HORTICULTURE RESEARCH INTERNATIONAL

STOCKBRIDGE HOUSE

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

Experiment Leader: J Hembry, HRI Stockbridge House, Cawood, Selby, North Yorkshire YO8 0TZ

Project Leader: P Emmett

Contract Number: FV38d

Period Covered: 1992

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

CAWOOD · SELBY · NORTH YORKSHIRE YO8 0TZ
TELEPHONE: SELBY (0757) 268275 · FACSIMILE: SELBY (0757) 268996

Index

Abstract

A range of herbicide treatments and black polythene and paper mulches were evaluated for their effect on yield and quality of early summer cauliflower and iceberg lettuce with and without crop covers and irrigation. Fat Hen was the main weed during this trial and it was not controlled by propachlor. All other herbicide combinations gave relatively good weed control and mulches controlled virtually all weeds. The nonwoven cover promoted weed growth.

The nonwoven cover increased the total marketable yield of cauliflower with a higher number of large size heads. The nonwoven cover also increased the mean marketable head weight of lettuce. Crop covers advanced maturity by up to 10 days. Irrigation applied to maintain the soil at field capacity had no effect upon the performance of herbicides compared with irrigation to maintain a soil moisture deficit of 25 mm.

Objective

To evaluate standard herbicides, black polyethylene mulch and irrigation, with and without crop covers on crops of early summer cauliflower and iceberg lettuce.

Materials and Methods

Site

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

The trials were grown on a sandy loam of the Quorndon Series in an open sunny position.

Treatments

Test Crops: Early summer cauliflower - Cultivar: Mechelse Carillon
Iceberg lettuce - Cultivar: Kelvin

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

Weed Control:

Cauliflower

Hand weeded

Black polyethylene mulch

Propachlor (Ramrod Flowable) at 9 l/ha post-planting

Trifluralin (Tristar) at half-rate 1.15 l/ha pre-planting plus propachlor (Ramrod Flowable) at 9 l/ha post-planting

Propachlor (Ramrod Flowable) at 9 l/ha plus chlorthal-dimethyl (Dacthal) at 6 kg/ha post-planting

Pendimethalin (Sovereign 330 EC) at 4 l/ha pre-planting

Pendimethalin (Sovereign 330 EC) at 4 l/ha pre-planting plus propachlor (Ramrod Flowable) at 9 l/ha post-planting

Pendimethalin (Sovereign 330 EC) at 4 l/ha pre-planting plus Metazachlor (Butisan S) at 2.3 l/ha post-planting

Lettuce

Hand weeded

Black polyethylene mulch

Paper mulch

Propachlor (Ramrod Flowable)* at two-thirds rate 4 l/ha pre-planting

Propachlor (Ramrod Flowable)* at two-thirds rate 4 l/ha pre-planting plus propyzamide (Kerb 50W) at 1.4 kg/ha post-planting

Trifluralin (Tristar) at 1.16 l/ha plus propachlor (Ramrod Flowable)* at two-thirds rate 4 l/ha pre-planting

Trifluralin (Tristar) at 1.16 l/ha pre-planting plus propyzamide (Kerb 50W) at half rate 1.4 kg/ha post-planting

Trifluralin (Tristar) at 1.16 l/ha plus chloropropham + diuron + propham (Atlas Pink C) at 22 l/ha pre-planting

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

Irrigation: Soil maintained at full water capacity.
Soil moisture deficit 25 mm.

Spacing

Each plot was 1.8 m wide with three rows of cauliflower and four rows of lettuce per bed. This gave spacings of:

Cauliflower:	600 mm x 450 mm
Lettuce:	375 mm x 300 mm

Design

The experimental design was a randomised block with three replicates for each crop. 30 heads of cauliflower were recorded from the middle row of each plot, and 40 heads of lettuce from the middle two rows of each plot.

Records

Crop diary (see Appendix I)
Weed assessments
Crop yield in size grades
Crop quality
Maturity period

Results

SECTION 1: CAULIFLOWER

Table 1: Cauliflower: Effect of covers on number of weeds/m^2 for the hand weeded treatment at first weed assessment (6.5.92)*.

Cover	Total	Chickweed	Fat Hen	Mayweed	Shepherd's Purse
No cover	159	5	102	17	19
Nonwoven	360	11	261	41	22
Perforated polythene	297	7	207	62	10

* Weeds were removed on this date after assessment.

The use of crop covers promoted the germination of Fat Hen and Mayweed seedlings. The nonwoven cover promoted weed germination to a greater extent than perforated polythene.

Table 2: Cauliflower: Effect of herbicides and covers on number of weeds/m^2 at harvest - Mean of irrigation treatments.

Herbicide	Total	Chickweed	Fat Hen	Mayweed	Shepherd's Purse
No Cover					
Hand weeded*	81	1	66	4	2
Polythene mulch	2	0	1	0	0
Ramrod	98	4	78	3	4
Tristar + Ramrod	61	4	40	5	6
Ramrod + Dacthal	38	0	15	14	6
Sovereign	29	1	17	2	5
Sovereign + Ramrod	32	0	25	2	3
Sovereign + Butisan	8	0	5	0	0
Nonwoven Cover					
Hand weeded*	50	4	35	2	2
Polythene mulch	6	1	4	0	0
Ramrod	124	4	95	13	5
Tristar + Ramrod	96	6	51	13	17
Ramrod + Dacthal	38	0	1	25	8
Sovereign	14	1	0	3	4
Sovereign + Ramrod	5	0	1	1	1
Sovereign + Butisan	3	0	0	2	1
Perforated Polythene Cover					
Hand weeded*	40	1	18	12	2
Polythene mulch	4	1	2	1	0
Ramrod	155	0	134	12	4
Tristar + Ramrod	101	0	79	12	3
Ramrod + Dacthal	37	0	11	14	6
Sovereign	18	0	8	4	3
Sovereign + Ramrod	5	0	1	1	1
Sovereign + Butisan	19	0	13	1	1
SED (84 df)					
Between covers	21.2				
Within same cover	20.8				
LSD (P = 0.05)					
Between covers	42.2				
Within same cover	41.4				

* Weed growth after weed removal by hand on 6.5.92

Weed growth (weeds/m^2) was highest on plots treated with Ramrod or Tristar + Ramrod. This was due to a large amount of Fat Hen. In addition, the use of crop covers significantly increased the number of weeds per m^2 on these treatments.

Ramrod + Dacthal produced a similar number of weeds per m^2 to the hand weeded control and crop covers did not affect this result. Relatively high numbers of weeds were recorded for the hand weeded control. These were seedlings which had germinated since hand weeding on 6.5.92. Covers reduced the number of weeds recorded for this treatment as crop growth was more advanced under covers, restricting the passage of light to the soil.

Treatments with Sovereign reduced weed germination. This was due to excellent control of Mayweed and Fat Hen. The level of weed control with these treatments was not influenced by the use of crop covers.

The polythene mulch gave the highest level of weed suppression.

Figures for percentage weed ground cover were similar to those for weed germination with the highest percentage weed cover recorded for Ramrod and Tristar + Ramrod treatments, and the lowest percentage for Sovereign. The nonwoven cover increased the percentage weed ground cover for Tristar + Ramrod and Ramrod + Dacthal treatments while the polythene cover did not promote weed growth.

Irrigation had no affect on weed control.

Table 3: Cauliflower: Maturity dates for cover treatments - Mean of herbicides x irrigation treatments.

Cover	10% Cut	50% Cut	90% Cut	Length of Cut (days)
No cover	4 Jun	11 Jun	15 Jun	11
Nonwoven	2 Jun	4 Jun	8 Jun	7
Perforated polythene	29 May	5 Jun	11 Jun	13
SED (8 df)	0.5	0.4	0.2	0.6
LSD (P = 0.05)	1.2	0.9	0.5	1.4

Crop covers advanced maturity compared with the no cover treatment. Plots with perforated polythene were earlier to 10% cut, but the nonwoven cover gave the shortest length of cut and was earlier to 50% and 90% cut.

Weed control treatments had no effect upon maturity date.

Table 4: Cauliflower: Effect of covers on marketable yield, quality and head size - Mean of herbicides x irrigation treatments.

Cover	Total Mkt. Yield (crates/ha)	No. of heads as % of no. planted (angle transformation)*				
		Class I	Class II	Size 4	Size 5	Size 6+7
No cover	2039	58	24	32	33	32
Nonwoven	2337	59	25	21	31	45
Perforated polythene	1953	60	24	36	37	24
SED (8 df)	100.3	2.6	1.7	2.3	0.9	2.7
LSD (P = 0.05)	231	6.0	3.9	5.3	2.1	6.2

* See Appendix II, Table 12 for actual percentages

The nonwoven cover increased the total marketable yield compared with no cover and perforated polythene. This was due to a higher number of large heads. Perforated polythene produced a significantly lower number of large heads than both no cover and nonwoven cover treatments.

Covering did not effect crop quality.

Irrigation had no affect upon yield or quality for the different cover treatments.

Table 5: Cauliflower: Effect of herbicides on marketable yield, quality and head size - Mean of covers x irrigation treatments.

Cover	Total Mkt Yield (crates/ha)	No. of heads as % of no. planted (angle transform)* Class I	Class II	Size 4	Size 5	Size 6+7
Hand weeded	2329	67	20	26	35	39
Black polythene	1942	59	23	35	35	28
Ramrod	2010	53	29	29	33	32
Tristar + Ramrod	2066	59	24	31	33	33
Ramrod + Dacthal	2190	58	26	27	36	35
Sovereign	2136	58	26	28	34	35
Sovereign + Ramrod	2140	60	25	32	35	33
Sovereign + Butisan	2066	58	24	30	33	34
SED (84 df)	84.8	2.6	2.0	2.3	2.0	2.7
LSD (P = 0.05)	168.9	5.2	4.0	5.3	4.0	6.2

* See Appendix II, Table 13 for actual percentages

All treatments except Ramrod + Dacthal produced a significantly lower total marketable yield than the hand weeded control. Ramrod + Dacthal gave a similar yield to the control.

All treatments produced a lower percentage of Class I heads than the hand weeded control. Ramrod produced the lowest percentage of Class I and the highest percentage of Class II heads.

All treatments except Ramrod + Dacthal and Sovereign produced fewer large (size 6 + 7) heads than the hand weeded control. Black polythene mulch produced the highest percentage of small (size 4) heads.

Covering had no significant effect upon the yield or quality of heads from the different herbicide treatments (see Appendix II, Table 14).

Irrigation had no affect on yield or quality recorded for the different weed control treatments.

Discussion

Crop covers promoted weed germination and subsequent weed growth rate.

Ramrod gave the poorest weed control due to Fat Hen not being within its control spectrum. The addition of Tristar at half rate gave partial control of Fat Hen, but Tristar at full rate would have improved results. Ramrod + Dacthal gave generally good weed control. The best weed control results were recorded with treatments including Sovereign. The application of Ramrod or Butisan S with Sovereign provided additional control of Mayweed which further improved results. The polythene mulch also gave almost complete control of weeds.

The hand weeded control gave the highest yield and quality. All the herbicides and the black polythene mulch reduced the marketable yield and quality to some extent. Sovereign reduced yield to a greater extent than Ramrod + Dacthal, and the addition of Butisan S reduced yield further. Butisan S would normally be applied after the transplanted crop has established. Under these circumstances however, where the crop cover needs to be laid as soon as possible after planting to promote early establishment, Butisan S was applied immediately after planting. Ramrod and Ramrod + Tristar gave particularly poor results due to poor control of Fat Hen and a lot of weed competition during crop growth. The black polythene mulch led to the lowest marketable yield, which may have been due to water stress. The use of a nonwoven crop cover however, significantly improved yield. The nonwoven cover increased the number of large size heads and maintained high quality. These benefits were not recorded from the perforated polythene cover, but both crop covers advanced maturity by up to 6 days.

All herbicide treatments and black polythene mulch tended to increase the percentage of loose heads and the percentage of heads with green bracts. These factors are frequently caused by adverse growing conditions - very high temperatures under the crop covers during May would have increased stress on the plant. These defects reduced the quality of heads, increasing the percentage of Class II.

The quantity of irrigation applied did not affect the performance of herbicides. One treatment provided irrigation at a soil moisture deficit of 25 mm, while the other treatment represented a wet season with irrigation applied to maintain the soil at field capacity.

Conclusions

1. Crop covers advanced maturity by up to 6 days.

2. Crop covers, in particular the nonwoven, promoted weed germination.

3. Sovereign, Sovereign + Ramrod and Sovereign + Butisan S provided the best weed control. Ramrod + Dacthal also provided effective weed control. Ramrod alone gave poor weed control due to Fat Hen not being within its weed control spectrum, and the presence of weeds reduced yield and quality. The addition of Tristar at half rate was not sufficient to control all the Fat Hen. Black polythene mulch controlled all weeds.

4. Herbicide treatments and black polythene mulch reduced marketable yield and quality.

5. The nonwoven cover increased marketable yield and head size. The highest increases in marketable yield were recorded for black polythene mulch, Ramrod + Dacthal and Sovereign + Ramrod. The use of a nonwoven cover with Ramrod + Dacthal and Sovereign + Ramrod led to comaprable yields with the hand weeded control.

6. The quantity of irrigation applied did not affect the performance of herbicides. For successful weed control, the soil should be moist at the time of herbicide application.

Recommendations

The trial should be continued for a further year to substantiate the effect of crop covers on the yield and quality of cauliflower when treated with different herbicides. Tristar should be included at full rate and Butisan S at half rate in future work, and irrigation treatments excluded.

SECTION 2: LETTUCE

Table 6: Lettuce: Effect of covers on number of weeds/m^2 for the hand weeded treatment at first assessment (6.5.92)*.

Cover	Total	Chickweed	Fat Hen	Groundsel	Mayweed	Shepherd's Purse
No cover	100	26	9	3	21	6
Nonwoven	140	30	27	5	58	14
Perforated polythene	98	19	34	5	20	7

* Weeds were removed on this date after assessment.

The nonwoven cover increased the number of germinating weeds. Perforated polythene gave similar results to no cover except for an increase in the number of Fat Hen.

Table 7: Lettuce: Effect of herbicides and covers on number of weeds/m^2 at harvest - Mean of irrigation treatments.

Treatment	Total	Chickweed	Fat Hen	Mayweed	Shepherd's Purse
No Cover					
Hand weeded*	41	8	15	4	2
Polythene mulch	3	2	0	0	0
Paper mulch	16	2	4	4	1
Ramrod	122	18	68	22	2
Ramrod + Kerb	31	0	12	15	1
Tristar + Ramrod	40	4	7	21	5
Tristar + Kerb	20	0	4	11	3
Tristar + Atlas	29	0	14	8	5
Nonwoven Cover					
Hand weeded*	48	24	7	13	3
Polythene mulch	6	5	1	0	0
Paper mulch	20	5	16	3	1
Ramrod	160	67	47	27	7
Ramrod + Kerb	35	2	6	21	3
Tristar + Ramrod	67	5	6	38	13
Tristar + Kerb	43	0	0	34	5
Tristar + Atlas	36	1	4	20	3
Perforated Polythene Cover					
Hand weeded*	26	7	9	3	2
Polythene mulch	2	1	1	0	0
Paper mulch	16	5	6	2	1
Ramrod	65	9	34	5	4
Ramrod + Kerb	25	1	5	15	1
Tristar + Ramrod	40	4	14	11	4
Tristar + Kerb	24	1	2	12	2
Tristar + Atlas	26	0	3	14	4
SED (84 df)					
Between covers	20.8				
Within same cover	18.4				
LSD (P = 0.05)					
Between covers	41.4				
Within same cover	36.7				

* Weed growth since weed removal by hand on 6.5.92

Ramrod + Kerb, Tristar + Ramrod, Tristar + Kerb and Tristar + Atlas all gave relatively good weed control.

The highest total number of weeds per m^2 was recorded on the Ramrod alone treatment due to the high number of Fat Hen.

The use of Ramrod at 4 l/ha did not control Mayweed.

Black polythene and paper mulches controlled the majority of weeds - black polythene produced the best weed control results.

The nonwoven cover increased the number of weeds per m^2 compared with no cover. This was due mainly to more Chickweed and Mayweed. Use of perforated polythene did not affect the number of weeds per m^2.

Figures for percentage weed ground cover were similar to those recorded for the numbers of weeds germinating.

Table 8: Lettuce: Effect of covers on maturity and marketable yield - Mean of herbicides x irrigation treatments.

Cover	Mean date of cut	Mean head weight (g)
No cover	3 Jun	409
Nonwoven	25 May	506
Perforated polythene	24 May	455
SED (8 df)	0.5	25.9
LSD (P = 0.05)	1.2	59.7

Use of crop covers advanced maturity by up to 10 days. The nonwoven cover produced a larger mean head weight than the no cover treatment. Perforated polythene also tended to increase mean head weight but differences were not significant.

Table 9: Lettuce: Effect of herbicides on maturity and marketable yield - Mean of covers x irrigation treatments.

Cover	Mean date of cut	Mean head weight (g)
Hand weeded	27 May	465
Polythene mulch	28 May	461
Paper mulch	29 May	432
Ramrod	28 May	437
Ramrod + Kerb	28 May	448
Tristar + Ramrod	28 May	463
Tristar + Kerb	27 May	481
Tristar + Atlas	27 May	468
SED (84 df)	0.5	13.9
LSD (P = 0.05)	1.0	27.7

Weed control treatments had minimal effect upon maturity.

Ramrod and the paper mulch reduced mean head weight compared with the hand weeded control. All other treatments gave similar results to the control.

Covers had no significant effect on maturity and mean head weight for the different herbicide treatments.

Table 10: Lettuce: Effect of herbicides and covers on quality - Mean of irrigation treatments.

Treatment	No. of heads as % of no. planted (angle transform)*	
	Class I	Class II
No Cover		
Hand weeded	66	3
Polythene mulch	64	0
Paper mulch	46	0
Ramrod	57	0
Ramrod + Kerb	61	0
Tristar + Ramrod	64	0
Tristar + Kerb	70	0
Tristar + Atlas	69	0
Nonwoven Cover		
Hand weeded	70	2
Polythene mulch	69	2
Paper mulch	71	2
Ramrod	48	12
Ramrod + Kerb	65	3
Tristar + Ramrod	65	2
Tristar + Kerb	66	2
Tristar + Atlas	66	2
Perforated Polythene Cover		
Hand weeded	71	2
Polythene mulch	61	3
Paper mulch	69	0
Ramrod	67	2
Ramrod + Kerb	67	0
Tristar + Ramrod	67	4
Tristar + Kerb	70	5
Tristar + Atlas	78	0
SED (84 df)		
Between covers	5.9	2.6
Within same cover	5.8	2.5
LSD (P = 0.05)		
Between covers	13.6	6.0
Within same cover	13.4	5.8

* See Appendix III, Table 16 for actual percentages.

Paper mulch produced a low percentage of marketable heads where no crop cover was used. The use of nonwoven or perforated polythene covers however, improved the yield of Class I heads so that the paper mulch gave results comparable to the hand weeded control.

Under the nonwoven cover the quality of heads treated with Ramrod was reduced.

Table 11: Lettuce: Effect of herbicides and covers on unmarketable head defects - Mean of irrigation treatments.

Treatment	No. of heads as % of no. planted (angle transform)*				
	Total Unmkt.	Small	Immature	Botrytis	Missing
No Cover					
Hand weeded	16	8	7	0	12
Polythene mulch	23	20	8	2	11
Paper mulch	39	31	18	6	21
Ramrod	31	8	21	13	8
Ramrod + Kerb	22	15	12	0	14
Tristar + Ramrod	21	8	16	0	14
Tristar + Kerb	18	11	9	0	10
Tristar + Atlas	19	12	9	0	8
Nonwoven Cover					
Hand weeded	18	7	4	6	5
Polythene mulch	17	10	4	6	12
Paper mulch	18	10	0	12	3
Ramrod	35	16	13	19	5
Ramrod + Kerb	20	15	2	14	10
Tristar + Ramrod	22	14	5	5	8
Tristar + Kerb	17	10	0	8	9
Tristar + Atlas	18	10	2	10	10
Perforated Polythene Cover					
Hand weeded	15	6	5	10	8
Polythene mulch	20	14	8	5	15
Paper mulch	20	14	6	7	6
Ramrod	19	15	3	10	10
Ramrod + Kerb	21	19	0	2	6
Tristar + Ramrod	16	10	2	7	11
Tristar + Kerb	10	5	0	8	8
Tristar + Atlas	11	5	5	3	2
SED (84 df)					
Between covers	5.2	4.9	4.7	4.4	4.6
Within same cover	5.1	4.9	4.7	4.0	4.8
LSD (P = 0.05)					
Between covers	10.4	9.8	9.4	8.8	9.2
Within same cover	10.2	9.8	9.4	8.0	9.6

* See Appendix III, Table 17 for actual percentages.

With no cover, paper mulch increased the number of unmarketable heads compared with the hand weeded control, producing a higher number of small and immature heads. Ramrod also increased the number of unmarketable heads, producing a higher number of immature heads and heads affected by Botrytis.

Under perforated polythene, all weed control treatments were equivalent, producing a level of unmarketable heads similar to that of the hand weeded no cover treatment.

Under the nonwoven cover, Ramrod produced more unmarketable heads than the hand weeded control. All other treatments gave similar results to the hand weeded no cover treatment, although the nonwoven cover tended to produce more heads with Botrytis and less small and immature heads.

Discussion

The nonwoven cover increased the number of weeds germinating and their subsequent growth rate. The perforated polythene cover however, had little affect on weed germination or growth rate. As lettuce is a relatively low-growing crop, sufficient air space would have remained beneath the polythene cover for continued air exchange via the perforations leading to cooler temperatures, which would not have encouraged weed growth.

Both crop covers improved mean head weight for all weed control treatments. The nonwoven cover gave the best result. There was however, evidence of reduced quality from the nonwoven cover due to increased incidence of Botrytis from the presence of weeds.

Ramrod was used during the first year of this trial in 1991 at its full recommended rate of 6 l/ha (Specific Off-Label Approval 0518/88 - pre-planting). Results showed excellent weed control but crop growth was retarded, maturity delayed and yield reduced. During this 1992 trial, Ramrod was used at a reduced rate of 4 l/ha. Crop yield and quality were poor however, due to Fat Hen not being within the weed control spectrum of Ramrod - the high cover of Fat Hen reduced crop growth and increased the incidence of Botrytis. The addition of Kerb at half rate or Tristar, controlled Fat Hen and improved results giving high yields and good quality heads.

During this trial, Ramrod at 4 l/ha did not control the relatively low levels of Mayweed. Had the incidence of Mayweed been greater, results would not have been as good for all treatments. There was also some evidence of delayed crop growth with Ramrod at 4 l/ha, as slightly higher percentages of small heads were recorded. The use of Ramrod at reduced rates requires further investigation.

Tristar + Kerb and Tristar + Atlas gave adequate weed control and good quality yields.

The polythene mulch was laid by machine. Attempts were also made to lay the paper mulch by machine but it tore readily and had to be laid by hand. Both the polythene and paper mulches provided excellent weed control but crop yields and quality were poor, particularly where no crop cover were used. The addition of a cover prevented the mulches from being buffetted during high winds and damaging the crop and as a result, yields improved. There was still, however, a high percentage of unmarketable heads, which included small and missing heads.

No significant effects were recorded from the irrigation treatments on the performance of herbicides under covers. This would mean that during a very wet season, herbicides would give similar results to a standard irrigation programme maintaining a soil moisture deficit of 25 mm, providing adequate moisture was present when the herbicides were applied. Irrigation treatments had no significant affect on crop yield or quality.

Conclusions

1. Crop covers advanced maturity by up to 10 days.

2. The nonwoven cover promoted weed germination and growth rate. Perforated polythene did not affect weed growth.

3. Crop covers increased mean head weight. The nonwoven cover produced the highest mean head weight.

4. The nonwoven cover tended to reduce quality where weeds were not controlled, as restricted air movement promoted the incidence of Botrytis.

5. Ramrod (at 4 l/ha) gave poor crop yield and quality during this trial as Fat Hen is not within its weed control spectrum. The addition of Kerb (at half rate) or Tristar allowed control of Fat Hen and improved results. Ramrod at 4 l/ha did not control Mayweed. If Mayweed had been more prolific during this trial, results would have been poorer from all herbicide treatments. The use of Ramrod at reduced rates requires further evaluation.

6. Tristar + Atlas and Tristar + Kerb (at half rate) gave good weed control and good quality yields.

7. The black polythene and paper mulches provided excellent weed control but the paper mulch in particular, led to poor crop yield and quality. Covering improved crop growth as it minimised damage to the crop from the mulches during strong winds. The paper mulch was very brittle and tore when laid by machine.

8. During a very wet season, the results of this trial suggest that herbicides would perform similarly to conditions where irrigation is applied at a soil moisture deficit of 25 mm. It is essential that adequate soil moisture is present when herbicides are applied.

Recommendations

The trial should be continued for a further year. The use of Ramrod at different application rates should be studied under crop covers, on its own and in combination with other herbicides. Irrigation treatments should be excluded.

APPENDIX I: CROP DIARY

CAULIFLOWER

9 March	Applied fertiliser at 250:50:200 kg/ha NPK.
23 March	Planted cauliflower: Hassy 104 modules.
26 March	Covers laid as appropriate.
6 May	Weed removal for hand weeded treatment (covers lifted and replaced).
18 May	Removed perforated polythene cover (curds 5-10 mm diameter).
22 May	First harvest.
18 June	Final harvest.

LETTUCE

9 March	Applied fertiliser at 200:50:125 kg/ha NPK.
17 March	Planted lettuce: 38 mm blocks.
18 March	Covers laid as appropriate.
6 May	Weed removal for hand weeded treatment (covers lifted and replaced).
11 May	Removed perforated polythene cover (2 weeks after hearting).
20 May	Removed nonwoven cover (at first harvest).
20 May	First harvest.
9 June	Final harvest.

APPENDIX II: CAULIFLOWER

Table 12: Cauliflower: Effect of covers on head characteristics - Mean of herbicides x irrigation treatments - actual percentages.

Cover	No. of heads as % of no. planted				
	Class I	Class II	Size 4	Size 5	Size 6+7
No cover	71	18	30	30	29
Nonwoven	73	18	14	27	50
Perforated polythene	73	18	34	37	19

Table 13: Cauliflower: Effect of herbicides on head characteristics - Mean of covers x irrigation treatments - actual percentages.

Herbicide	No. of heads as % of no. planted				
	Class I	Class II	Size 4	Size 5	Size 6+7
Hand weeded	84	12	22	33	41
Black polythene	73	16	35	29	25
Ramrod	63	24	25	31	31
Tristar + Ramrod	72	17	27	30	32
Ramrod + Dacthal	72	20	22	35	35
Sovereign	70	20	23	32	35
Sovereign + Ramrod	74	19	29	33	31
Sovereign + Butisan	71	17	26	30	33

Table 14: Cauliflower: Marketable yield and head size for cover x herbicide treatments - Mean of irrigation treatments.

Cover	Total Mkt Yield (crates/ha)	No. of heads as % of no. planted (angle transform)* Class I	Class II	Size 4	Size 5	Size 6+7
No Cover						
Hand weeded	2282	64	4	28	33	40
Black polythene	1734	57	14	43	29	22
Ramrod	1928	55	11	33	33	30
Tristar + Ramrod	2067	59	7	33	31	34
Ramrod + Dacthal	2118	58	12	27	37	34
Sovereign	2139	57	10	30	34	36
Sovereign + Ramrod	2050	59	7	35	34	32
Sovereign + Butisan	1996	58	11	32	36	30
Nonwoven Cover						
Hand weeded	2540	66	3	18	30	50
Black polythene	2278	61	4	22	33	42
Ramrod	2257	54	7	16	30	45
Tristar + Ramrod	2253	58	4	23	33	41
Ramrod + Dacthal	2519	62	4	19	30	50
Sovereign	2287	55	10	21	31	44
Sovereign + Ramrod	2422	60	2	26	31	45
Sovereign + Butisan	2139	56	10	24	28	42
Perforated Polythene Cover						
Hand weeded	2164	70	4	34	41	28
Black polythene	1814	60	15	41	35	19
Ramrod	1844	49	9	37	36	21
Tristar + Ramrod	1877	60	11	37	35	25
Ramrod + Dacthal	1932	56	10	35	40	23
Sovereign	1983	60	11	34	39	25
Sovereign + Ramrod	1949	62	10	35	40	23
Sovereign + Butisan	2063	60	12	33	35	31
SED (84 df)						
Between covers	170.1	4.9	4.9	4.1	3.3	5.2
Within same cover	146.8	4.6	4.7	3.9	3.4	4.7
LSD (P = 0.05)						
Between covers	338.8	9.8	9.8	8.2	6.6	10.4
Within same cover	292.4	9.2	9.4	7.8	6.8	9.4

* See Appendix II, Table 15 for actual percentages

Table 15: Cauliflower: Effect of covers and herbicides on head characteristics - Mean of irrigation treatments - actual percentages.

Treatment	No. of heads as % of no. planted				
	Class I	Class II	Size 4	Size 5	Size 6+7
No Cover					
Hand weeded	79	15	23	29	42
Black polythene	69	17	46	24	16
Ramrod	67	20	31	31	15
Tristar + Ramrod	73	17	29	27	33
Ramrod + Dacthal	71	18	26	37	32
Sovereign	70	21	25	31	35
Sovereign + Ramrod	72	19	33	31	28
Sovereign + Butisan	71	18	29	35	25
Nonwoven Cover					
Hand weeded	83	13	12	26	58
Black polythene	76	14	15	30	45
Ramrod	65	20	8	20	51
Tristar + Ramrod	72	18	17	30	43
Ramrod + Dacthal	77	18	11	26	58
Sovereign	67	22	13	27	49
Sovereign + Ramrod	75	21	19	27	50
Sovereign + Butisan	68	17	18	23	44
Perforated Polythene Cover					
Hand weeded	88	9	32	43	23
Black polythene	74	15	43	33	13
Ramrod	56	32	37	35	16
Tristar + Ramrod	73	15	36	33	19
Ramrod + Dacthal	63	23	33	42	16
Sovereign	74	17	32	39	20
Sovereign + Ramrod	76	15	33	41	17
Sovereign + Butisan	74	17	30	33	28

APPENDIX III: LETTUCE

Table 16: Lettuce: Effect of covers and herbicides on marketable yield - Mean of irrigation treatments - actual percentages.

Treatment	No. of heads as % of no. planted	
	Class I	Class II
No Cover		
Hand weeded	88	2
Polythene mulch	80	0
Paper mulch	51	0
Ramrod	69	0
Ramrod + Kerb	74	0
Tristar + Ramrod	80	0
Tristar + Kerb	88	0
Tristar + Atlas	86	0
Nonwoven Cover		
Hand weeded	88	0
Polythene mulch	86	0
Paper mulch	89	0
Ramrod	56	9
Ramrod + Kerb	82	1
Tristar + Ramrod	81	0
Tristar + Kerb	92	1
Tristar + Atlas	82	0
Perforated Polythene Cover		
Hand weeded	88	0
Polythene mulch	75	1
Paper mulch	87	0
Ramrod	83	0
Ramrod + Kerb	79	0
Tristar + Ramrod	84	2
Tristar + Kerb	97	2
Tristar + Atlas	94	0

Table 17: Effect of covers on unmarketable head defects - Mean of irrigation treatments - actual percentages.

Treatment	No. of heads as % of no. planted				
	Total Unmkt.	Small	Immature	Botrytis	Missing
No Cover					
Hand weeded	8	3	4	0	2
Polythene mulch	16	13	3	1	4
Paper mulch	39	27	10	3	10
Ramrod	27	4	20	10	4
Ramrod + Kerb	16	9	6	0	10
Tristar + Ramrod	13	5	9	0	7
Tristar + Kerb	10	5	3	0	3
Tristar + Atlas	11	5	5	0	3
Nonwoven Cover					
Hand weeded	10	4	2	3	2
Polythene mulch	9	3	1	2	5
Paper mulch	11	4	0	6	0
Ramrod	34	8	8	13	2
Ramrod + Kerb	13	9	0	7	4
Tristar + Ramrod	15	9	2	3	3
Tristar + Kerb	10	5	0	5	0
Tristar + Atlas	10	4	0	5	8
Perforated Polythene Cover					
Hand weeded	9	2	2	5	3
Polythene mulch	15	8	5	2	10
Paper mulch	12	7	2	3	1
Ramrod	11	8	1	5	5
Ramrod + Kerb	19	17	0	0	3
Tristar + Ramrod	9	5	0	2	5
Tristar + Kerb	5	2	0	3	0
Tristar + Atlas	6	2	2	1	0