HORTICULTURE RESEARCH INTERNATIONAL

STOCKBRIDGE HOUSE

A REPORT TO THE HORTICULTURAL DEVELOPMENT COUNCIL,
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CROP COVERS: EFFECT OF RATES OF NITROGEN ON YIELD AND QUALITY

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Summary

A range of nitrogen base fertiliser rates were evaluated for their effect on yield and quality of early carrots, cabbage and lettuce with and without crop covers. Crop covers advanced maturity for all three crops and increased the yield of carrots. Carrots produced similar yields from nitrogen fertiliser applications up to 80% less than the ADAS standard recommendation. Nonwoven crop covers gave high yields of cabbage and lettuce at 45% less nitrogen fertiliser, due to higher soil temperatures under the covers and more efficient use of nitrogen. There was evidence of less nitrate-N remaining in the soil at harvest. Perforated polyethylene covers encouraged dry tipburn in lettuce due to high temperatures in May.

Objective

To evaluate three rates of nitrogen fertiliser compared with no nitrogen fertiliser on carrots, cabbage and lettuce with and without crop covers.

Materials and Methods

Site

HRI Stockbridge House, Cawood, Selby, North Yorkshire, YO8 0TZ

Soil Type

Sandy loam of the Quorndon Series in an open sunny position.

Treatments

Test Crops:

Early crisp lettuce, cultivar Saladin
Early summer cabbage, cultivar Derby Day
Early carrots, cultivar Nairobi

Crop Covers:

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

Rates of Nitrogen Fertiliser (applied according to soil analysis):

Standard (ADAS recommendation)
45% less than standard
80% less than standard
None (control)

Base Fertiliser Applications (NPK):

Carrots	60:100:100	(Standard N)
	33:100:100	(45% less N)
	12:100:100	(80% less N)
	0:100:100	(No N)
Cabbage	300:25:175	(Standard N)
	165:25:175	(45% less N)
	60:25:175	(80% less N)
	0:25:175	(No N)
Lettuce	200:100:100	(Standard N)
	110:100:100	(45% less N)
	40:100:100	(80% less N)
	0:100:100	(No N)

Irrigation:

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

Spacing

Carrots	Four rows per 1.83 m bed, 37.5 cm between rows, drilled at 66 seeds/metre (130 seeds/m^2).
Cabbage	Four rows per 1.83 m bed, 37.5 cm between rows, 30 cm within rows.
Lettuce	Four rows per 1.83 m bed, 37.5 cm between rows, 30 cm within rows.

Design

The experimental design was a split plot design with covers at main plot level and nitrogen rates at sub-plot level. There were four replicates for each crop.

Recorded Plants per Plot

Carrots	2 m from each of the middle two rows at each harvest
Cabbage	20 plants from each of the middle two rows
Lettuce	20 plants from each of the middle two rows

Records

Crop diary (see Appendix I)

Yield and quality

Maturity period

Soil analysis before base dressing, and at harvest for mineral-nitrogen.

Results

1. CABBAGE

Table 1: Cabbage: Effect of covers on maturity and yield - Mean of nitrogen rates.

Cover	Date of 50% Cut	Total Mkt Yield (t/ha)	Mean Mkt Head Wgt (g)	Class I as % of no. planted*	Small as % of no. planted*
No cover	12 June	40	647	70 (83)	17 (13)
Nonwoven	8 June	43	687	71 (85)	15 (12)
Perforated polythene	8 June	43	684	71 (87)	17 (12)
SED (6 df)	0.4	2.3	14.9	3.4	2.9
LSD (P=0.05)	1.0	4.7	36.5	7.0	6.0

* Angle transformation (actual percentage in brackets)

Nonwoven and perforated polythene covers advanced maturity by 4 days and increased mean head weight compared with plots with no cover. The use of covers had no significant effect on total marketable yield or quality.

Table 2: Cabbage: Effect of nitrogen rates on maturity and yield - Mean of covers.

Nitrogen Rate	Date of 50% Cut	Total Mkt Yield (t/ha)	Mean Head Wgt (g)	Class I as % of no. planted*	Small as % of no. planted*
Standard	6 June	52	755	81 (96)	6 (3)
45% less	7 June	48	726	78 (94)	9 (5)
80% less	10 June	43	662	73 (91)	15 (8)
Nil	16 June	23	548	51 (59)	36 (35)
SED (27 df)	0.5	2.0	19.3	3.4	3.2
LSD (P=0.05)	1.0	4.1	39.6	7.0	6.6

* Angle transformation (actual percentage in brackets)

80% less and nil nitrogen treatments delayed maturity compared with standard and 45% less nitrogen, and produced a lower total marketable yield and mean head weight.

Nil nitrogen also produced a lower percentage of Class I and higher percentage of small heads than standard and 45% less nitrogen. 80% less nitrogen gave intermediate results.

Covers had no significant affect on yield or quality of cabbage from the different nitrogen treatments (see Appendix II, Table 10).

Table 3: Cabbage: Soil analysis at harvest.

Cover/ Nitrogen Rate	Amount of Nitrate-N (mg/kg) Soil Depth 0-30 cm	30-60 cm
Before base dressing	10	8
No Cover		
Standard	24	17
45% less	8	10
80% less	4	4
Nil	4	3
Nonwoven Cover		
Standard	14	13
45% less	7	7
80% less	4	3
Nil	4	4
Perforated Polythene Cover		
Standard	29	15
45% less	10	7
80% less	5	2
Nil	3	2
SED (27 df)		
Between covers	2.6	2.5
Within same cover	2.3	2.7
LSD (P = 0.05)		
Between covers	5.3	5.1
Within same cover	4.7	5.5

For all cover treatments, more nitrate-N remained in the soil following the standard rate of nitrogen application - the nonwoven cover gave a significantly lower result at 0-30 cm depth than no cover or perforated polythene. The lower rates of nitrogen all significantly reduced nitrate-N levels remaining at both soil depths, but there were no significant differences between them.

2. LETTUCE

Table 4: Effect of covers and nitrogen rates on maturity.

Cover/ Nitrogen Rate	No. of heads cut as % of total no. of marketable heads				
	Harvest 1 18 May	Harvest 2 21 May	Harvest 3 27 May	Harvest 4 2 June	Harvest 5 5 June
No Cover					
Standard	0	1	59	40	0
45% less	0	0	65	36	0
80% less	0	6	68	25	0
Nil	0	9	52	40	0
Nonwoven Cover					
Standard	5	58	35	0	2
45% less	5	83	10	0	2
80% less	29	70	1	0	1
Nil	11	80	7	0	2
Perforated Polythene Cover					
Standard	69	25	0	1	6
45% less	53	26	0	1	20
80% less	37	29	2	3	29
Nil	42	23	1	0	35

Perforated polythene led to earlier maturity of some heads compared with nonwoven and no crop covers but it also, however, led to the longest length of cut for all nitrogen applications below the standard application, due to late maturity of a number of heads.

The nonwoven cover advanced maturity compared with no crop cover - particularly at low rates of nitrogen fertiliser.

Table 5: Lettuce: Effect of covers on marketable yield - Mean of nitrogen rates.

Cover	Mean Head Weight (g)	Class I as % of no. planted*	Class II as % of no. planted*	Total Mkt as % of no. planted*
No crop cover	623	67 (82)	16 (13)	80 (95)
Nonwoven	626	55 (65)	29 (29)	78 (93)
Perforated polythene	499	48 (54)	37 (37)	75 (91)
SED (6 df)	26.6	3.0	2.8	1.2
LSD (P = 0.05)	65.1	7.3	6.9	2.9

* Angle transformation (actual percentage in brackets)

No crop cover and nonwoven cover produced a higher mean head weight and total marketable yield than perforated polythene. Both crop cover treatments reduced head quality (% Class I) compared with the non-covered crop.

Table 6: Lettuce: Effect of nitrogen rates on marketable yield - Mean of covers.

Nitrogen Rate	Mean Head Weight (g)	Class I as % of no. planted*	Class II as % of no. planted*	Total Mkt as % of no. planted*
Standard	687	73 (91)	12 (6)	81 (96)
45% less	622	67 (82)	17 (14)	81 (95)
80% less	546	49 (56)	37 (37)	79 (94)
Nil	475	38 (39)	44 (48)	71 (87)
SED (27 df)	11.9	2.9	3.4	3.5
LSD (P = 0.05)	24.4	6.0	7.0	7.2

* Angle transformation (actual percentage in brackets)

Mean marketable head weight and percentage Class I decreased with lower rates of nitrogen while percentage Class II increased. This was due to a higher incidence of dry tipburn. Nil nitrogen produced a lower total percentage marketable than the other nitrogen treatments.

Covers had no significant affect upon the yield or quality of lettuce from the different nitrogen rates (see Appendix II, Table 11).

Table 7: Lettuce: Soil analysis at harvest.

Cover/ Nitrogen Rate	Amount of Nitrate-N (mg/kg) Soil Depth 0-30 cm	30-60 cm
Before base dressing	10	7
No Cover		
Standard	43	14
45% less	9	7
80% less	4	5
Nil	3	4
Nonwoven Cover		
Standard	17	22
45% less	9	9
80% less	4	4
Nil	3	4
Perforated Polythene Cover		
Standard	46	19
45% less	30	8
80% less	8	5
Nil	5	3
SED (27 df)		
Between covers	10.7	3.6
Within same cover	9.0	3.1
LSD (P = 0.05)		
Between covers	22.0	7.4
Within same cover	18.5	6.4

At the standard rate of nitrogen application, nitrate-N was lowest under the nonwoven covers at 0-30 cm compared with the other cover treatments.

Use of lower rates of nitrogen fertiliser reduced levels of nitrate-N remaining at harvest.

3. CARROTS

Table 8: Carrots: Effect of covers and nitrogen rates on total marketable yield (>12 mm) (t/ha)

Cover/ Nitrogen Rate	Harvest 1 16 June	Harvest 2 13 July	Harvest 3 22 July	Mean
No Cover				
Standard	13	65	75	51
45% less	14	64	73	50
80% less	14	64	77	52
Nil	15	73	76	55
Nonwoven Cover				
Standard	25	88	95	69
45% less	23	91	92	69
80% less	24	87	93	68
Nil	20	76	89	62
Perforated Polythene Cover				
Standard	27	83	100	70
45% less	29	91	91	70
80% less	30	88	108	75
Nil	28	74	89	64
SED (27 df)				
Between covers	2.2	8.3	8.7	4.6
Within same cover	1.7	5.3	8.2	3.2
LSD (P = 0.05)				
Between covers	4.5	17.0	17.6	9.4
Within same cover	3.5	10.9	16.8	6.6

Where no cover was used, nitrogen rate did not affect mean yield, but under both nonwoven and perforated polythene covers the nil nitrogen gave a significant reduction in yield. Nitrogen reductions of 45% and 80% did not affect yield.

Total marketable yield was higher at each harvest date for the covered treatments compared with no cover.

Table 9: Carrots: Soil analysis at harvest.

Cover/ Nitrogen Rate	Amount of Nitrate-N (mg/kg) Soil Depth 0-30 cm	30-60 cm
Before base dressing	10	7
No Cover		
Standard	9	9
45% less	7	7
80% less	6	6
Nil	5	5
Nonwoven Cover		
Standard	7	8
45% less	6	5
80% less	5	4
Nil	5	4
Perforated Polythene Cover		
Standard	8	5
45% less	5	4
80% less	5	4
Nil	4	4
SED (27 df)		
Between covers	1.1	1.0
Within same cover	1.2	1.0
LSD (P = 0.05)		
Between covers	2.3	2.1
Within same cover	2.3	2.1

There was no significant difference in the amount of nitrate-N remaining in the soil at harvest between any of the covering or nitrogen application treatments at 0-30 cm depth. At 30-60 cm depth, 80% less and nil nitrogen with no cover or a nonwoven cover reduced the amount of nitrate-N remaining compared with the standard rate of nitrogen.

Discussion

Cabbage

Reducing the level of nitrogen fertiliser by 45% did not significantly reduce marketable yield or quality of cabbage heads. In general, covers improved marketable yield, probably due to increased soil temperatures (see Appendix III). They also advanced maturity and maintained high quality.

Lettuce

The results for lettuce showed a greater response to lower levels of nitrogen, with reduced mean head weights and a lower percentage of Class I. The nonwoven cover however, improved mean head weight so that 45% less nitrogen gave a result comparable to the standard nitrogen fertiliser treatment with no crop cover. The higher yield from the nonwoven cover was due to increased soil temperatures under the crop cover and more efficient use of nitrogen. The high percentage of Class II heads recorded at low rates of nitrogen, particularly under crop covers, was the result of dry tipburn. The soil moisture deficit was maintained at 25 mm with regular irrigation, but high temperatures before cover removal during May increased the incidence of dry tipburn. This could have been overcome by earlier cover removal, but at the expense of early maturity. The problem was most severe under perforated polythene.

Carrots

Crop covers led to earlier maturity of carrots. Higher soil temperatures under the covers also improved the usage of nitrogen so that yields were higher compared with no covers. These improvements in yield were not however reflected in the amount of nitrate-N remaining in the soil at harvest. As carrots have a relatively low demand for nitrogen this result was expected.

Conclusions

1. Crop covers advanced maturity.

2. The standard and 45% less nitrogen treatments gave similar numbers of marketable heads and similar yields for cabbage and lettuce, indicating the possibility of reducing nitrogen input whilst not compromising yield or quality.

3. The 80% less and nil nitrogen treatments gave lower marketable yields and reduced head size for both cabbage and lettuce, and also delayed crop maturity. Carrots were generally unresponsive to the rate of nitrogen fertiliser.

4. The quality of lettuce was poorer at the two lowest rates of nitrogen, with an increase in the incidence of dry tipburn, particularly under perforated polythene.

5. The total quantity of nitrate-N remaining in the soil at harvest was highest when the standard ADAS recommended rate of fertiliser had been applied. In general the 45% less nitrogen treatment had an average 43% less nitrogen remaining in the soil after harvest compared to the full rate, for both the cabbage and lettuce crops.

6. Reducing the rate of nitrogen application reduced the amount of nitrate-N remaining in the soil at harvest.

7. The amount of nitrate-N remaining in the soil at harvest was generally lower for the nonwoven cover at the standard recommended rate of nitrogen, and this may have been due to the more uniform uptake by the plant due to the higher soil temperatures and less fluctuating air temperature compared with the perforated polythene.

Recommendations

The trial should be continued for one further year. The range of fertiliser rates should be increased in order to develop fully a nitrogen response curve for use under crop covers. Results should be applied to the Nitrogen Response Model for vegetables developed by HRI Wellesbourne.

APPENDIX I: CROP DIARIES

CABBAGE

6 April	Applied fertiliser
7 April	Planted cabbage: Hassy 308 modules. Applied herbicide: Propachlor (as Albrass) at 9 l/ha and chlorthal-dimethyl (as Dacthal) at 6 kg/ha.
8 April	Covered.
15 May	Removed perforated polythene cover.
2 June	Removed nonwoven cover.
2 June	First harvest.
19 June	Final harvest.

LETTUCE

2 March	Applied fertiliser.
3 March	Planted lettuce: 38 mm blocks.
4 March	Applied herbicide: Propyzamide (as Kerb 50W) at 2.8 kg/ha. Covered.
11 May	Removed perforated polythene cover.
21 May	Removed nonwoven cover.
18 May	First harvest.
5 June	Final harvest.

CARROTS

25 February	Applied fertiliser.
26 February	Drilled carrot seed at 130 seeds/m^2.
28 February	Applied herbicide: Linuron (as Liquid Linuron 15) at 3.5 l/ha. Covered.
18 May	Removed perforated polythene cover.
8 June	Removed nonwoven cover.
16 June	First harvest.
13 July	Second harvest.
22 July	Third harvest.

APPENDIX II:

Table 10: Cabbage: Effect of covers and nitrogen rate on yield and quality.

Cover/ Nitrogen Rate	Total Mkt Yield (t/ha)	Mean Head Wgt (g)	Class I as % of no. planted*	Small as % of no. planted*
No Cover				
Standard	49	723	80 (96)	10 (4)
45% less	50	725	83 (96)	4 (2)
80% less	42	651	73 (91)	15 (7)
Nil	18	488	45 (50)	38 (39)
Nonwoven Cover				
Standard	54	774	84 (98)	2 (1)
45% less	50	740	79 (95)	6 (3)
80% less	44	684	72 (90)	17 (9)
Nil	23	551	51 (59)	36 (36)
Perforated Polythene Cover				
Standard	53	768	81 (96)	6 (3)
45% less	46	712	73 (90)	17 (9)
80% less	43	653	75 (93)	15 (7)
Nil	29	604	56 (68)	33 (31)
SED (27 df)				
Between covers	3.8	32.5	6.1	5.6
Within same cover	3.5	33.4	5.9	5.5
LSD (P = 0.05)				
Between covers	7.8	66.7	12.5	11.5
Within same cover	7.2	68.5	12.1	11.3

* Angle transformation (actual percentages in brackets)

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

Cover/ Nitrogen Rate	Mean Head Weight (g)	Class I as % of no. planted*	Class II as % of no. planted*	Total Mkt as % of no. planted*
No Crop Cover				
Standard	717	77 (94)	5 (1)	80 (96)
45% less	664	77 (93)	2 (1)	78 (94)
80% less	585	66 (83)	23 (16)	86 (99)
Nil	525	50 (57)	35 (35)	78 (92)
Nonwoven Cover				
Standard	762	73 (91)	11 (5)	81 (96)
45% less	686	71 (89)	15 (9)	85 (98)
80% less	577	47 (53)	39 (41)	80 (94)
Nil	481	30 (26)	51 (60)	69 (86)
Perforated Polythene Cover				
Standard	583	68 (86)	20 (11)	82 (98)
45% less	516	52 (63)	34 (31)	80 (94)
80% less	478	34 (34)	48 (55)	71 (89)
Nil	419	36 (34)	45 (50)	67 (84)
SED (27 df)				
Between covers	32.1	5.3	5.8	5.4
Within same cover	20.7	5.1	5.9	6.1
LSD (P = 0.05)				
Between covers	65.9	10.9	11.9	11.1
Within same cover	42.5	10.5	12.1	12.5

* Angle transformation (actual percentage in brackets)

APPENDIX III:

Table 12: Accumulated Day Degrees (above 4 °C) at 50 mm soil depth.

A. CABBAGE

Cover	14 Apr-15 May*	16 May-2 Jun+	Total
No crop cover	226	209	435
Nonwoven	288	210	498
Perforated polythene	299	173	472

B. LETTUCE

Cover	2 Mar-11 May*	12 May-21 May+	Total
No crop cover	395	129	516
Nonwoven	410	111	521
Perforated polythene	477	103	580

C. CARROTS

Cover	2 Mar-15 May*	16 May-2 Jun+	Total
No crop cover	397	244	641
Nonwoven	540	260	800
Perforated polythene	553	248	801

* Perforated polythene cover removed.

\+ Nonwoven cover removed.