To: Dr E Moorehouse
Horticultural Development Council
18 Lavant Street
Petersfield
Hants GU32 3EW

PREDICTION OF NITROGEN REQUIREMENT FOR VEGETABLES
FV17a PART 2
BRUSSELS SPROUTS AND CEREALS

From: C R Rahn BSc PhD*
ADAS Soil & Water Research Centre
Anstey Hall Maris Lane
Trumpington
Cambridge CB2 2LF
Tel: 0223 840011

* now at Horticulture Research International, Wellsbourne

Correspondence/contact regarding this research to
Dr B J Chambers at above address

CONTENTS

SUMMARY

ADAS nitrogen recommendations for Brussels sprouts grown on silt soils are currently 200 kg/ha following cereals (Index 0) and 150 kg/ha following vegetable crops receiving more than 200 kg/ha N (Index 1 soils). These recommendations were tested following a double cauliflower crop to which had been applied N rates varying from 0 - 600 kg in 1989 and 0 - 450 kg in 1990 on a silt loam soil in Lincolnshire.

Maximum marketable yield of buttons was achieved in 1989 where 360 kg/ha of nitrogen had been applied to the previous cauliflower crops and 120 kg/ha N was applied to the Brussels sprout crop at planting. In 1990 maximum yield was achieved where 300 kg/ha N had been applied to the previous cauliflower crops without the application of fertiliser N to the sprout crop. The difference in response to fertiliser applied to the sprout crop could not be explained by taking into account the fertiliser applied to previous crops or by a simple interpretation of mineral N at planting.

Maximum yields of sprouts in both seasons were achieved where the total level of soil mineral N 0-90 cm was 330 kg/ha at planting provided at least 95 kg/ha of the total was found in the top 30 cm. In 1990 more of the soil mineral N was in the top 30 cm due to later incorporation of cauliflower residues so there was less response to freshly added N. Where supplementary fertiliser was applied to reach these levels maximum yields were also achieved. Where excessive amounts of fertiliser were applied, total size of plant increased, but sprout yield did not. Soil mineral N levels at harvest of sprouts were less than 100 kg/ha where optimal rates of N fertiliser had been applied. This is typical of ADAS N index 0 situations.

Sprouts where very effective at removing nitrogen from the soil. However N contained in crop residues ranged from 60 to 268 kg/ha and this was not immediately available to the following spring cereal crop. At planting, levels of soil mineral N were still typical of ADAS index 0 indicating minimal turnover of N from the sprout residues. N did not mineralise substantially from the sprouts until early April in 1989 and mid April in 1990.

In 1990 maximum grain yields of spring barley were achieved without any application of fresh fertiliser where 420 kg/ha N had been applied to the previous 3 crops of brassicas in any combination of N treatments ie 300 + 120, 360 + 60, or 420 + 0. Increased levels of N led to lodging and lower yields. In 1991 maximum yield of spring wheats were only achieved with an application of at least 500 kg/ha to the previous brassica crops. Measurements of N supply (by mineral N) at planting would have suggested addition of substantial amounts of N to the cereal crops with a high risk of causing lodging and loss of yield. Measurements of N in crop and soil in April may provide a better tool but this was not tested.

Mineral N at harvest of cereals was typical of that normally expected after cereals. At optimum yield the cereals utilised most of N from sprout residues in 1989/90 but not in the second year 1990/91. In the second year mineralisation of N from the sprout residues was slower and less available to support the growth of spring wheat.

RECOMMENDATIONS FOR FERTILISING BRUSSELS SPROUTS AND CEREAL CROPS IN A BRASSICA ROTATION

The quantity of nitrogen left behind by brassica crops can be substantial - up to 270 kg/ha from well grown crops. This nitrogen would be worth £81/ha (@ 30 p/kg) to the grower and therefore should be taken into account when fertilising following crops.

The following strategy is suggested for Brussels sprouts:-

1. Where
Brussels sprouts are grown in essentially arable rotations without additions of animal manures the best estimate of fertiliser requirement will be given by existing ADAS fertiliser recommendations (MAFF 1981). (See Table i in the introduction).

2. Where crops are grown in brassica rotations or on fields which have received substantial quantities of animal manures in their history fertiliser recommendations should be based on measurements of soil mineral nitrogen just before planting.

The following is suggested for cereals planted in brassica rotations:-

1. Fertiliser recommendations for cereals should be based on timely measurements of soil mineral nitrogen. Soil mineral nitrogen should not be measured too early to allow for mineralisation of nitrogen from crop debris to have taken place.

Measurements of soil mineral nitrogen should be made to a depth of 90 cm. Samples should be taken after mineralisation of previously incorporated crop residues. This could be several months following winter incorporation or as little as two weeks in the summer. Samples should be kept cool and analysed within 24 hours of sampling or frozen until the analysis can be carried out.

If little mineral N is available in the surface layers to support the growth and development of young sprout plants, fertiliser nitrogen may still be necessary even where profile nitrogen levels are high. It should be remembered that poor soil structure by reducing root development could reduce the availability of nitrogen to the growing crop.

Interpretation of the measurements of soil mineral nitrogen can be provided by the HRI nitrogen model.

A sampling, analysis and interpretation service is provided by ADAS as part of their soil mineral nitrogen service.

PREDICTION OF NITROGEN REQUIREMENT FOR VEGETABLES
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INTRODUCTION

Although nitrogen is the key nutrient for both vegetable yield and quality, there are only crude and often inaccurate methods for estimating nitrogen requirement, mostly based on previous cropping (N Index see Table i). N supply from the soil is a major source of nitrogen for the crop, and commonly varies four-fold and occasionally as much as ten-fold between fields. The current ADAS nitrogen index accounts for only a minor part of the field to field variation in soil nitrogen supply and frequently results in overuse of nitrogen fertiliser and occasionally in underuse. Underuse reduces marketable produce, whereas overuse reduces crop quality, increases nitrate levels in produce and enhances leakage of nitrate into non-agricultural water.

Individual field estimates of nitrogen available to crops can be made from measurements of the amount of mineral nitrogen ($NO3^-$ and $NH4^+$) in soil to the depth of rooting, but additional work is needed to understand how best to use this measure of available nitrogen. To improve prediction by modelling and other means, 5 specific features need to be explored:-

a) The influence of fertiliser nitrogen applied to one crop on the overall soil nitrogen supply to the next crop and on the rate of mineralisation of crop residues.

b) The extent to which different levels of fertiliser nitrogen leave mineral nitrogen in soil at crop harvest.

c) The minimum level to which crop roots can reduce nitrate levels in soil (probably species specific).

d) The immobilisation of fertiliser nitrogen by the soil microflora and the extent of its re-appearance in the year of application.

e) The extent to which defoliation through the growing season contributes to the apparent reduction in recovery of nitrogen by crops.

Part 1, of this report (Rahn 1993), has already described the role of crop residues in the fertiliser requirements of the cauliflower crops. This report considers the effect of residual N on the growth of sprouts and cereals following these crops.

Table ia ADAS Nitrogen index based on last crop grown from Reference Book 209 (MAFF 1981)

Nitrogen Index 0	Nitrogen Index 1	Nitrogen Index 2
Cereals	Peas or beans	Any crop in field receiving large frequent dressings of farmyard manure or slurry
Sugar beet	Potatoes	
Maize	Oilseed rape	
Vegetables receiving less than 200kg/ha N	Vegetables receiving more than 200 kg/ha N	Lucerne
Forage crops removed	Forage crops grazed	Long leys, grazed or cut and grazed, high N(b)
Leys (1-2 year), grazed or cut and grazed, low N(a)	Leys (1-2 year), grazed or cut and grazed (high N(b)	Permanent pasture, cut only, grazed or cut and grazed
Leys (1-2 year), cut only	Long leys, cut only	
Permanent pasture, poor quality, matted	Long leys, grazed or cut and grazed low N(a)	

(a) Low N - less than 250 kg/ha N per year and low clover content
(b) High N - more than 250 kg/ha N per year or high clover content

Table ib. ADAS Fertiliser recommendations based on N index taken from Reference Book 209 (MAFF 1981)

	Nitrogen index 0	1	2
	kg/ha N		
Brussels sprouts			
Silt and brickearths	200	150	100
Other soils	300	250	200
Cauliflowers			
Early, late Summer and Autumn	250	200	125
Spring Barley			
Mineral soils (not sandy or shallow)	150	100	40
Spring Wheat			
Deep silty and clay soils	125	50	Nil

OBJECTIVES

To develop a more comprehensive basis on which to quantify soil nitrogen supply to brassica crops and thereby improve fertiliser nitrogen prediction.

To evaluate the contribution of residues from brassica crops to the supply of nitrogen to succeeding crops.

MATERIALS AND METHODS

Design

Two experiments were carried out during the period 1988-1991: An HDC sponsored experiment in 1988 and a MAFF commissioned repeat in 1989. The experiments were situated at HRI-Kirton (formerly Kirton EHS). The cropping pattern is outlined below.

Experiment Sponsors	Cropping				
	1987	1988	1989	1990	1991
HDC	Grass	2 x Cauliflower	Brussels sprouts	S. Barley	-
MAFF	Brassicas	Barley	2 x Cauliflower	Brussels sprouts	S. Wheat

Details of crop husbandry are shown in Appendix 1.

The crops immediately prior to the early summer cauliflowers received no fertiliser nitrogen, and were therefore thought likely to leave residues consistent with N index 0 soils.

The first early summer cauliflower crop was planted in March and was treated with 6 levels of N in 1988 and 5 levels in 1989. This allowed the response of an early summer cauliflower crop to fertiliser nitrogen to be measured. The plots were split to test the response to fertiliser N applied to the second crop with different levels of first crop residues. Plots were split into 6 in 1988 and into 3 in 1989. At this stage each treatment was replicated 3 times in fully randomised blocks.

A third crop, Brussels sprouts, was planted in May of the following year. In the HDC experiment the effect of residues from the 2 cauliflower crops on the response of Brussels sprouts to 3 levels fresh fertiliser nitrogen (0, 60, 120 N kg/ha) was tested with no replication. In the MAFF experiment 2 levels (0, 200 kg/ha N) were tested with twofold replication.

A fourth test crop, a cereal, receiving no additional fertiliser was grown to assess the amount of available N from residues of the previous brassica rotation.

Table ii **Treatments and Diary of Events - 1988 HDC Experiment**

	Crop	Crop	Crop	Crop
Crop:	Cauliflower	Cauliflower	Brussels	S Barley
Variety:	"Perfection"	"White Rock"	"Stephen"	"Blenheim"
Planted as:	$6cm^3$ blocks	'308' Module	'308' Module	Seed @ 154kg/ha
Date planted:	30/3/88	8/7/88	19/5/89	21/2/90
Plant spacing:	61cm x 46cm	61cm x 46cm	61cm x 46cm	-
Plot size m:	10.98 x 18.72	3.66 x 7.36	3.66 x 7.36	3.66 x 7.36
Treatments:	6	36	108	108
Replicates:	3	3	1	1
Nitrogen rates (kg/ha):	0 60 120 180 240 300	0 60 120 180 240 300	0 60 120 - - -	0 - - - - -
Dates nitrogen applied:	29/3/88 27/4/88	8/7/88 -	22/5/89 -	None -
Method:	Split ½ at each date	Single dressing at planting	Single dressing at planting	-
Harvesting	13/6/88	29/9-1/11	19/12/89	6/8/90
Residue incorporation	24/6/88	15/12/88	26/1/90	3/1/90 -
Method	Rotovated/ Ploughed	Ploughed	Ploughed	-

Table iii **Treatments and Diary of Events - 1989 MAFF Experiment**

	Crop 1	Crop 2	Crop 3	Crop 4
Crop:	Cauliflower	Cauliflower	Brussels	S Wheat
Variety:	Perfection	White Rock	Dolmic	Tonic
Planted as:	6cm^3 blocks	'308' modules	'308' modules	Seed @ 154 kg/ha
Date planted:	8/3/89	5/7/89	16/5/90	22/2/91
Plant spacing:	61cm x 46cm	61cm x 46cm	61cm x 46cm	
Plot size m:	10.98 x 7.82	3.66 x 7.82	3.66 x 3.91	3.66 x 3.91
Treatments:	5	15	30*	30
Replicates:	3	3	2*	2
Nitrogen rates (kg/ha):	0	0	0	0
	75	75	200	-
	150	150	-	-
	225	-	-	-
	300	-	-	-
Date nitrogen applied:	28/2/89 12/4/89	5/7/89	18/5/90	None
Method:	Split ½ at each date	Single Dressing at planting	Single Dressing at planting	-
Harvesting				
Total yield:	8/6/89	4/10/89	30/10/90	24/8/91
Marketable yield:	22/5-19/6	25/9-19/10	"	"
Residue incorporation				
Date	22/6/89	7/11/89 (1) 16-19/2/90 (2)	6/12/90 21/1/91	-
Method	Disc/plough	Chop (1) Plough (2)	Plough	-

* 1 replication lost due to top dressing as farm crop in error.

MEASUREMENTS

Soil Mineral N

Measurements of soil mineral N (0-15, 15-30, 30-60, 60-90cm) were made prior to planting and at the harvest of each crop, from samples of 6 cores per plot. Samples were frozen within 24 hours and defrosted at room temperature before extraction with 2M KCl.

Crop yields (Brussels sprouts)

Marketable yield

Marketable yields were determined by first stripping leaves off the plants in the field, transporting the stalks supporting buttons to a farm based sprout stripper. Sprout buttons were removed and graded by size: <12.5, 12.5-20, 20-30, 30-40 and >40mm. These were weighed fresh and sub-samples were removed for determination of DM. Very small buttons and small loose leaves were recorded as waste. Stalks were returned to the plots from which they were harvested.

The following assessments were made on the sprout plants before harvest:-

Average height cm (from 5 plants)
Uniformity of height (score 1-9 1, least uniform, 9 most uniform)
Lodging score (1-9, 1 = all lodged, 9 = all vertical)
Sprout spacing (score 1-9, 1 = close, 9 = wide)
Mildew on leaves (Recorded as 1%)

The following assessments were made on the harvested buttons:-

Sprout cleanness (score 1-9, 1 = very blemished, 9 = very clean)
Solidity (score 1-9, 1 = loose, 9 = solid)
Winginess (score 1-9, 1 = wingy, 9 = leaves tight)
Smoothness (score 1-9, 1 = rough, 9 = smooth)
Colour (score 1-9, 1 = pale green, 9 = dark green)

All assessments were made in accordance with the techniques described by Holland 1985.

Fresh and dry matter yields and N offtake

Plants were harvested at ground level in order to assess total fresh weight (FW) and dry matter (DM) yields. In 1989 these determinations were made on the end 10 plants of the plot. One guard row was left on either side of these 10 plants.

Leaves were removed from these plants and weighed fresh, they were then chopped up in large baskets on plots. Sub-samples of at least 0.3 kg were removed and dried in an oven at 60°C for 48 hours to determine dry matter (DM%).

All buttons were removed and weighed fresh, a sub sample of 100 buttons was taken for the determination of DM%. Stalks were cut at ground level, weighed fresh, sliced down the middle and chopped; sub-samples of about 0.5 kg were taken for determination of DM%.

In 1990 the harvesting techniques were more efficient in that the same plants were sampled for marketable and total yields. The leaves were stripped from the central 20 plants and weighed fresh. These were chopped in large baskets and sub-samples taken for DM%. Stalks were cut at ground level and taken to a sprout stripper where the buttons were removed and graded. Sub samples were taken for DM%. Stalks were weighed fresh and processed through a garden waste shredder to obtain a suitably macerated sub-sample for drying and further chemical analysis. All stalks were returned to their original plots and were spread.

Dried samples were stored before being analysed for % N and nitrate content.

Table iv Harvesting techniques adopted for determining fresh (FW) and dry matter (DM) yields and N offtakes for Brussels sprouts

1989 HDC Experiment	**Marketable yield**	**Whole crop harvest**
Total number of plants sampled	40	10
Harvesting	19/12/89 3/1/90 Two harvest dates	18-20/12/89 Single harvest over 3 day period
<u>Assessments</u>		
Buttons	√ Graded	√ Ungraded
Leaves	-	√
Stalk	-	√

Whole crop harvest used for calculation of N offtake, N balance, nitrogen in crop residues. Marketable yield data for yield of buttons size grades and quality.

1990 MAFF Experiment

	Marketable yield	Whole crop harvest
Total number of plants sampled	24	24 plants buttons 20 plants leaves 20 plants stalks
Harvesting date (same plants sampled for each determination)	30/10/90	As marketable yield
Assessments		
Buttons	√ Graded	√ Graded
Leaves	-	√
Stalks	-	√

Presentation of data statistical analysis

For simplicity, data for sprout and cereal crops has been presented to show the effects of freshly applied fertiliser to the sprouts given certain amounts of nitrogen to the previous cauliflower crops. This assumes that the residual effect of nitrogen applied to the first cauliflower crop has an equal effect to that of the second crop.

As a result of this different treatments have different numbers of replicates see table v. For example the treatment receiving no fertiliser has only one replicate plot in the HDC Experiment, other treatments receiving more nitrogen have several more. Data is more reliable with smaller errors where replication is greater. Where there are few replicates errors are 1.3 times larger than quoted on the tables in the text.

Statistical analysis was performed using Genstat. Estimates of errors were made by analysis of variance and are quoted as Standard Error of Difference (SED) with their significance given by a probability (p). Where values of p are less than 0.05 the differences are significant at the 95% level, if less than 0.01, at the 99% level. Percentage values were transformed before analysis.

Table v Number of plots incorporated into table means

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60	120	Mean
0	1	1	1	3
60	2	2	2	6
120	3	3	3	9
180	4	4	4	12
240	5	5	5	15
300	6	6	6	18
360	5	5	4	15
420	4	4	4	12
480	3	3	2	6
540	2	2	2	6
600	1	1	1	3
Mean	36	36	36	108

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200	Mean
0	2	2	4
75	4	4	8
150	6	6	12
225	6	6	12
300	6	6	12
375	4	4	8
450	2	2	4
Mean	30	30	60

Rainfall

Monthly rainfall figures for the cropping years are presented in the following table, together with the 30 year mean values.

Table vi Monthly rainfall (mm)for HRI Kirton

	1988	1989	1990	1991	30yr Mean
January	89.8	32.5	38.9	50.4	47.7
February	27.2	20.4	66.0	50.7	34.2
March	65.9	58.1	14.0	29.7	45.7
April	29.8	68.1	21.9	43.4	44.6
May	61.2	7.2	17.0	15.1	47.5
June	33.9	59.7	42.0	57.2	52.5
July	78.5	32.1	20.0	27.9	45.5
August	48.0	33.1	37.8	11.9	53.7
September	28.3	38.9	26.0	65.4	45.0
October	39.4	33.5	38.1	23.1	41.9
November	47.4	41.7	52.9	33.8	55.6
December	16.4	71.3	39.0	26.3	48.8
Total	565.8	496.6	413.6	434.9	562.7

The spring of 1990 especially February was wetter than usual followed by a dry March, April and May. July and September were drier than average. Overall rainfall was only 77% of the 30 year mean.

1991 was similarly dry especially in March, May, August, October, November and December.

RESULTS - BRUSSELS SPROUT CROP

Brussels Sprout Crop

Marketable yield of buttons

The yields of sprouts ranged from 7.3-14.9 t/ha in 1989, and 13.4-16.8 t/ha in 1990 (fig 1,table 1). In 1989 yield was signficantly affected by freshly applied nitrogen or and by the residue of nitrogen applied to the previous crops in 1988. Large amounts of nitrogen applied to the previous crops were insufficient to produce maximum yields without freshly applied nitrogen. Maximum yields were achieved where 120 kg/ha N was applied to the sprout crop when following at least 360 kg/ha given to the previous two cauliflower crops.

By contrast in 1990, where sufficient N had been applied for maximum cauliflower yields there was no need to apply any additional fertiliser nitrogen to the sprout crop. Sprout yield was depressed when 200 kg/ha N was applied to those plots with large N residues from the previous cauliflowers. Tables 3, 4 and 5 show how the size grades of sprouts varied with nitrogen applied.

In both seasons over 70% of the buttons were in the 20-30 mm grade (Table 3). In 1989 the proportion varied from 73% to just over 90%; fresh fertiliser nitrogen made little difference to this proportion, once more than 300 kg/ha had been applied to the previous two crops. There were few sprouts in the large (>30 mm) grade so the remaining sprouts were in the 12.5 - 20 mm grade with the largest proportion where insufficient N had been applied for maximum total button yield.

In 1990 (70-80%) of the buttons were in the 20-30 mm grade. The maximum proportion of sprouts in this grade were achieved with high previous fertilisation or 200 kg/ha fresh N. Acceptable yields were achieved with 300 kg/ha applied to the previous crop with no additional fertiliser.

Figure 1a. Yield of marketable sprouts 1989 (t/ha)

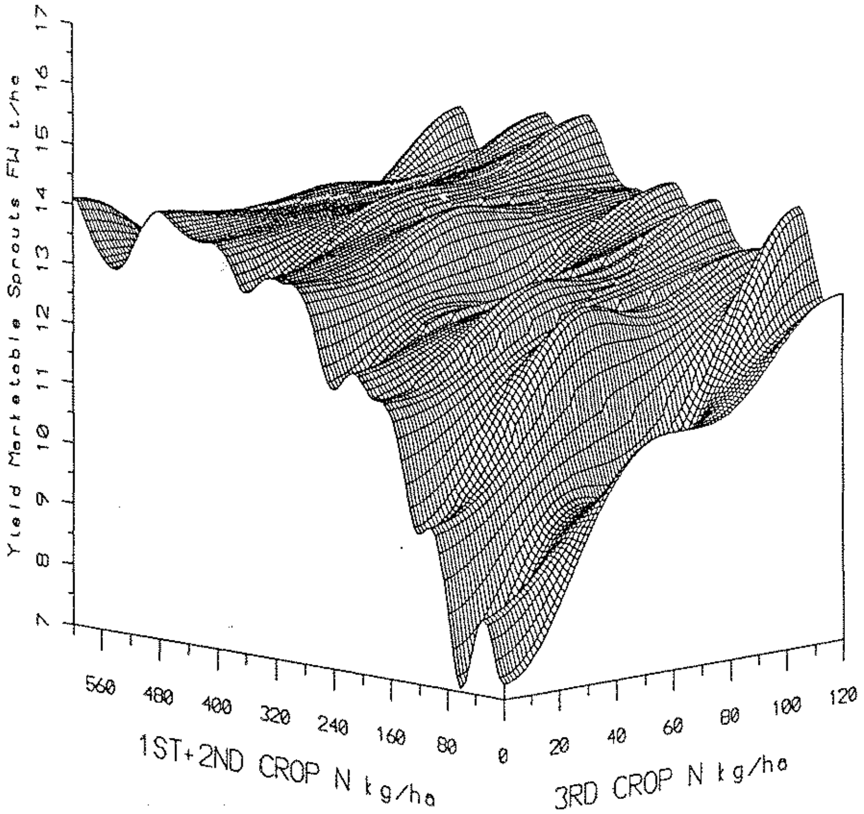
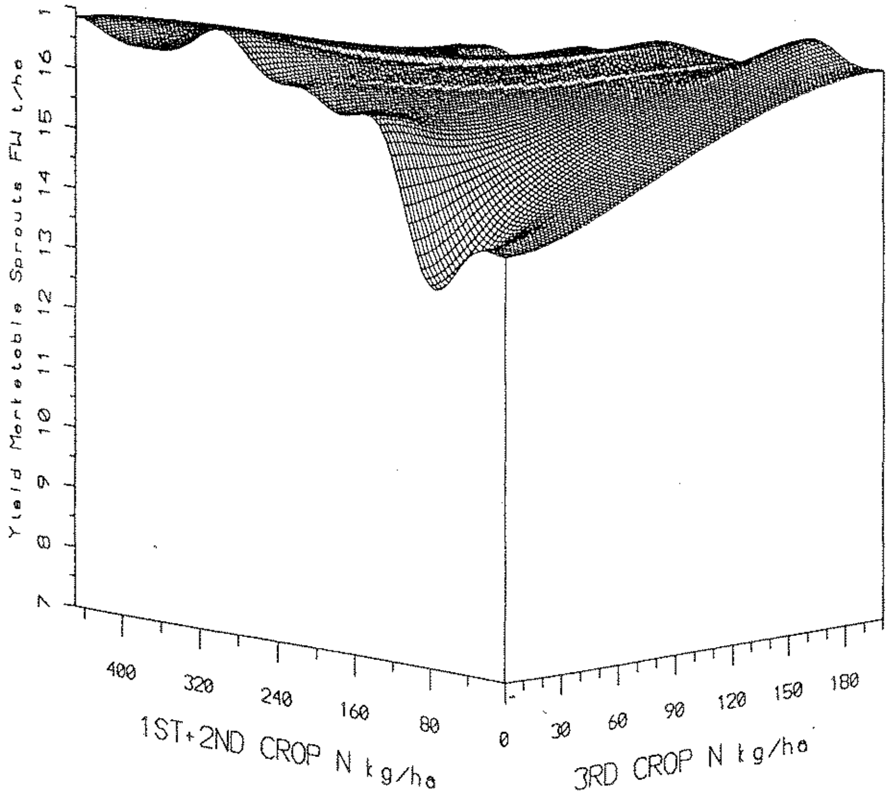


Figure 1b. Yield of marketable sprouts 1990 (t/ha)



The variety Dolmic produced some sprouts in the >30 mm grade with the largest proportion being found where no nitrogen had been applied. Where excess N had been applied yield reductions were associated with a smaller percentage of > 30 mm grade. In 1989 there were also fewer buttons in the 12.5 - 20 mm grade.

Sprout nitrate contents (Table 5) were on average 346 mg/kg fresh weight in 1989 and 136 mg/kg fresh weight in 1990. In both seasons nitrate levels were not at a level likely to reduce the marketability of the crop.

Harvesting and Quality Factors

The characteristics of sprouts recorded at harvest are given in Tables 6 to 15.

	Table No.	Average value of score 1989	1990
Harvest date	6		
Average height (cm)	7	71.9	65.3
Uniformity of height (s)	8	6.1	5.0
Lodging (s)	9	6.0	6.5
Sprout spacing (s)	10	6.0	5.2
Winginess (s)	11	5.8	3.0
Smoothness (s)	12	6.2	3.8
Solidity (s)	13	8.1	6.5
Colour (s)	14	6.6	4.6
Cleanness	15	6.4	6.2
Mildew buttons/leaves not recorded		levels < 1%	

S = score 1-9, 1 = worst, 9 = best (see Materials & Methods)

In 1989 adequate supplies of nitrogen for yield ensured that most plots were harvested on 19 December (Table 6). Where little nitrogen had been applied the buttons were not ready for harvest until 4 January. In 1990 all sprouts were harvested at the end of October.

Height was boosted by nitrogen, both residual and freshly applied.

Uniformity of height was within a satisfactory range (>5) except in 1990 where no nitrogen had been applied to the sprouts or previous crops. Taller plants were more susceptible to lodging.

Lodging increased with increasing nitrogen supply (Table 9, Fig 2). Where scores were less than 5, lodging would have severely restrict mechanical harvesting. This was the case in 1989 where fertiliser was applied to the sprouts following excessive nitrogen given to the previous crop.

In 1990 lodging increased with increasing available nitrogen but would only restrict mechanical harvesting where 200 kg/ha had been applied following cauliflowers receiving a total N dressing of 450 kg/ha.

Figure 2a. Lodging Score 1989

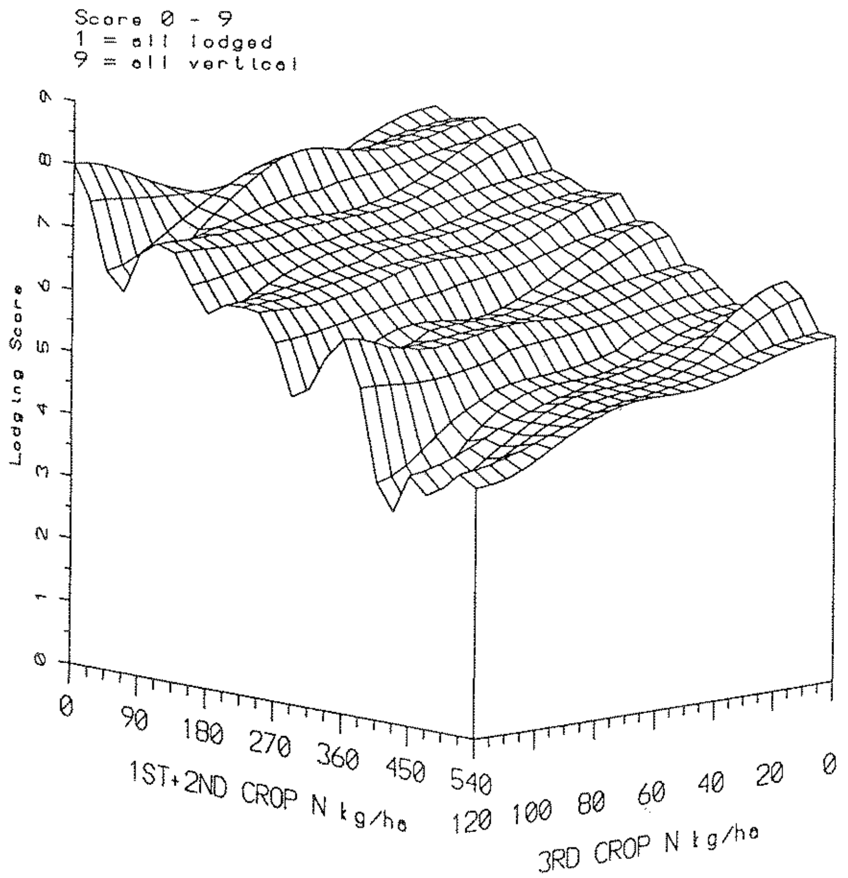
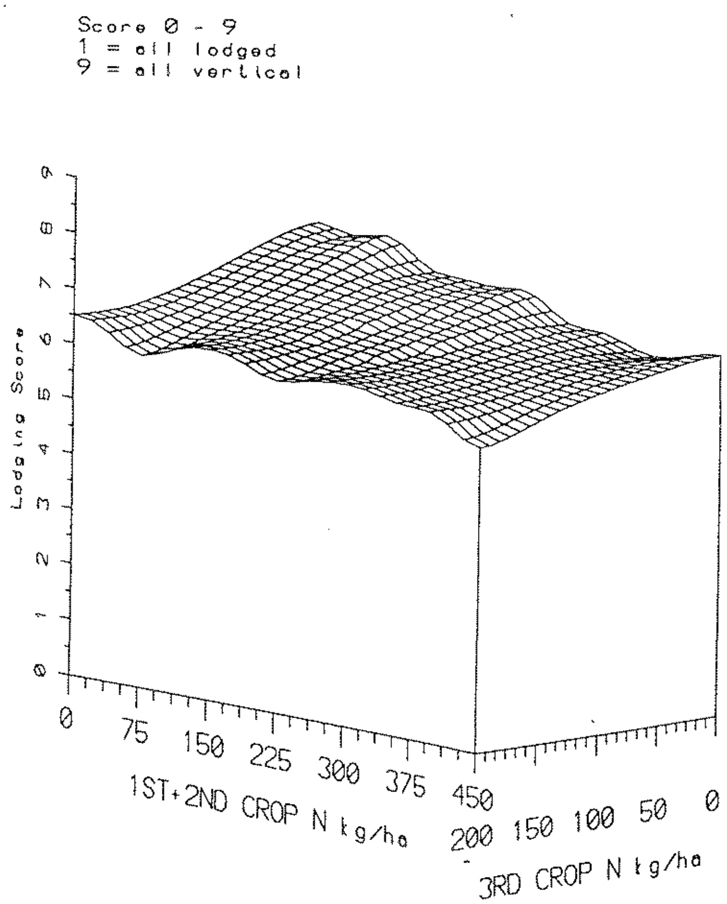


Figure 2b. Lodging Score 1990



As nitrogen increased height of plants it also increased the spacing of buttons - Table 10. Sprout spacing was always within acceptable limits for machine harvesting. Sprout spacing was narrower in 1990 for the variety Dolmic.

Winginess (Table 11) was only a problem in 1990. This defect was aggravated by N application.

Button smoothness (Table 12) was satisfactory in 1989 with a tendency to become rougher with increasing nitrogen supply. In 1990 Dolmic sprouts tended to be rougher.

Sprout solidity (Table 13) was satisfactory in both seasons, there were no significant effects of nitrogen.

Ideal colour for sprouts is within the range 6-7. Sprouts in 1989 were satisfactory but pale in 1990 (Table 14). Sprouts were clean in both seasons (Table 15), nitrogen reduced cleanliness in 1989 and increased it slightly in 1990. Mildew levels on the leaves and buttons were at very low levels - less than 1% in both seasons.

In summary where satisfactory levels of N were applied to the previous cauliflower crops (360 kg/ha), 120 kg/ha fresh nitrogen was required for maximum marketable yield in 1989. In 1990 maximum yields of buttons were achieved without the addition of any fresh fertiliser nitrogen given enough fertiliser had been applied for satisfactory levels of previous cauliflower crop. An addition of 200 kg/ha nitrogen led to significantly reduced yields with larger proportions of small sprouts.

Lodging was potentially a problem in both years where excessive quantities of nitrogen had been applied to the sprouts and previous crops. Buttons were of poorer quality in the 1990 season particularly with respect to winginess, smoothness and colour. Some of the difference between seasons will be varietal rather than seasonal (NIAB 1993).

Fresh and dry matter yields

Table 16 shows the total fresh weight yields which ranged from 29.2 - 82.1 t/ha in 1989 and 41.7 and 69.4 t/ha in 1990. Yields were significantly increased by nitrogen applied to the sprouts and/or previous crops In both years the highest total yield could not be achieved by residual N alone. In 1989 maximum yields were achieved with a combination of >420 kg/ha N applied to the previous crops and 120 kg/ha applied to the sprouts. In 1990 highest total yield was achieved with 225 kg/ha N applied to the previous crop in combination with 200 kg/ha to the sprouts. Table 17 shows the total dry matter yields which ranged from 5.3 - 12.7 t/ha in 1989 and 7.9 - 10.4 t/ha in 1990.

Sprout total dry matter yields were similar in both seasons (Table 18), with average yields of 2.2 and 2.4 t/ha in 1989 and 1990 seasons respectively. In 1989 there was a positive response to freshly applied N, in 1990 following nitrogen given to the cauliflowers freshly applied nitrogen reduced yield.

In both seasons the proportion of dry matter harvested as buttons tended to be lower with higher rates of nitrogen applied (Table 18).

In summary total fresh and dry matter yield of sprouts were significantly increased by nitrogen in both seasons. The proportion of crop harvested as buttons decreased with increasing nitrogen level (Fig 3). A larger plant does not always give rise to a larger yield of marketable buttons. This was very noticeable so in 1990 when applied N increased total dry matter yield but reduced the yield of buttons.

Crop nitrogen offtake

Table 20 shows crop nitrogen offtake which ranged from 83 - 388 kg/ha N in 1989 and 166 - 293 kg/ha N in 1990. The highest N offtake were seen in 1989 where large amounts of N had been applied to the previous crops in combination with 120 kg/ha applied to the sprouts. Where enough N was applied for maximum marketable yields, N offtake was around 290 kg/ha N. In 1990 maximum marketable yields of sprouts was associated with a whole crop N uptake of 240 kg/ha.

Nitrogen offtake in harvested buttons varied from 22 - 120 kg/ha in 1989, and 65 - 106 kg/ha in 1990 (Table 21, Fig 4). At optimum marketable yield nitrogen offtake was 105 kg/ha in 1989 and 95 kg/ha in 1990. Increasing levels of N only increased removal of N in the buttons by a small amount. Nitrogen harvest index % (ie proportion of N taken up removed in the buttons) varied from 26.7 - 42.4% in 1989, and 31.2 - 41.8% in 1990 (Table 2). The largest harvest indices were observed at moderate N levels. At maximum marketable yields in 1989 the harvest index was 36% and 39.2% in 1990. Harvest index decreased significantly where excessive levels of fertiliser were applied.

Table 23 and 24 show nitrogen offtake in the unharvested leaves and stalks. Nitrogen content of the leaves varied from 34 - 163 kg/ha N in 1989 and 70 - 132 kg/ha in 1990. At optimum levels of N for marketable yield, 95.0 kg/ha was in leaf in 1989 and 105 kg/ha N in 1990. Excessive quantities of N gave rise to increased nitrogen in the leaves. Nitrogen content of the stalks ranged from 27 - 130 kg/ha N in 1989 and 24-67 kg/ha N in 1990. At optimum N for marketable yield 93 kg/ha was measured in the stalks in 1989 and 41 in 1990.

Nitrogen applied to sprouts or previous crops, significantly increased nitrogen offtake in the stalk. Stalk N content appeared to reach a ceiling of 120 kg/ha even where excessive quantities of N had been applied.

In summary plants took up 290 kg/ha N in 1989 and 245 kg/ha N in 1990 to give maximum marketable yield. Where larger quantities of N were applied, N offtake increased up to 388 kg/ha. Where maximum marketable yields were obtained 105.1 (36%) and 95.2 (39.1%) kg/ha N were removed by the crop as buttons in 1989 and 1990 respectively. Where large amounts of fertiliser were applied the nitrogen contents of the buttons only increased to 120 kg/ha. Nitrogen significantly increased the amount of nitrogen in the leaves. N taken up in excess of that required for maximum yield was located in the leaves.

Figure 3a. Yield of sprout plant 1989 (100% Dry Matter)

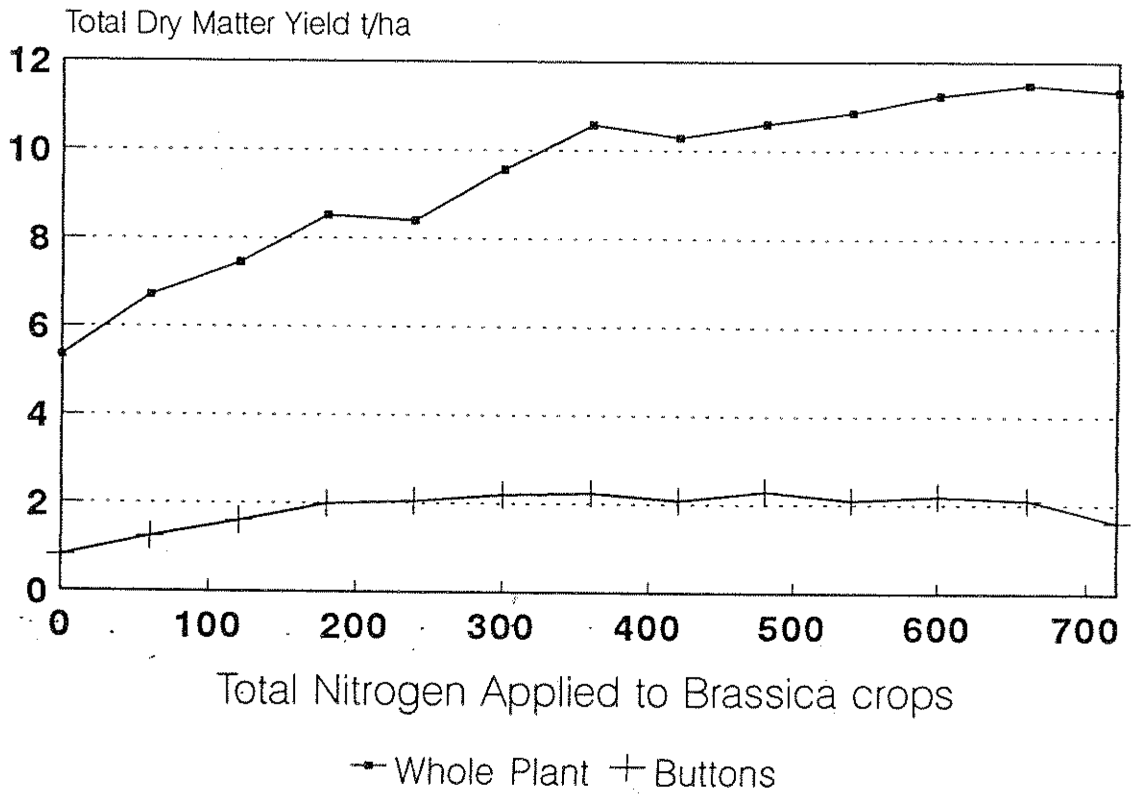


Figure 3b. Yield of sprout plant 1990 (100% Dry Matter)

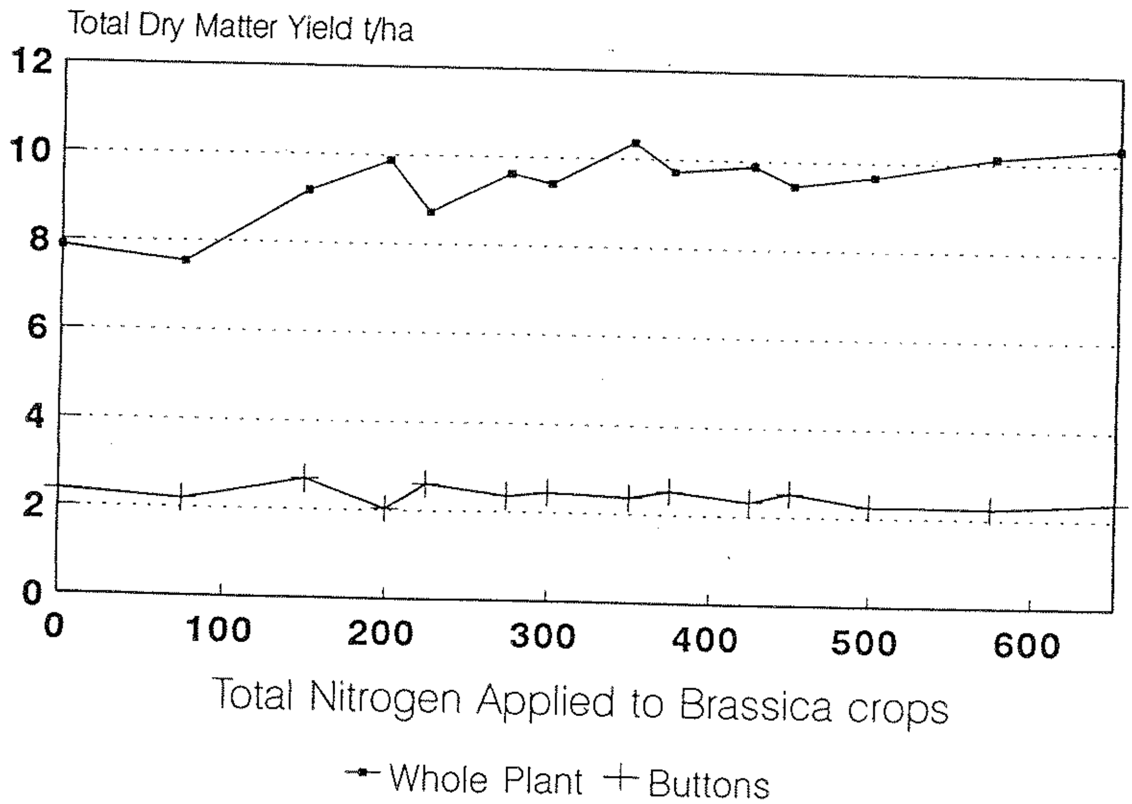


Figure 4a. Nitrogen content of sprout plants 1989

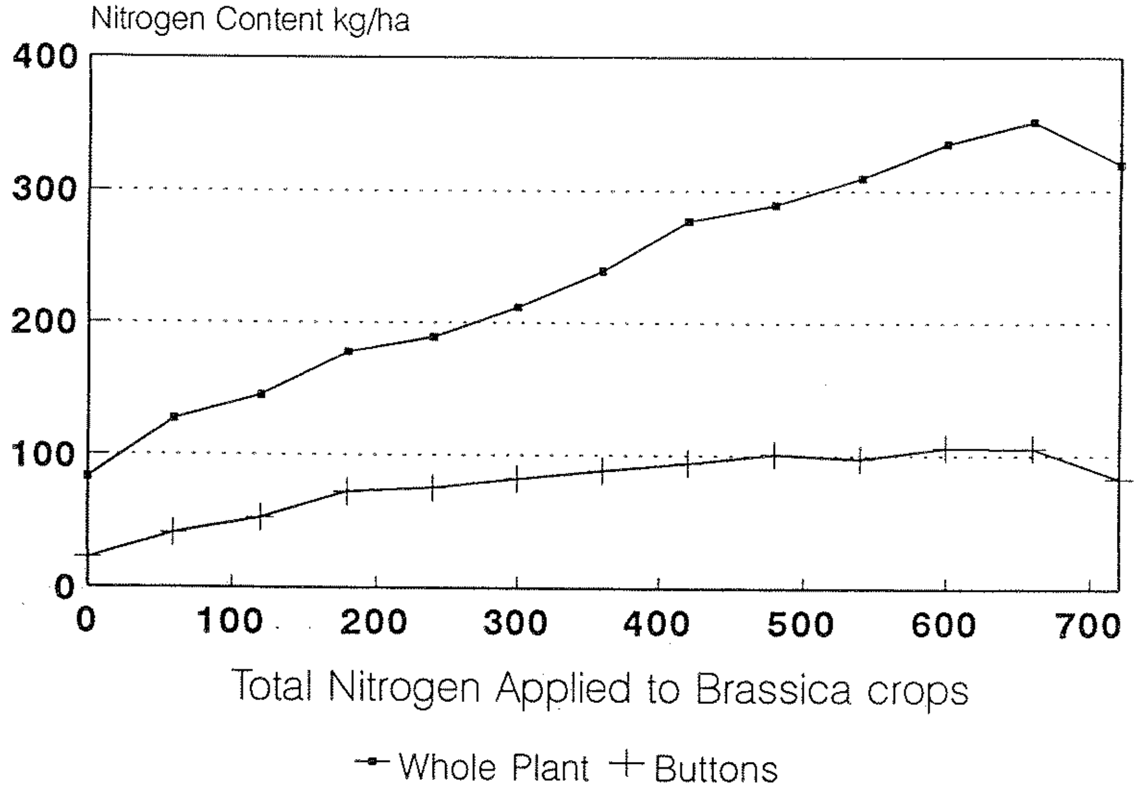
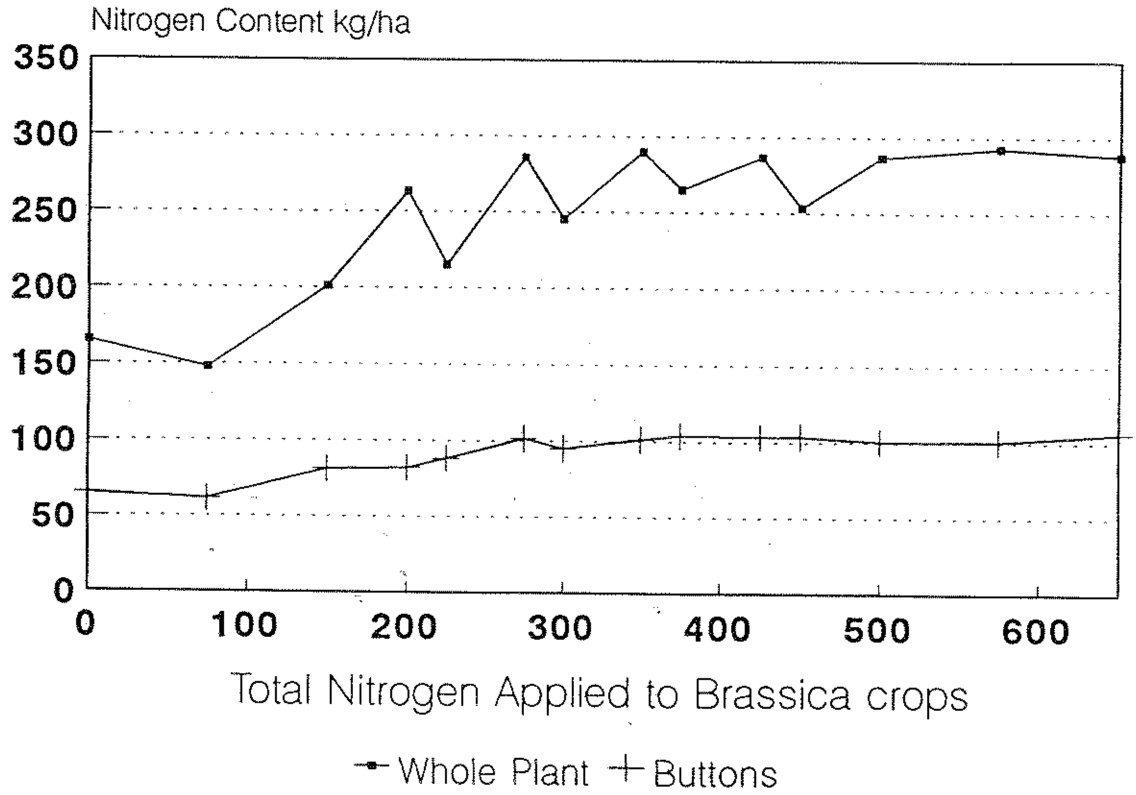


Figure 4b. Nitrogen content of sprout plants 1990



Nitrogen Residues from Sprout Crop

Table 25 shows the quantities of nitrogen returned to the soil as leaf and stalk. These ranged from 61 - 268 kg/ha in 1989 and 86 - 192 kg/ha N in 1990. Quantities of nitrogen in the residues were significantly increased by nitrogen to the sprouts or previous cauliflower crops. Where optimum N had been applied for marketable yields 188 kg/ha N was left in 1989 and 150 kg/ha N in 1990. Where larger amounts of nitrogen had been applied nitrogen in crop residues increased by a further 80 kg/ha in 1989 and by 42 kg/ha in 1990.

Table 26 shows the levels of soil mineral N at harvest which ranged from 23 - 136 kg/ha in 1989 and 33 - 179 kg/ha in 1990. At moderate rates of fertiliser soil mineral N levels were typical of those found in index 0 situations (ie around 90 kg/ha). Only where very large rates of fertiliser had been applied did soil mineral nitrogen increase. The largest increases are likely to be due to unused fertiliser, especially where 200 kg/ha N had been applied in 1990.

The quantity of nitrogen potentially available for the next crop (ie in crop and soil residues) is shown in Table 27. Between 84 and 365 kg/ha N remained in 1989 and 137 - 361 kg/ha N remained in 1990. Where optimal levels of fertiliser were given 226 kg/ha remained in 1989 and 203 kg/ha in 1990.

Nitrogen balance during growth of crop 3

Table 28 shows the nitrogen balance between crop at planting (soil mineral N plus fertiliser) and at harvest (soil mineral N plus N in crop). Net mineralisation (accumulation of N in crop and soil) was largest in the 1989 season, decreasing with application of N to the Brussels sprouts.

In 1990 nitrogen was immobilised except where no nitrogen had been applied. There was more mineral N at planting, fertiliser rates were higher and there was a substantial net immobilisation of nitrogen over the growing season.

Turnover of nitrogen from Brussels sprouts residues

Figure 5 shows that there was an inefficient turnover of nitrogen between N at harvest of the sprouts and planting of the cereal crops. The levels of mineral N in the soil at this stage were little different from those expected in a low residue rotation (nitrogen index 0).

Figure 5 also shows that in the 1990/91 season, N as soil mineral N and nitrogen contained in the growing cereal crop increased between planting date and May. This indicates that nitrogen had been released from the sprout residues.

Figs 6 (Tables 29, 30 and 31) show that soil mineral N (0-30 cm) reached a maximum during early April in 1990 and mid April in 1991. Mineral N levels decreasing after April due to crop uptake. The later peak level of mineral N in 1991 may relate to lower soil temperature, especially during February. Variation in the date of mineralisation of nitrogen from the sprout residues makes it difficult to predict their contribution to the nutrition of the next crop.

Figure 5. Mineralisation of sprout residues between sprout and cereal crops

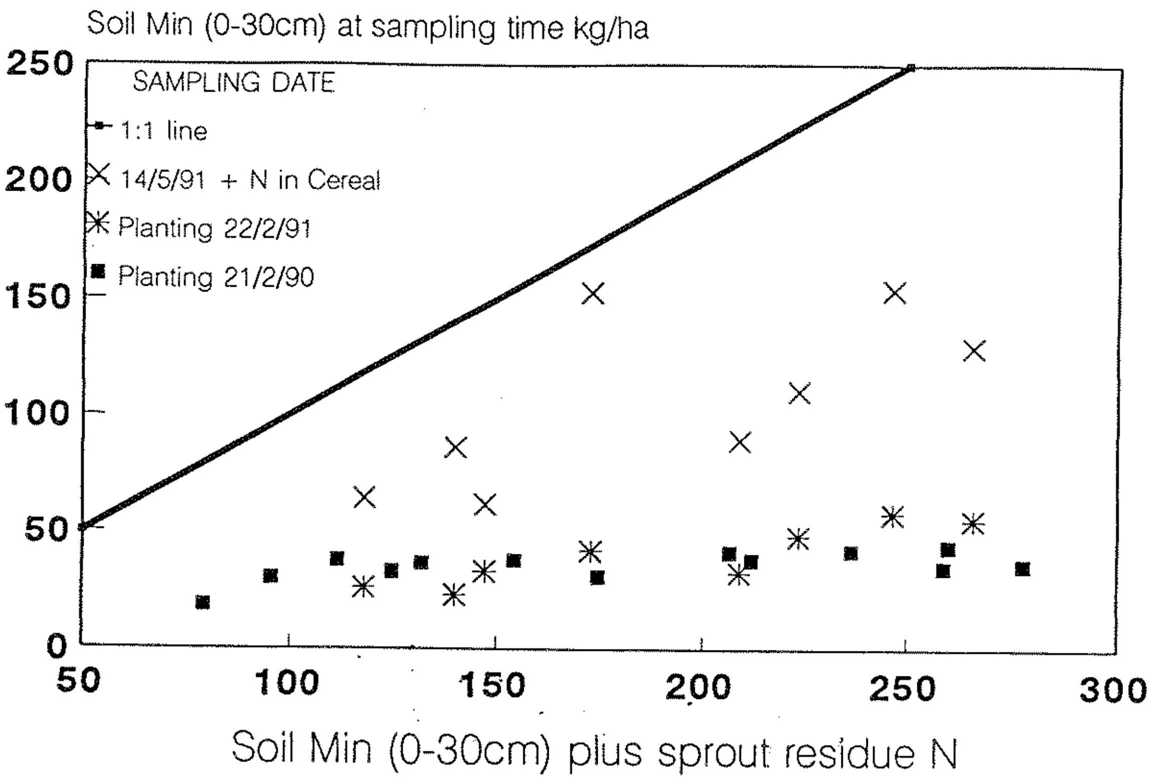


Figure 6a. Mineralisation of N from sprout residues (kg/haN @ 0-30 cm) with soil temeprature @ 20 cm depth : 1990

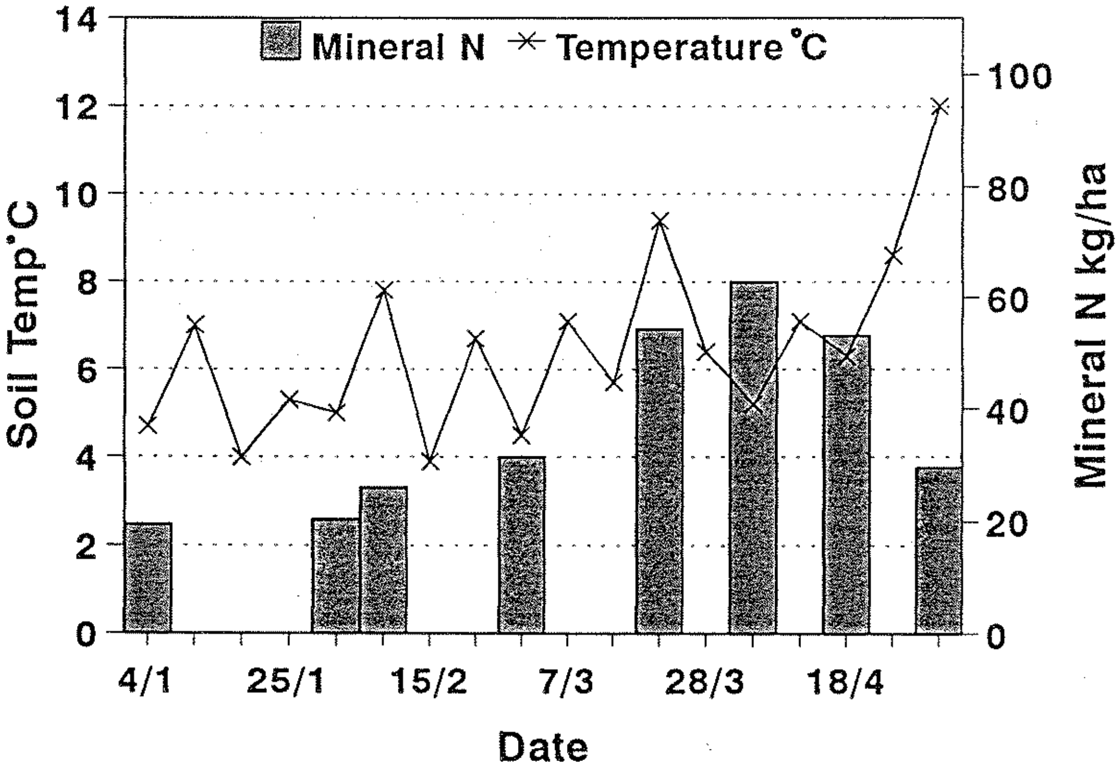


Figure 6b. Mineralisation of N from sprout residues (kg/haN @ 0-30 cm) with soil temperature @ 20 cm depth : 1991

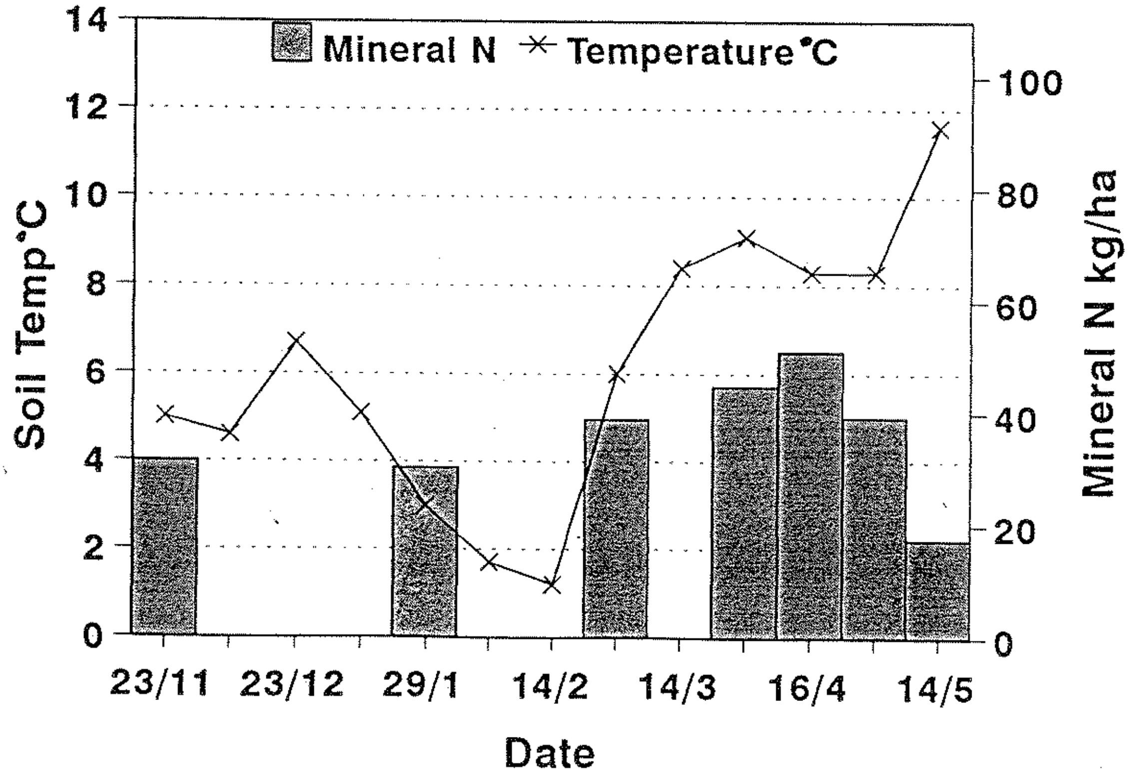


TABLE 1 - Yield marketable buttons FW t/ha

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 SED = 2.5 p <0.001	120	Mean SED = 1.5 p <0.001
0	7.3	10.9	12.7	10.3
60	7.1	9.5	14.1	10.2
120	9.5	12.8	13.2	11.8
180	11.6	13.1	13.9	12.9
240	11.6	12.5	14.1	12.8
300	13.3	14.1	13.9	13.7
360	13.0	14.3	14.9	14.1
420	13.7	13.9	14.9	14.2
480	14.1	14.1	13.6	13.9
540	13.0	12.9	14.8	13.5
600	14.1	11.9	12.9	12.9
Mean SED = 0.28 p <0.001	12.1	13.2	14.1	13.1

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 SED = 0.97 p = 0.025	Mean SED = 0.61 p = 0.05
0	14.1	16.2	15.1
75	13.4	16.1	14.7
150	16.1	15.9	15.9
225	16.3	16.0	16.2
300	17.0	15.7	16.4
375	16.5	15.2	15.9
450	16.8	15.3	16.1
Mean SED = 0.34 p = 0.66	15.9	15.8	15.9

TABLE 2 **% Buttons in 12.5-20mm grade**
Percentages analysed as angle transformed data are shown in parenthesis

HDC Experiment

Nitrogen applied to sprouts (kg/ha)

Previous N (kg/ha)	0		60 (SED = 2.4) (p <0.001)		120		Mean (SED = 1.5) (p <0.001)	
0	27.0	(31.3)	13.1	(21.2)	10.6	(19.0)	16.9	(23.9)
60	27.7	(31.7)	18.5	(25.4)	10.1	(18.5)	18.8	(25.2)
120	18.3	(25.3)	10.9	(19.2)	12.4	(20.6)	13.9	(21.7)
180	14.0	(21.9)	12.1	(20.2)	12.3	(20.4)	12.8	(20.8)
240	12.9	(20.8)	12.9	(21.1)	10.9	(19.1)	12.3	(20.4)
300	11.4	(19.5)	11.3	(19.5)	11.1	(19.4)	11.2	(19.5)
360	13.7	(21.5)	10.3	(18.7)	9.7	(18.1)	11.2	(19.4)
420	11.7	(20.0)	11.6	(19.9)	10.6	(19.0)	11.3	(19.6)
480	11.8	(20.1)	13.2	(21.2)	11.7	(19.9)	12.2	(20.4)
540	13.7	(21.6)	15.5	(23.2)	10.3	(18.9)	13.2	(21.2)
600	9.6	(18.0)	18.9	(25.8)	13.3	(21.4)	13.9	(21.7)
Mean (SED = 0.5) (p <0.001)	14.3	(21.9)	12.5	(20.6)	11.1	(19.4)	12.6	(20.6)

MAFF Experiment

Nitrogen applied to sprouts (kg/ha)

Previous N (kg/ha)	0		200 (SED = 1.4) (p = 0.54)		Mean (SED = 0.90) (p = 0.19)	
0	10.5	(18.9)	10.0	(18.4)	10.2	(18.6)
75	10.5	(18.9)	10.1	(18.5)	10.3	(18.7)
150	9.2	(17.6)	11.9	(20.1)	10.5	(18.9)
225	9.8	(18.2)	12.1	(20.7)	11.0	(19.3)
300	10.1	(18.5)	12.6	(20.7)	11.4	(19.6)
375	11.4	(19.6)	12.6	(20.7)	12.0	(20.2)
450	11.1	(19.5)	14.5	(22.4)	12.8	(20.9)
Mean (SED = 0.49) (p = 0.003)	10.2	(18.6)	12.0	(20.2)	11.1	(19.4)

TABLE 3 **% Buttons in 20-30mm grade**

Percentages analysed as angle transformed data are shown in parenthesis

<u>HDC Experiment</u>

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0		60 (SED = 2.1) (p <0.001)		120		Mean (SED = 1.83) (p <0.001)	
0	72.7	(58.5)	85.5	(67.6)	88.7	(70.4)	82.3	(65.5)
60	72.2	(58.2)	81.1	(64.2)	88.6	(70.3)	80.6	(64.2)
120	80.6	(63.9)	88.0	(69.8)	86.8	(68.7)	85.1	(67.4)
180	84.6	(66.9)	87.2	(69.1)	86.6	(68.6)	86.1	(68.2)
240	86.5	(68.6)	86.3	(68.7)	88.0	(69.8)	86.9	(68.9)
300	86.0	(68.1)	87.6	(69.4)	88.3	(70.2)	87.3	(69.2)
360	85.3	(67.6)	89.2	(70.8)	89.0	(70.7)	87.8	(69.7)
420	87.8	(69.5)	88.3	(70.0)	88.9	(70.6)	88.3	(70.0)
480	87.3	(69.2)	86.6	(68.6)	87.4	(69.3)	87.1	(69.0)
540	86.2	(68.3)	84.3	(66.7)	88.8	(70.4)	86.4	(68.5)
600	90.4	(72.0)	80.9	(64.2)	86.7	(68.6)	86.0	(68.2)
Mean (SED = 0.46) (p 0.001)	84.7	(67.2)	86.8	(68.6)	88.1	(69.8)	86.5	

<u>MAFF Experiment</u>

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0		200 (SED = 2.4) (p = 0.25)		Mean (SED = 1.7) (p = 0.69)	
0	70.4	(57.2)	78.4	(62.4)	74.4	(59.8)
75	73.1	(58.8)	80.6	(64.0)	76.9	(61.4)
150	74.8	(60.0)	77.7	(61.8)	76.2	(60.9)
225	77.3	(61.6)	78.1	(62.2)	77.7	(61.9)
300	76.3	(61.0)	78.5	(62.4)	77.4	(61.7)
375	77.7	(62.0)	75.1	(60.0)	76.4	(61.0)
450	80.2	(63.6)	79.4	(63.0)	79.8	(63.3)
Mean (SED = 0.75) (p = 0.06)	75.8	(60.7)	78.1	(62.2)	77.0	(61.4)

TABLE 4 % Buttons in >30mm grade

Percentages analysed as angle transformed data are shown in parenthesis

<u>HDC Experiment</u>

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0		60 (SED = 2.7) (p = 0.24)		120		Mean (SED = 1.6) (p = 0.06)	
0	0.25	(2.8)	1.39	(6.8)	0.65	(4.6)	0.76	(4.7)
60	0.06	(1.0)	0.42	(3.6)	1.37	(6.3)	0.62	(3.6)
120	1.04	(5.6)	1.13	(6.1)	0.82	(5.1)	0.99	(5.6)
180	1.43	(6.1)	0.72	(4.1)	1.11	(5.0)	1.09	(5.1)
240	0.67	(4.6)	0.67	(3.4)	1.10	(5.7)	0.82	(4.6)
300	2.62	(9.1)	1.17	(5.7)	0.61	(4.4)	1.47	(6.4)
360	0.98	(4.4)	0.49	(3.7)	1.29	(6.3)	0.92	(4.8)
420	0.51	(3.8)	0.19	(1.8)	0.51	(4.0)	0.41	(3.2)
480	0.87	(4.7)	0.26	(2.8)	0.92	(4.5)	0.68	(4.0)
540	0.10	(1.2)	0.20	(1.8)	0.75	(4.6)	0.35	(2.5)
600	0.00	(0)	0.14	(2.1)	0.00	(0)	0.05	(6.7)
Mean (SED = 0.06) (p = 0.1)	1.06	(4.9)	0.65	(3.9)	0.89	(4.9)	0.87	(4.6)

<u>MAFF Experiment</u>

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0		200 (SED = 3.7) (p = 0.64)		Mean (SED = 2.6) (p = 0.36)	
0	19.1	(25.7)	11.6	(19.8)	15.3	(22.8)
75	16.4	(23.7)	9.2	(17.4)	12.8	(20.6)
150	16.0	(23.1)	10.5	(18.8)	13.2	(21.0)
225	12.9	(20.8)	9.8	(17.7)	11.3	(19.2)
300	13.6	(21.3)	9.0	(17.1)	11.2	(19.2)
375	11.0	(18.5)	12.3	(20.4)	11.7	(19.4)
450	8.6	(17.0)	6.0	(14.2)	7.3	(15.6)
Mean (SED = 1.14) (p = 0.006)	14.0	(21.5)	9.9	(18.0)	11.9	(19.8)

TABLE 5 Button nitrate content mg/kg fresh WT

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60	120	Mean
	SED = 264 p = 0.97			SED = 152 p = 0.15
0	382.6	609.4	654.6	548.8
60	234.0	158.3	326.7	239.6
120	392.0	288.7	420.1	366.6
180	235.0	222.8	336.2	264.7
240	204.8	357.5	421.9	328.1
300	156.6	339.2	266.5	254.1
360	421.4	410.6	439.0	423.7
420	466.4	605.5	451.4	507.8
480	244.5	370.4	228.4	281.1
540	293.5	538.9	174.4	335.6
600	657.6	285.1	417.9	453.6
Mean SED = 58 p = 0.41	302.2	373.7	363.2	346.4

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200	Mean
	SED = 30.9 p = 0.16		SED = 25.2 p = 0.62
0	107	98	103
75	97	166	132
150	132	133	133
225	109	170	139
300	128	170	149
375	132	159	145
450	95	148	121
Mean SED = 8.0 p <0.001	118	154	136

TABLE 6 **Harvesting date - % Plots harvested by 19/12/89**

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 50.0, p = 0.36)	120	Mean (SED = 28.9, p = 0.02)
0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0
120	0.0	0.0	33.3	11.1
180	25.0	50.0	100.0	58.3
240	0.0	40.0	60.0	33.3
300	16.7	33.3	83.3	44.4
360	80.0	60.0	40.0	60.0
420	75.0	50.0	50.0	58.3
480	100.0	66.7	66.7	77.8
540	50.0	100.0	50.0	66.7
600	100.0	0.0	100.0	66.7
Mean (SED = 10.9, p = 0.16)	38.9	41.7	58.3	46.3

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 (SED = , p =)	Mean (SED = , p =)
0			
75			
150			
225	All plots harvested on 31/10/90		
300			
375			
450			
Mean (SED = , p =)			

TABLE 7 Brussels Sprouts - average height of 5 plants (cm)

HDC Experiment

Nitrogen applied to sprouts (kg/ha)

Previous N (kg/ha)	0	60 SED = 6.05 p = 0.11	120	Mean SED = 3.50 p <0.001
0	44.4	58.6	68.4	57.1
60	46.5	59.0	65.3	56.9
120	50.3	60.4	67.7	59.4
180	57.9	64.5	74.7	65.7
240	59.5	66.0	75.7	67.0
300	65.3	68.8	82.6	72.2
360	69.5	78.1	79.6	75.7
420	79.2	81.1	82.8	81.0
480	78.8	83.4	88.4	85.5
540	81.8	87.6	80.1	83.2
600	85.0	84.0	91.2	86.7
Mean SED = 1.32 p <0.001	65.5	71.7	78.3	71.9

MAFF Experiment

Nitrogen applied to sprouts (kg/ha)

Previous N (kg/ha)	0	200 SED = 3.00 p = 0.05	Mean SED = 1.95 p <0.001
0	50.7	64.1	57.4
75	51.7	67.4	59.5
150	59.1	69.4	64.2
225	61.9	70.1	66.0
300	65.2	71.4	68.3
375	66.7	70.0	68.4
450	68.9	71.9	70.4
Mean SED = 1.02 p <0.001	61.0	69.6	65.3

TABLE 8 **Brussels Sprouts - Uniformity of Height**
(Score 1 = least uniform, 9 = uniform)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 (SED = 0.86, p = 0.08)	120	Mean (SED = 0.5, p = 0.009)
0	7.00	6.00	7.00	6.67
60	7.50	6.50	5.50	6.50
120	7.33	6.67	6.67	6.89
180	7.00	6.25	6.25	6.50
240	6.00	7.00	6.00	6.33
300	5.83	5.33	6.00	5.72
360	6.00	5.80	6.00	5.93
420	5.75	6.25	5.75	5.92
480	5.67	6.67	5.00	5.78
540	6.50	5.00	5.00	5.50
600	5.00	6.00	7.00	6.00
Mean (SED = 0.19, p = 0.27)	6.25	6.14	5.94	6.11

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 (SED = 1.06, p = 0.26)	Mean (SED = 0.62, p = 0.004)
0	4.50	6.50	5.50
75	3.25	4.75	4.00
150	3.00	6.00	4.50
225	4.00	5.17	4.58
300	5.17	6.00	5.58
375	6.00	5.50	5.75
450	6.50	6.50	6.50
Mean (SED = 0.38, p = 0.003)	4.40	5.67	5.03

TABLE 9 **Brussels Sprouts - Lodging (Score 1 = lodged, 9 = upright)**

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 1.03, p = 0.115)	120	Mean (SED = 0.5, p <0.001)
0	8.00	7.00	8.00	7.67
60	8.00	8.00	6.00	7.33
120	8.00	7.00	7.00	7.33
180	7.25	6.75	6.00	6.67
240	7.20	6.60	6.20	6.67
300	6.83	5.67	4.83	5.78
360	6.20	5.80	6.00	6.00
420	5.75	5.00	3.25	4.67
480	6.33	5.00	3.67	5.00
540	5.50	5.00	4.00	4.83
600	3.00	7.00	5.00	5.00
Mean (SED = 0.22, p <0.001)	6.69	6.08	5.33	6.04

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 (SED = 0.64, p = 0.71)	Mean (SED = 0.43, p = 0.30)
0	7.50	6.50	7.00
75	7.50	6.00	6.75
150	7.00	6.33	6.67
225	7.00	6.00	6.50
300	6.50	6.17	6.33
375	6.25	6.00	6.13
450	6.50	5.50	6.00
Mean (SED = 0.2, p = 0.001)	6.87	6.10	6.48

TABLE 10 Brussels Sprouts - Button Spacing on stem
(Score 1 = close, 9 = wide)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 SED = 0.659 p = 0.31	120	Mean SED = 0.37 p <0.001
0	5.00	5.00	6.00	5.33
60	5.00	5.50	6.00	5.50
120	5.33	5.67	6.00	5.67
180	5.25	5.50	5.75	5.50
240	5.40	5.60	6.60	5.87
300	5.83	5.50	6.50	5.94
360	5.60	6.60	6.20	6.13
420	6.25	6.75	6.75	6.58
480	7.00	7.00	6.67	6.89
540	6.50	7.00	6.50	6.67
600	7.00	6.00	7.00	6.67
Mean SED = 0.14 p <0.001	5.78	6.03	6.36	6.06

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0 SED = 0.28 p = 0.40	200	Mean SED = 0.35 p = 0.27
0	5.00	5.00	5.00
75	4.75	5.00	4.86
150	5.00	5.33	5.17
225	5.17	5.33	5.25
300	5.33	5.50	5.42
375	5.25	5.25	5.25
450	5.00	6.00	5.50
Mean SED = 0.009 p = 0.02	5.10	5.33	5.22

TABLE 11 **Brussels Sprouts - Winginess of button**
(Score 1 = wingy, 2 = leaves tight)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 SED = 1.08 p = 0.49	120	Mean SED = 0.63 p = 0.09
0	6.00	5.00	6.00	5.67
60	7.50	7.00	7.00	7.17
120	6.33	1.13	6.00	6.22
180	6.25	5.50	5.25	5.67
240	6.60	5.80	5.20	5.87
300	5.83	6.17	4.83	5.61
360	5.80	5.20	5.00	5.33
420	5.25	6.50	5.50	5.75
480	5.00	5.33	6.33	5.56
540	6.50	6.00	5.00	5.83
600	5.00	6.00	6.00	5.67
Mean SED = 0.24 p = 0.08	6.00	5.86	5.47	5.78

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 SED = 0.57 p = 0.76	Mean SED = 0.47 p = 0.83
0	3.50	3.00	3.25
75	3.25	2.50	2.86
150	3.33	3.00	3.17
225	3.17	2.33	2.75
300	3.17	3.00	3.08
375	3.00	2.75	2.86
450	3.00	2.50	2.75
Mean SED = 0.14 p = 0.003	3.20	2.73	2.97

TABLE 12 **Brussels Sprouts - Smoothness of buttons**
(Score 1 = rough, 9 = smooth)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 0.96, p = 0.13)	120	Mean (SED = 0.56, p = 0.20)
0	7.00	6.00	7.00	6.67
60	7.50	7.00	7.00	7.17
120	7.00	6.00	7.00	6.67
180	6.75	5.75	5.75	6.08
240	7.40	6.20	5.60	6.40
300	6.33	6.67	5.17	6.06
360	6.20	5.80	5.80	5.93
420	5.75	6.75	6.50	6.33
480	5.33	6.67	6.00	6.00
540	6.00	6.00	6.00	6.00
600	6.00	7.00	6.00	6.33
Mean (SED = 0.21, p = 0.06)	6.47	6.31	5.97	6.25

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200	Mean (SED = 0.43, p = 0.18)
	SED = 0.58, p = 0.12		
0	4.00	3.00	3.50
75	4.00	3.50	3.75
150	3.00	4.00	3.50
225	4.50	4.00	4.25
300	3.83	3.83	3.83
375	3.50	3.25	3.38
450	4.00	4.00	4.00
Mean (SED = 0.18, p = 0.71)	3.80	3.73	3.77

TABLE 13 **Brussels Sprouts - Solidity of buttons**
(Score 1 = loose, 9 = solid)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60	120	Mean
		SED = 0.38 p = 0.66		SED = 0.22 p = 0.60
0	8.00	8.00	8.00	8.00
60	8.00	8.50	8.50	8.33
120	8.67	8.00	8.00	8.22
180	8.25	8.00	8.00	8.08
240	8.40	8.00	8.00	8.13
300	8.00	8.17	7.83	8.00
360	8.00	8.00	8.00	8.00
420	8.25	8.25	8.00	8.17
480	8.00	8.00	8.00	8.00
540	8.50	8.00	8.00	8.17
600	8.00	8.00	8.00	8.00
Mean	8.19	8.08	8.00	8.09
SED = 0.08				
p = 0.07				

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200	Mean
	SED = 0.63 p = 0.31		SED = 0.42 p = 0.20
0	6.50	6.00	6.25
75	6.25	5.75	6.00
150	6.17	6.83	6.50
225	6.83	6.83	6.83
300	6.50	7.00	6.75
375	6.75	5.75	6.25
450	6.50	7.00	6.75
Mean	6.50	6.53	6.52
SED = 0.21			
p = 0.88			

TABLE 14 **Brussels Sprouts - Colour of buttons**
(Score 1 = pale green, 9 = dark green)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 SED = 0.65 p = 0.58	120	Mean SED = 0.37 p = 0.09
0	6.00	7.00	6.00	6.33
60	5.50	6.00	6.50	6.00
120	6.00	7.00	6.33	6.44
180	6.75	6.50	6.75	6.67
240	6.40	6.60	6.60	6.53
300	7.00	6.67	7.00	6.89
360	6.80	7.00	6.80	6.87
420	6.75	6.25	6.50	6.50
480	6.67	6.00	6.33	6.33
540	6.50	6.00	7.00	6.50
600	6.00	6.00	7.00	6.33
Mean SED = 0.14 p = 0.58	6.56	6.53	6.67	6.58

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 SED = 0.43 p = 0.98	Mean SED = 0.30 p = 0.16
0	4.00	4.00	4.00
75	5.00	4.75	4.86
150	4.50	4.50	4.50
225	4.50	4.67	4.58
300	4.67	4.67	4.67
375	4.50	4.75	4.63
450	5.00	5.00	5.00
Mean SED = 0.14 p = 0.81	4.60	4.63	4.62

TABLE 15 **Brussels Sprouts - Cleanness of buttons**
(Score 1 = very blemished, 9 = very clean)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60	120	Mean
		SED = 0.84 p = 0.70		SED = 0.48 p = 0.45
0	6.00	7.00	7.00	6.67
60	7.00	6.50	6.50	6.67
120	7.00	6.33	6.67	6.67
180	6.50	5.75	6.50	6.25
240	6.60	5.80	6.60	6.33
300	6.67	6.50	6.17	6.44
360	6.80	6.60	6.00	6.47
420	7.25	6.25	6.25	6.58
480	6.33	5.33	5.67	5.78
540	6.50	7.00	6.50	6.67
600	7.00	5.00	7.00	6.33
Mean SED = 0.18 p = 0.015	6.72	6.19	6.33	6.42

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200	Mean
		SED = 0.58 p = 0.39	SED = 0.42 p = 0.14
0	5.00	6.50	5.75
75	5.25	6.50	5.86
150	5.83	6.33	6.08
225	6.00	6.33	6.17
300	6.67	6.67	6.67
375	6.50	6.75	6.63
450	6.00	6.50	6.25
Mean SED = 0.18 p = 0.01	6.25	6.50	6.25

TABLE 16 **Brussels Sprouts - Total above ground fresh weight t/ha**

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 7.9, p = 0.92)	120	Mean (SED = 4.6, p <0.001)
0	29.2	42.4	46.7	39.4
60	37.1	43.3	57.2	45.9
120	42.0	51.4	55.3	49.6
180	52.8	54.4	58.1	55.1
240	52.1	58.6	66.8	59.2
300	59.8	59.3	68.7	62.6
360	62.5	65.4	71.5	66.5
420	62.3	69.8	75.1	69.1
480	71.1	68.3	73.3	70.9
540	70.7	74.3	82.1	75.7
600	71.2	62.1	67.6	67.0
Mean (SED = 1.7, p <0.001)	56.9	60.3	67.1	61.4

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 (SED = 4.8, p = 0.013)	Mean (SED = 3.6, p = 0.01)
0	42.5	67.5	55.0
75	41.7	65.4	53.6
150	53.5	65.7	59.6
225	54.7	69.4	62.1
300	62.4	66.7	64.6
375	60.3	69.4	64.9
450	57.0	68.1	62.6
Mean (SED = 1.5, p <0.001)	54.4	67.4	60.9

TABLE 17 Brussels Sprouts - above ground total dry matter yield t/ha

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 1.5, p = 0.96)	120	Mean (SED = 0.9, p <0.001)
0	5.3	7.4	7.4	6.7
60	6.4	7.1	9.2	7.6
120	7.7	8.2	9.6	8.5
180	8.4	7.7	9.8	8.6
240	8.2	9.6	10.7	9.5
300	9.4	10.7	10.9	10.3
360	10.3	10.4	11.0	10.6
420	9.2	10.0	11.1	10.1
480	10.6	10.5	11.9	11.0
540	11.0	10.4	12.7	11.4
600	10.8	9.0	11.3	10.4
Mean	9.0	9.5	10.7	9.8
SED = 0.3				
p <0.001				

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 (SED = 0.85, p = 0.75)	Mean (SED = 0.40, p = 0.007)
0	7.9	9.9	8.9
75	7.5	9.6	8.6
150	9.2	10.4	9.8
225	8.7	9.8	9.3
300	9.4	9.7	9.6
375	9.7	10.1	9.9
450	9.5	10.3	9.9
Mean	8.9	10.0	9.4
SED = 0.34			
p = 0.005			

TABLE 18 Brussels Sprouts - Total dry weight matter buttons t/ha

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 (SED = 0.37, p = 0.56)	120	Mean (SED = 0.2, p <0.001)
0	0.8	1.2	1.8	1.3
60	1.2	1.7	2.0	1.6
120	1.5	2.0	2.1	1.9
180	2.0	2.0	2.1	2.0
240	2.1	2.2	2.4	2.2
300	2.3	2.2	2.2	2.2
360	2.1	2.1	2.4	2.2
420	1.9	2.3	2.4	2.2
480	2.1	2.1	2.2	2.1
540	1.7	2.2	2.4	2.1
600	2.0	1.5	1.6	1.7
Mean (SED = 0.08, p = 0.003)	1.9	2.1	2.2	2.1

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 (SED = 0.20, p = 0.62)	Mean (SED = 0.13, p = 0.14)
0	2.4	2.0	2.2
75	2.2	2.4	2.3
150	2.7	2.4	2.5
225	2.6	2.7	2.5
300	2.4	2.3	2.4
375	2.5	2.2	2.3
450	2.5	2.4	2.5
Mean (SED = 0.07, p = 0.002)	2.5	2.3	2.4

TABLE 19 Brussels Sprouts - Harvest Index, % of total dry weight in buttons harvested

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 3.48, p = 0.16)	120	Mean (SED = 2.01, p = 0.003)
0	15.2	16.7	23.9	18.6
60	19.5	24.0	21.9	21.8
120	19.1	24.2	22.3	21.9
180	23.4	26.4	21.6	23.8
240	24.9	22.9	22.7	23.6
300	24.7	20.9	20.0	21.9
360	21.2	20.7	22.3	21.4
420	20.9	22.6	21.1	21.6
480	19.8	19.7	18.7	19.4
540	15.4	21.9	18.6	18.6
600	18.5	17.1	14.2	16.6
Mean (SED = 0.76, p = 0.35)	21.6	22.2	21.1	21.6

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0 (SED = 2.56, p = 0.60)	200	Mean (SED = 1.83, p = 0.51)
0	30.2	20.9	25.6
75	29.4	24.6	27.0
150	29.4	23.1	26.2
225	29.9	24.0	26.9
300	26.3	23.3	24.8
375	26.4	23.0	24.7
450	26.9	22.9	24.9
Mean (SED = 0.81, p <0.001)	28.4	23.3	25.8

TABLE 20 **Brussels Sprouts - Total nitrogen offtake (kg/ha) whole crop**

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 SED = 48 p = 0.98	120	Mean SED = 27.8 p <0.001
0	82.7	142.5	152.0	125.7
60	118.9	136.0	196.2	150.4
120	148.3	176.3	197.8	174.1
180	169.3	184.6	196.0	183.3
240	186.7	218.0	252.4	219.0
300	216.7	229.7	291.7	246.1
360	237.3	286.7	293.3	272.4
420	243.2	286.1	328.6	286.0
480	287.9	285.3	369.8	314.4
540	308.0	300.1	388.3	332.1
600	302.4	278.9	319.6	300.3
Mean SED = 10.5 p <0.001	211.6	235.1	275.6	240.8

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 SED = 25.6 p = 0.09	Mean SED = 12.7 p = <0.001
0	166	263	214
75	148	286	217
150	201	290	246
225	215	287	251
300	245	287	266
375	265	293	279
450	254	288	271
Mean SED = 9.9 p <0.001	215	287	251

TABLE 21 Brussels Sprouts - Nitrogen offtake (kg/ha) in harvested buttons

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 18.5, p <0.001)	120	Mean (SED = 10.7, p <0.001)
0	22.1	42.6	60.8	41.8
60	40.0	52.5	74.3	55.6
120	49.6	69.3	71.3	63.4
180	73.5	76.6	79.3	76.5
240	76.5	79.7	98.3	84.8
300	86.1	81.3	96.7	88.0
360	87.5	94.7	105.1	95.7
420	89.3	101.8	106.8	99.3
480	92.6	97.1	104.4	98.1
540	79.9	111.4	120.2	103.8
600	100.3	76.3	82.7	86.4
Mean (SED = 4.04, p <0.001)	77.1	83.9	94.5	85.2

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0 (SED = 7.3, p = 0.016)	200	Mean (SED = 2.8, p <0.001)
0	65.2	82.3	73.8
75	61.6	101.8	81.7
150	81.5	101.4	91.4
225	88.4	103.7	96.1
300	95.2	100.9	98.0
375	104.0	100.9	102.5
450	103.9	106.0	104.9
Mean (SED = 3.5, p <0.001)	86.4	100.8	93.6

TABLE 22 Brussels Sprouts - Nitrogen harvest index - % of total uptake removed in buttons

HDC Experiment

Nitrogen applied to sprouts (kg/ha)

Previous N (kg/ha)	0	60 SED = 5.83 p = 0.44	120	Mean SED = 3.67 p <0.001
0	26.7	29.9	39.9	32.2
60	33.5	38.9	37.7	36.7
120	33.4	39.5	36.4	36.4
180	42.4	41.9	41.9	42.1
240	41.2	36.9	39.3	39.1
300	39.7	36.3	33.4	36.5
360	37.3	33.7	36.1	35.7
420	36.9	35.3	32.2	34.8
480	32.1	34.0	28.4	31.5
540	25.9	37.1	30.7	31.2
600	33.2	27.3	25.9	28.8
Mean SED = 1.23 p = 0.50	36.8	36.4	35.3	36.1

MAFF Experiment

Nitrogen applied to sprouts (kg/ha)

Previous N (kg/ha)	0 SED = 3.5 p = 0.97	200	Mean SED = 1.9 p = 0.52
0	39.4	31.2	35.3
75	41.8	35.7	38.8
150	40.7	35.1	37.9
225	41.1	36.6	38.8
300	39.2	35.1	37.2
375	40.6	34.9	37.8
450	41.2	37.3	39.2
Mean SED = 1.3 p <0.001	40.6	35.4	38.0

TABLE 23 Brussels sprouts - Nitrogen offtake leaves (kg/ha)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 27.9, p = 0.306)	120	Mean (SED = 16.1, p <0.001)
0	33.6	69.9	48.0	50.5
60	43.0	41.8	65.2	50.0
120	64.1	53.1	66.2	61.1
180	45.0	49.1	53.8	49.3
240	55.1	73.5	73.5	67.4
300	67.8	70.4	93.5	77.2
360	81.4	110.1	95.0	95.5
420	75.9	83.5	98.8	86.1
480	91.2	91.8	163.0	115.4
540	116.8	75.4	150.0	114.1
600	71.4	101.6	131.2	101.4
Mean (SED = 6.1, p <0.001)	68.4	75.3	92.0	

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 (SED = 23.5, p = 0.71)	Mean (SED = 12.7, p = 0.22)
0	70.4	127.1	98.8
75	58.0	132.2	95.1
150	82.6	133.0	107.8
225	86.0	124.6	105.3
300	105.0	132.2	118.6
375	109.2	131.3	120.2
450	93.4	114.1	103.8
Mean (SED = 8.8, p <0.001)	87.9	129.2	108.5

TABLE 24 Brussels Sprouts - Nitrogen offtake stalks (kg/ha)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 SED = 21.7 p = 0.90	120	Mean SED = 12.5 p <0.001
0	27.0	30.1	43.2	33.4
60	35.8	41.7	56.6	44.7
120	34.7	54.0	60.3	49.6
180	50.8	58.9	62.9	57.6
240	55.1	64.8	80.6	66.8
300	62.8	78.1	101.5	80.8
360	68.4	81.9	93.21	81.2
420	78.0	100.7	123.0	100.6
480	104.1	96.3	102.4	100.9
540	111.2	113.3	118.1	114.2
600	130.7	101.0	105.6	112.4
Mean SED = 4.7 p <0.001	66.0	75.9	89.1	

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 SED = 4.1 p = 0.004	Mean SED = 3.3 p <0.001
0	24.3	46.3	35.3
75	24.7	47.0	35.9
150	33.0	49.8	41.4
225	36.8	52.3	44.6
300	41.3	48.7	45.0
375	47.3	54.2	50.8
450	52.6	62.6	57.6
Mean SED = 1.1 p <0.001	36.9	51.0	43.9

TABLE 25 **Brussels Sprouts - Nitrogen residues (stalk + leaves) kg/ha N**

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 SED = 37.2 p = 0.84	120	Mean SED = 21.5 p <0.001
0	60.6	100.0	91.2	83.9
60	78.9	83.5	121.8	94.7
120	98.7	107.1	126.4	110.7
180	95.9	108.0	116.7	106.9
240	110.2	178.3	154.1	134.2
300	130.6	148.4	195.0	158.0
360	149.8	192.0	188.2	176.7
420	157.9	184.3	221.8	186.7
480	195.3	188.2	265.4	216.3
540	228.1	188.7	268.0	228.3
600	202.1	202.6	236.8	213.8
Mean SED = 8.11 p <0.001	134.5	151.2	181.1	155.6

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0 SED = 23.6 p = 0.43	200	Mean SED = 11.9 p = 0.010
0	100.0	181.0	141.0
75	86.0	184.0	135.0
150	120.0	189.0	154.0
225	127.0	183.0	155.0
300	150.0	186.0	168.0
375	161.0	192.0	177.0
450	150.0	182.0	166.0
Mean SED = 9.1 p <0.001	129.0	186.0	158.0

TABLE 26 **Brussels Sprouts - Soil mineral nitrogen harvest 0-90 cm kg/ha**

HDC Experiment

Date = 6/1/90

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60	120	Mean
		SED = 11.6 p <0.001		SED = 6.7 p <0.001
0	23.0	28.6	17.2	22.9
60	27.9	29.3	37.6	31.6
120	28.3	20.7	29.0	26.0
180	31.5	28.2	35.1	31.6
240	27.0	72.2	37.8	32.3
300	28.4	33.4	75.2	32.3
360	33.0	49.3	78.3	40.2
420	46.4	46.4	53.4	48.7
480	37.7	51.7	65.1	51.5
540	78.2	72.5	97.1	69.3
600	50.0	136.6	94.6	93.7
Mean SED = 2.5 p <0.001	32.9	41.5	44.7	39.7

MAFF Experiment

Date = 23/11/90

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200	Mean
	SED = 29.3 p = 0.05		SED = 19.5 p <0.001
0	32.7	47.3	40.0
75	31.2	55.8	43.5
150	31.7	63.5	47.6
225	65.3	64.9	65.1
300	52.5	134.5	93.5
375	61.0	160.9	111.0
450	78.9	179.2	129.1
Mean SED = 9.8 p <0.001	49.6	96.6	73.1

TABLE 27 Potential nitrogen residues after harvest of third crop kg/ha N (Nitrogen in soil 0-90 cm plus crop residue N)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60	120	Mean
		SED = 38.1, p = 0.44		SED = 22.0, p <0.001
0	83.6	128.6	108.4	106.9
60	106.8	112.8	159.4	126.4
120	127.0	127.8	155.5	136.7
180	127.4	136.2	151.9	178.5
240	137.2	170.5	191.9	166.5
300	158.9	181.9	230.2	190.4
360	182.8	241.3	226.4	216.9
420	200.3	230.7	275.2	235.4
480	233.0	239.9	330.6	267.8
540	266.3	261.2	365.1	297.5
600	252.1	339.2	331.5	307.6
Mean	167.4	192.7	225.8	193.5
SED = 8.3, p <0.001				

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200	Mean
	SED = 38.0, p = 0.57		SED = 27.0, p <0.001
0	133.0	228.0	181.0
75	118.0	240.0	179.0
150	152.0	252.0	202.0
225	192.0	248.0	220.0
300	203.0	321.0	262.0
375	222.0	353.0	288.0
450	229.0	361.0	295.0
Mean	179.0	282.0	231.0
SED = 11.9, p <0.001			

TABLE 28 **Brussels Sprouts - Mineralisation of N during crop growth**

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 65.26, p = 0.961)	120	Mean (SED = 37.68, p = 0.18)
0	-1.5	6.5	-38.8	-11.3
60	41.0	-27.0	18.5	10.9
120	49.1	-17.7	21.6	3.3
180	65.8	4.6	37.4	11.0
240	63.6	25.7	3.5	30.9
300	85.0	-4.1	3.2	28.0
360	57.7	12.2	-8.3	20.6
420	-2.6	-13.3	25.72	3.3
480	60.7	56.5	35.8	51.0
540	0.6	-12.0	-5.0	-5.5
600	-64.0	-81.3	-88.6	-78.0
Mean (SED = 14.24, p <0.001)	47.7	2.6	-3.0	15.8

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 (SED = 32.0, p = 0.54)	Mean (SED = 41.87, p = 0.27)
0	11.6	-75.9	-32.1
75	-2.1	-39.2	-20.6
150	24.2	-55.3	-15.5
225	25.9	-102.8	-38.5
300	-18.9	-95.6	-57.3
375	-20.8	-93.3	-57.0
450	-54.3	-120.0	-87.2
Mean (SED = 12.0, p <0.001)	0.3	-81.5	-40.6

TABLE 29 **Mineralisation of Brussels Sprout crop residues 1989/1990**

N applied to Brussels sprout crop	Crop N Residue Harvest	Soil mineral N 0-30 cm kg/ha Date 5/6 Jan (Harvest)	1/2	9/2	6/3	19/3	4/4	18/4	2/5
0	71.0	19.1	18.5	18.3	26.7	42.6	71.0	40.2	24.8
60	101.0	19.6	22.2	38.3	29.7	54.9	60.4	64.3	22.6
120	120.0	19.9	20.6	21.5	38.0	65.8	57.3	55.1	41.5

* Plots sampled also had either 0, 60 or 120 kg/ha N applied to the first crop only

TABLE 30 **Mineralisation of residues from Brussels Sprout crops 1990/91**

N applied to previous crops	Soil mineral 0-30 cm kg/ha 23/11/90		29/1/91		27/3/91		2/4/91	
Sprout N	0	200	0	200	0	200	0	200
0	17.9	28.1	44.6	27.6	26.0	32.7	25.0	61.0
150	18.2	30.2	29.5	24.1	23.2	48.1	39.4	53.6
300	17.4	67.1	22.8	33.8	33.2	55.1	44.1	53.0
450	22.9	65.0	25.7	42.2	42.1	58.0	40.2	39.3
Mean	18.9	44.1	29.6	31.1	29.5	48.4	37.6	52.1
Mean (date	31.5		30.4		39.0		44.9	

N applied to previous crops	Soil mineral 0-30 cm kg/ha 16/4/91		29/4/91		14/5/91	
Sprout N	0	200	0	200	0	200
0	22.0	49.1	25.6	35.5	14.7	17.1
150	50.2	60.8	37.6	40.8	16.0	16.2
300	42.0	58.6	32.4	70.3	16.6	24.7
450	60.5	58.7	37.6	35.6	14.4	23.5
Mean	45.0	57.2	34.2	44.6	15.5	19.5
Mean (date)	51.1		39.4		17.5	

TABLE 31. **Brussels Sprouts/Cereals N balance November/May - kg/ha**

Balance	23/11/90 Mineral N (0-90)		Crop Residue N		23/11/90 Potential N Residue	
	0	200	0	200	0	200
0	32.7	47.3	100	181	133	228
150	32.0	52.2	122	194	154	246
300	32.4	115.5	130	199	162	314
450	78.9	179.2	150	182	229	361
Mean	41.6	89.3	125	190	166	279

	14/5/91 Mineral N (0-90)		Crop N		14/5/91 Total		Net change N immobilised	
	0	200	0	200	0	200	0	200
0	23.5	28.1	49.6	72.2	73.1	100	59.9	128
150	27.6	34.8	70.4	94.3	92.9	129	56.3	117
300	42.6	56.9	45.3	104.5	87.9	161	74.5	153
450	51.4	114.5	138.4	130.2	189.9	24.5	39.0	116
Mean	34.5	53.8	74.8	99.1	109.3	153	57.2	126

RESULTS - SPRING CEREALS

Results Spring Cereals

Yields

In 1990 grain yields of barley (Blenheim) were maximum where 420 kg/ha N in total had been applied to the previous three brassica crops (Fig 7, Table 32). In order to maximise the yields of the previous brassica crops this was best applied as 300 kg.ha to the first cauliflower, none to the second and 120 kg/ha to the Brussels sprouts. Crops receiving more than this level of nitrogen showed a large decrease in yield associated with lodging (Table 33) and poor grain filling with large numbers of <2.2 mm grain (Fig 8).

In 1991 maximum grain yields of wheat (cv Tonic) occurred where more than 500 kg/ha N had been applied to the previous three brassica crops (Fig 7, Table 32). This was in excess of that required for maximum marketable yields of the brassica crop which was 300 kg/ha for the first cauliflowers and none for the 2nd cauliflower and Brussels sprout crop. Additional nitrogen applied to the brassica crops did not cause lodging or reduce yield.

Grain nitrogen (Table 34) was significantly increased by nitrogen applied to the previous brassica crops in both seasons. Grain N ranged from 1.48 - 2.29% in 1990 and 1.5 and 2.5% in 1991. At optimum levels of N the barley grain in 1990 would be unlikely to have attracted a malting premium because of high grain N and high screenings. The wheat in 1991 had a protein content of 10.4% where 500 kg/ha N had been applied to the previous brassica crops.

The amount of nitrogen in the crop at harvest (Table 35) varied from 84 - 226 kg/ha N in 1990 and 81 and 246 kg/ha in 1991. Nitrogen applied to the previous crops significantly increased uptake.

At harvest the levels of soil mineral N (Table 36) were typical of index 0 soils with no more than 73 kg/ha and 47 kg/ha in 1990 and 1991 seasons respectively.

Figure 7a. Grain yield spring barley 1990

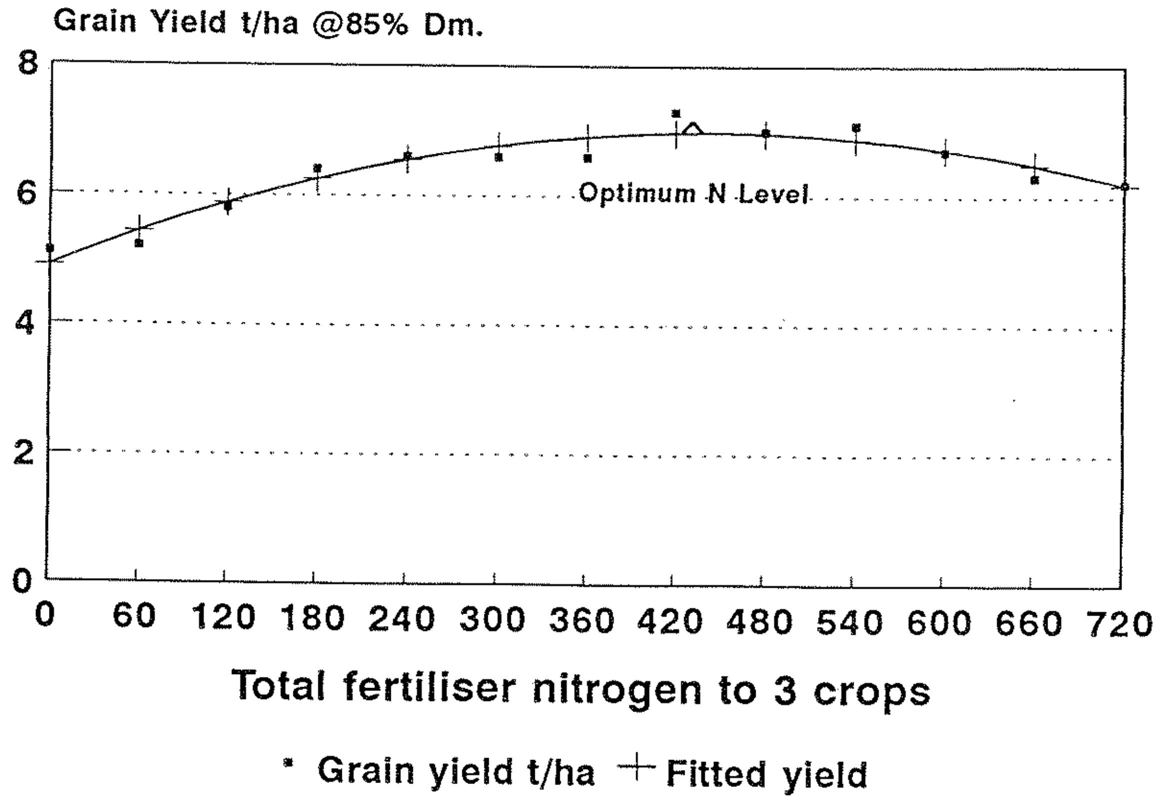


Figure 7b. Grain yield of spring wheat 1991

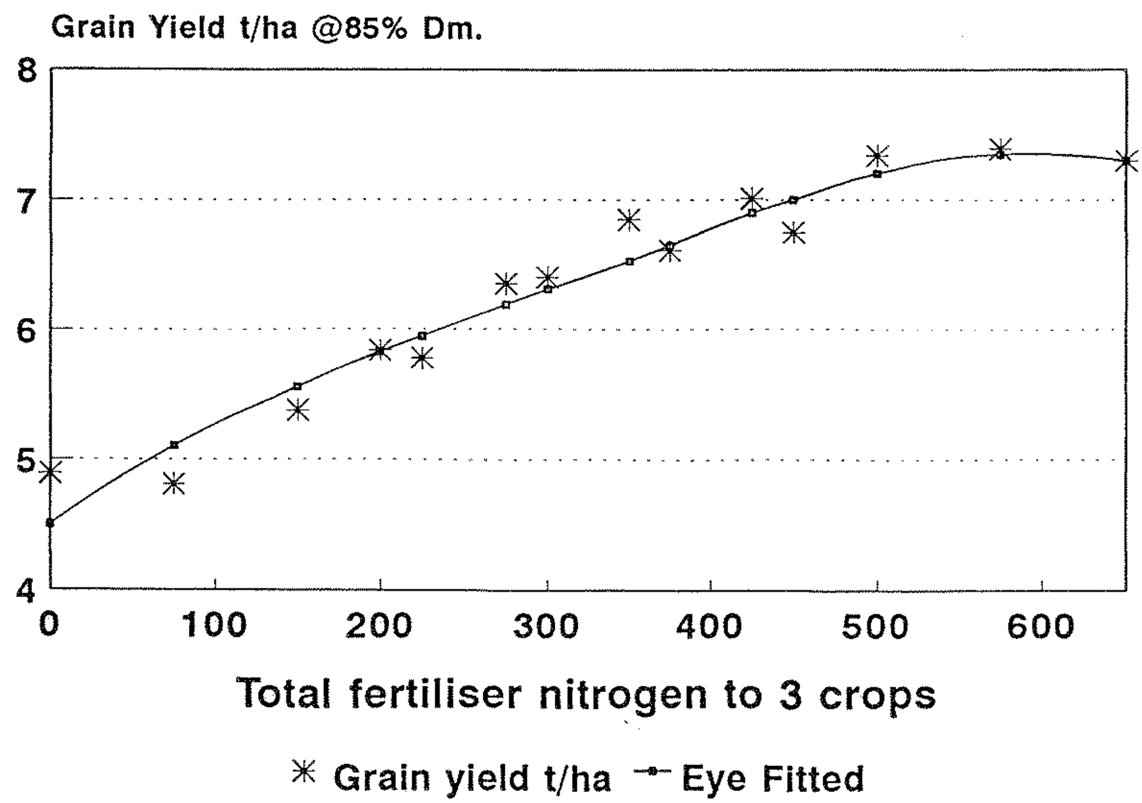


Figure 8. Distribution of grass size in spring barley 1990

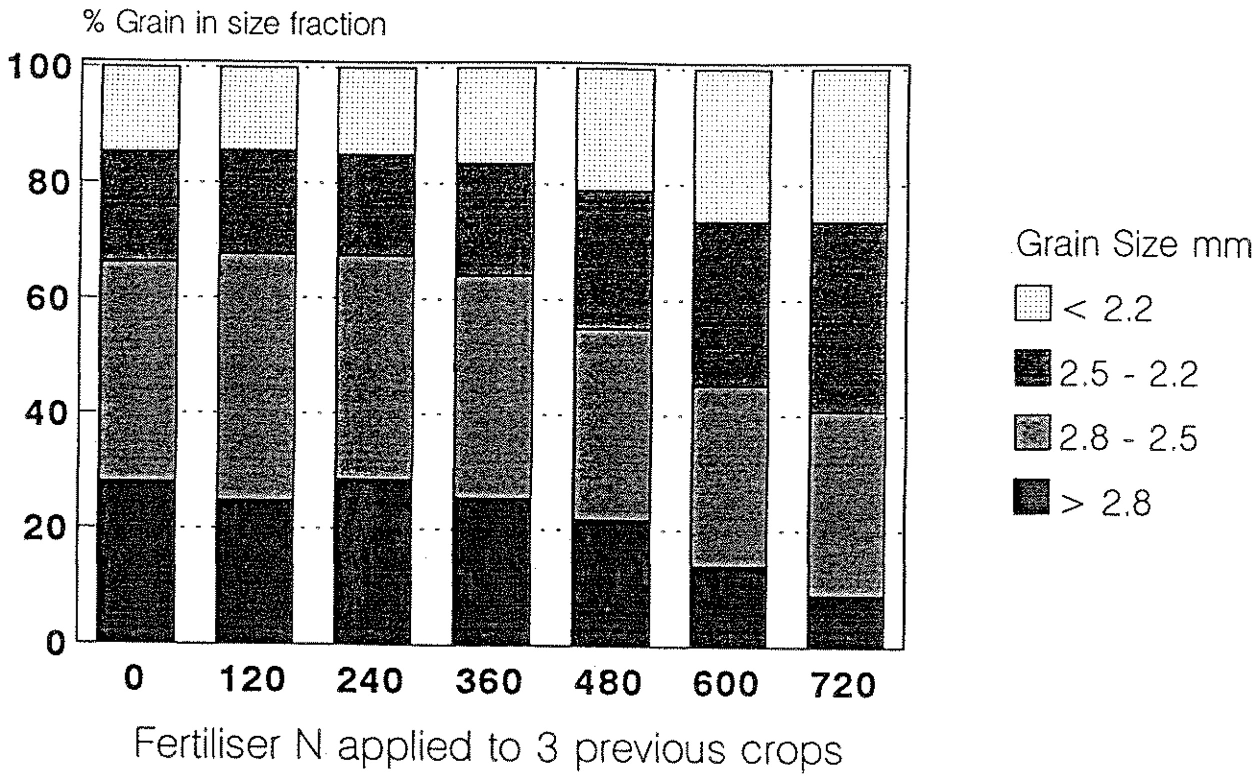


Figure 9. Nitrogen residues from Brussels Sprout crop

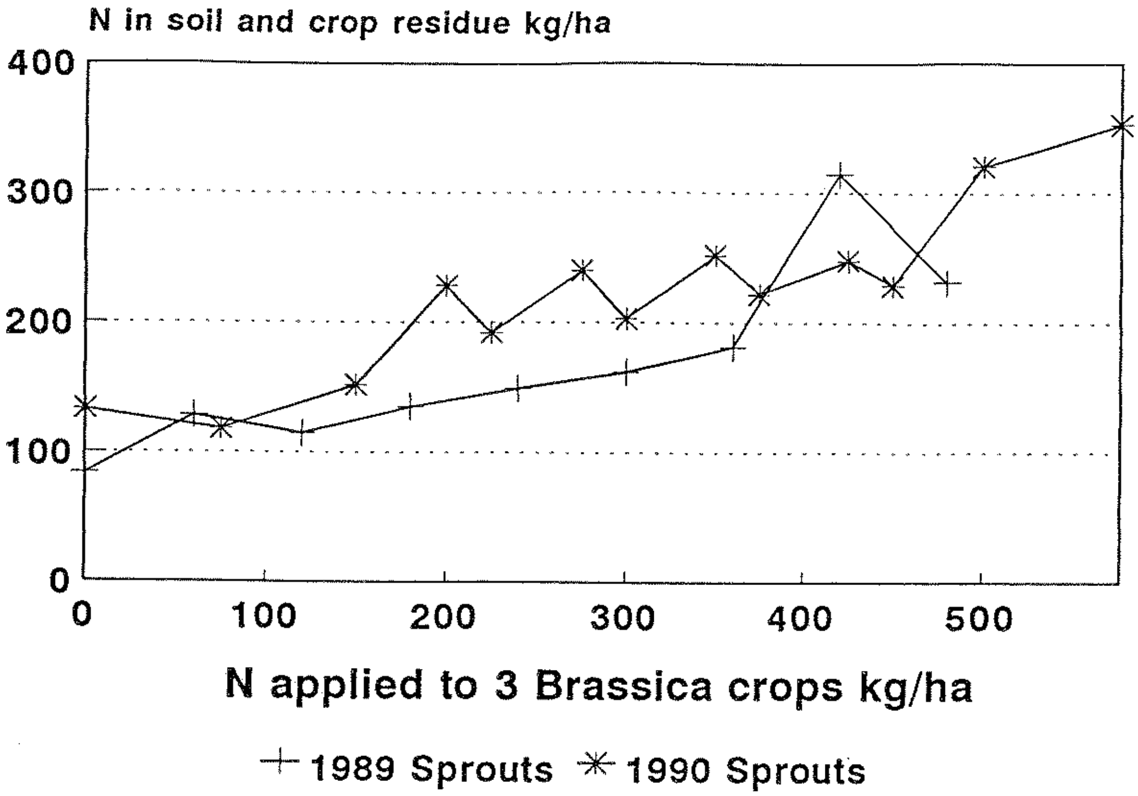
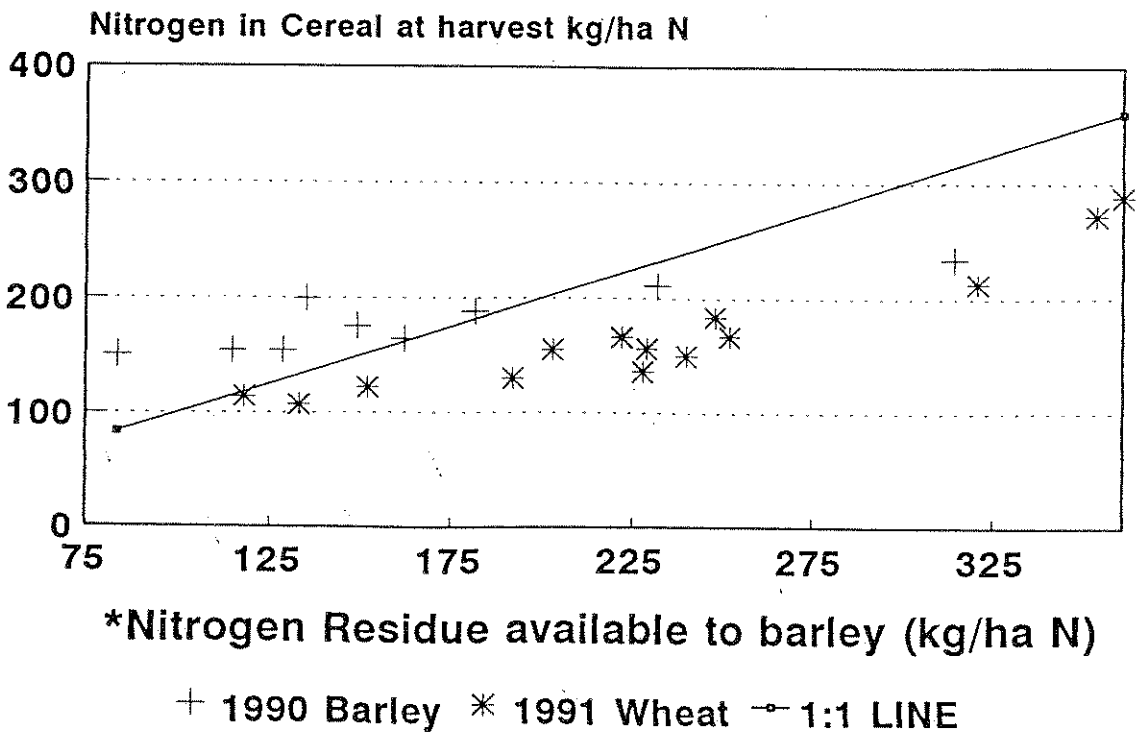


Figure 10. Utilisation of nitrogen residues from sprouts by a spring cereals



*Nitrogen in soil (0 - 90 cm) + crop N at Harvest.

Fig 9 shows the relationship between N applied to the three brassica crops and nitrogen remaining as soil mineral N and in sprout residues. The residue steadily increased with increasing N applied to the brassica crops ranging from about 100 to over 300 kg/ha N. The larger yielding 1990 crop left larger residues of N for the same application of fertiliser.

Fig 10, Table 37 show the nitrogen balance between the harvest of the sprout crop (ie mineral N and crop residue N at harvest) and harvest of the cereal crop (mineral N harvest + N in cereal crop). In 1990 there is a net accumulation of nitrogen except at higher levels of fertilisation. This is in contrast with 1990 where there was a much larger net loss of nitrogen even where no fertiliser had been applied. There is no clear reason for the poor utilization of nitrogen from the 1991 sprout residues.

TABLE 32 Spring Cereals - Grain yield t/ha 85% DM

HDC Experiment - Spring Barley

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 (SED = 0.51, p = 0.037)	120	Mean (SED = 0.30, p <0.001)
0	5.08	5.84	6.37	5.76
60	4.94	5.51	6.58	5.68
120	5.85	6.15	6.42	6.14
180	6.50	7.02	6.43	6.65
240	6.43	6.50	6.80	6.58
300	6.86	6.49	7.19	6.84
360	6.60	7.32	7.29	7.07
420	7.32	6.69	7.13	7.05
480	7.03	6.92	6.93	6.96
540	7.22	6.64	6.56	6.81
600	6.22	5.94	6.18	6.12
Mean (SED = 0.11, p = 0.02)	6.55	6.62	6.85	6.67

MAFF Experiment - Spring Wheat

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 (SED = 0.37, p = 0.46)	Mean (SED = 0.24, p <0.001)
0	4.89	5.84	5.36
75	4.81	6.35	5.58
150	5.38	6.85	6.11
225	5.78	7.01	6.40
300	6.40	7.34	6.87
375	6.61	7.39	7.00
450	6.75	7.30	7.02
Mean (SED = 0.13, p <0.001)	5.81	6.95	6.38

TABLE 33 Spring Cerelas - Lodging score - % Area plot lodged

HDC Experiment - 1990 Spring Barley

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60	120	Mean
		SED = 19.6 p = 0.12		SED = 7.8 p <0.001
0	0	0	0	0
60	0	0	0	0
120	0	0	0	0
180	0	0	0	0
240	0	0	0	0
300	0	0	1.0	0
360	0.2	1.0	0	0.3
420	0	18.5	29.3	0.4
480	0	20.0	33.3	15.9
540	0.5	32.5	20.0	17.8
600	40.0	95.0	80.0	17.7
Mean	1.2	8.3	9.5	6.3

SED = 7.8
p = 0.012

MAFF Experiment - 1991 Spring Wheat

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha 0	200	Mean
0			
75			
150			
225	No lodging at harvest		
300			
375			
450			
Mean			
SED			
p			

TABLE 34 Spring Cereals - Grain N%

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 0.14, p = 0.095)	120	Mean (SED = 0.08, p <0.001)
0	1.55	1.48	1.68	1.57
60	1.59	1.64	1.75	1.66
120	1.65	1.87	1.60	1.71
180	1.69	1.85	1.80	1.78
240	1.67	1.79	1.88	1.78
300	1.76	1.69	1.97	1.81
360	1.80	1.96	2.02	1.92
420	1.90	2.11	2.04	2.02
480	1.90	2.10	2.63	2.02
540	2.02	2.20	2.06	2.09
600	2.29	2.17	2.13	2.20
Mean (SED = 0.03, p <0.001)	1.78	1.89	1.92	1.86

MAFF Experiment

(Protein values in parenthesis)

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0		200 (SED = 0.13, p = 0.015)		Mean (SED = 0.10, p <0.001)	
0	1.52	(7.5)	1.64	(8.0)	1.58	(7.7)
75	1.54	(7.6)	1.67	(8.2)	1.61	(7.9
150	1.58	(7.8)	1.80	(8.8)	1.69	(8.3)
225	1.61	(7.9)	1.91	(9.4)	1.76	(8.6)
300	1.76	(8.6)	2.13	(10.4)	1.95	(9.5)
375	1.84	(9.0)	2.37	(11.6)	2.10	(10.3)
450	1.80	(8.8)	2.50	(12.3)	2.15	(10.6)
Mean	1.66	(8.2)	1.98	(9.7)	1.82	(8.9)

SED = 0.04
p <0.001

TABLE 35 Spring Cereals - Total N offtake at harvest

HDC Experiment

	Nitrogen applied to sprouts (kg/ha)			
Previous N (kg/ha)	0	60 SED = 20.1 p = 0.012	120	Mean SED = 17.6 p <0.001
0	84	103	117	101
60	84	97	134	105
120	104	130	128	121
180	132	152	136	140
240	122	136	157	138
300	140	128	169	146
360	145	173	169	163
420	165	180	180	175
480	155	174	172	167
540	180	202	154	179
600	226	197	173	198
Mean SED = 4.4 p <0.001	138	151	158	149

MAFF Experiment

	Nitrogen applied to sprouts (kg/ha)		
Previous N (kg/ha)	0 SED = 16.1 p = 0.02	200	Mean SED = 11.1 p <0.001
0	81	104	92
75	82	116	100
150	93	135	114
225	102	150	126
300	124	178	151
375	137	225	181
450	131	246	189
Mean SED = 5.2 p <0.001	107	162	134

TABLE 36 Spring Cereals - Soil Mineral N at Harvest

HDC Experiment

Date sampling = 21/8/90

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	60 (SED = 14.4, p = 0.29)	120	Mean (SED = 8.3, p = 0.34)
0	67	35	55	52
60	-	-	-	-
120	40	54	38	44
180	-	-	-	-
240	43	54	50	49
300	-	-	-	-
360	73	46	63	60
420	-	-	-	-
480	-	-	-	-
540	-	-	-	-
600	-	-	-	-
Mean (SED = 6.7, p = 0.99)	50	50	49	50

MAFF Experiment (All plots)

Date sampling = 4/9/91

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha): 0	200 (SED = 5.9, p <0.001)	Mean (SED = 5.6, p = 0.66)
0	27	32	29
75	31	33	32
150	29	32	30
225	29	34	31
300	31	34	33
375	30	47	38
450	25	42	33
Mean (SED = 0.93, p <0.001)	29	36	33

TABLE 37 Spring Cereals - Nitrogen Balance
(Nitrogen in sprout residues + soil) - (Nitrogen in crop and soil harvest cereals)

HDC Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	60 SED = 32.8 p = 0.39	120	Mean SED = 20.7 p = 0.034
0	+67	+26	+60	+51
60	-	-	-	-
120	+29	+64	+24	+39
180	-	-	-	-
240	+28	+3	+4	+12
300	-	-	-	-
360	+13	-80	-21	-29
420	-	-	-	-
480	-	-	-	-
540	-	-	-	-
600	-	-	-	-
Mean SED = 16.6 p = 0.46	+32	+12	+14	+19

MAFF Experiment

Previous N (kg/ha)	Nitrogen applied to sprouts (kg/ha) 0	200 SED = 31.2 p = 0.28	Mean SED = 20.8 p = 0.62
0	-26	-92	-59
75	-4	-90	-47
150	-29	-85	-57
225	-62	-64	-63
300	-48	-108	-78
375	-56	-81	-69
450	-73	-73	-73
Mean SED = 10.4 p <0.001	-42	-85	-64

DISCUSSION

Prediction of nitrogen requirement

Discussion Nitrogen Prediction for Brussels Sprouts

Fig 11 shows the response to fertiliser nitrogen (120 kg/ha in 1989, 200 kg/ha in 1990) given different levels of fertiliser to the previous two cauliflower crops. Response to nitrogen declined sharply with increasing previous N applied. Response was much lower in the 1990 season in spite of the larger amount of N applied. For individual seasons the response to fresh nitrogen was well related to the nitrogen level applied to the previous two crops. In 1989 there was no response when application was > 480 kg/ha, in 1990 this figure was only about 200 kg/ha N. N applied to the previous two crops on its own was therefore unable to explain the fertiliser requirement for the sprout crop. Thus previously applied N is not suitable for use in a predictive model.

The results of alternative models for nitrogen response are shown in table 38 b below.

TABLE 38 **Percentage Variance (R^2) in yield response accounted for by various parameters with and without an allowance for different years.**

Parameter	Without year	With year
Early N fertiliser	40.5	79.5
Mineral N 0-90 cm	61.0	67.1
0-30 cm and 30-90 cm	67.3	66.0

Fig 12 shows the relationship between mineral N (0-90 cm) at planting and response to N fertiliser. The seasonal effects are better dealt with by this approach. Response to fertiliser N in the 1990 season is still less than that given in 1989 for a similar level of soil mineral N. The best explanation of this is to take into account the distribution of nitrogen within the soil profile. Fig 13 (Table 39) shows that there was more mineral N in the top 30 cm in the 1990 season. If this is taken into account, 67% of the variation in response to fertiliser is accounted for and there is no improvement when the year term is included.

Yield response Y for these two trials is given by:-

$$Y = 6.5 - 0.03*A - 0.016*B$$

Where Y = Yield response of buttons to nitrogen (t/ha fresh weight; kg/ha N)

A = Soil mineral N (kg/ha) in 0-30 cm layer at planting

B = Soil mineral N (kg/ha) in 30-90 cm layer at planting

The regression is significant at the <0.001 level of probability.

Figure 11. Response of sprouts to nitrogen

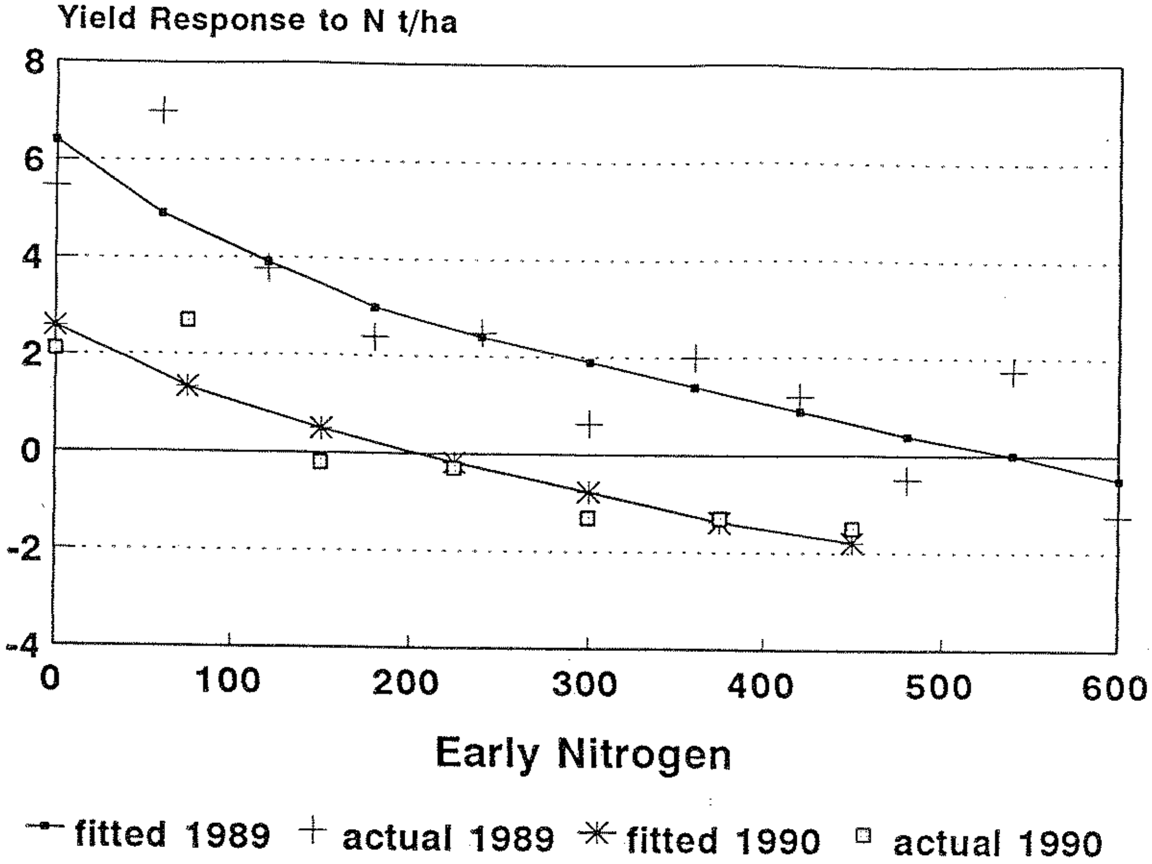


Figure 12. Response of sprouts to nitrogen

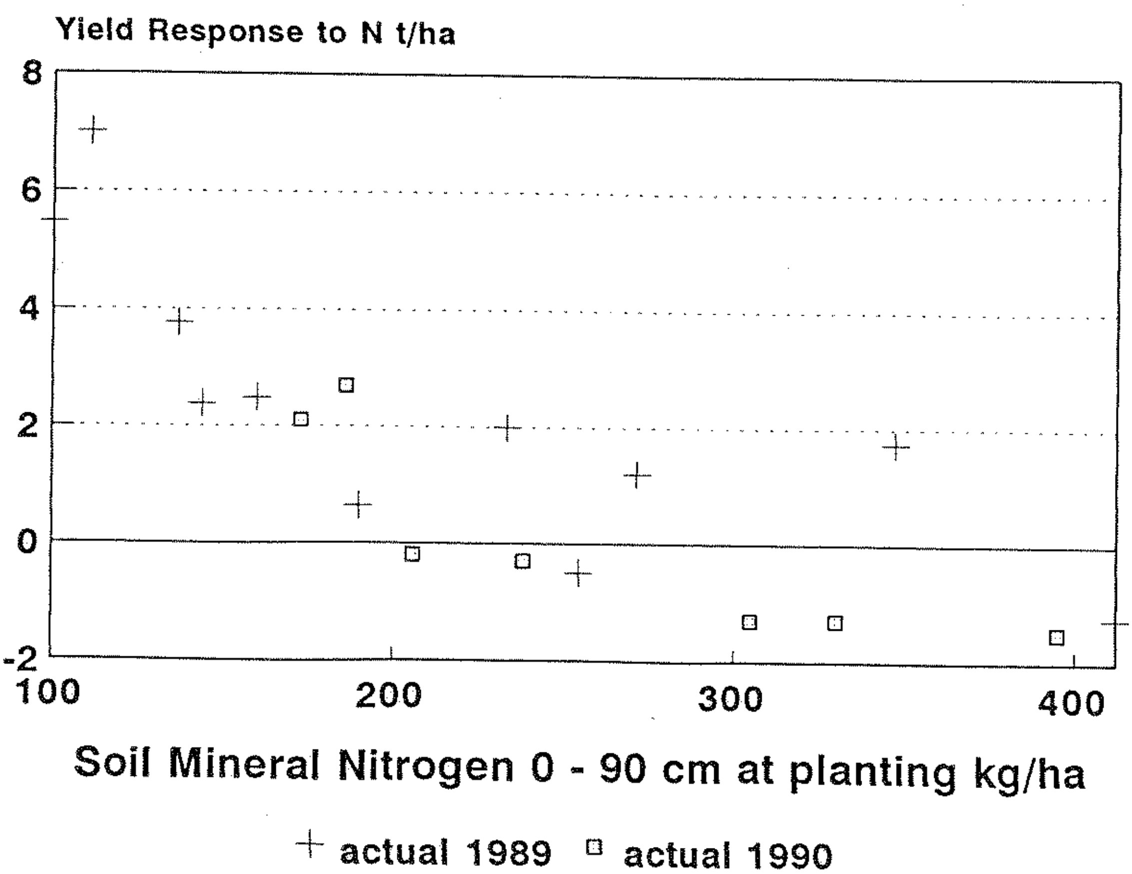


Figure 13a. Soil mineral nitrogen at planting Brussels sprouts (2 May 1989)

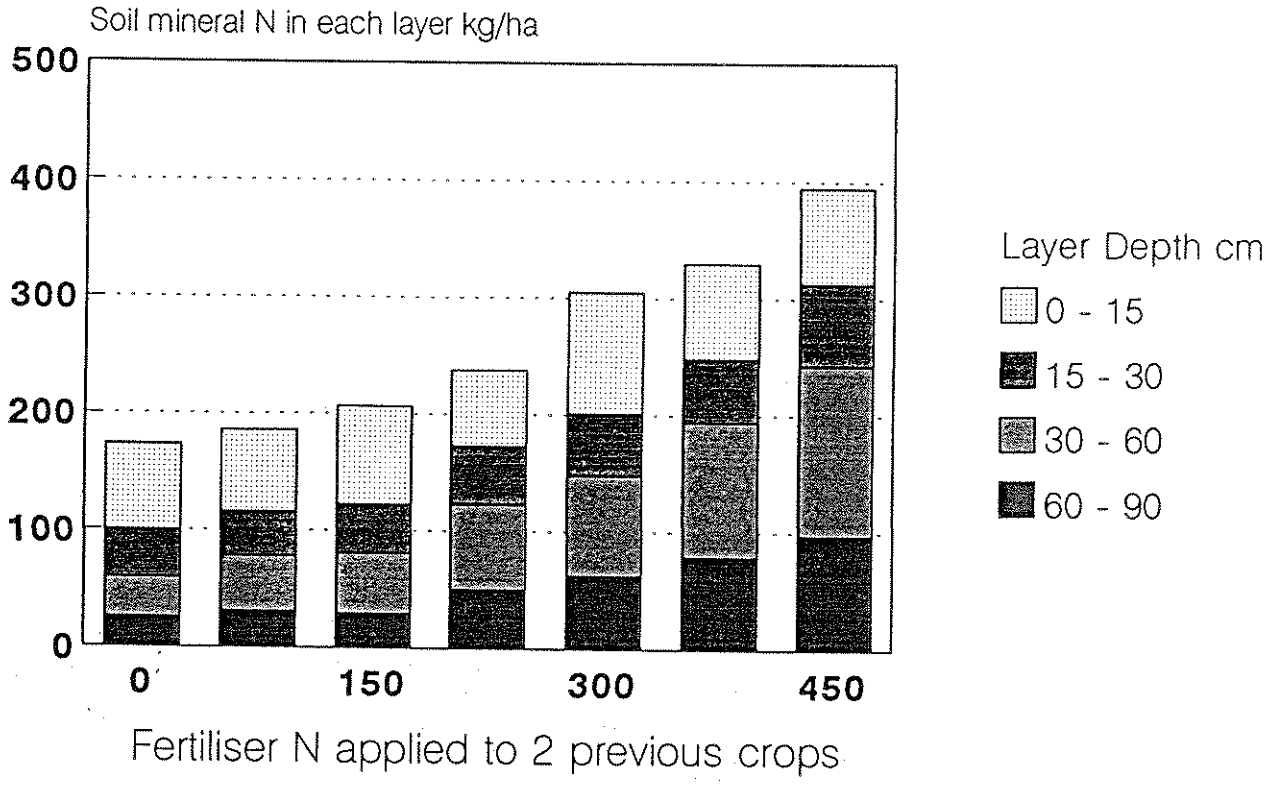


Figure 13b. Soil mineral nitrogen at planting Brussels sprouts (15 May 1990)

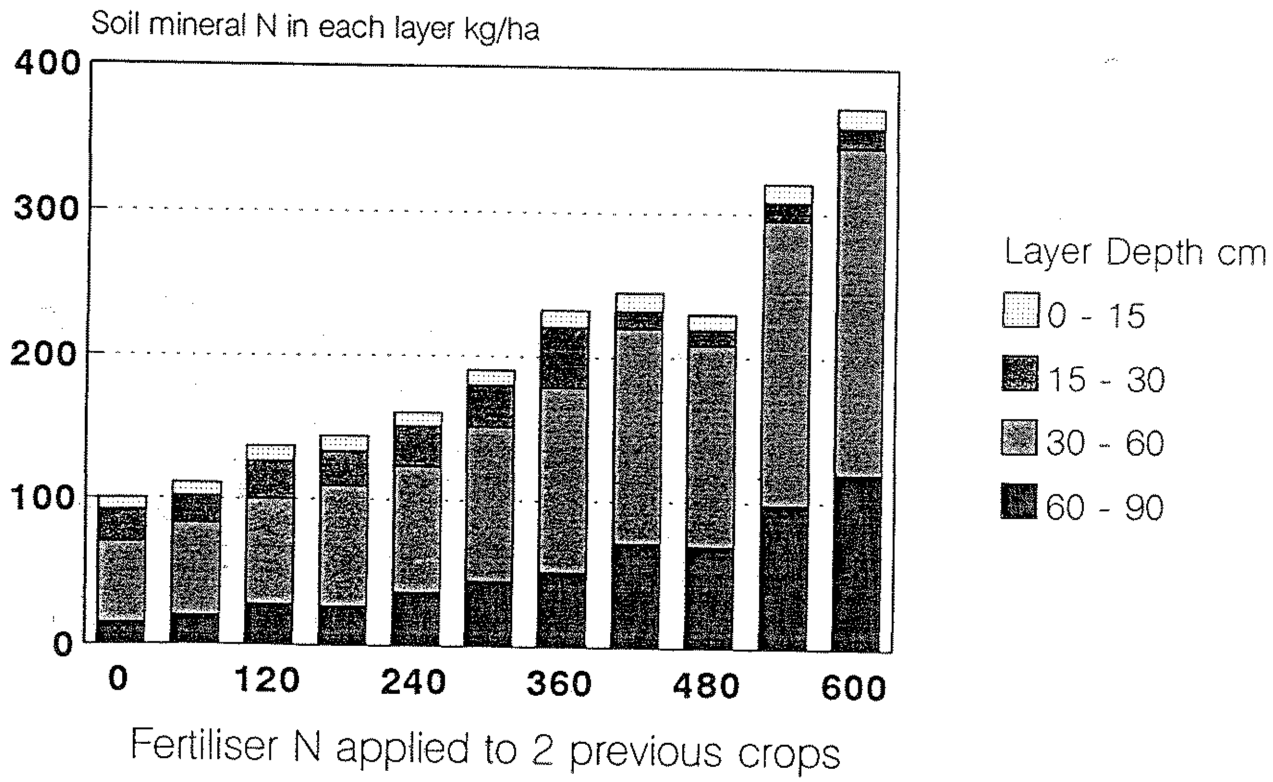


TABLE 39 Soil mineral N at planting sprouts

HDC Experiment - Sampled 2/5/89

Nitrogen Applied Crop 1 + 2	(kg/ha) 0-90 cm	% 0-15	% 15-30	% 30-60	% 60-90
0	100	8.2	22	55	15
60	111	8.7	16	58	18
120	137	7.7	19	53	20
180	144	7.7	16	58	18
240	160	5.0	17	55	22
300	190	5.5	15	56	24
360	233	5.2	18	55	22
420	271	4.5	15	56	36
480	254	4.6	15	54	26
540	347	3.6	11	56	28
600	412	3.2	13	55	29
Mean	204	5.8	15.9	55.7	22.6
SED	21.9	1.13	3.6	4.6	4.2
p	<0.001	<0.001	0.22	0.97	0.026

MAFF Experiment - sampled 15/5/90

Nitrogen Applied Crop 1 + 2	(kg/ha) 0-90 cm	% 0-15	% 15-30	% 30-60	% 60-90
0	173	42	23	20	15
75	186	38	20	25	17
150	206	41	20	25	14
225	238	27	21	31	21
300	305	33	18	28	21
375	330	25	16	35	24
450	395	21	18	37	25
Mean	256	32.7	19.4	28.6	19.3
SED	22.1	4.9	3.3	2.4	2.7
p	<0.001	0.003	0.41	<0.001	0.003

The results indicate the importance of readily available N within the early root zone (0-30 cm). This was supplied by fertiliser in 1989 and by existing soil mineral N in 1990.

German workers (Lorenz *et al* 1989) have suggested that Brussels sprouts have a need for 95 kg/ha N in the surface 30 cm of the soil profile to support early growth. They also suggest that the total amount of N required for a fresh weight yield of 15 t/ha buttons is 330 kg/ha N allowing 270 kg/ha in the crop and 60 kg/ha N in the soil at harvest. Table 40 shows the status of the experimental treatments relative to these requirements. The 1989 crop is suffering from a shortage of nitrogen throughout its life. Where sufficient N had been applied for maximum marketable yield of cauliflowers, a top-dressing of 140 kg/a is suggested (MAFF Reference Book 209 would recommend 150 kg.ha on silt soils following brassicas). Where very high levels of fertiliser had been applied to the previous crops, ie 540, 600 kg/ha a small dressing of 30-40 kg/ha is recommended to provide for the early needs of the crop.

In 1990 where much more of the mineral N was in the top 30 cm of soil the crops are predicted to be suffering from N shortage later in their growing season except at very high levels of N application to the previous cauliflower crops. Where sufficient N had been applied to the previous cauliflowers for maximum marketable yield (ie 300 kg/ha N) only a small quantity of nitrogen was required to supplement existing N in the soil. Where an unnecessarily large application (200 kg/ha) was applied there was a tendency for yield to be depressed.

In both seasons the measurement of soil mineral N at planting when interpreted in the way described above, provided sensible fertiliser recommendations taking into account the previous field history.

The critical levels of soil mineral N in 0-30 and 30-90 layer need further verification before they can be used for sprouts on other soil types and may need checking for sprouts of different vigour and yield level.

TABLE 40 Brussels Sprouts - N supply status
Nitrogen requirement 95 kg/ha 0-30, 330 kg/ha 0-90 at planting after Lorenz et al (1989)

Fertiliser recommendation in parenthesis

HDC Experiment

	Nitrogen applied to sprouts (kg/ha)		
Previous	0	60	120
0	D (230)	D	DL
60	D (220)	D	DL
120	D (193)	DL	DL
180	D (186)	DL	DL
240	D (170)	DL	DL
300	D (140)	DL	DL
360	D (97)	DL	OK
420	D (59)	OK	OK
480	D (76)	DL	OK
540	DE (43)	OK	OK
600	DE (29)	OK	OK

MAFF Experiment

	Nitrogen applied to sprouts (kg/ha)	
Previous N (kg/ha)	0	200
0	DL (157)	OK
75	DL (144)	OK
150	DL (124)	OK
225	DL (92)	OK
300	DL (25)	OK
375	OK	OK
450	OK	OK

N Status key

OK = satisfactory
D = insufficient all season
DE = insufficient early season
DL = insufficient mid late season

Use of soil mineral N to predict need for nitrogen fertilisation of cereal crops

Measurements of soil mineral N in the spring following the incorporation of Brussels sprout residues, were found to be much lower than expected due to slow mineralisation. In 1990 where enough N had been applied for maximum yield of brassicas, maximum yield of barley was achieved. An assumption could be made that no additional N would be necessary for cereals following an adequately fertilised sprout crop. However, this was not the case in 1991 where wheat used the residual N from Brussels sprouts much less efficiently. In 1991 wheat following optimal levels of N fertilisation for brassicas would have needed additional fertiliser for optimum grain yield. From this experiment it is not possible to predict the amount. Measurements of mineral N at planting would be misleading, but further measurements of mineral N in the soil and Crop N in April might be used to recommend the need for top-dressing.

CONCLUSIONS

Prediction of Nitrogen requirement

CONCLUSIONS

1. Brussels sprouts grown in a brassica rotation may still require applications of fertiliser to produce maximum yields of buttons inspite of incorporation of up to 135 kg/ha from the previous autumn cauliflower crop.

2. The likely contribution of nitrogen from previously incorporated residues can be assessed by measurement of soil mineral nitrogen at planting of the Brussels sprout crop.

3. For maximum yield of sprouts on a silt soil the level of soil mineral nitrogen to 90 cm depth at planting should be 330 kg/ha. At least 95 kg/ha of this should be in the top 30 cm. If soil mineral N levels are lower, then fertiliser nitrogen will be needed. In the 1989 season supplementary nitrogen was necessary, in 1990, where enough N had been applied for maximum yield of previous crops, no additional nitrogen was needed by the sprouts.

4. Later incorporation of brassica crop residues may reduce the risk of nitrogen being leached from the rooting zone of future crops.

5. Excessive applications of fertiliser to the previous brassica crops or to the sprouts can given rise to lodging and in severe cases reduction in yield.

6. Brussels sprouts are very effective in removing nitrogen from the soil, an optimally grown crop leaving less than 100 kg/ha at harvest. However, only ⅓ of the crop is removed as marketable sprouts leaving up to 175 kg/ha in crop debris.

7. Mineralisation of nitrogen from winter incorporated sprout debris is very dependant on weather conditions following incorporation and it can be several months before it is released to the soil.

8. Cereals following well fertilised sprouts may still require fresh applications of fertiliser nitrogen to achieve maximum yield. The assessment of nitrogen supply for a cereal following Brussels sprouts is complicated by the slow speed of nitrogen mineralisation during the winter. Measurements of soil mineral N at planting of the spring cereals seriously underestimated the potential supply of nitrogen.

9. Further work is required to assess the best way of recommending nitrogen for cereal crops following sprouts.

10. Further investigations are required to confirm the results from these experiments on other soil types. On lighter soils in the West, leaching may reduce the effectiveness of incorporated N residues.

11. Further work should investigate methods of residue management to maximise carryover of nitrogen in crop residue between seasons.

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REFERENCES

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APPENDIX

SITE PLANS AND HISTORY

APPENDIX

HDC NITROGEN PREDICTION TRIAL 1988/89, TREATMENT PLAN

BLOCK II | BLOCK III

58	59	60	64	65	66	70	71	72	94	95	96	100	101	102	106	107	108
BE	BC	BG	EA	EC	EB	AD	AE	AC	GA	GE	GG	DE	DC	DA	CD	CC	CG

55	56	57	61	62	63	67	68	69	91	92	93	97	98	99	103	104	105
BA	BB	BD	EG	ED	EE	AB	AG	AA	GC	GB	GB	DB	DD	DG	CE	CB	CA

40	41	42	46	47	48	52	53	54	76	77	78	82	83	84	88	89	90
GB	GG	GE	CD	CC	CE	DA	DE	DG	BB	BD	BA	EE	EA	EB	AC	AA	AD

37	38	39	43	44	45	49	50	51	73	74	75	79	80	81	85	86	87
GA	GC	GD	CB	CA	GG	DC	DB	DD	BC	BE	BG	EC	ED	EG	AB	AE	AG

41.44 m

22	23	24	28	29	30	34	35	36
CE	CB	CG	EA	EC	ED	GB	GA	GD

34.08 m
30.08 m

19	20	21	25	26	27	31	32	33
	CC	CA	CD	EB	EE	EG	GC	GEGG

22.72 m
18.72 m

4	5	6	10	11	12	16	17	18
AD	AG	AE	DC	DB	DA	BA	BE	BG

11.36 m
7.36 m

1	2	3	7	8	9	13	14	15
AA	AC	AV	DD	DE	DG	BB	BC	BD

Om

32.94 m
Block I

TREATMENT CODES

A 0 kg/ha
B 60 kg/ha
C 120 kg/ha
D 180 kg/ha
E 240 kg/ha
G 300 kg/ha

1st letter refers to 1st N
2nd letter refers to 2nd N

ie GA received
1st N application of 300 kg/ha
2nd N application of 0 kg/ha

APPENDIX

CROP 1 1988

KIRTON EHS - DIARY SHEET

TRIAL:	HDC/Nitrate Responses	CROP:	E.S. Cauli
FIELD/SOIL TYPE:	Lane 1. Coarse silty marine alluvial		
PREVIOUS CROPPING:	1987 Grass 1986 A.S. Onion lifted + grass		
SOIL ANALYSIS:	pH 8.0 N-1, P-3, K-1		
CULTIVATIONS:	Ploughed on 9-10/2/88 N -> S Worked with Lely 7/3/88		
FERTILISER:	50 kg/ha $p^{2}0^{5}$, 432 kg/ha $K^{2}0$ 7/3/88 N applied as trts 28-29/3/88 S. Science		
SOWING/PLANTING:	Sown Perfection in 6 cm Blocks		
INSECTICIDES:	28/4/88 Birlane applied		
FUNGICIDES:			
HERBICIDES:	Albrass + Dacthal 6/4/88		
IRRIGATION:			

NOTES:

KITRON EHS - TRIAL DIARY SHEET

TRIAL:	Brussels sprouts 1989/90 - Soil Science Nitrate Response Trial
FIELD/SOIL TYPE:	Lane 1/Coarse Silty Marine Alluvial
SOIL ANALYSIS:	pH 7.5 N-1 P-3 K-1
PREVIOUS CROPPING:	1987 - Grass 1988 - Cauliflowers
CULTIVATIONS:	Ploughed - 15 December 1988, E-W, turning soil to N
FERTILISER:	HDC trial area (4227 m^2) given P & K only - 150 kgsulphate of potash and 48 kg Triple Super Phosphate on 17 May 1989.
SOWING PLANTING:	Sown - w/b 13 March 1989, all Stephen, GPG 308 Planted - 19 May 1989 by machine

DATE	OPERATION
9 & 10 May 1989	Field ploughed
19 May 1989	Trial planted by machine
1 June 1989	Sprayed with 6 pts Albrass + 5½ lb Dacthal/acre
10 June 1989	Sprayed with 8 fl oz Metasystox/acre in at least 90 gals
26 June 1989	Sprayed with 6 oz/ac Aphox and 3½fl oz/ac Toppel
3 July 1989	Sprayed as above with Aphox and Toppel
9 July 1989	Sprayed with 8 fl oz Metasystox + 4½ fl oz Toppel/acre
7 August 1989	Sprayed with 42 fl oz/acre Chiltern Olé, for powdery mildew
9 August 1989	Sprayed with 8 oz Metasystox + 3½ fl oz Toppel/acre
23 August 1989	Sprayed with 7 fl oz Bayfidan/acre
20 September 1989	Sprayed with 8 fl oz Metasystox/acre
10 October 1989	Sprayed with 7 fl oz Bayfidan/acre
23 October 1989	Sprayed with 8 fl oz/acre Metasystox plus wetter
15 December 1989	Measurements and field assessments taken for all plots.
26 January 1990	Ploughed

KIRTON EHS - TRIAL DIARY SHEET

21/2/90	Cultivation with Lely
21/2/90	Drilled with 'Blenheim' at 154 kg/ha
1/6/90	Calixin spray
6/8/90	Harvested plot combine

APPENDIX

NITRATE RESPONSES 1989, TREATMENT PLAN

87.84 m

19.64 m

DB	DA	DC	AA	AC	AB	CC	CB	CA	DC	DA	DB	EA	EC	EB	BB	BA	BC	EC	EA	EB	AC	AA	AB
10	11	12	13	14	15	22	23	24	25	26	27	28	29	30	37	38	39	40	41	42	43	44	45

11.8 m

7.82 m

EA	EB	EC	CB	CC	CA	BC	BB	BA	BA	BC	BB	AC	AA	AB	DB	DA	DB	CA	CC	CB
1	2	3	4	5	6	7	8	9	16	17	18	19	20	21	31	32	33	34	35	36

7.85 m

BLOCK I BLOCK II BLOCK III

A 0 kg/ha
B 75 kg/ha
C 150 kg/ha
D 225 kg/ha
E 300 kg/ha

1st letter of codes relates to 1st N treatment
2nd letter of code relates to 2nd treatment
ie EA received;
1st N application of 300 kg/ha
2nd N application of 0 kg/ha

APPENDIX CROP 1 1989

KIRTON EHS - TRIAL DIARY SHEET

TRIAL:	S. Science - Nitrates CROP: E.S. Cauli 1989
FIELD/SOIL TYPE:	Asplands 1 - Gley soil. Coarse silty marine alluvial
PREVIOUS CROPPING:	1987 Brassica 1988 Barley
SOIL ANALYSIS:	Sept 88 - pH 7.5 N-0, P-2, K-1
CULTIVATIONS:	Ploughed 5/12/88. One pass with Lely at planting
FERTILISER:	S.S. do N trts. 27/2/89 63.82 kg Sulphate of Potash & 26.6 kg Triple super phosphate
SOWING/PLANTING:	Sown: 17/10 Perfection 24 308 GPG trays 5/12 308 -> P. Blocks 70 trays Planted: 8/3/89 as plan
INSECTICIDES:	10/6/89 Toppel
FUNGICIDES:	
HERBICIDES:	11/3 Ramrod/Dacthal applied
IRRIGATION:	
NOTES:	In prop - sprayed Filex & Basilex when stood in venlo, then sprayed Repulse on 3/11, 11/11, 25/11, 9/12, 23/12, 6/1, 27/1 6/2 Fans put in venlo 22/2 stood out on standing ground

APPENDIX

CROP 2 1989

KIRTON EHS - TRIAL DIARY SHEET

TRIAL:	S. Science - Nitrates	CROP: A. Cauli 1989
FIELD/SOIL TYPE:	Asplands 1 - Gley soil. Coarse silty marine alluvial	
PREVIOUS CROPPING:	1987 Brassica 1988 Barley	
SOIL ANALYSIS:	Sept 88 - pH 7.5 N-0, P-2, K-1	
CULTIVATIONS:	Double crop. E.S. Disced in 22/6/89 + ploughed	
FERTILISER:	S.S. do N trts. 3/7/89 63.8 kg Sulphate of Potash & 26.6 kg Triple super phosphate	
SOWING/PLANTING:	Sown: 20/5/89. 20 x 308 trays W. Rock Planted: 5/7/89 Dursban trt	
INSECTICIDES:	31/7/89 Toppel & Aphox. Repeat 22/8 & 16/9	
FUNGICIDES:		
HERBICIDES:	11/7/89 Ramrod & Dacthal	
IRRIGATION:		

NOTES:

KIRTON EHS - TRIAL DIARY SHEET

TRIAL:	Brussels sprouts 1990/91 - Nitrate Responses
FIELD/SOIL TYPE:	Asplands 1/Gley soil - Course Silty Marine Alluvial
SOIL ANALYSIS:	pH 7.3 N-0 P-4 K-2
PREVIOUS CROPPING:	1988 - Wheat 1989 - Double cropped cauliflowers
CULTIVATIONS:	16-19 February 1990 - ploughed
FERTILISER:	
SOWING/PLANTING:	Sown: 16 March 1990 (5 GPG 309 trays Dolmic) Planted: 16 May 1990 Chlorpyrifos applied pre-planting as a Dursban 4 drench
23 May 1990	Propachlor as 9 l/ha Albrass and Chlorthal-dimethyl as 6 kg/ha Dacthal applied
13 June 1990	Demeton-S-methyl as 560 ml/ha Metasystox 55 plus Agral applied
18 July 1990	Triazophos as 840 ml/ha Hostathion applied
27 July 1990	Disulfotan as 14 kg/ha Disyston applied 90 gals
1 August 1990	Chlorothalonil & metalaxyl as 2 l/ha Folio 575 FW applied
21 August 1990	Demeton-S-methyl as 560 ml/ha Metasystox 55 and Cypermethrin as 250 ml/ha Ambush C applied
24 August 1990	Chlorthalonil & metalaxyl as 2 l/ha Folio 575 FW applied
4 September 1990	Demeton-S-methyl as 560 ml/ha Metasystox 55 and Cypermethrin as 250 ml/ha Ambush C applied
14 September 1990	Triadimenol as 500 ml/ha Bayfiden applied
14 September 1990	Tirchlorfon as 1.75 kg/ha Dipterex 80 applied
7 November 1990	Heptenophos as 840 ml/ha Hostaquick and Deltamethrin as 150 ml/ha Decis applied
6 December 1990	Ploughed
14 January 1991	2 t/acre lime applied

21 January 1991	Ploughed
22 February 1991	Cultivation with Lely and Tonic drilled at 154 kg/ha seed
24 August 1991	Harvested with plot combine

CR04811

Oct