A REPORT TO THE HORTICULTURAL DEVELOPMENT COUNCIL
18 LAVANT STREET, PETERSFIELD, HANTS, GU32 3EW

CROP COVERS: FERTILISER RATES FOR YIELD AND QUALITY

FINAL REPORT

Project Number:	FV38B
Project Title:	Crop Covers: Fertiliser rates for yield and quality.
Project Leader:	Julie Hembry
Location of Project:	Horticulture Research International Stockbridge House Cawood Selby North Yorkshire YO8 0TZ Tel: 0757 268275 Fax: 0757 268996
Project Coordinator:	Peter Emmett
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Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature ..Julie Hembry.....

Julie Hembry
Project Leader

Date ..12/11/93.....

Report authorised by ..M R Bradley.....
(signature)

M R Bradley
Head of Station
HRI Stockbridge House
Cawood
Selby
North Yorkshire
YO8 0TZ

Date ..12.11.93.....

Contents

Relevance to Growers and Practical Application

This project aimed to establish the maturity date, yield and quality of early crops of carrots, iceberg lettuce and round-headed cabbage grown under crop covers with reduced rates of nitrogen fertiliser.

A 45% reduction in the rate of nitrogen fertiliser did not reduce the yield or quality of early carrots grown under crop covers. A double crop cover of nonwoven 17 g/m^2 + perforated polythene 500 holes/m^2 advanced the maturity of carrots giving very high yields on 23 June, with the potential to harvest earlier. The nonwoven cover when used alone also gave high, early yields.

A 45% reduction in the rate of nitrogen fertiliser did not reduce the number or quality of marketable lettuce, but it did reduce the mean head weight of the iceberg product. The nonwoven cover significantly increased mean head weight but not sufficiently to offset the weight loss from the reduced nitrogen input.

A 40% reduction in nitrogen fertiliser did not delay maturity or reduce the yield or quality of early cabbage when grown under crop covers. A nonwoven cover advanced maturity of cabbage by 7 days while perforated polythene only advanced maturity by 2-3 days. Yield and quality were similar for both crop covers.

Summary

Objective

The project aimed to evaluate the effect of different rates of nitrogen fertiliser on the yield and quality of early crops of carrots, cabbage and iceberg lettuce when grown with and without crop covers.

Treatments

1. Early Carrots

Cultivar:

Nairobi F1 Hybrid

Crop Covers:

None

Nonwoven (17 g/m^2)

Perforated polythene (500 x 10 mm holes/m^2)

Nonwoven (17 g/m^2) + perforated polythene (500 x 10 mm holes/m^2)

Rate of Nitrogen Fertiliser:

Standard (ADAS) recommendation

45% less than standard

80% less than standard

No nitrogen fertiliser

2. Iceberg Lettuce

Cultivar:

Kelvin

Crop Covers:

None

Nonwoven (17 g/m^2)

Perforated polythene (500 x 10 mm holes/m^2)

Nonwoven (17 g/m^2) + perforated polythene (500 x 10 mm holes/m^2)

Rate of Nitrogen Fertiliser:

Standard (ADAS) recommendation

45% less than standard

80% less than standard

No nitrogen fertiliser

3. Early Cabbage

Cultivar:

Derby Day F1 Hybrid

Crop Covers:

None

Nonwoven (17 g/m^2)

Perforated polythene (500 x 10 mm holes/m^2)

Rate of Nitrogen Fertiliser:

Standard (ADAS) recommendation

20% less than standard

40% less than standard

60% less than standard

80% less than standard

No nitrogen fertiliser

For both treatments with a crop cover, all nitrogen fertiliser was applied as a base dressing. For treatments with no crop cover, the traditional method of fertiliser application was used, with a maximum of 100 kg/ha nitrogen applied as a base dressing and the remainder as a top dressing 4 weeks after planting.

Results

The results of this investigation are based on a sandy loam soil type. The treatments have not been tested on other soil types.

Carrots

1. The nonwoven + perforated polythene double cover increased air and soil temperature the most. The perforated polythene and nonwoven covers also increased air and soil temperatures.

2. The nonwoven + perforated double cover significantly advanced maturity, producing very high yields of early carrots on 23 June. There is potential to harvest earlier and still achieve high yields.

3. Both nonwoven and perforated polythene covers increased early yield compared with the uncovered crop, the nonwoven cover to a greater extent than perforated polythene.

4. Generally, a reduction in nitrogen fertiliser by 45% or 80% less than the standard ADAS recommendation did not affect yield.

Iceberg Lettuce

1. Crop covers advanced maturity by 11 days. A reduction in nitrogen fertiliser by 45% less than the standard ADAS recommendation did not delay maturity.

2. The nonwoven cover produced the highest number of marketable heads and the highest percentage of Class I heads. The perforated polythene cover tended to reduce the number marketable due to a high percentage of small heads, while the double cover overall gave similar results to the nonwoven cover used alone.

3. A reduction in nitrogen fertiliser by 45% did not significantly reduce the number or quality of marketable heads.

4. The nonwoven cover produced a higher mean head weight than perforated polythene. The double cover gave similar results to the nonwoven cover.

5. A reduction in nitrogen fertiliser by 45% reduced the mean head weight of iceberg lettuce. The nonwoven cover increased mean head weight of lettuce grown with 45% less nitrogen, but the increase in weight was insufficient to offset the loss in yield from the lower rate of nitrogen. Head weight was still above 450 g.

6. The nonwoven cover and the double cover reduced the amount of mineral-nitrogen remaining in the soil at harvest. Generally more mineral-nitrogen remained under the perforated polythene cover.

Cabbage

1. The nonwoven and perforated polythene covers advanced maturity of cabbage by 7 and 2-3 days respectively.

2. Nitrogen fertiliser rates up to 40 and 60% less than the standard rate did not delay maturity under perforated polythene and nonwoven covers respectively.

3. The mean head weight and total marketable yield of cabbage under crop covers was unaffected by nitrogen rates up to 40% less than the standard.

4. Generally, the amount of mineral-nitrogen remaining in the soil at harvest was similar for all cover treatments. High levels remained following the standard rate of nitrogen, with a large reduction measured for all treatments using less nitrogen fertiliser.

Action Points for Growers

1. Growers can reduce nitrogen fertiliser costs and minimise potential leaching problems by using less fertiliser under crop covers early in the season.

2. The combination of a double cover - nonwoven 17 g/m^2 + perforated polythene 500 holes/m^2, with 45% less nitrogen fertiliser, will significantly advance maturity and produce high yields of excellent quality carrots.

3. A nonwoven cover with 45% less nitrogen fertiliser will reduce mean head weight of iceberg lettuce. Further investigation is required to determine the potential reduction in nitrogen for high yield of iceberg lettuce. A 45% reduction in nitrogen will, however, produce high yields of crisp lettuce.

4. A nonwoven or perforated polythene cover with 40% less nitrogen fertiliser will produce high quality, early yields of cabbage.

Practical and Financial Benefits

The combination of high early yields when prices are high and reduced input costs due to reduced nitrogen fertiliser application give clear financial benefits.

EXPERIMENTAL SECTION

Objective

To evaluate the effect of different rates of nitrogen fertiliser on early crops of carrots, cabbage and iceberg lettuce grown with and without crop covers.

Materials and Methods

Site

Horticulture Research International, Stockbridge House, Cawood, Selby, North Yorkshire, YO8 0TZ.

Soil Type

Sandy loam texture of the Quorndon Series.

Treatments

1. Early Carrots

Cultivar:

Nairobi F1 Hybrid

Crop Covers:

None
Nonwoven (17 g/m^2)
Perforated polythene (500 x 10 mm holes/m^2)
Nonwoven (17 g/m^2) + perforated polythene (500 x 10 mm holes/m^2)

Rate of Nitrogen Fertiliser:

Standard (ADAS) recommendation
45% less than standard
80% less than standard
No nitrogen fertiliser

Base Fertiliser Applications (kg/ha NPK):

60:76:125 (standard N)
33:76:125 (45% less N)
12:76:125 (80% less N)
0:76:125 (no N)

2. Iceberg Lettuce

Cultivar:

Kelvin

Crop Covers:

None
Nonwoven (17 g/m^2)
Perforated polythene (500 x 10 mm holes/m^2)
Nonwoven (17 g/m^2) + perforated polythene (500 x 10 mm holes/m^2)

Rate of Nitrogen Fertiliser:

Standard (ADAS) recommendation
45% less than standard
80% less than standard
No nitrogen fertiliser

Base Fertiliser Applications (kg/ha NPK):

200:31:125 (standard N)
110:31:125 (45% less N)
40:31:125 (80% less N)
0:31:125 (no N)

3. Early Cabbage

Cultivar:

Derby Day F1 Hybrid

Crop Covers:

None
Nonwoven (17 g/m^2)
Perforated polythene (500 x 10 mm holes/m^2)

Rate of Nitrogen Fertiliser:

Standard (ADAS) recommendation
20% less than standard
40% less than standard
60% less than standard
80% less than standard
No nitrogen fertiliser

All nitrogen fertiliser was applied as a base dressing for both cover treatments. Where no cover used, a maximum of 100 kg/ha nitrogen was applied as a base dressing and the remainder as a top dressing 4 weeks after planting.

Summary of nitrogen fertiliser application (kg/ha) for cabbage.

Nitrogen Fertiliser Treatment (kg/ha)	No Cover		Cover	
	Base Dressing	Top Dressing	Base Dressing	Top Dressing
300 (standard N)	100	200	300	-
240 (20% less N)	100	140	240	-
180 (40% less N)	100	80	180	-
120 (60% less N)	100	20	120	-
60 (80% less N)	60	-	60	-
0 (nil N)	-	-	-	-

A base dressing application of 25:175 kg/ha P:K was applied to all treatments.

Irrigation

Irrigation was applied to all crops when the soil moisture deficit reached 25 mm.

Spacing

Carrots	Four rows per 1.83 m bed, 37.5 cm between rows, drilled at 150 seeds/m^2.
Lettuce	Four rows per 1.83 m bed, 37.5 cm between rows, 30 cm within rows.
Cabbage	Four rows per 1.83 m bed, 37.5 cm between rows, 37.5 cm within rows.

Design

The trial design was a split plot design with covers at main plot level and nitrogen rates at sub-plot level. There were three replicates for the carrot and lettuce crops, and four replicates for cabbage.

Statistical Analysis

Data were subjected to analysis of variance. Where appropriate the data was angularly transformed to improve the validity of the analysis. The least significant differences (LSDs) are provided where the differences between treatments were significant at the 5% level. Where the differences were not significant then this is indicated by NS (not significant) and this indicates that results were similar for all treatments.

Recorded Plants per Plot

Carrots	2 m from each of the middle two rows at each of three harvests.
Lettuce	20 plants from each of the middle two rows.
Cabbage	20 plants from each of the middle two rows.

Records

* Crop diary (see Appendix I)

* Yield and quality at harvest

* Maturity period

* Soil analysis before base dressing and at harvest for mineral -nitrogen (lettuce and cabbage only)

* Soil temperature at soil surface and 5 cm depth for all cover treatments.

Results

1. CARROTS

Table 1: Carrots: Effect of covers and nitrogen rates on total marketable yield (>12 mm) (t/ha).

Cover/ Nitrogen Rate	Harvest 1 23 June	Harvest 2 5 July	Harvest 3 13 July
No Cover			
Standard N	22	29	31
45% less N	23	30	33
80% less N	22	28	31
Nil N	20	27	27
Nonwoven Cover			
Standard N	37	41	45
45% less N	34	42	53
80% less N	37	39	51
Nil N	31	42	50
Perforated Polythene Cover			
Standard N	34	32	37
45% less N	27	30	31
80% less N	30	31	36
Nil N	27	30	35
Nonwoven + Perforated Polythene Covers			
Standard N	46	48	52
45% less N	49	52	59
80% less N	44	52	59
Nil N	48	48	54
SED (24 df)			
Between treatments with different covers	3.1	3.8	6.0
Within same cover treatment	2.3	2.6	3.9
LSD (P = 0.05)			
Between treatments with different covers	6	8	12
Within same cover treatment	5	5	8

All crop covers led to higher yields of carrots than no cover at the first harvest date.

The nonwoven + perforated polythene double cover produced the highest yield of carrots at the first and second harvest dates. At the third harvest, the nonwoven cover gave a similar yield to the double cover treatment. The nonwoven cover also produced a higher yield of carrots than perforated polythene at all harvest dates.

In general, reducing the rate of nitrogen fertiliser did not reduce yield. The only exception was at the first harvest date where nil nitrogen reduced yield under a nonwoven cover, and nil nitrogen or 45% less nitrogen reduced yield under a perforated polythene cover.

2. ICEBERG LETTUCE

Table 2: Lettuce: Effect of covers and nitrogen rates on maturity.

Cover/ Nitrogen Rate	No. of heads cut as % of total no. of marketable heads					
	H.1 24 May	H.2 25 May	H.3 28 May	H.4 1 Jun	H.5 4 Jun	H.6 9 Jun
No Cover						
Standard N	0	0	0	0	67	33
45% less N	0	0	0	0	61	39
80% less N	0	0	0	0	14	86
Nil N						
Nonwoven Cover						
Standard N	83	0	9	8	0	0
45% less N	80	0	12	8	0	0
80% less N	74	0	6	14	6	0
Nil N	24	0	0	13	53	11
Perforated Polythene Cover						
Standard N	0	86	0	12	0	0
45% less N	33	42	17	8	0	0
80% less N	0	47	0	16	37	0
Nil N	0	14	0	0	44	42
Nonwoven + Perforated Polythene Covers						
Standard N	81	0	8	11	0	0
45% less N	89	0	0	11	0	0
80% less N	75	0	8	17	0	0
Nil N	63	0	0	0	38	0

All cover treatments led to earlier maturity than the uncovered control. Perforated polythene was one day later than the nonwoven and double covers.

Treatments with 45% less nitrogen led to a similar maturity date to the standard rate of nitrogen. 80% less nitrogen and nil nitrogen tended to delay maturity.

Table 3: Lettuce: Effect of nitrogen rates on yield and quality - mean of crop covers.

Nitrogen Rate	Total no. mkt. as % of no. planted*	No. Cl.I as % of no. planted*	Mean mkt. head wgt. (g)	Total no. unmkt. as % of no. planted*	No. small as % of no. planted*
Standard N	78 (93)	75 (90)	501	10 (5)	8 (4)
45% less N	74 (91)	73 (90)	458	15 (8)	11 (6)
80% less N	67 (83)	66 (82)	405	22 (16)	20 (14)
Nil N	48 (56)	48 (55)	382	41 (43)	35 (35)
SED (24 df)	2.9	2.7	13.9	2.6	2.5
LSD (P = 0.05)	6	6	29	5	5

* Angle transform (actual percentage).

45% less nitrogen did not reduce the number or quality of marketable heads. 80% less and nil nitrogen, however, increased the number of unmarketable heads mainly due to more small heads.

Reduced rates of nitrogen fertiliser significantly reduced mean marketable head weight.

Table 4a: Lettuce: Effect of a nonwoven crop cover on yield and quality - mean of nitrogen rates.

Crop Cover	Total no. mkt. as % of no. planted*	No. Cl.I as % of no. planted*	Mean mkt. head wgt. (g)	Total no. unmkt. as % of no. planted*	No. small as % of no. planted*
Without nonwoven	61 (74)	60 (73)	406	27 (24)	27 (23)
With nonwoven	72 (87)	71 (86)	466	17 (12)	10 (6)
SED (6 df)	4.0	3.8	13.5	3.7	4.1
LSD (P = 0.05)	10	9	33	9	10

* Angle transform (actual percentage).

Table 4b: Lettuce: Effect of a perforated polythene cover on yield and quality - mean of nitrogen rates.

Crop Cover	Total no. mkt. as % of no. planted*	No. Cl.I as % of no. planted*	Mean mkt. head wgt. (g)	Total no. unmkt. as % of no. planted*	No. small as % of no. planted*
Without perforated polythene	68 (83)	67 (81)	431	20 (16)	17 (13)
With perforated polythene	65 (78)	64 (78)	442	24 (20)	20 (17)
SED (6 df)	4.0	3.8	13.5	3.7	4.1
LSD (P = 0.05)	NS	NS	NS	NS	NS

* Angle transform (actual percentage).

The use of a nonwoven crop cover improved the total number of marketable, the number of Class I heads and the mean head weight of lettuce compared with no nonwoven crop cover (Table 4a). The use of perforated polythene however did not improve the number or quality of heads (Table 4b).

Table 5: Lettuce: Effect of cover type and nitrogen rates on mean marketable head weight.

Nitrogen Rate	Mean Marketable Head Weight (g)			
	Without Nonwoven	With Nonwoven	Without Perforated Polythene	With Perforated Polythene
Standard N	457	544	495	506
45% less N	418	497	448	467
80% less N	388	423	397	414
Nil N	362	401	382	381
SED (24 df)				
Between treatments with different covers	21.7		21.7	
Within same cover treatment	19.7		19.7	
LSD (P = 0.05)				
Between treatments with different covers	45		NS	
Within same cover treatment	41		41	

The nonwoven cover significantly increased mean marketable head weight for standard and 45% less nitrogen treatments. Perforated polythene had no affect on mean marketable head weight.

There were no significant benefits in yield or quality using a nonwoven + perforated polythene double cover during this trial - results were similar to the nonwoven cover used alone. Full details are given in Appendix II, Table 10.

Table 6: Lettuce: Effect of covers and nitrogen rates on the amount of mineral-nitrogen remaining in the soil at harvest.

Cover/ Nitrogen Rate	Amount of mineral-N (kg/ha) Soil Depth: 0-30 cm	30-60 cm	Total (0-60 cm)
Before base dressing	33	21	54
No Cover			
Standard N	42	137	179
45% less N	16	69	85
80% less N	12	33	45
Nil N	12	20	32
Nonwoven Cover			
Standard N	28	75	103
45% less N	18	47	65
80% less N	12	27	39
Nil N	12	10	22
Perforated Polythene Cover			
Standard N	79	56	135
45% less N	40	38	78
80% less N	13	22	35
Nil N	10	12	22
Nonwoven + Perforated Polythene Covers			
Standard N	26	65	91
45% less N	13	31	44
80% less N	13	17	30
Nil N	12	14	26
SED (24 df)			
Between treatments with different covers	16.8	14.9	-
Within same cover treatment	16.7	12.5	-
LSD (P = 0.05)			
Between treatments with different covers	35	31	-
Within same cover treatment	35	26	-

Use of lower rates of nitrogen fertiliser reduced levels of mineral-nitrogen remaining in the soil at harvest.

At the standard rate of nitrogen fertiliser, treatments with a nonwoven cover reduced the level of mineral-nitrogen remaining at soil depth 0-30 cm, compared with perforated polythene.

At soil depth 30-60 cm, all cover treatments reduced the amount of mineral-nitrogen remaining in the soil at the standard rate of nitrogen fertiliser, compared with the uncovered control.

3. CABBAGE

Table 7: Cabbage: Effect of covers and nitrogen on maturity and yield.

Cover/Nitrogen Rate	Mean date of cut	Mean head weight (g)	Total marketable yield (t/ha)
No Cover			
Standard N	16 Jun	817	58
20% less N	17 Jun	796	53
40% less N	17 Jun	762	51
60% less N	17 Jun	735	51
80% less N	18 Jun	665	41
Nil N	22 Jun	479	15
Nonwoven Cover			
Standard N	10 Jun	783	56
20% less N	10 Jun	825	56
40% less N	10 Jun	808	56
60% less N	10 Jun	740	51
80% less N	14 Jun	738	50
Nil N	22 Jun	573	22
Perforated Polythene Cover			
Standard N	14 Jun	886	61
20% less N	14 Jun	879	61
40% less N	15 Jun	859	60
60% less N	16 Jun	819	54
80% less N	19 Jun	725	49
Nil N	22 Jun	509	16
SED (45 df)			
Between treatments with different covers	0.6	28.9	3.4
Within same cover treatment	0.6	28.4	3.3
LSD (P = 0.05)			
Between treatments with different covers	1	58	7
Within same cover treatment	1	57	7

All marketable yield was Class I quality.

Maturity

The nonwoven cover advanced maturity by 6-7 days at all rates of nitrogen fertiliser (except nil) compared with no cover. Perforated polythene advanced maturity by 2 days.

20 and 40% less nitrogen fertiliser did not delay the maturity of cabbage for any of the treatments. In addition, 60% less nitrogen fertiliser did not delay maturity for no cover and the nonwoven cover.

Mean Head Weight

Both crop covers produced a higher mean head weight than no cover. Perforated polythene also produced a higher mean head weight than the nonwoven cover.

Reducing nitrogen fertiliser by up to 40% did not significantly reduce mean head weight for crops grown with or without crop covers.

Total Marketable Yield

Perforated polythene increased the total marketable yield of cabbage compared with no cover. The nonwoven cover did not differ significantly from either of the other cover treatments.

40% less nitrogen fertiliser did not reduce the total marketable yield of cabbage grown under perforated polythene , while up to 80% less nitrogen fertiliser did not reduce marketable yield under the nonwoven cover (see Appendix IV, Figure 1 for graphical presentation).

Table 8: Cabbage: Effect of nitrogen rates on the number of marketable and unmarketable heads - mean of crop cover treatments.

Nitrogen Rate	No. of heads as % of no. planted* Total Marketable	Total Unmarketable	Small
Standard N	87 (99)	2 (1)	2 (1)
20% less N	80 (96)	8 (4)	5 (2)
40% less N	81 (96)	8 (3)	8 (3)
60% less N	79 (96)	9 (3)	8 (3)
80% less N	74 (92)	16 (8)	15 (7)
Nil N	43 (46)	47 (53)	47 (46)
SED (45 df)	2.8	3.0	2.9
LSD (P = 0.05)	6	6	6

* Angle transform (actual percentage).

Reducing nitrogen fertiliser by 60 and 80% less than the standard rate of nitrogen and nil nitrogen reduced the total number of marketable heads and increased the number of unmarketable heads (due to an increase in the number of small heads).

Table 9: Cabbage: Effect of covers and nitrogen rates on the amount of mineral-nitrogen remaining in the soil at harvest.

Cover/ Nitrogen Rate	Amount of mineral-N (kg/ha) Soil Depth: 0-30 cm	30-60 cm	Total (0-60 cm)
Before base dressing	28	57	85
No Cover			
Standard N	94	45	139
20% less N	41	47	88
40% less N	24	31	55
60% less N	12	24	36
80% less N	13	22	35
Nil N	82	12	94
Nonwoven Cover			
Standard N	48	116	164
20% less N	12	38	50
40% less N	17	29	46
60% less N	20	22	42
80% less N	241	25	266
Nil N	13	11	24
Perforated Polythene Cover			
Standard N	38	77	115
20% less N	19	25	44
40% less N	18	32	50
60% less N	10	17	27
80% less N	10	14	24
Nil N	9	30	39
SED (45 df)			
Between treatments with different covers	82.9	19.4	-
Within same cover treatment	81.8	18.2	-
LSD (P = 0.05)			
Between treatments with different covers	167	39	-
Within same cover treatment	165	37	-

The soil analysis results for mineral-nitrogen were inconsistent for a number of treatments and should therefore be treated with caution.

In general, reducing the rate of nitrogen fertiliser reduced the amount of mineral-nitrogen remaining in the soil at harvest. Overall, there were lower rates of mineral-nitrogen remaining under the nonwoven and perforated polythene crop covers at soil depth 0-30 cm compared with the uncovered control. At 30-60 cm, results were more variable with higher rates of mineral-nitrogen recorded under both nonwoven and perforated polythene covers compared with no cover at the standard rate of nitrogen.

Discussion

Carrots

a) Crop Covers

Crop covers led to significantly earlier maturity. At the first harvest date (23 June), the nonwoven + perforated polythene double cover produced the highest yield. The yield difference was so great that there would appear to be potential to harvest up to 2 weeks earlier. The reason for this was the significant increase in air and hence soil temperatures beneath the crop covers (see Appendix III, Tables 12a and 12b), which increased the mineralisation rate of nitrogen. The nonwoven cover used on its own also gave high early yields.

b) Nitrogen Fertiliser

The amount of mineral-nitrogen in the soil prior to base dressing was fairly low at 33 kg/ha (soil depth 0-30 cm). Carrots have a relatively low demand for nitrogen so it was not unexpected that reducing nitrogen fertiliser by 45% or 80% did not adversely affect the yield or quality of carrots. The trial results confirmed this.

Iceberg Lettuce

a) Crop Covers

Crop covers advanced maturity by 11 days.

The nonwoven cover improved the yield and quality of lettuce while perforated polythene had no affect on yield or quality. The use of a double cover (nonwoven + perforated polythene) gave similar results to the nonwoven cover during this trial. If lettuce were planted in late February/early March (at least 2 weeks earlier than the planting of this trial), a double cover may advance maturity.

Comparable increases in temperature were recorded for lettuce under crop covers to those recorded for carrots (see Appendix III, Tables 13a and 13b). Overall the nonwoven and perforated polythene covers accumulated a comparable number of day degrees, while the double cover accumulated a higher number of day degrees. There was some evidence of earlier maturity from the double cover with a higher percentage of heads cut at the first harvest, but overall, yield and quality of lettuce from the double cover were similar to results for the nonwoven cover when used alone. The poor results for perforated polythene, however, may be attributed to uneven moisture distribution through the polythene cover, resulting in reduced and/or variable growth rates - hence the higher levels of mineral-nitrogen remaining in the soil at harvest. This would have been less of a problem under the double cover as the nonwoven material would have absorbed any rainfall that fell onto the polythene resulting in relatively even moisture distribution.

b) Nitrogen Fertiliser

A 45% reduction in nitrogen fertiliser did not delay maturity or reduce the quality of lettuce from any of the cover treatments. It did however, reduce mean marketable head weight.

Results from the two previous years of this project were based on a test crop of crisp lettuce for which yield was unaffected by a 45% reduction in nitrogen fertiliser. For iceberg lettuce, the test crop this year, 45% less nitrogen was insufficient to produce the dense heart required, even though there was clear benefit from the nonwoven cover. The nonwoven cover increased the mean head weight of lettuce (by approximately 25%) from the standard and 45% less nitrogen treatments. Unfortunately, however, this increase in head weight was not quite sufficient to offset the loss in weight which resulted from the 45% less fertiliser input. This treatment still produced a good head weight of above 450 g which was similar to the mean head weight achieved from a standard nitrogen application with no cover.

Further investigation is required to determine the potential reduction in nitrogen fertiliser for high yields of iceberg lettuce grown under a nonwoven cover.

In general, there was less mineral-nitrogen remaining under the nonwoven cover and double cover at harvest. 45% less nitrogen under the nonwoven cover led to a similar amount of mineral-nitrogen remaining in the soil to the amount measured over the trial area prior to base dressing, suggesting efficient use of all fertiliser applied. Results under the double cover for 45% less nitrogen indicated additional use of nitrogen, depleting soil reserves by 10 kg/ha N.

Cabbage

a) Crop Covers

The nonwoven cover advanced maturity by 6-7 days and crops under perforated polythene were advanced by 2 days.

The perforated polythene produced a higher total marketable yield than no cover. There were no significant differences in marketable yield between perforated polythene and nonwoven crop covers.

b) Nitrogen Fertiliser

A reduction in nitrogen fertiliser by 40% less than the standard recommendation did not delay maturity or reduce mean head weight or total marketable yield.

The amount of mineral-nitrogen remaining in the soil at harvest was very variable. For both cover treatments there was a large difference between the amount remaining for the standard rate of nitrogen, and the amount remaining for all other nitrogen treatments. It is difficult to explain this large difference. The results also showed more mineral-nitrogen remaining at 0-30 cm and less at 30-60 cm for the uncovered treatment, compared with both cover treatments.

Conclusions

The results of this investigation are based on a sandy loam soil type. The treatments have not been tested on other soil types.

Carrots

1. The nonwoven + perforated polythene double cover increased air and soil temperature the most. The perforated polythene and nonwoven covers also increased air and soil temperatures.

2. The nonwoven + perforated double cover significantly advanced maturity, producing very high yields of early carrots on 23 June. There is potential to harvest earlier and still achieve high yields.

3. Both nonwoven and perforated polythene covers increased early yield compared with the uncovered crop, the nonwoven cover to a greater extent than perforated polythene.

4. Generally, a reduction in nitrogen fertiliser by 45% or 80% less than the standard ADAS recommendation did not affect yield.

Iceberg Lettuce

1. Crop covers advanced maturity by 11 days. A reduction in nitrogen fertiliser by 45% less than the standard ADAS recommendation did not delay maturity.

2. The nonwoven cover produced the highest number of marketable heads and the highest percentage of Class I heads. The perforated polythene cover tended to reduce the number marketable due to a high percentage of small heads, while the double cover overall gave similar results to the nonwoven cover used alone.

3. A reduction in nitrogen fertiliser by 45% did not significantly reduce the number or quality of marketable heads.

4. The nonwoven cover produced a higher mean head weight than perforated polythene. The double cover gave similar results to the nonwoven cover.

5. A reduction in nitrogen fertiliser by 45% reduced the mean head weight of iceberg lettuce. The nonwoven cover increased mean head weight of lettuce grown with 45% less nitrogen, but the increase in weight was insufficient to offset the loss in yield from the lower rate of nitrogen. Head weight was still above 450 g.

6. The nonwoven cover and the double cover reduced the amount of mineral-nitrogen remaining in the soil at harvest. Generally more mineral-nitrogen remained under the perforated polythene cover.

Cabbage

1. The nonwoven and perforated polythene covers advanced maturity of cabbage by 7 and 2-3 days respectively.

2. In this trial nitrogen fertiliser rates up to 40 and 60% less than the standard rate did not delay maturity under perforated polythene and nonwoven covers respectively.

3. The mean head weight and total marketable yield of cabbage under crop covers was unaffected by nitrogen rates up to 40% less than the standard.

4. Generally, results for mineral-nitrogen remaining in the soil at harvest were similar between cover treatments. High levels remained following the standard rate of nitrogen, with a large reduction measured for all treatments using less nitrogen fertiliser.

Recommendations

Further investigation is required:

i) to determine the potential reduction in nitrogen fertiliser input for high yield and quality of iceberg lettuce grown under crop covers.

ii) to substantiate results for double covers when used on early carrots and iceberg lettuce.

APPENDIX I: CROP DIARIES

CARROTS

15 February	Applied P + K fertiliser.
22 February	Applied N fertiliser.
24 February	Drilled carrot seed. Applied herbicide: Linuron (as Liquid Linuron 15) at 4.2 l/ha. Covered.
23 April	Removed perforated polythene from double cover treatment.
30 April	Removed perforated polythene cover.
27 May	Removed nonwoven covers from both treatments.
23 June	First harvest.
5 July	Second harvest.
13 July	Third harvest.

ICEBERG LETTUCE

15 February	Applied P + K fertiliser.
8 March	Applied N fertiliser.
16 March	Planted lettuce: 38 mm blocks. Applied herbicide: Propyzamide (as Kerb 50W) at 2.8 kg/ha. Covered.
23 April	Removed perforated polythene from double cover treatment.
30 April	Removed perforated polythene cover.
21 May	Removed nonwoven cover.
24 May	First harvest.
9 Jun	Final harvest.

CABBAGE

29 March	Applied P + K fertiliser. Applied N base fertiliser according to treatment.
31 March	Planted cabbage: Hassy 308 modules.
1 April	Applied herbicide: Propachlor (as Ramrod Flowable) at 9 l/ha and chlorthal-dimethyl (as Dacthal W75) at 6 kg/ha.
2 April	Covered.
30 April	Removed perforated polythene cover.
5 May	Applied N top dressing to uncovered treatments.
26 May	Removed nonwoven cover.
8 June	First harvest.
22 June	Final harvest.

APPENDIX II:

Table 10: Lettuce: Effect of covers and nitrogen rates on yield and quality.

Nitrogen Rate	Total no. mkt. as % of no. planted*	No. Cl.I as % of no. planted*	Mean mkt. head wgt. (g)	Total no. unmkt. as % of no. planted*	No. small as % of no. planted*
No Cover					
Standard N	71	67	470	16	16
45% less N	69	66	433	19	18
80% less N	63	62	392	25	24
Nil N	45	45	360	43	43
Nonwoven Cover					
Standard N	87	85	521	3	0
45% less N	80	80	464	9	4
80% less N	74	73	402	15	10
Nil N	57	57	404	32	20
Perforated Polythene Cover					
Standard N	76	76	445	13	13
45% less N	68	68	403	21	19
80% less N	57	56	385	33	33
Nil N	41	40	364	48	48
Nonwoven + Perforated Polythene Covers					
Standard N	76	71	567	10	4
45% less N	77	76	530	10	3
80% less N	74	73	443	15	13
Nil N	50	50	398	40	30
SED (24 df)					
Between treatments with different covers	7.5	7.2	30.8	6.8	7.2
Within same cover treatment	5.8	5.5	27.9	5.2	5.0

* Angle transform, see Appendix II, Table 11, for actual percentages.

Table 11: Lettuce: Effect of covers and nitrogen rates on yield and quality - actual percentages.

Cover/ Nitrogen Rate	No. of heads as % of no. planted			
	Total Mkt.	Class I	Total Unmkt.	Small
No Cover				
Standard N	89	84	8	8
45% less N	86	83	12	10
80% less N	79	78	18	18
Nil N	50	50	47	46
Nonwoven Cover				
Standard N	99	93	1	0
45% less N	96	96	3	2
80% less N	93	91	7	4
Nil N	70	69	29	13
Perforated Polythene Cover				
Standard N	91	91	8	8
45% less N	86	86	13	11
80% less N	70	69	30	29
Nil N	43	43	50	54
Nonwoven + Perforated Polythene Covers				
Standard N	92	89	4	2
45% less N	95	94	3	1
80% less N	92	91	8	5
No N	59	59	41	25

APPENDIX III:

Table 12a: Carrots: Accumulated day degrees (above 4°C) at air temperature under crop covers.

Cover		26 Feb-23 Apr*	24 Apr-30 Apr+	1 May-27 May@	Total
1.	No cover	203	52	200	455
2.	Nonwoven	222	56	227	505
3.	Perforated polythene	278	71	196	545
4.	Nonwoven + perforated polythene	322	57	219	598

Table 12b: Carrots: Accumulated day degrees (above 4°C) at 50 cm soil depth.

Cover		26 Feb-23 Apr*	24 Apr-30 Apr+	1 May-27 May@	Total
1.	No cover	172	55	226	453
2.	Nonwoven	228	66	256	550
3.	Perforated polythene	262	75	228	565
4.	Nonwoven + perforated polythene	284	66	255	605

* Perforated polythene removed from nonwoven + perforated polythene cover combination (Treatment 4).

\+ Perforated polythene cover removed (Treatment 3).

@ Nonwoven cover removed (Treatments 2 and 4).

Table 13a: Lettuce: Accumulated day degrees (above 4°C) at air temperature under crop covers.

Cover		9 Mar-23 Apr*	24 Apr-30 Apr+	1 May-21 May@	Total
1.	No cover	169	52	184	405
2.	Nonwoven	197	61	215	473
3.	Perforated polythene	217	69	183	469
4.	Nonwoven + perforated polythene	289	59	205	553

Table 13b: Lettuce: Accumulated day degrees (above 4°C) at 50 cm soil depth.

Cover		9 Mar-23 Apr*	24 Apr-30 Apr+	1 May-21 May@	Total
1.	No cover	133	56	191	380
2.	Nonwoven	215	71	234	520
3.	Perforated polythene	219	74	199	492
4.	Nonwoven + perforated polythene	276	70	234	580

* Perforated polythene removed from nonwoven + perforated polythene cover combination (Treatment 4).

\+ Perforated polythene cover removed (Treatment 3).

@ Nonwoven cover removed (Treatments 2 and 3).

APPENDIX IV:

FIGURE 1