Project Title	Early production Lettuce, Calabrese, Carrots and overwinter field storage of Carrots. Bio-degradable Covers and Mulches - Comparison of Field Performance and Economic Evaluation.
Project number:	FV 280
Project leader:	John Birkenshaw, ADAS
Report:	Final Year, 2008
Previous reports	Initial Report, April 2006 – The Scope for Bio-degradable Crop Covers in Vegetable Production Annual, Year 1, December 2006 Annual, Year 2, February 2008
Key staff:	John Birkenshaw, ADAS Don Tiffin, ADAS Martyn Watling, ADAS
Location of project:	2006 -Herringswell, Suffolk 2007 – Kirton, Lincs. & Stretham, Cambs. 2007/8 – Baconsthorpe, Norfolk
Project coordinator:	Martin Evans, Freshgro Ltd., Inkersall Grange Farm, Bilsthorpe, Notts. NG22 8TN
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Key words:	Crop covers, crop mulches, plastic, biodegradable, carrot, field storage, early production, waste, 'Mater-bi', Envirocare.

The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

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

John Birkenshaw
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Signature ..... John Birkenshaw..... Date ...10 August 2008

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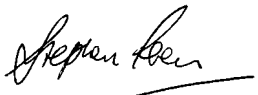

Signature .... Date ….19 September 2008

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FV 280

Early Production and Overwinter Field Storage of Carrots. Bio-degradable Covers and Mulches - Comparison of Field Performance and Economic Evaluation

Headline

- Carrots and lettuce grown under oil or corn starch derived bio-degradable crop covers had yields equivalent to crops grown with standard commercial crop covers.
- Calabrese grown under bio-degradable crop covers yielded less than crops grown under standard commercial covers due to narrow cover widths adversely affecting growth and damage.
- The corn starch derived cover ‘‘Mater-bi’’ degraded in the field by October compared to other materials used on early carrot, lettuce and calabrese.
- Carrots strawed and over-wintered under oil or corn starch derived bio-degradable covers yielded equivalent to crops under standard black plastic.

Background and expected deliverables

Approximately 20% of UK carrot crop is covered with clear plastic to encourage early growth and cropping. In addition, more than 40% of the crop area is harvested from the field between January and May, using black plastic covers and a straw layer to prevent frost damage and re-growth in spring. Consequently, costs of production are highest during this over-winter period,

Significant quantities of polythene are used for both early and late field stored production in carrots. This is estimated at around 1,400 tonnes annually when purchased, but nearly 10,000 tonnes (including soil contamination) after use, costing in excess of £0.5m to dispose of each year.

Similarly, other vegetable crops also use quantities of plastic covers and mulches, principally for early production. For example, about 15% (2,853 ha) of the Brassica area and 20% (1,003 ha) of the lettuce area are covered annually. Although some plastic covers can be re used, ultimately these crops account for a further 1,230 tonnes of waste plastic needing to be disposed of annually [2003 data].

The introduction of the Agricultural Waste Regulations in 2006 has meant that burning

or burying waste plastic on farm is no longer possible, and it will need to be disposed of through licensed contractors. Recycling continues to pose problems because of the soil contamination usually associated with these covers and logistical difficulties. Disposal to landfill is still possible, but the outlook is one of increasing costs for both transport and landfill tax.

The project aim is to assess the field performance, effect on crop growth and yield, and economic viability of currently available biodegradable covers and mulches, to establish if these can be substituted for the standard polythene currently used by industry.

The original proposal for a demonstration project examining use on carrots was extended at the request of the HDC Field Vegetable Panel to Brassica (calabrese) and lettuce crops. These however require the use of wide covers on grounds of practicality and economic feasibility. Despite extensive enquiries, no manufacturers were found with the capacity to manufacture biodegradable covers much beyond a 2.2m width, so this extension to the work was deferred until 2007.

The expected deliverables from the overall project were:

a) A review of the scope, availability and cost of available biodegradable crop covers and mulches (see Initial Report, April 2006)

b) An evaluation of the economics of substituting biodegradable covers for polythene on early crops of carrots, calabrese and lettuce and of over-wintered carrots (Initial Report, April 2006)

c) A field demonstration of up to 4 biodegradable covers for early carrots (Annual Report, Year 1, Dec. 2006)

d) A field demonstration of up to 4 biodegradable covers for early lettuce and calabrese (Annual Report, Year 2, Feb .2008)

e) A demonstration of up to 4 biodegradable mulches for over-wintered field storage of carrots (Final Report, Sept 2008))

Treatments for the final demonstration site, for biodegradable mulches for over-wintered field storage of carrots were applied on 30 October 2007**.**

Summary of the project (2008) and main conclusions

Biodegradable covers on field stored carrots

On demonstration plots, the black bio-degradable crop covers ‘‘Mater-bi’’, ‘‘Biotelo’’, and ‘‘Biolene’’, (all corn starch-derived) and black woven viscose fleece (partially degradable, oil-based) were compared with commercial standard black polythene (40 micron thickness) for preserving field stored carrots over winter 2007/08.

Carrot crops stored under the biodegradable covers produced crops of similar marketability to those under the standard black polythene treatment when harvested monthly between November 2007 and April 2008, although there were some signs of crop regrowth and reduced marketability in the ‘‘Biolene’’ and Viscose fleece treatments at the latest (April) sampling date. Biodegradable covers also preserved crop quality, as measured by dry matter and total sugar content, equivalent to the commercial standard. All degradable covers maintained adequate tensile strength throughout the winter, but none were of equivalent tensile strength to the commercial standard, so could not be used to remove the straw at harvest.

The soil temperatures recorded under each type of cover were similar to the commercial standard.

To test an alternative disposal method, samples of all degradable covers were composted for 7 days following removal from the crop in a batch of organic municipal waste using a closed composting unit. The effect of this treatment on the breakdown of covers was negligible and the 7-day composting process used for domestic organic waste is evidently not a satisfactory method of disposal.

Main points:

- In 2 field demonstrations, early carrots and lettuce grown under bio-degradable crop covers, derived from oil or corn starch, produced crops equivalent in yield and earliness to those grown under standard commercial crop covers.
- In a third field demonstration, calabrese grown under bio-degradable crop covers failed to produce a crop equivalent in yield and earliness to those grown under standard commercial covers, though this was principally due to narrow cover widths restricting plant growth, wind and wildlife damage rather than the materials themselves.
- When the crop cover ‘‘Mater-bi’’, made from corn starch, was removed from the early carrot crop, left in the wheeling and covered with soil, its degradation in the field was virtually complete by October. Initial experience showed that the other materials used

on early carrot, lettuce and calabrese did not breakdown within a reasonable period of time and would need removing from the field for composting elsewhere.

- In a fourth field demonstration, field-stored carrots over-wintered under bio-degradable crop covers derived from oil or corn starch and covered with straw, produced crops broadly equivalent in yield and quality to those field stored under standard commercial black plastic covers and straw. There were however indications of a slight reduction in marketability under some covers at late removal dates, possibly related to cover thickness, which needs further investigation.

Financial benefits

Field stored carrots are produced using black plastic on a 'use once then dispose' basis, on bed systems ranging from 1.8m to 2.2m wide; production is efficiently mechanised. The cost of purchasing, laying, removing and disposing of plastic covers is estimated at £712.50/ha., at 2007/8 prices, excluding labour and machinery costs.

Switching to bio-degradable materials made from starch (bio-polymers) is likely to cost significantly more, say £1640/ha, due to their higher purchase price. However, increased sales of biodegradable materials would help bring the cost down and the possibility of leaving the material in field to degrade rather than having to retrieve it has attractions. The cost of standard black plastic is directly linked to the price of oil which has risen significantly over the last 12 months.

Table 1 Costs associated with 'standard' plastic crop covers

Crop	Cover type	System	Rolls/ ha	Material cost/ha(£)	Laying cost/ha (£)	Removal cost/ha (£)	Disposal cost/ha (£)	Total cost/ha (£)
Field stored carrots	Black Plastic	2m width	14	362.5	Nil	200	150 (recycling or landfill)	712.50

Action points for growers

- Growers can have some confidence that black biodegradable covers have the potential to offer similar agronomic advantages to standard black plastic covers for field stored over-wintered carrots.
- Growers should encourage the development of a range of biodegradable materials of suitable widths and tensile strength by liaising with manufacturers and distributors and increasing their awareness of vegetable production systems.
- Samples of biodegradable covers placed in a closed composting unit along with organic municipal waste for 7 days did not accelerate degradation, which takes several months, following soil incorporation.

Science Section

Introduction

The cost of disposing or recycling of plastic waste is increasing significantly and is a topic of both industry and public concern. The wide geographical distribution of vegetable businesses using horticultural plastic, and their extensive use of rented land, adds to the cost of collection for recycling or disposal to landfill.

From 15 May 2006, it has been illegal to burn or bury waste plastic crop covers on farm. Degradable materials are available, but are only likely to be adopted if technically satisfactory and approximately competitive in price and overall cost, including disposal.

At present, the price of bio-polymers (manufactured from starch or cellulose) is still fairly high compared with plastic (c. 30 - 50% more), though this is at least in part due to lower volumes being manufactured.

Demonstration treatments for Early Production of Carrots 2006

For a detailed description of Materials and Methods employed, Results, Discussion and Conclusions, please see HDC Project Report FV280 Year 1, December 2006.

Demonstration treatments for Early Production of Lettuce 2007

For a detailed description of Materials and Methods employed, Results, Discussion and Conclusions, please see HDC Project Report FV280 Year 2, February 2008.

Demonstration treatments for Early Production of Calabrese 2007

For a detailed description of Materials and Methods employed, Results, Discussion and Conclusions, please see HDC Project Report FV280 Year 2, February 2008.

Demonstration treatments for Field-stored Carrots 2007/08

Materials and Methods

After examination of the available materials, 4 biodegradable products were selected and compared with the industry standard polythene cover, applied to a crop of carrots grown for over-wintered field storage on a sandy loam soil at Baconsthorpe, Norfolk. All treatments were covered with a layer of straw as an insulator. In detail, the treatments and specifications comprised:

Crop Cover Specifications

1. Industry standard cover, 2m wide, 40 micron thickness, black plastic.

2. ‘'Mater-bi' (supplier: Capatex), 2m wide, 20 micron thickness, black, expected cover life 20 weeks.

3. ‘Biotelo’ (supplier: Tildenet), 1m wide, 15 micron thickness, black, expected cover life 20 weeks.

4. ‘Biolene’ (supplier: Ilex Organics), 2m wide, 15 micron thickness, black, expected cover life 20 weeks.

5. Woven viscose polyester fleece, (supplier: Capatex), 2.2m wide, 20 g/m^2, expected life 12 months.

6. Biodegradable cover/straw sandwich using ‘‘Mater-bi’’, see (2) above); 50% of the straw laid under the ‘Mater-bi’ and 50% above.

Treatments 2, 3, 4, 5 and 6 were applied manually, having first removed the black plastic laid mechanically, and then replacing the straw over the demonstration treatments. Straw was applied as per industry practice, i.e. approximately 50 tonnes/ha, some 300mm deep at laying.

Covers were planned to remain in situ until harvest (April), with crop sampling at monthly intervals from January 2008.

Demonstration set- up – Baconsthorpe, Norfolk.

1. Industry standard

2.. ‘‘Mater-bi’’

3. ‘‘Biotelo’’

4. ‘‘Biolene’’

5. Woven viscose

6. ‘‘Mater-bi’/Straw sandwich’

Images 1, 3, 4 taken on 17/02/08; Images 2, 5, 6 on 9/04/08.

Crop Diary

17 May 2007	Demonstration plots drilled
25-30 October 2007	Commercial crop cover applied and straw placed
30 October 2007	Degradable cover treatments applied

Carrot variety was Nairobi.

Records taken

1. Assessments of crop re-growth and percentage marketability, from January 2008 (22 Jan, 19 Feb, 24 March, 10 April).
2. Analysis of percentage total sugar content and dry matter at approximately monthly intervals, from January 2008.
3. Soil temperatures under each cover treatment, on the soil surface and at 200mm depth.
4. Monthly observations to assess biodegradable cover life and strength.
5. Speed of degradation in soil following the demonstration.

Results and Discussion

Results – Cover Strength

The strength of each material was scored on a 1 – 5 scale at laying and at monthly intervals from January 2008, with 5 = strong & entire and 1 = completely degraded, disintegrating. There was little measurable deterioration whilst crop covers were in place; 'Biolene' was the weakest material when laid, although it did not deteriorate. Only 'Biotelo' was found to have weakened, from the March sampling date onwards. However, no biodegradable cover was as strong as the standard black plastic which is currently used to remove straw from the bed at harvest; they would not be strong enough to do this. An alternative approach is required to remove both straw and cover from the bed to enable harvesting to take place.

Table 2 Cover strength scores at 5 assessment dates

Treatment	30 October	22 January	19 February	24 March	10 April
Standard	5	5	5	5	5
'Mater-bi'	2	2	2	2	2
'Mater-bi'/straw	2	2	2	2	2
'Biotelo'	2	2	2	1	1
'Biolene'	1	1	1	1	1
Viscose fleece	3	3	3	3	3

Results – Temperature records

Soil temperature records show that all treatments maintained adequate frost protection equally under the conditions experienced at the site, and there were only minor differences between treatments. As was expected, fluctuations at the surface were more marked than at 12cm soil depth (for charts see Appendix).

Results – Plant Re growth

Levels of plant re-growth were nil for all cover types between October and March but at the April assessment date some re-growth was evident under 'Biolene' and the woven viscose fleece.

Table 3 Leaf re-growth measurements at 4 dates (mm)

Treatment	22 January 2008	19 February 2008	24 March 2008	10 April 2008
Standard	0	0	0	0
'Mater-bi'	0	0	0	0
'Mater-bi'/straw sandwich	0	0	0	0
'Biotelo'	0	0	0	0
'Biolene'	0	0	0	10
Viscose fleece	0	0	0	12

Results – Marketability

Table 4 Percentage marketable roots

Treatment	30 Oct. 2007	22 Jan. 2008	19 Feb. 2008	24 Mar. 2008	10 Apr. 2008
Standard	69.3	70.5	67.1	65.2	65.2
'Mater-bi'	65.2	67.4	67.0	64.3	64.3
'Mater-bi'/straw	63.6	70.7	66.5	62.6	62.6
'Biotelo'	72.6	67.3	65.4	59.4	64.4
'Biolene'	64.9	65.8	67.2	59.3	59.3
Viscose fleece	74.4	68.5	65.0	61.4	60.0

All treatments preserved the percentage marketability of carrots through the winter of 2007/08 until April. However, signs of regrowth and a tendency for lower percentage marketability for ''Biolene'' and woven viscose fleece indicate these materials are may be less suitable for extended field storage of carrots, which may have been related to their thickness/opaqueness to light penetration.

Results – Dry matter

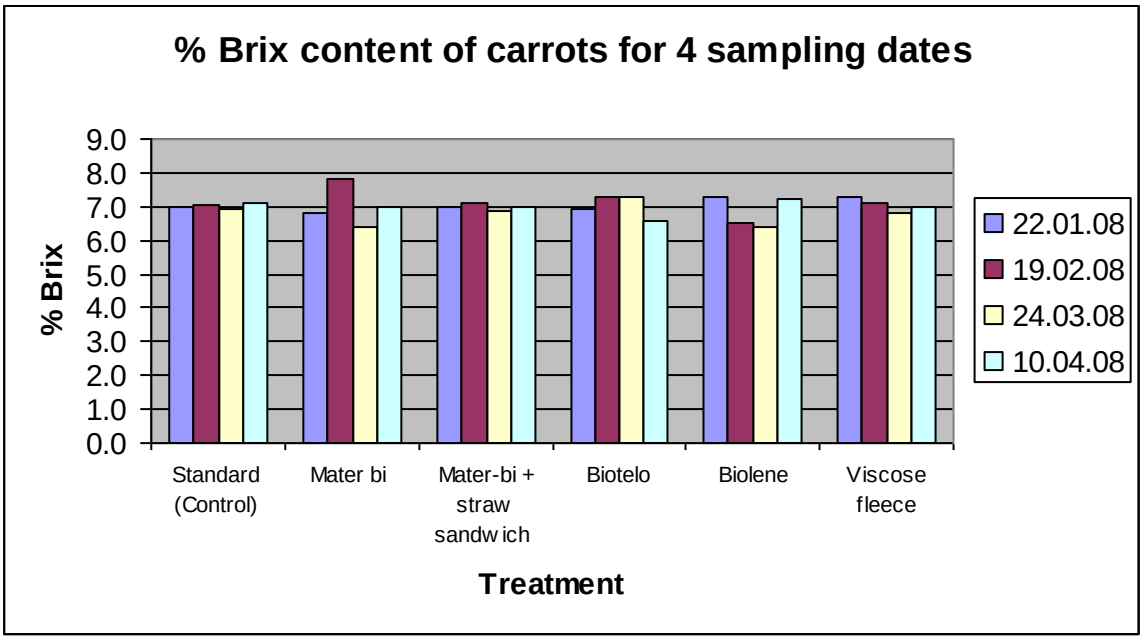
The total % dry matter was measured and results indicate that dry matter did not decline between October and April and there were no substantial differences between the treatments.

Table 5 Percentage dry matter

Treatment	30 Oct. 2007	22 Jan. 2008	19 Feb. 2008	24 Mar. 2008	10 Apr. 2008
Standard	8.6	8.5	8.8	9.2	8.6
'Mater-bi'	8.7	8.6	9.0	8.8	8.8
'Mater-bi'/straw	8.9	8.7	8.7	8.5	8.7
'Biotelo'	8.7	8.9	8.7	9.0	8.9
'Biolene'	8.6	8.7	8.7	8.7	7.9
Viscose fleece	8.5	8.6	8.7	9.1	9.1

Results – % Total Sugar content

The total sugar content was measured by the Brix method and results indicate that sugar levels did not decline between October and April and there was no difference between the treatments.



Results - Degradability

Samples of each degradable cover were sent to The ADAS Composting Unit at St Ives, Cambs, on 11 April 2008 for composting with organic municipal waste in a closed composting system for 7 days, but this had a negligible degrading effect. Samples of each of the biodegradable covers were buried in the field after the assessment on 10 April and, with the exception of woven viscose fleece which had not degraded, all biodegradable materials had degraded to a flaky stage by 23 June 2008.

Conclusions - Field Stored Carrots

- The black degradable crop covers 'Mater-bi' and 'Biotelo' trialled on field stored carrots over the 2007/8 winter produced crops equivalent to the industry standard when assessed in April 2008.
- Although the demonstration was not replicated, assessments indicated that there may be increased crop regrowth and a lower percentage of marketable roots later in the storage period (April) with the black degradable covers 'Biolene' and woven viscose fleece; these may be less suitable for extended field storage of carrots overwinter, possibly because their lighter construction allowed more light penetration.
- The tensile strength of all the black degradable materials trialled was less than the industry standard black plastic and they were incapable of being used to remove straw from the bed without tearing. An alternative approach needs to be devised.
- Percentage dry matter and total sugar were preserved by all the treatments trialled.
- Soil temperature records indicate that all biodegradable covers maintained frost protection broadly equivalent to the industry standard black plastic.
- Samples of the biodegradable covers composted for 7 days with municipal waste in a closed composting unit did not degrade. The biodegradable covers used, when incorporated in soil in April 2008, all broke down to into flaky pieces within 10 weeks, with the exception of the woven viscose material, which did not deteriorate.
- Development of the use of biodegradable covers, given broadly equivalent performance when used on the over-wintered field-stored carrot crop, will depend on products becoming more competitive in price (which may occur as result of increased demand), the rate at which the cost of disposing of the current standard polythene rises, and the pressures on producers to adopt more environmentally benign measures.

Technology transfer

A site Open Day was held for field stored carrots on 10 April 2008.

References

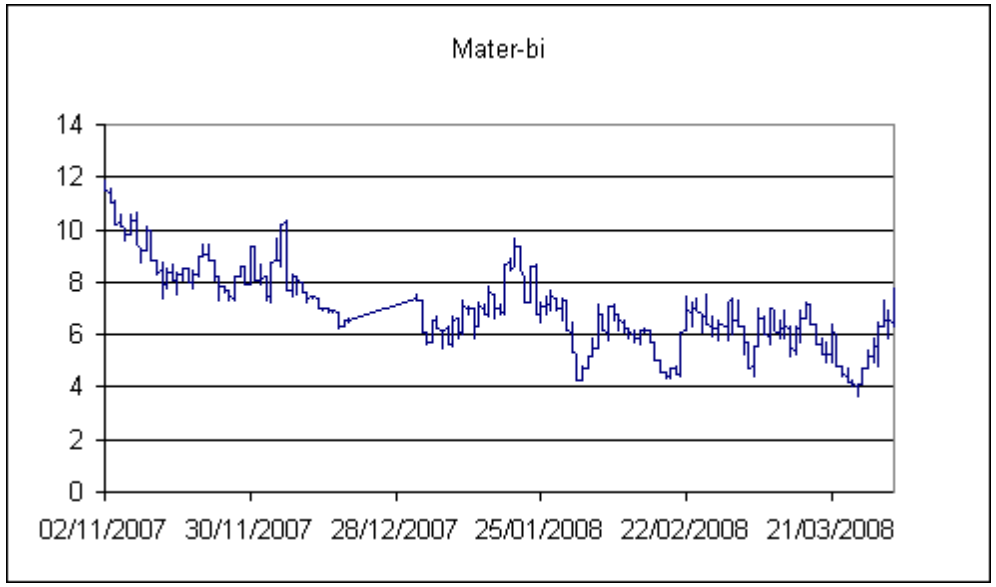
HDC Project FV 145a, Managed ventilation of plastic crop covers used for early production of carrots.

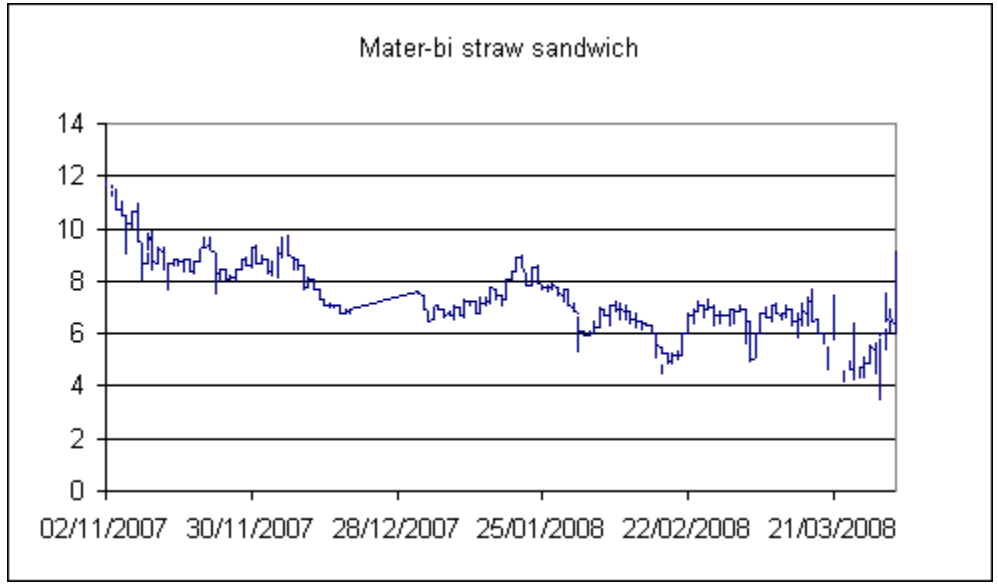
HDC Project, FV 280, The Scope for Bio-degradable Crop Covers in Vegetable Production, April 2006.

HDC Project, FV 280, Biodegradable Covers and Mulches. Field Performance- Early Carrot Production, December 2006.

HDC Project, FV 280, Biodegradable Covers and Mulches. Field Performance- Early Lettuce and Calabrese Production, February 2008.

Sensors under fleece on soil surface





Sensors under fleece inserted to 12cm