

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:	Annual Year 2, February 2008
Previous reports	<ul style="list-style-type: none"> • Annual, Year 1 December 2006 • Initial Report, April 2006 – The Scope for Bio-degradable Crop Covers in Vegetable Production
Key staff:	John Birkenshaw, ADAS Don Tiffin, ADAS Martyn Watling, ADAS
Location of project:	Herringswell, Suffolk
Project coordinator:	Martin Evans, Freshgro Ltd., Inkersall Grange Farm, Bilsthorpe, Notts. NG22 8TN
Date project commenced:	February 2006
Date completion due:	30 September 2008
Key words:	Crop covers, crop mulches, plastic, biodegradable, carrot, field storage, early production, waste, Mater-bi, Envirocare.

Whilst reports issued under the auspices of the HDC are prepared from the best available information, neither the authors nor the HDC can accept any responsibility for inaccuracy or liability for loss, damage or injury from the application of any concept or procedure discussed.

The contents of this publication are strictly private to HDC members. No part of this publication may be copied or reproduced in any form or by any means without prior written permission of the Horticultural Development Company.

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
ADAS Associate Consultant
ADAS UK Ltd

Signature John Birkenshaw..... Date ...10 April 2008

Report authorised by:

Stephen Perkins
Segment Manager
ADAS UK Ltd



Signature Date 3 June 2008

CONTENTS

	Page
Grower Summary	
Headline	1
Background and expected deliverables	1
Summary of the project and main conclusions	3
Financial benefits	4
Action points for growers	5
Science section	
Demonstration treatments – Introduction	7
Demonstration treatments for early lettuce 2007	8
Demonstration treatments for early calabrese 2007	14
Conclusions	18
Technology transfer	18
References	18
Appendices	18

GROWER SUMMARY

Headlines

- 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.
- The financial assessment of using these products has been included. With world oil prices moving the knock-on costs of oil-based plastic may change, so growers are urged to monitor the pricing situation.

Background and expected deliverables

Approximately 20% of UK maincrop carrot production is covered with clear plastic to encourage early growth and cropping. In addition, more than 40% of the UK carrot crop is harvested from the field between January and May, with black plastic used to prevent re-growth in spring harvested crops. Costs of production are highest during this overwinter period, due to the use of straw and black polythene to protect the crop from frost and to delay foliage re-growth in spring.

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 to dispose of annually.

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.

Disposal to landfill will be possible, but the outlook is one of increasing costs for 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.

In approving the original proposal for a project examining use on carrots, The HDC Field Vegetable Panel requested that the demonstration be extended 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 are:

- a) A review of the scope, availability and cost of available biodegradable crop covers and mulches

- 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
- c) To carry out a demonstration of up to 4 biodegradable covers for early carrots (2006)
- d) To carry out a demonstration of up to 4 biodegradable mulches for overwinter field storage of carrots (2006/7)

The review and evaluation, (a) & (b), are dealt with in detail in FV280, Initial report, April 2006. The results of the demonstration of mulches on the early carrot crop (c) may be found in the Year 1 Annual report for HDC Project FV280, December 2006.

The demonstration site for biodegradable mulches for over winter field storage of carrots was set up on 12 December 2006. However, this was unfortunately destroyed by a contractor, due to lack of communication on site. The demonstration is being repeated for the 2007/8 season and results will be reported in early autumn 2008.

Summary of the project (2006 and 2007) and main conclusions

Biodegradable covers on early carrots, lettuce and calabrese

On demonstration plots, the bio-degradable crop covers, 'Envirocare' (oil derived) and 'Mater-bi' (corn starch derived), were compared with commercial standard polythene (40 micron thickness, 200 holes/m²) for producing early carrots in spring 2006. Envirocare, Mater-bi, Degradyl and viscose fleece were compared on lettuce and calabrese in spring 2007.

Carrot crops grown under the biodegradable covers produced similar yields when harvested in June and provided comparable crop advancement (earliness). Transplanted crops of lettuce grown under biodegradable covers also produced similar yields at harvest and provided comparable advancement (earliness). Transplanted calabrese crops grown under the biodegradable covers did not produce crops equivalent to the commercial standard crop cover. Biodegradable covers were more prone to wind damage and the narrow widths reduced crop performance in calabrese. The soil temperatures recorded under each type of cover were similar, except for viscose fleece which did not warm the soil to the same extent. On frosty nights viscose fleece and the very thin Degradyl did

not maintain the soil temperature to the same extent as Materbi, Envirocare or the commercial standard.

The degradable crop cover made from oil, Envirocare, maintained tensile strength throughout and was easily removed for disposal. However, degradation was minimal when left in the carrot field until September.

The degradable cover made from corn starch, Mater-bi, maintained tensile strength sufficiently to produce crops, but could not be recovered from the field without tearing. Degradation in the soil (carrot field) was virtually complete by October 2006, offering the possibility of leaving biodegradable crop covers in the field to decay rather than recovering them for recycling (or disposal to landfill).

Degradyl was included in the lettuce and calabrese demonstrations but this proved to be susceptible to wind damage and was torn beyond repair 2 weeks after laying. Similarly viscose fleece was more prone to wind damage, although it survived longer than Degradyl.

To test an alternative disposal method, samples of both 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 cover breakdown was negligible and the 7day composting process used for domestic organic waste is evidently not a satisfactory method of disposal.

Financial benefits

Early carrots are produced using plastic on a 'use once, then dispose' basis, on bed systems from 1.8m to 2.2m wide; production is efficiently mechanised. The cost of purchasing, laying, removing and disposing of polythene covers is estimated at £628 to £770/ha.

Switching to bio-degradable materials made from starch (bio-polymers) is likely to cost significantly more, say £1174 to £1200/ha. This is due to the limited width available, 1.5m, which increases the number of beds/ha and increases the laying costs and the higher material purchase price. However fabrication of greater widths 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.

Switching to bio-degradable plastic made from oil, (e.g. Envirocare), is however competitive on price, costing £732 to £753/ha. This cost includes £20 to £41.15/ha removal cost, as with standard practice (e.g. as would be the case for composting), but this would not be incurred if soil incorporation can be successfully developed.

The current industry practice for early lettuce production is to use fleece of various thickness and widths. The cost of the current system is estimated to be £347/ha/annum and assumes 2 seasons use, then disposal.

Most Brassica growers use wide (12 to 18 m) plastic and re-use for a second season or more. The cost of the current system is therefore estimated at £466/ha/annum, based on 2 season's use, then disposal.

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 (£)
Early Carrots	Plastic	Bed system 1.8-2.2m	8 - 11	437.50 - 550	61.72 (7.5hrs @£8.23)	41.15 (5 staff hrs)	87.5 - 117.5	628 - 770
	Fleece	Bed system	18 - 22	685 - 753	61.72 (7.5 hrs)	41.15	31.25 - 42	819 - 898
Early Lettuce	Fleece	6m width	1.7 to 3.4	370	142.70 6 person team + tractor	34 2 person team + tractor	75 Landfill	437
Early Calabrese	Plastic	12m width	3 - 4	308 per annum, 2 years use	125	125	62	466

Action points for growers

- Growers can have some confidence that biodegradable covers have the potential to offer similar agronomic advantages to standard polythene covers for early carrots and

lettuce. Bio degradable crops covers are not yet suitable for calabrese crops currently grown commercially under wide crops covers, up to 24m.

- Growers should encourage the development of a range of biodegradable materials of suitable widths and lifespan by liaising with manufacturers and distributors and increasing awareness of vegetable production systems.
- Degradable crop covers currently manufactured are too narrow for commercial use on transplanted brassicas and lettuce. Some current offerings are marginal for all crops, needing a width greater than 2m.
- ‘Mater-bi’ has the potential for soil incorporation after harvest, but ‘Envirocare’ degrades more slowly and initial experience indicates it is not suitable for incorporating into the soil.
- ‘Degradyl’ and viscose fleece were easily damaged by wind and difficult to replace.
- Samples placed in a closed composting unit along with organic municipal waste for 7 days did not accelerate degradation.

Science Section

Demonstration treatments for Early Production of Carrots 2006, Lettuce 2007 and Calabrese 2007

Introduction

The cost of disposing 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 increasing 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% more), though this is at least in part due to lower volumes being manufactured. In addition, there are currently technical difficulties manufacturing widths greater than 1.5m. 'Mater-bi', supplied by Capatex, as used in this demonstration, is an example of a bio-polymer.

Conventional plastic products with shorter polymer chains, which degrade more quickly, are also being developed. However, these materials may need approval or an exemption licence from the Environment Agency for disposal in the field. These at present offer more competitive pricing, high strength and ease of use in the field, with the possibility of soil incorporation after use. An example is 'Envirocare', supplied by JK Poly and developed by Ciba Geigy. Envirocare is a 25 micron film that can be programmed for a claimed useful life of between 21 days and 300 days, after which it degrades in the soil, taking some 10 months, it is said, to completely degrade.

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

Materials and Methods - Lettuce

After examination of the available materials, 4 biodegradable products were compared with the industry standard – non woven fleece – for early production of lettuce on an organic peaty soil at Stretham, Cambridgeshire. These were:

Crop Cover Specifications

1. Industry standard 6m wide, 17 g/m² non-woven fleece.
2. ‘Mater-bi’ supplied by Capatex, 20 micron, no holes and 200 x 1 cm diameter ventilation holes/sq m applied manually, expected life 10–20 weeks.
3. ‘Envirocare’ supplied by JK Poly, 1.85m wide, 40 microns thick, 200 holes/m², programmed to start to degrade after 12 weeks.
4. Viscose polyester fleece, 2.2m wide, 20 g/m², supplied by Capatex.
5. ‘Degradyl’, 2m wide, 12 microns thick, supplied by Lin-Pac. Ventilation holes made as for Mater-bi.

Covers were applied at planting (or in the case of Mater-bi a little later) and removed at weekly intervals over 3 weeks, starting in mid-April.

Lettuce varieties used were Red Oak Leaf and Salanova.

Records taken

1. Weekly assessment of crop growth stage – diameter of plants
2. Assessment of yield at harvest – individual head weight of 20 lettuces
3. Soil temperatures were recorded under each type of cover (except Mater-bi)
4. Monthly observations to assess biodegradable product life, to establish optimum and latest possible removal date

Crop Diary

Both lettuce varieties were planted 13 March 07. Due to commercial constraints it was not practical to place the demonstration on one variety.

The commercial crop cover (fleece) was placed over the crop on 13 March 07, as were the Envirocare, Viscose fleece and Degradyl treatments. The Mater-bi cover was late arriving and was applied 28 March 07; prior to this, the Mater-bi plots were covered with commercial fleece.

Soil conditions at planting (black organic fen peat soil) were excellent and followed by dry sunny conditions through April. Crop growth was rapid and covers were removed at weekly intervals, 11 April, 18 April and 26 April 07.

Results and Discussion

Results - Cover Strength

The strength of each material was scored on a 1 – 5 scale at monthly intervals, with 5 = strong & entire and 1 = completely degraded, disintegrating. There was no measurable deterioration of any material whilst covering this crop. However, differences in strength and resistance to tearing were apparent at the start and the materials were ranked as follows:

Table 2 Cover strength scores

Crop Cover	Strength Score 1 - 5 5 = Strongest	Observations
Commercial fleece	4	Used once on lettuce then used on a different crop and ultimately disposed of to landfill.
Mater - Bi	4	Almost as strong as commercial crop covers made from polythene.
Envirocare	5	Equivalent to commercial crop covers made from polythene.
Viscose Fleece	3	Susceptible to tearing and difficult to pull out of soil for removal.
Degradyl	2	Easily torn and susceptible to wind damage, difficult to pull out of the soil for removal.

Results - Temperature Records

Temperature records show that the soil under commercial fleece, Degradyl and Envirocare was warmer than viscose fleece during the first weeks of March. The greater width of commercial fleece provided an increased soil temperature compared with all the demonstration plots during March.

Subsequently wind damage to Degradyl and Viscose fleece caused a reduction in the soil temperature and disturbance of the soil temperature probes. Soil temperatures under Mater-bi were not recorded due to the late arrival of this material.

Results - Plant Establishment & Growth

Plant establishment was similar across all cover types, but subsequent growth rates varied. Total plant diameter of 20 plants/plot was measured at each cover removal date and means are shown below:

Table 3 Lettuce sizes at 3 cover removal dates

Crop Cover	Plant Diameter (mm), 11 April	Plant Diameter (mm), 18 April	Plant Diameter (mm), 26 April
Commercial fleece on Red Oakleaf	165	230	250
Mater – Bi on Red Oakleaf	170	200	215
Envirocare on Red Oakleaf	215	250	270
Viscose Fleece on Red Oakleaf	190	300	325
Commercial fleece on Salanova *	140	180	190
Degradyl on Salanova *	140	170	180

* The variety Salanova has a smaller ‘frame’ compared with Red Oakleaf.

When covers were removed, it was observed that the colour of Red Oakleaf plants varied between cover treatments. The proportion of green leaf was higher on plants covered with Mater-bi and Viscose fleece compared with the commercial standard fleece. The colour of lettuce grown under Envirocare was similar to the commercial standard. However, this difference had disappeared 1 week after covers were removed.

Lettuce demonstration showing colour variation, Stretham, Cambs.



Results - Lettuce Head Weights

Table 4 Mean Head Weight 28 April 2007 (g)

Crop Cover	Red Oak Leaf	Salanova
Commercial fleece	129	78
Mater - Bi	106	Not available*
Envirocare	129	Not available*
Viscose Fleece	149	Not available*
Degradyl on Salanova	Not available*	134

* Commercial constraints prevented all the demonstration plots from being placed on one variety.

The mean head weight of lettuce grown under Envirocare and viscose fleece exceeded the mean head weight of lettuce grown under the commercial standard fleece but lettuce grown under Mater-bi did not. Degradyl was easily damaged by wind and very little material was left on the plots at the final cover removal date. However, where Degradyl remained in place, lettuce grew well and the mean head weight of plants in these areas also exceeded the commercial standard fleece.

Degradability

Samples of each degradable cover were sent to The ADAS Composting Unit at St Ives, Cambs. for composting with organic municipal waste in a closed composting system for 7 days. Mater-bi and Envirocare were composted this way in 2006 and Degradyl, viscose fleece and Mater-bi in 2007, but composting for 7 days had a negligible degrading effect.

Conclusions

- The degradable crop covers Degradyl, Viscose Fleece and Envirocare trialled on early lettuce in 2007 season had the potential of producing lettuce crops equivalent in yield and quality to the industry standard. Plants grown under Mater bi appeared to have a lower yield than the commercial standard; both Degradyl and viscose fleece were susceptible to wind damage.

- On cover removal, there was a difference in leaf colour which remained for 7 days, this could have commercial potential where mixed leaf colours are required in the final product using different cover materials or removal dates on one variety. However, natural light eliminated the colour difference 7 days after cover removal.
- Cover removal date can be used to aid continuity at harvest as with commercial fleece.
- Degradyl and Viscose fleece are more susceptible to wind damage and could not be removed or replaced without tearing.
- Currently the cover width is limited and vegetable growers need a range of wider degradable crop covers to match their production systems.
- Mater – bi has potential for soil incorporation after harvest (judged on results with early carrots in the 2006 season), but Envirocare, Degradyl and Viscose fleece appear to degrade very slowly, requiring removal from the field and longer term composting.

Demonstration treatments for Early Production of Calabrese 2007

Materials and Methods - Calabrese

After examination of the available materials, 4 biodegradable products were compared with the industry standard polythene cover – 200 micron, 12 m wide, with 500 holes/m² – for early production of calabrese on a silt soil at Kirton, Lincolnshire. These were:

Crop Cover Specifications

1. Industry standard 12m wide, 500 holes/m² polythene.
2. 'Mater-bi' supplied by Capatex, 20 micron, no holes – 500 one cm ventilation holes applied manually, expected cover life 10–20 weeks.
3. 'Envirocare' supplied by JK Poly, 1.85m wide, 40 microns thick, 200 holes/m², programmed to start to degrade after 12 weeks.
4. Viscose polyester fleece, supplied by Capatex, 2.2m wide, 20 g/m², expected life 12 months.
5. Degradyl supplied by Lin-Pac, 2m wide, 12 microns thick, expected life 4 months.

Covers were planned to be removed at weekly intervals over a 3 week period but wind damage to the plots prevented timely removal.

Demonstration set- up – Calabrese, Kirton, Lincs.



Records taken

1. Monthly assessment of crop growth stage – maximum spread diameter of plants.
2. Assessment of yield in size grades at harvest – above and below 25 mm crown diameter
3. Soil temperatures were recorded under each cover treatment.
4. Monthly observations to assess biodegradable product life, to establish optimum and latest possible removal date.

Varieties were Marathon and Iron Man

Crop Diary

Demonstration plots planted 14/15 March 07.

Commercial crop cover was placed on 23/24 March 07; Cover treatments, Envirocare, Viscose fleece and Degradyl were applied on 24 March 07. Cover treatment Mater-bi was applied 28 March 07.

Wind damage on 30 April/1 May effectively removed Degradyl and Viscose fleece; Mater-Bi and Envirocare were removed on 19 May. Plants growing on exposed, uncovered, plots suffered damage from wildlife which destroyed any advantage provided by the covers.

Calabrese plots after cover removal



Results - Cover Strength

The strength of each material was scored on a 1 – 5 scale at monthly intervals, with 5 = strong & entire and 1 = completely degraded, disintegrating. There was no measurable deterioration of any material whilst covering this crop. However, there were intrinsic differences in strength apparent at the start and the materials were ranked as follows:

Table 5 Cover strength scores

Crop Cover	Strength 1 - 5 5 = Strongest	Observations
Commercial Plastic	5	Used for 1 to 3 seasons then disposed of to landfill or recycled.
Mater – Bi	4	Almost as strong as commercial crop covers made from polythene, easily removed from the soil.
Envirocare	5	Equivalent to commercial crop covers made from polythene.
Viscose Fleece	3	Susceptible to tearing and difficult to pull out of the soil for removal. Strong winds in mid May caused significant damage.
Degradyl	2	Easily torn and susceptible to wind damage, difficult to pull out of the soil for removal.

Results - Temperature records

Soil temperature records show that Envirocare and Mater–bi kept the temperature higher than Viscose fleece and Degradyl in the first 2 weeks after planting. However, wind damage disrupted the temperature probes and caused damage to the crop covers making further comparisons unreliable.

Results - Plant Growth

Plant establishment was equal across all cover types but subsequent growth rates varied. Plant height of 20 plants/plot was measured twice in April; spear diameter was measured

on 22 May. The narrow width of biodegradable materials restricted crop growth on all plots.

Table 6 Growth measurements at 3 dates

Crop Cover	Plant height (mm) mean of 20 plants on 7 April	Plant height (mm) mean of 20 plants on 27 April	Spear Diameter(mm) mean of 20 plants on 22 May
Commercial Plastic	320	410	21
Mater - Bi	200	215	12
Envirocare	250	340	24
Viscose Fleece	220	240	15
Degradyl	200	220	13

Table 7 Mean head weight (g) from 20 plants on 11 June 2007)

Crop Cover	Mean head weight (g)	Mean head diameter (cm)
Commercial Plastic	455.0	14.5
Mater - Bi	168.5	5.0
Envirocare	257.5	12.5
Viscose Fleece	320.3	14.5
Degradyl	233.0	10.0

The commercial crop grew well and was not significantly affected by wild life after cover removal. However, the demonstration plots were continually affected by wild life damage following premature cover removal by wind damage soon after planting. This significantly affected plant growth and final yield.

Degradability

Samples of each degradable cover were sent to The ADAS Composting Unit at St Ives, Cambs. for composting with organic municipal waste in a closed composting system for 7 days. Mater-bi and Envirocare were composted this way in 2006; Degradyl, viscose fleece and Mater-bi in 2007, but composting in this way for 7 days had a negligible degrading effect.

Conclusions

- The degradable crop covers trialled on early calabrese this season did not produce crops equivalent in earliness to the industry standard due to narrow widths restricting growth, premature removal by wind damage followed by wild life damage.
- Strong winds in mid May caused significant damage to Degradyl and Viscose fleece but not to Envirocare or Mater bi which are inherently stronger materials.
- At cover removal, plants covered with Envirocare showed improved plant height and spear diameter over plots covered with Mater-bi and those plots which suffered wind and wild life damage, but lagged behind those covered with standard fleece.
- There is a fundamental difficulty with the narrow cover widths in which biodegradable materials are currently available – vegetable growers need a range of wider degradable crop covers to match their production systems.

Technology transfer

Site Open Days were held for lettuce on 1 May 2007 and Calabrese on 30 May 2007.

References

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

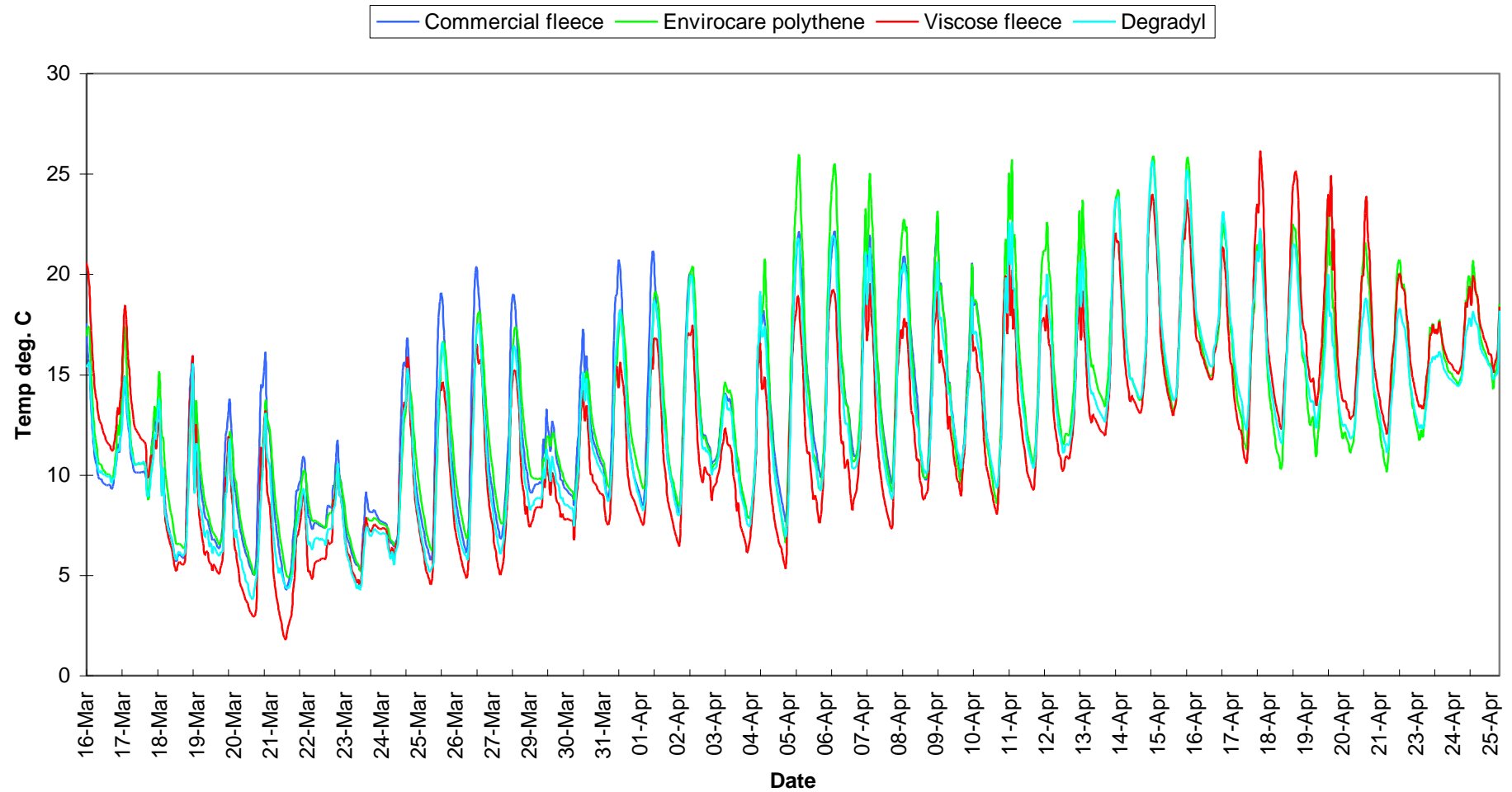
HDC Project, FV 280, The Scope for Bio-degradable Crop Covers in Vegetable Production, April 2006.

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

Appendix 1

Soil temperature recorded in 2007 - Lettuce

Comparison of Biodegradable mulches Lettuces Stretham 2007
Mean temperature deg C



Soil temperatures recorded in 2007 - Calabrese

