

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

**CROP COVERS: THE EFFECT OF
HERBICIDES ON YIELD
AND QUALITY**

FINAL REPORT

Project Number: FV38d

Project Title: Crop Covers: The effect of herbicides on 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

Date Project Commenced: Late January 1993

Date Completed: Late June 1993

Report Date: November 1993

Key Words: crop covers, early summer
cauliflower, early iceberg lettuce,
paper mulch, herbicide

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 *22/11/93*

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

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

Date *22.11.93*

Contents

	Page
Relevance to Growers and Practical Application	5
Summary	6-8
Results	9-10
Action Points for Growers	11
Practical and Financial Benefits	11
Introduction	12
Objective	12
Materials and Methods	12-16
Section 1: Cauliflower	
Results	17-21
Discussion	22
Conclusions	22
Section 2: Iceberg Lettuce	
Results	23-29
Discussion	30-31
Conclusions	31
Recommendations	32
Appendix I: Crop Diaries	33-34
Appendix II: Cauliflower - Tables 12, 13, 14 & 15	35-38
Appendix III: Lettuce - Tables 16 & 17	39-40

Relevance to Growers and Practical Application

Application

The project aimed to determine the effects of standard herbicide applications, and black paper mulch on the maturity, yield and quality of early crops of cauliflower and iceberg lettuce grown under crop covers. The project included spray applications of herbicides through a nonwoven cover, 5 or 12 days after planting.

All herbicides applied to cauliflower (Tristar + Ramrod, Ramrod + Dacthal, Sovereign and Sovereign + Ramrod) provided excellent weed control and produced high yields and quality. The black paper mulch provided excellent weed control but reduced yield and quality. There was no difference in yield or quality between the nonwoven cover and the perforated polythene.

For iceberg lettuce, excellent results were achieved from a spray application of Ramrod + Kerb through a nonwoven cover 5 or 12 days after planting, compared with pre-covering sprays. Weed control was improved, maturity of the lettuce advanced by 3 days and the percentage of marketable and Class I heads increased. At present the only recommendation for Ramrod on outdoor lettuce is a pre-planting application (Specific Off-Label Approval 0518/88), but data is being generated to achieve a Specific Off-Label Approval for post-planting application. The nonwoven and perforated polythene covers led to similar maturity and yield for pre-covering herbicide treatments. The black paper mulch produced a good head weight, but it delayed maturity and tended to reduce quality.

Summary

Objective

To evaluate standard herbicides and paper mulch for yield and quality of early cauliflower and iceberg lettuce when grown under crop covers.

Treatments

Test Crops

Early summer cauliflower, cultivar Alpha Jubro.

Early iceberg lettuce, cultivar Kelvin.

Crop Covers

Nonwoven 17 g/m².

Perforated polythene 500 x 10 mm holes/m², 10.5 m wide.

Weed Control

Cauliflower

1. Hand weeded.
2. Black paper mulch.
3. Trifluralin (as Tristar) at 2.3 l/ha pre-planting + propachlor (as Ramrod Flowable) at 9 l/ha post-planting.
4. Ramrod Flowable at 9 l/ha and chlorthal-dimethyl (as Dacthal W75) at 6 kg/ha post-planting.
5. Pendimethalin (as Sovereign 330 EC) at 4 l/ha pre-planting.
6. Sovereign 330 EC at 4 l/ha pre-planting + Ramrod Flowable at 9 l/ha post-planting.

Lettuce

1. Hand weeded.
2. Black paper mulch.
3. Propachlor (as Ramrod Flowable) at 6 l/ha pre-planting* + propyzamide (as Kerb 50W) at 2.8 kg/ha post-planting.
4. Ramrod Flowable at 4 l/ha pre-planting + Kerb 50W at 2.8 kg/ha post-planting.
5. Ramrod Flowable at 6 l/ha post-planting* + Kerb 50W at 2.8 kg/ha post-planting.
6. Ramrod Flowable at 4 l/ha post-planting + Kerb 50W at 2.8 kg/ha post-planting.
7. Ramrod Flowable at 6 l/ha + trifluralin (as Tristar) at 1.16 l/ha pre-planting + Kerb 50W at 2.8 kg/ha post-planting.
8. Ramrod Flowable at 4 l/ha + Tristar at 1.16 l/ha pre-planting + Kerb 50W at 2.8 kg/ha post-planting.

* Specific Off-Label Approval (0518/88) on outdoor lettuce at 6 l/ha pre-planting.

* No recommendation at present for application post-planting.

- Additional herbicide treatments sprayed through nonwoven 17 g/m² crop cover.
9. Ramrod Flowable at 6 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 5 days after planting.
 10. Ramrod Flowable at 4 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 5 days after planting.
 11. Ramrod Flowable at 6 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 12 days after planting.
 12. Ramrod Flowable at 4 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 12 days after planting.
 13. Ramrod Flowable at 6 l/ha + Kerb 50W at 2.8 kg/ha applied 5 days after planting.
 14. Ramrod Flowable at 4 l/ha + Kerb 50W at 2.8 kg/ha applied 5 days after planting.
 15. Ramrod Flowable at 6 l/ha + Kerb 50W at 2.8 kg/ha applied 12 days after planting.
 16. Ramrod Flowable at 4 l/ha + Kerb 50W at 2.8 kg/ha applied 12 days after planting.

Water Volume

All herbicides were applied in a water volume of 450 l/hectare. Herbicides were only applied through the nonwoven 17 g/m² crop cover when the cover was wet.

Irrigation

15 mm of irrigation was applied when a soil moisture deficit of 25 mm was recorded.

Results

Cauliflower

1. The nonwoven crop cover promoted weed germination to a greater extent than perforated polythene, but all herbicide treatments controlled the additional weed effectively.
2. Maturity, yield and quality were unaffected by choice of herbicide. Paper mulch however, delayed maturity and reduced yield and quality possibly due to moisture stress.
3. The nonwoven cover led to maturity 4 days earlier than perforated polythene. Nonwoven and perforated polythene covers produced similar yield and quality.

Iceberg Lettuce

1. The nonwoven crop cover promoted weed germination to a greater extent than perforated polythene. All herbicide applications reduced weed populations effectively. The paper mulch gave excellent weed control.
2. Maturity, yield and quality were similar under nonwoven and perforated polythene crop covers with pre-covering applied sprays. The paper mulch produced a good mean head weight but tended to delay maturity and reduce head quality.
3. There was no difference between Ramrod applied at 4 or 6 l/ha pre-covering on weed control, maturity, yield or quality of lettuce at harvest.
4. Application of Ramrod @ 6 l/ha through a nonwoven crop cover delayed maturity by 2-3 days compared with application at 4 l/ha. Rate of Ramrod applied through a crop cover had no effect on weed control, yield or quality of lettuce at harvest.

5. Application of Ramrod post-planting (no recommendation at present - data being generated for a Specific Off-Label Approval) gave superior weed control and crop quality to application pre-planting (Specific Off-Label Approval 0518/88).
6. The application of Tristar + Ramrod pre-planting improved crop quality compared with Ramrod applied alone, probably due to reduced weed populations and weed ground cover during the life of the crop.
7. Spray application of Ramrod + Kerb through a nonwoven cover, 5 or 12 days after planting, provided excellent weed control, advanced crop maturity by 3 days and increased the number of marketable and Class I heads.

Action Points for Growers

1. Tristar + Ramrod, Ramrod + Dacthal, Sovereign and Sovereign + Ramrod all worked effectively under crop covers and did not delay maturity of cauliflower, or reduce yield and quality. Herbicides for use under crop covers can therefore be selected for problem weeds and cost effectiveness.
2. Initial investigation into weed control provided by spray application through covers has given excellent results for iceberg lettuce. At present there are no herbicides apart from Kerb 50W that are recommended for application post-planting. Data is however being generated for Specific Off-Label Approvals for Ramrod Flowable to be applied at 6 l/ha post-planting, and Stomp 400 at 5 l/ha post-planting. Until this time further investigations into spraying through covers should continue and include the afore mentioned chemicals.

At present there are no guidelines from Pesticides Safety Division (PSD) as regards the legality of spray application through crop covers. It would, however, seem likely that a Specific Off-Label Approval will be required in future for a chemical to be used in this way. Future investigations should therefore include sufficient plant material for residue analysis.

Practical and Financial Benefits

Crop covers produce high yields early in the season when prices are high. Herbicide application will not affect the yield and quality of the crop if carefully selected.

The range of herbicides for weed control in lettuce will increase if Specific Off-Label Approvals are achieved for Ramrod Flowable and Stomp 400 post-planting. The potential of spray application through a nonwoven cover gives the grower a great deal of flexibility at the time of planting when very often conditions are not suitable for spraying, but the crop cover must be applied immediately for the earliest establishment.

EXPERIMENTAL SECTION

Introduction

Effective weed control under crop covers is essential to maintain crop yield and quality. There are a wide range of herbicides available for brassicas, but few for lettuce. This trial evaluated herbicide combinations under crop covers for cauliflower, and pre and post-planting use of Ramrod Flowable at various rates (in combination with Kerb 50W) for iceberg lettuce. The technique of spray application through a nonwoven crop cover was also evaluated for iceberg lettuce.

Objective

To evaluate the effect of standard herbicides and a paper mulch on yield and quality of early cauliflower and iceberg lettuce when grown under crop covers and to generate efficacy data for herbicide application through nonwoven crop covers.

Materials and Methods

Site

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

Soil Type

Sandy loam of the Quorndon Series.

Treatments

Test Crops

Early summer cauliflower, cultivar Alpha Jubro.

Early iceberg lettuce, cultivar Kelvin.

Crop Covers

Nonwoven 17 g/m².

Perforated polythene 500 x 10 mm holes/m², 10.5 m wide.

Weed Control

Cauliflower

1. Hand weeded.
2. Black paper mulch.
3. Trifluralin (as Tristar) at 2.3 l/ha pre-planting + propachlor (as Ramrod Flowable) at 9 l/ha post-planting.
4. Ramrod Flowable at 9 l/ha and chlorthal-dimethyl (as Dacthal W75) at 6 kg/ha post-planting.
5. Pendimethalin (as Sovereign 330 EC) at 4 l/ha pre-planting.
6. Sovereign 330 EC at 4 l/ha pre-planting + Ramrod Flowable at 9 l/ha post-planting.

Lettuce

1. Hand weeded.
2. Black paper mulch.
3. Propachlor (as Ramrod Flowable) at 6 l/ha pre-planting* + propyzamide (as Kerb 50W) at 2.8 kg/ha post-planting.
4. Ramrod Flowable at 4 l/ha pre-planting + Kerb 50W at 2.8 kg/ha post-planting.

5. Ramrod Flowable at 6 l/ha post-planting* + Kerb 50W at 2.8 kg/ha post-planting.
6. Ramrod Flowable at 4 l/ha post-planting + Kerb 50W at 2.8 kg/ha post-planting.
7. Ramrod Flowable at 6 l/ha + trifluralin (as Tristar) at 1.16 l/ha pre-planting + Kerb 50W at 2.8 kg/ha post-planting.
8. Ramrod Flowable at 4 l/ha + Tristar at 1.16 l/ha pre-planting + Kerb 50W at 2.8 kg/ha post-planting.

* Specific Off-Label Approval (0518/88) on outdoor lettuce at 6 l/ha pre-planting.

* No recommendation at present for application post-planting.

- Additional herbicide treatments sprayed through nonwoven 17 g/m² crop cover.

9. Ramrod Flowable at 6 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 5 days after planting.
10. Ramrod Flowable at 4 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 5 days after planting.
11. Ramrod Flowable at 6 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 12 days after planting.
12. Ramrod Flowable at 4 l/ha pre-planting + Kerb 50W at 2.8 kg/ha applied 12 days after planting.
13. Ramrod Flowable at 6 l/ha + Kerb 50W at 2.8 kg/ha applied 5 days after planting.

14. Ramrod Flowable at 4 l/ha + Kerb 50W at 2.8 kg/ha applied 5 days after planting.
15. Ramrod Flowable at 6 l/ha + Kerb 50W at 2.8 kg/ha applied 12 days after planting.
16. Ramrod Flowable at 4 l/ha + Kerb 50W at 2.8 kg/ha applied 12 days after planting.

Water Volume

All herbicides were applied in a water volume of 450 l/ha. Herbicides were only applied through the nonwoven 17 g/m² crop cover when the cover was wet.

Irrigation

15 mm of irrigation was applied when a soil moisture deficit of 25 mm was recorded.

Spacing

Cauliflower: 3 rows/1.83 m bed, 60 cm between rows,
 45 cm within rows.

Iceberg Lettuce: 4 rows/1.83 m bed, 37.5 cm between rows,
 30 cm within rows.

Design

The experiment design was a split plot with covers at main plot level and weed control treatments at sub-plot level. There were 3 replicates for each crop.

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 difference (LSD) is the minimum difference when comparing any two figures within a given column, that is required for those figures to be statistically different. LSDs are provided where the differences between treatments are significant at the 5% level. Where the differences are not significant then this is indicated by NS (not significant) and this indicates that results were similar for all treatments.

Recorded Plants per Plot

Cauliflower: 30 plants from the middle row.

Iceberg Lettuce: 20 plants from the middle two rows.

Records

- * Crop diary (see Appendix I).
- * Weed Assessments: Number of weeds/m² and % ground cover of weed species - 6 weeks after planting and at harvest.
- * Crop yield and quality.
- * Crop maturity.

SECTION 1: CAULIFLOWER

Results

Table 1: Cauliflower: Effect of crop cover and weed control treatment on number of weeds and percentage weed ground cover.

Cover/Weed Control	6 weeks after planting - 4 May*		At harvest - 1 June	
	Total no./m ²	% ground cover	Total no./m ²	% ground cover
<u>Nonwoven Cover</u>				
Hand weeded	273	19	43	43
Paper mulch	0	0	5	4
Tristar + Ramrod	13	1	16	7
Ramrod + Dacthal	38	1	38	22
Sovereign	15	1	13	14
Sovereign + Ramrod	6	1	6	2
<u>Perforated Polythene Cover</u>				
Hand weeded	71	6	34	17
Paper mulch	0	0	3	1
Tristar + Ramrod	14	0	13	4
Ramrod + Dacthal	13	1	16	6
Sovereign	18	1	17	13
Sovereign + Ramrod	2	1	4	4

* After assessment, the weeds were removed from the hand weeded plots and crop covers replaced.

All the weeds at the first assessment (4 May) were at the seedling stage and percentage ground cover at that time was minimal.

The nonwoven cover promoted weed germination to a greater extent than perforated polythene. All the herbicides and the paper mulch controlled the majority of weeds under both types of cover. The combination of Sovereign + Ramrod was particularly effective.

Between the first and second assessment dates further weed germination was minimal for all herbicide and paper mulch treatments. On the hand weeded plots, germination was encouraged by soil disturbance following weeding on 4 May. The growth rate of weeds was similar between crop covers.

The main weeds requiring control during this trial were Mayweed, Shepherd's Purse, Chickweed, Fat Hen and Groundsel.

Table 2: Cauliflower: Effect of covers on maturity - mean of weed control treatments.

Cover	Date of 10% cut	Date of 50% cut	Date of 90% cut	Length of cut (days)
Nonwoven	2 June	7 June	13 June	11
Perforated polythene	6 June	10 June	16 June	10
SED (2 df)	0.8	0.7	2.9	2.4
LSD (P = 0.05)	3	3	NS	NS

The nonwoven cover led earlier maturity than the perforated polythene with significantly earlier 10 and 50% cut dates. There was no significant difference in the date of 90% cut or the length of cut.

Table 3: Cauliflower: Effect of weed control method on maturity - mean of crop cover types.

Cover	Date of 10% cut	Date of 50% cut	Date of 90% cut	Length of cut (days)
Hand weeded	3 June	8 June	14 June	10
Paper mulch	5 June	11 June	17 June	12
Tristar + Ramrod	3 June	8 June	14 June	11
Ramrod + Dacthal	5 June	9 June	15 June	10
Sovereign	3 June	8 June	14 June	11
Sovereign + Ramrod	3 June	7 June	13 June	10
SED (20 df)	0.9	0.9	1.4	1.3
LSD (P = 0.05)	NS	2	3	NS

Paper mulch delayed maturity, particularly the dates of 50 and 90% cut. Weed control method did not affect the length of cut.

The effect of the weed control treatments on maturity was the same for both types of crop cover (data not presented).

Table 4: Cauliflower: Effect of weed control method on yield and quality at harvest - mean of crop cover types.

Weed Control	Yield (crates/ha)			No. of Class I heads as % of no. planted*	Total no. mkt. heads as % of no. planted*
	Class I	Class II	Total mkt.		
Hand weeded	2079	173	2252	68 (86)	76 (93)
Paper mulch	1628	304	1931	58 (71)	68 (86)
Tristar + Ramrod	2045	215	2260	69 (84)	76 (93)
Ramrod + Dacthal	2074	186	2260	67 (83)	74 (91)
Sovereign	2015	169	2184	68 (86)	75 (93)
Sovereign + Ramrod	2256	156	2412	74 (90)	81 (96)
SED (20 df)	184.8	79.5	112.1	4.9	3.9
LSD (P = 0.05)	323	NS	234	10	8

* Angle transform (actual percentage in brackets).

None of the herbicide treatments had any significant effect on yield or quality compared with the hand weeded control. Paper mulch, however, reduced both yield and quality.

The effect of the weed control treatments on yield and quality was the same for both types of crop cover (see Appendix II, Table 12 for details).

Table 5: Cauliflower: Effect of weed control method on head characteristics at harvest - mean of crop cover types.

Weed Control	No. of heads as % of no. planted - angle transform*					
	Buttons	Size 4	Size 5	Size 6	Medium	Loose
Hand weeded	5	22	41	35	75	16
Paper mulch	15	30	38	28	68	23
Tristar + Ramrod	6	17	46	34	75	13
Ramrod + Dacthal	7	21	39	38	73	19
Sovereign	7	26	41	33	75	15
Sovereign + Ramrod	5	19	40	40	81	13
SED (20 df)	4.0	3.7	3.0	4.0	3.9	3.5
LSD (P = 0.05)	8	8	6	8	8	7

* Angle transform - see Appendix II, Table 13 for actual percentages.

All herbicide treatments produced head characteristics similar to the hand weeded control. The paper mulch however increased the number of buttons and small size heads, and produced more loose heads.

The effect of weed control treatments on head characteristics was the same for both types of crop cover (see Appendix II, Table 14 for details).

Discussion

The nonwoven crop cover promoted weed germination to a greater extent than perforated polythene. All herbicide combinations and the paper mulch controlled weeds effectively under crop covers. Sovereign + Ramrod was most effective.

The nonwoven cover advanced crop maturity by 4 days compared with perforated polythene. The paper mulch delayed the final maturity by 3 days and reduced yield and quality at harvest; there was an increase in the number of buttons and small heads, and in the number of loose heads. The paper mulch continually dried out during warm weather and tended to absorb available moisture from the soil so that plants may have suffered from water stress. The herbicide treatments produced similar yield and quality to the hand weeded control.

The effectiveness of the herbicides used in this project was not dependent on crop cover type. Herbicides can be selected for problem weeds and cost effectiveness.

Conclusions

1. The nonwoven crop cover promoted weed germination to a greater extent than perforated polythene, but all herbicide treatments controlled the additional weed effectively.
2. Maturity, yield and quality were unaffected by choice of herbicide. Paper mulch however, delayed maturity and reduced yield and quality possibly due to moisture stress.
3. The nonwoven cover led to maturity 4 days earlier than perforated polythene. Nonwoven and perforated polythene covers produced similar yield and quality.

SECTION 2: ICEBERG LETTUCE

Results

The main weeds requiring control during this trial were Mayweed, Shepherd's Purse, Fat Hen and Groundsel.

Table 6: Iceberg Lettuce: Effect of cover type and timing of spray application on the number and percentage ground cover of weeds - mean of weed control treatments.

Treatment	6 weeks after planting - 4 May		At harvest - 21 May	
	Total no. weeds/m ²	% ground cover	Total no. weeds/m ²	% ground cover
<u>Perforated polythene cover</u>				
Spray pre-covering	30	4	18	7
<u>Nonwoven cover</u>				
Spray pre-covering	59	3	39	20
Spray through cover	19	1	26	12

At the first assessment, spray applications through a nonwoven cover reduced the number of germinating weeds compared with pre-covering spray treatments (under the same cover).

The perforated polythene cover did not promote weed germination to the same extent as the nonwoven cover and led to a lower percentage weed ground cover at harvest compared with pre-covering sprays under a nonwoven cover.

Table 7: Iceberg Lettuce: Effect of paper mulch and rate of Ramrod applied pre-covering on the number and percentage ground cover of weeds - mean of cover types and timing of Ramrod application.

Treatment	6 weeks after planting - 4 May*		At harvest - 21 May	
	Total no. weeds/m ²	% ground cover	Total no. weeds/m ²	% ground cover
<u>Pre-covering Applications</u>				
Hand weeded	201	24	52	18
Paper mulch	0	0	1	1
Ramrod at 4 l	31	1	34	18
Ramrod at 6 l	22	1	25	11

* After assessment, the weeds were removed from the hand weeded control and crop covers replaced.

At the first weed assessment, all weed control treatments reduced the number of weeds germinating and the percentage weed ground cover compared with the hand weeded control.

At the second assessment, paper mulch and Ramrod applied at 6 l/ha pre-covering continued to suppress weed germination compared with the handweeded control. Only the paper mulch reduced the percentage ground cover of weeds at harvest.

Table 8: Iceberg Lettuce: Effect of paper mulch and timing of Ramrod applied pre-covering on the number and percentage ground cover of weeds - mean of cover types and rate of Ramrod applied.

Treatment	6 weeks after planting - 4 May*		At harvest - 21 May	
	Total no. weeds/m ²	% ground cover	Total no. weeds/m ²	% ground cover
<u>Pre-covering Applications</u>				
Hand weeded	201	24	52	18
Black Paper mulch	0	0	1	1
Ramrod applied pre-planting [†]	33	1	38	20
Ramrod applied post-planting [†]	23	1	24	12
Ramrod applied pre-planting with Tristar [†]	22	1	27	11

* After assessment, the weeds were removed from the hand weeded plots and crop covers replaced.

[†] Plus Kerb 50W applied post-planting.

At the first weed assessment, all weed control treatments reduced the number and percentage ground cover of weeds compared with the hand weeded control.

At the second assessment, paper mulch and Ramrod applied post-planting continued to reduce the number of weeds germinating compared with the hand weeded control. Only paper mulch reduced the percentage weed ground cover at harvest.

There were no differences in weed control between any of the herbicide treatments applied through a nonwoven cover, and crop cover type had no affect on weed control provided by the different pre-covering weed treatments (see Appendix III, Table 16 for details).

Table 9: Iceberg Lettuce: Effect of pre-covering herbicide application and timing of Ramrod application through a nonwoven crop cover on maturity, yield and quality at harvest - mean of cover types and weed control treatments.

Treatment	Mean Date of cut	Mean mkt. head wt. (g)	No. of heads as % of no. planted*	
			Total mkt.	Class I
Spray pre-covering	3 June	441	67 (84)	65 (81)
<u>Spray Application through Nonwoven Cover</u>				
Ramrod pre-planting + Kerb through cover	3 June	433	66 (83)	64 (80)
Ramrod + Kerb through cover	31 May	463	71 (87)	69 (87)
SED (42 df)				
Between pre-covering spray application and spray application through cover	0.6	11.2	2.2	2.4
Between treatments applied through cover	0.6	10.3	2.6	2.0
LSD (P = 0.05)				
Between pre-covering spray application and spray application through cover	1	NS	NS	NS
Between treatments applied through cover	1	21	4	4

* Angle transform (actual percentage in brackets).

Application of Ramrod (+ Kerb) through a nonwoven cover advanced maturity by 3 days compared with applying Ramrod pre-planting (+ Kerb through a nonwoven cover), or spraying pre-covering.

Ramrod (+ Kerb) applied through a nonwoven cover produced a larger mean head weight and higher number of marketable and Class I heads compared with applying Ramrod pre-planting (+ Kerb through a nonwoven cover).

The timing of herbicide application through a nonwoven cover (5 or 12 days post-planting) had no affect on maturity, yield or quality. The rate of Ramrod also had no affect on yield or quality (see Appendix III, Table 17 for details).

Table 10: Iceberg Lettuce: Effect of rate of Ramrod applied through a nonwoven cover on maturity - mean of weed control treatments.

Treatment	Mean Date of Cut
<u>Spray Application through Nonwoven Cover</u>	
Ramrod @ 4 l*	31 May
Ramrod @ 6 l*	3 June
SED (42 df)	0.6
LSD (P = 0.05)	1

* Plus Kerb 50W

Ramrod applied at 4 l/ha through a nonwoven crop cover led to 2-3 days earlier maturity than when applied at 6 l/ha.

Table 11: Iceberg Lettuce: Effect of herbicide application through a nonwoven crop cover and timing of Ramrod application pre-covering on maturity, yield and quality at harvest - mean of cover types and weed control treatments.

Treatment	Mean Date of cut	Mean mkt. wgt. (g)	No. of heads as % of no. planted*	
			Total mkt.	Class I
Spray application through cover	1 June	448	68 (86)	67 (84)
<u>Pre-covering Applications</u>				
Hand weeded	1 June	446	67 (85)	64 (80)
Paper mulch	2 June	450	65 (82)	60 (75)
Ramrod applied pre-planting ⁺	4 June	433	63 (78)	61 (82)
Ramrod applied post-planting ⁺	3 June	449	68 (86)	66 (86)
Ramrod applied pre-planting with Tristar ⁺	4 June	433	70 (87)	68 (88)
<u>SED (42 df) Comparison of means between:</u>				
Hand weeded with paper	1.1	18.4	3.7	3.5
Ramrod treatments	0.7	13.0	2.6	2.5
Hand weed or paper with Ramrod	0.9	15.9	3.2	3.0
Hand weed or paper with spray through cover	0.8	14.6	2.9	2.8
Ramrod with spray through cover	0.6	11.4	2.3	2.2
<u>LSD (P = 0.05) Comparison of means between:</u>				
Hand weeded with paper	NS	NS	NS	NS
Ramrod treatments	NS	NS	5	5
Hand weed or paper with Ramrod	2	NS	NS	6
Hand weed or paper with spray through cover	NS	NS	NS	6
Ramrod with spray through cover	1	NS	5	4

* Angle transform (actual percentage in brackets).

⁺ Plus Kerb 50W applied post-planting.

The hand weeded control and spray application through a nonwoven cover advanced the mean cut date by 3 days compared with Ramrod applied on its own pre-planting.

There was no significant difference in mean marketable head weight between treatments.

The paper mulch and Ramrod applied on its own pre-planting produced fewer marketable and Class I heads than Ramrod applied with Tristar pre-planting or spray application through a nonwoven cover.

Unmarketable Heads

There were no significant differences in the number of unmarketable heads between treatments. The majority of unmarketable heads were underweight. Ramrod applied pre-planting increased the number of missing heads compared with Ramrod applied with Tristar pre-planting (pre-covering treatments). (Data not presented).

Discussion

As with the cauliflower trial, the nonwoven crop cover promoted weed germination to a greater extent than perforated polythene. Delayed spraying of Ramrod + Kerb through a nonwoven cover however, either 5 or 12 days after planting, provided more efficient weed control than spray applications pre-covering. This combination of herbicides and method of application also advanced maturity by 3 days, increased the mean head weight of lettuce, and led to a higher percentage of marketable heads (due to fewer missing heads).

The rate of application of Ramrod (4 or 6 l/ha) either pre-covering, or applied through a nonwoven cover, had no significant affect on weed control, yield or quality. Ramrod applied at 6 l/ha through a nonwoven cover, however, delayed maturity by 2-3 days compared with Ramrod at 4 l/ha.

Ramrod applied alone pre-planting (Specific Off-Label Approval 0158/88 on outdoor lettuce at 6 l/ha pre-planting), reduced the total percentage of marketable heads and the percentage of Class I compared with Ramrod + Tristar applied pre-planting. This was due to the improved weed control provided by Tristar. Ramrod applied post-planting (either pre-covering or applied through a nonwoven cover) gave similar results to Ramrod + Tristar applied pre-planting. As yet there is no recommendation for application of Ramrod post-planting, but data is being generated for a Specific Off-Label Approval.

The method of applying pesticides through crop covers provides the grower with flexibility. For early crops, it is essential to apply crop covers as soon as possible after planting. Weather conditions, however, may not be suitable for herbicide application at this time, and plants may still be very tender. Spraying through a nonwoven cover up to 12 days later, alleviates these problems whilst still providing the same, if not better weed control, maturity and excellent yield and quality.

All sprays applied through a nonwoven crop cover during this trial were applied following rain or heavy dew, when the crop cover was very wet.

Conclusions

1. The nonwoven crop cover promoted weed germination to a greater extent than perforated polythene. All herbicide applications reduced weed populations effectively. The paper mulch gave excellent weed control.
2. Maturity, yield and quality were similar under nonwoven and perforated polythene crop covers with pre-covering applied sprays. The paper mulch, however, produced a good mean head weight but tended to delay maturity and reduce head quality.
3. There was no difference between Ramrod applied at 4 or 6 l/ha pre-covering on weed control, maturity, yield or quality of lettuce at harvest.
4. Application of Ramrod @ 6 l/ha through a nonwoven crop cover delayed maturity by 2-3 days compared with application at 4 l/ha. Rate of Ramrod applied through a crop cover had no effect on weed control, yield or quality of lettuce.
5. Application of Ramrod post-planting (no recommendation at present - data being generated for a Specific Off-Label Approval) gave superior weed control and crop quality to application pre-planting (Specific Off-Label Approval 0518/88).
6. The application of Tristar + Ramrod pre-planting improved crop quality compared with Ramrod applied alone, probably due to reduced weed populations and ground cover during the life of the crop.
7. Spray application of Ramrod + Kerb through a nonwoven cover, 5 or 12 days after planting, provided excellent weed control, advanced crop maturity by 3 days and increased the number of marketable heads.

Recommendations

Investigation into the efficacy of herbicides applied through crop covers should continue. The work should include:

1. a wider range of herbicides, including those for which Specific Off-Label Approval is at present being sought.
2. different water volumes to determine affects on the amount of active ingredient passing through the nonwoven crop cover and the efficacy of the herbicide.

APPENDIX I: CROP DIARIES

1. CAULIFLOWER

8 March	Applied fertiliser at 200:31:125 kg/ha NPK.
22 March	Applied Tristar pre-planting to moist soil and incorporated.
23 March	15 mm irrigation applied to trial area.
24 March	Applied Sovereign pre-planting to moist soil and laid paper mulch by machine. Planted cauliflower: Hassy 104 modules.
25 March	Applied post-planting herbicides. 7.5 mm irrigation applied to trial area.
26 March	Covered.
30 April	Removed perforated polythene cover.
4 May	Assessed weeds and hand weeded appropriate treatment (lifted nonwoven cover and replaced following weeding).
28 May	Removed nonwoven cover.
1 June	First harvest.
28 June	Final harvest.

2. LETTUCE

8 March Applied fertiliser at 160:31:125 kg/ha NPK.

22 March Applied Tristar pre-planting to moist soil and incorporated.

24 March 15 mm irrigation applied to trial area.
Applied paper mulch by machine.

25 March Applied Ramrod pre-planting to moist soil.
Planted lettuce: 38 mm blocks.
Applied post-planting herbicides.
10 mm irrigation applied to trial area.

26 March Covered.

31 March Trial area irrigated for 20 minutes. Applied herbicides through nonwoven cover (5 days after planting).

7 April Light drizzle.
Applied herbicides through nonwoven cover (12 days after planting).

4 May Removed perforated polythene cover.
Assessed weeds and handweeded appropriate treatment (lifted nonwoven cover and replaced following weeding).

21 May Removed nonwoven cover.

28 May First harvest.

8 June Final harvest.

APPENDIX II:

Table 12: Cauliflower: Effect of crop cover and weed control on yield and quality at harvest.

Cover/Weed Control	Yield (crates/ha)			No. of Class I heads as % of no. planted*	Total no. mkt. heads as % of no. planted*
	Class I	Class II	Total mkt.		
<u>Nonwoven Cover</u>					
Hand weeded	2142	186	2327	71 (90)	82 (97)
Paper mulch	1602	320	1923	58 (71)	70 (88)
Tristar + Ramrod	2201	169	2370	75 (89)	80 (96)
Ramrod + Dacthal	2294	169	2462	71 (89)	78 (96)
Sovereign	2066	210	2176	70 (88)	75 (93)
Sovereign + Ramrod	2142	236	2378	69 (87)	80 (96)
<u>Perforated Polythene Cover</u>					
Hand weeded	2015	160	2176	66 (82)	71 (89)
Paper mulch	1653	287	1940	58 (71)	67 (84)
Tristar + Ramrod	1889	261	2150	63 (79)	72 (90)
Ramrod + Dacthal	1855	202	2058	62 (78)	70 (87)
Sovereign	1965	228	2193	67 (83)	74 (92)
Sovereign + Ramrod	2370	76	2446	78 (93)	82 (97)
SED (20 df)					
Between covers	220.1	120.7	173.5	6.8	5.5
Within same cover	218.9	112.4	158.5	6.9	5.5

* Angle transform (actual percentage in brackets).

Table 13: Cauliflower: Effect of weed control method on head characteristics at harvest - mean of crop cover type - actual percentages.

Weed Control	Buttons	No. of heads as % of no. planted				
		Size 4	Size 5	Size 6	Medium	Loose
Hand weeded	1	16	43	34	92	8
Paper mulch	1	26	38	22	86	16
Tristar + Ramrod	0	11	51	31	92	7
Ramrod + Dacthal	1	13	40	38	91	11
Sovereign	2	20	43	29	93	7
Sovereign + Ramrod	0	12	42	42	96	6

Table 14: Cauliflower: Effect of crop cover and weed control on head characteristics at harvest.

Cover/ Weed Control	No. of heads as % of no. planted - angle transform*					
	Buttons	Size 4	Size 5	Size 6	Medium	Loose
<u>Nonwoven Cover</u>						
Hand weeded	4	22	44	34	80	16
Paper mulch	14	33	38	27	70	23
Tristar + Ramrod	9	13	48	35	80	12
Ramrod + Dacthal	7	16	41	42	77	18
Sovereign	6	27	40	32	75	15
Sovereign + Ramrod	7	17	46	36	80	18
<u>Perforated Polythene Cover</u>						
Hand weeded	7	23	38	36	70	16
Paper mulch	16	28	38	29	67	24
Tristar + Ramrod	4	22	44	32	70	14
Ramrod + Dacthal	7	26	38	33	70	20
Sovereign	9	25	42	33	74	15
Sovereign + Ramrod	4	22	35	42	82	7
SED (20 df)						
Between covers	5.5	6.0	4.7	5.4	5.6	4.7
Within same cover	5.7	5.2	4.2	5.7	5.5	5.0

* Angle transform - see Appendix III, Table 15 for actual percentages.

Table 15: Cauliflower: Effect of crop cover and weed control on head characteristics at harvest - actual percentage.

Weed Control	Buttons	No. of heads as % of no. planted				
		Size 4	Size 5	Size 6	Medium	Loose
<u>Nonwoven Cover</u>						
Hand weeded	1	16	49	32	96	8
Paper mulch	6	30	38	20	88	16
Tristar + Ramrod	3	8	54	33	96	7
Ramrod + Dacthal	2	8	42	46	94	10
Sovereign	3	22	42	29	93	7
Sovereign + Ramrod	2	9	51	36	96	10
<u>Perforated Polythene Cover</u>						
Hand weeded	2	16	38	36	88	8
Paper mulch	8	22	38	24	84	17
Tristar + Ramrod	1	14	48	28	88	7
Ramrod + Dacthal	2	19	38	30	87	12
Sovereign	1	18	44	30	92	7
Sovereign + Ramrod	1	16	33	48	97	2

APPENDIX III:

Table 16: Iceberg Lettuce: Effect of cover and weed control method on number and percentage ground cover of weeds.

Treatment	6 weeks after planting - 4 May*		At harvest - 21 May	
	Total no. weeds/m ²	% ground cover	Total no. weeds/m ²	% ground cover
<u>Perforated Polythene Cover: Pre-covering Treatments</u>				
Hand weeded	167	32	44	17
Paper mulch	0	1	1	1
Ramrod at 6 1 pre-planting + Kerb post-planting	12	1	16	5
Ramrod at 4 1 pre + Kerb post	18	1	19	7
Ramrod at 6 1 post + Kerb post	9	1	10	5
Ramrod at 4 1 post + Kerb post	15	1	16	8
Ramrod at 6 1 pre + Tristar pre + Kerb post	7	1	18	2
Ramrod at 4 1 pre + Tristar pre + Kerb post	13	1	20	9
<u>Nonwoven Cover: Pre-covering Treatments</u>				
Hand weeded	235	17	59	20
Paper mulch	0	0	1	1
Ramrod at 6 1 pre-planting + Kerb post-planting	49	1	52	28
Ramrod at 4 1 pre + Kerb post	54	2	63	40
Ramrod at 6 1 post + Kerb post	32	1	28	15
Ramrod at 4 1 post + Kerb post	37	1	43	22
Ramrod at 6 1 pre + Tristar pre + Kerb post	20	1	24	8
Ramrod at 4 1 pre + Tristar pre + Kerb post	48	1	44	23
<u>Nonwoven Cover: Spray Applied through Cover</u>				
Ramrod at 6 1 pre-planting + Kerb through cover after 5 days	21	1	25	10
Ramrod at 4 1 pre + Kerb through cover after 5 days	19	1	26	15
Ramrod at 6 1 pre + Kerb through cover after 12 days	11	1	14	7
Ramrod at 4 1 pre + Kerb through cover after 12 days	11	1	17	11
Ramrod at 6 1 + Kerb through cover after 5 days	22	1	30	15
Ramrod at 4 1 + Kerb through cover after 5 days	18	1	31	23
Ramrod at 6 1 + Kerb through cover after 12 days	11	1	16	5
Ramrod at 4 1 + Kerb through cover after 12 days	37	1	49	13

* After assessment, the weeds were removed from the hand weeded control.

APPENDIX III:

Table 17: Iceberg Lettuce: Effect of cover and weed control method on yield and quality at harvest.

Treatment	Mean Date of cut	Mean mkt. wgt. (g)	No. of heads as % of no. planted*	
			Total mkt.	Class I
<u>Perforated Polythene Cover: Pre-covering Treatments</u>				
Hand weeded				
Paper mulch				
Ramrod at 6 1 pre-planting + Kerb post-planting	2 June	455	69 (87)	62 (78)
Ramrod at 4 1 pre + Kerb post	3 June	449	67 (85)	60 (75)
Ramrod at 6 1 post + Kerb post	3 June	422	60 (73)	58 (70)
Ramrod at 4 1 post + Kerb post	3 June	433	65 (83)	64 (80)
Ramrod at 6 1 pre + Tristar pre + Kerb post	4 June	444	68 (86)	65 (83)
Ramrod at 4 1 pre + Tristar pre + Kerb post	3 June	446	64 (80)	62 (78)
Ramrod at 6 1 pre + Tristar pre + Kerb post	4 June	417	67 (83)	66 (82)
Ramrod at 4 1 pre + Tristar pre + Kerb post	3 June	434	69 (87)	67 (83)
<u>Nonwoven Cover: Pre-covering Treatments</u>				
Hand weeded				
Paper mulch				
Ramrod at 6 1 pre-planting + Kerb post-planting	31 May	438	68 (84)	67 (83)
Ramrod at 4 1 pre + Kerb post	2 June	451	63 (78)	60 (75)
Ramrod at 6 1 post + Kerb post	4 June	460	66 (83)	65 (82)
Ramrod at 4 1 post + Kerb post	3 June	414	60 (74)	59 (73)
Ramrod at 6 1 pre + Kerb post	2 June	424	70 (88)	68 (86)
Ramrod at 4 1 pre + Tristar pre + Kerb post	1 June	481	72 (90)	69 (86)
Ramrod at 6 1 pre + Tristar pre + Kerb post	2 June	446	67 (84)	66 (83)
Ramrod at 4 1 pre + Tristar pre + Kerb post	1 June	436	76 (94)	75 (93)
<u>Nonwoven Cover: Spray Applied through Cover</u>				
Ramrod at 6 1 pre-planting + Kerb through cover after 5 days	3 June	454	67 (84)	66 (83)
Ramrod at 4 1 pre + Kerb through cover after 5 days	2 June	436	67 (83)	67 (83)
Ramrod at 6 1 pre + Kerb through cover after 12 days	2 June	424	62 (78)	61 (76)
Ramrod at 4 1 pre + Kerb through cover after 12 days	1 June	417	67 (84)	64 (80)
Ramrod at 6 1 + Kerb through cover after 5 days	1 June	448	68 (86)	67 (84)
Ramrod at 4 1 + Kerb through cover after 5 days	30 May	480	72 (90)	69 (88)
Ramrod at 6 1 + Kerb through cover after 12 days	1 June	455	70 (88)	67 (85)
Ramrod at 4 1 + Kerb through cover after 12 days	31 May	470	74 (92)	73 (90)
SED (42 df)				
Between treatments with different covers	1.5	26.6	5.3	5.2
Within same cover treatment	1.5	26.0	5.3	5.0

* Angle transform (actual percentage in brackets)