertilisers (N, P, K, S)	
22/03/06	1st N split
05/04/06	150 kg/ha Kieserite
12/04/06	2nd N split
03/05/06	3rd N split
Crop Protection	
Herbicides	
18/11/05	Falcon (0.59 l/ha)
Insect/molluscicides	
14/09/05	Rivet slug pellets (5 kg/ha)
18/11/05	Cypermethrin (0.25 l/ha)
Fungicides	
18/11/05	Punch C (0.43 l/ha)
24/04/06	Riza (0.7 l/ha)
17/05/06	Proline (0.4 l/ha)

Site	**ADAS Rosemaund**
Field name:	Benty Bear
Soil texture:	Silty loam, Bromyard series
Sowing date	06/09/05
Harvest date:	29/07/06
Previous cropping	
Harvest year	
2005	Winter Wheat
2004	Potatoes
2003	Winter wheat
Soil analyses	
P - 06/02/06	Index 2
K - 06/02/06	Index 1
Mg - 06/02/06	Index 3
pH - 06/02/06	6.7
Fertilisers	
06/04/06	Kieserite (170 kg/ha)
Crop Protection	
Herbicides	
15/11/06	Kerb Flo (1.75 l/ha)
22/03/06	Dow Shield (0.349 l/ha)
Insect/molluscicides	
02/10/05	Metaldehyde (4 kg/ha)
15/11/06	Hallmark (0.075l/ha)
Fungicides	
15/11/06	Plover (0.25 l/ha)
31/01/06	Plover (0.25 l/ha)

Appendix 2. Site details 2006/7

Site	**ADAS Boxworth**
Field name:	Taylors
Soil texture:	Clay, Hanslope series
Sowing date	01/09/06
Harvest date:	19/07/07
Previous cropping	
Harvest year	
2006	W Wheat
2005	W Wheat
2004	W OSR
Soil analyses 16/01/06	
	pH 7.7 P Index 3 K Index 3 Mg Index 3
Fertilisers (N, P, K, S)	
26/02/07	N – applied to conventional plots various rates
21/03/07	Keiserite (120 kg/ha)
15/03/07	N – applied to conventional and managed plots various rates
04/04/07	N – applied to managed plots various rates
Crop Protection	
Herbicides	
05/09/06	Glyphos (2.0 l/ha), Butisan (1.0 l/ha), Trifluralin 480 (2.0 l/ha)
Insect/molluscicides	
05/09/06	Mini pellets (15 kg/ha)
13/10/06	Cypermethrin (0.25 l/ha)
01/05/07	Aphox (0.42 l/ha)
Fungicides	
13/10/06	Punch C (0.4 l/ha)
09/12/06	Punch C (0.4 l/ha)
14/03/07	Folicur applied to half trial (1.0 l/ha)

Site	**High Mowthorpe**
Field name:	Crow Tree
Soil texture:	Silty loam over chalk, Andover series
Sowing date	10/09/06
Harvest date:	01/08/07
Previous cropping	
Harvest year	
2006	Winter wheat
2005	Spring beans
2004	Winter wheat
Soil analyses	
	pH 7.9 P Index 3 K index 2+ Mg index 1 OM - %
Fertilisers (N, P, K, S)	
07/03/07	1st N split
15/03/07	Kieserite (150 kg/ha)
02/04/07	2nd N split
16/04/07	3rd N split
28/04/07	Bittersaltz (10 kg/ha)
Crop Protection	
Herbicides	
13/09/06	Katamaran (2.0 l/ha)
02/11/06	Falcon (0.45 l/ha)
Insect/molluscicides	
14/09/06	Mini slug pellets (8.0 kg/ha)
02/11/06	Cypermethrin (0.26 l/ha)
Fungicides	
02/11/06	Plover (0.3 l/ha)
29/03/07	Punch C (0.4 l/ha)
04/04/07	Folicur applied to half trial (1.0 l/ha)
28/04/07	Proline (0.4 l/ha)

Site	**ADAS Rosemaund**
Field name:	Stoney
Soil texture:	Silty Clay Loam (Bromyard Series)
Sowing date	29/08/06
Harvest date:	07/08/07
Previous cropping	
Harvest year	
2006	Winter Oats
2005	Winter Wheat
2004	Winter Oats
Soil analyses	pH 6.4 P 12 mg/l (index 1) K 157mg/l (index 2-) Mg 114mg/l (index 3) OM% 1.98%
Fertilisers (N, P, K, S)	
30/03/07	Kieserite (92.5 kg/ha)
Crop Protection	
Herbicides	
19/09/06	Katamarran (2.0 l/ha)
19/09/06	Laser (0.5 l/ha)
27/10/06	Falcon (1.0 l/ha)
Insect/molluscicides	
19/09/06	Cypermethrin (0.25 l/ha)
Fungicides	
27/10/06	Plover (0.25 l/ha)
01/02/07	Plover (0.25 l/ha)
23/03/07	Folicur applied to half trial (1.0 l/ha)
10/04/07	Proline (0.4 l/ha)

Appendix 3. Site details 2007/8

Site	**ADAS Boxworth**
Field name:	40 acres
Soil texture:	Clay loam
Sowing date	05-09-07
Harvest date:	11/08/08
Previous cropping	
Harvest year	
2007	Wheat
2006	Wheat
2005	OSR
Soil analyses 29.02.08	
	pH 7.3 P 16 mg/l K 211 mg/l Mg 109 mg/l OM 2.92 %
Fertilisers (N, P, K, S)	
27/02/08	1st N treatment
01/04/08	Keiserite 150 kg/ha
02/04/08	2nd N treatment
21/04/08	3rd N treatment
Crop protection	
14/04/08	Folicur to half the plots
Herbicides	
27/02/08	Crawler 3.5 l/ha
05/03/08	Galera 0.35 l/ha
Insect/molluscicides	
10/01/07	Draza slug pellets 6 kg/ha
08/11/07	Draza slug pellets 4 kg/ha
Fungicides	
12/11/07	Punch C – 0.4 l/ha
14/04/08	Punch C – 0.4 l/ha

Site	**High Mowthorpe**
Field name:	Crow Wood
Soil texture:	Shallow silt clay loam over chalk
Sowing date	06/09/07
Harvest date:	08/09/08
Previous cropping	
Harvest year	
2007	W Wheat (2nd)
2006	W Wheat (1st)
2005	W OSR
Soil analyses	
	pH 8 P 15 mg/l K 125 mg/l Mg 33 mgl OM
Fertilisers (N, P, K, S)	
19/10/07	Extran – 94 kg/ha
07/02/08	0:20:30 - 250 kg/ha
Crop Protection	
29/4/08	Folicur spread on half plots
Herbicides	
11/09/2007	Sultan (metazochlor) – 1 l/ha
11/09/2007	Trifluralin (trifluralin) – 1.3 l/ha
17/03/2008	Oram (bifenox) – 1 l/ha
Insect/molluscicides	
10/09/2007	TDS Major
02/10/2007	TDS Major
08/10/2007	Cypermethrin – 0.25 l/ha
19/05/2008	Mavrik – 0.2 l/ha
Fungicides	
11/02/2008	Difcor – 0.25 l/ha
17/04/2008	Proline – 0.4 l/ha

Site	**ADAS Rosemaund**	
Field name:	19 Acres - Sutton St Nicholas, Herefordshire	
Soil texture:	Silt clay loam	
Sowing date	03/09/08	
Harvest date:	07 & 08/08/08	
Previous cropping		
Harvest year		
2007	W.Wheat	
2006	Peas	
2005	W.Wheat	
Soil analyses	P	15 (mg/l)
	K	125
	Mg	167
	pH	7
Fertilisers (N, P, K, S)		
25/08/2007	0.0.60 – 185 kg/ha	
08/04/08	Keiserite – 151 kg/ha	
04/03/08	First N split	
28/03/08	Second N split	
14/04/08	Third N split	
Crop Protection		
04/04/08	Folicur applied to half the plots – 1 l/ha	
Herbicides		
03/09/2007	Treflan + Centium - 2l/ha +0.25l/ha	
Insect/molluscicides		
04/09/2007	Metaldehyde - 4kg/ha	
23/10/2007	Cypermethrin - 0.25l/ha	
Fungicides		
04/04/08	Contrast - 0.4l/ha	
22/04/08	Filan - 0.4kg/ha	