Project Title	Early production 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, December 2006
Previous report	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:	31 December 2007
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
ADAS Associate Consultant
ADAS UK Ltd

Signature .....John Birkenshaw..... Date 28 February 2008...

Report authorised by:

Stephen Perkins
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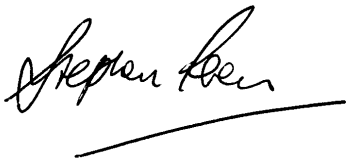

Signature ..... Date .... 30 January 2007

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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

- In a field demonstration, early carrots 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.
- When the crop cover 'Mater-bi', made from corn starch, was removed from the crop, left in the wheeling and covered with soil, its degradation in the field was virtually complete by October.
- As the current biodegradable mulches made from starch are only available in 1.5m wide rolls, their use is probably currently too high (wider rolls would reduce costs).
- Though the use of bio-degradable plastics made from oil is financially competitive a system for soil incorporation is required.

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 to be economically feasible. Despite extensive enquiries, no manufacturers were found who currently have the capacity to manufacture biodegradable covers much beyond a 2m width, so this extension to the work was deferred during 2006.

The expected deliverables from this 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.

Summary of the project (2006) and main conclusions

Biodegradable covers on early carrots

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/m^2) for producing early carrots in spring 2006. Crops grown under the biodegradable covers produced similar yields when harvested in June and provided comparable crop advancement (earliness). The soil temperatures recorded under each type of cover were similar. 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 field until September.

The degradable cover made from corn starch, Mater-bi, maintained tensile strength sufficiently to produce the crop, but could not be recovered from the field without tearing. Degradation in the soil 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).

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.

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 - 2.2 m	8 - 11	437.50 - 550	61.72 (7.5 hrs@£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

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.
- Growers should encourage the development of a range of biodegradable materials of suitable widths and lifespan by liasing 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 early carrots, needing a width of 2m plus.

- 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.
- 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

Introduction

The cost of disposing of plastic waste will increase significantly in the coming years and is a topic of both industry and public concern. The wide distribution of vegetable businesses using horticultural plastic and the 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.

Materials and Methods

After examination of the available materials, 2 biodegradable products were compared with the industry standard – perforated polythene - for early production of carrots on a loamy sand soil at Herringswell, Suffolk. These were:

Crop Cover Specifications

1. Industry standard perforated polythene, supplied by Jill Miles, 40 micron, 200 holes/m^2, 2.1m wide.
2. 'Mater-bi' supplied by Capatex, 20 micron, no holes – ventilation applied manually, expected life 10-20 weeks.
3. 'Envirocare' supplied by JK Poly, 1.85m wide, 40 micron, 200 holes/m^2, programmed to start to degrade after 12 weeks.

Treatments applied to Early Carrots 2006

1. Industry standard, perforated polythene
2. Mater-bi, left on crop until harvest
3. Mater-bi, removed for composting 16 May
4. Mater-bi, placed in wheeling 16 May
5. Envirocare, left on the crop until harvest
6. Envirocare, removed for composting 16 May
7. Envirocare, placed in the wheeling 16 May

Ventilation management was applied to Mater-bi as in HDC Project FV145a.

Records taken

1. Crop emergence counts
2. Monthly assessment of crop growth stage – numbers of leaves
3. Assessment of yield in size grades at harvest - above and below 25 mm crown diameter
4. Soil temperatures were recorded under the three covers
5. Monthly observations to assess biodegradable product life, to establish optimum and latest possible removal date. 1 – 5 scale; 5 = completely intact, 1 = totally disintegrated.

Removal at harvest

Various techniques were used at harvest to compare removal techniques on the plots.

1. Leave in place
2. Place in tractor wheeling for incorporation into soil
3. Remove for composting by slitting the film on the edges of the bed and rolling up

Each material was assessed on a 1 – 5 scale; 5 = completely intact and can be readily handled, 1 = disintegrated. Time to complete disintegration was assessed.

Treatment views showing cover types (2 May 2006)

Standard - Perforated Polythene

Bio-polymer - Mater-bi

Short-chain polymer -Envirocare

Crop Diary

Variety Nairobi, drilled 17 January 2006

Commercial crop cover placed on 20 January 2006

Cover treatments were applied 9 February 2006

Covers removed and/or disposal treatments applied 16 May 2006

Harvest records 22 June 2006

Results and Discussion

Soil temperature

Soil temperatures were recorded on for each treatment using probes at 3 different depths:

a) soil surface under the mulch

b) at 2cm depth

c) at 12.5 cm depth

As expected, temperatures fluctuated more at or close to the soil surface, but there was little difference between treatments. Example graphs are included at Appendix 1.

Cover Strength

The strength of each material was scored on a 1 – 5 scale at monthly intervals. There was no measurable deterioration of Envirocare and this material was easily removed on 16 May.

Mater-bi gradually lost strength and could not be removed mechanically on 16 May. However, Mater-bi did remain 'intact' until 16 May and did not cause a litter problem in the field.

Mean Score for tensile strength (5 = strong, 1 = disintegrated)

Treatment	Feb	March	April	May	June	July	Aug
Standard	5	5	5	5	removed		
Mater - bi	5	5	4	3	3	3	2
Envirocare	5	5	5	5	5	5	4

The tensile strength score through May to July for Mater-bi remained unchanged, possibly due to the abnormally high temperatures during this period. The rate of degradation increased following rainfall in August and Mater-bi had degraded to small pieces by the end of September. Envirocare maintained tensile strength equivalent to commercial standard plastic until harvest and was easily removed from the site in September with degradation being minimal.

Plant Establishment

Germination and subsequent plant stand counts were recorded at monthly intervals. Plant establishment was slow and prolonged in the cold spring. Plant stands under the Mater – bi cover were higher, with more advanced (taller) foliage development until April.

Mean number of plants/metre of row

Treatment	February	March	April	May
Standard	0	4	20	27
Mater - bi	0	10	36	32
Envirocare	0	5	19	34

Crop Stage - mean of 1m of row

Treatment	February	March	April	May
Standard	0	cotyledon	2.7 true leaves	6.4 true leaves
Mater - bi	0	emerging/first true leaf	2.8 true leaves	6.5 true leaves
Envirocare	0	cotyledon	2.7 true leaves	6.7 true leaves

Yield at Harvest - 22 June 2006

Treatment	> 25mm diameter		< 25mm diameter		Total wt t/ha
	No./m^2	Wt t/ha	No./m^2	Wt t/ha	
Standard 1	34	13.70	20	2.77	
Standard 2	28	10.43	25	4.93	
Standard 3	45	15.68	25	2.88	
Total	107	39.81	70	10.58	
Mean	**35.7**	**13.27**	**23.3**	**3.53**	**16.80**
Mater-bi composted	43	14.27	40	4.66	
Mater-bi wheeling	32	12.86	19	2.75	
Mater-bi left on	53	16.34	25	2.50	
Total	128	43.47	84	9.91	
Mean	**42.7**	**14.49**	**28**	**3.30**	**17.79**
Envirocare composted	52	14.43	52	4.20	
Envirocare wheeling	48	17.98	24	3.13	
Envirocare left on	43	13.50	20	2.53	
Total	143	45.91	96	9.86	
Mean	**47.7**	**15.30**	**32**	**3.29**	**18.59**

Degradability

Following cover removal on 16 May, samples of degradable covers were taken to the ADAS composting unit at St Ives, Cambs. to be incorporated into municipal organic waste and composted in a closed tunnel system for 7 days. The tensile strength score was not reduced by this method of composting and alternative methods of composting will need to be sought.

Samples of degradable covers were also placed in the bed wheelings on 16 May and held in place by scraping soil from each shoulder of the bed. Mater-bi slowly disintegrated through July and August to the point where it was not detectable by the first week of October. There was no litter problem due to the soil covering. Envirocare did not degrade significantly and was removed from the site in August.

Samples of degradable crop covers were left on the crop and gradually disintegrated, but sufficient was left to adversely affect irrigation and harvesting.

Approaching harvest - little sign of degradation (15 May 2006)

Mater-bi – slit for crop ventilation

Folded back to wheelings

Soil scraped over cover to aid degradation

Covers left on to harvest - too slow to degrade naturally

Post-harvest cover degradation

One month after harvest – covers still evident (dry conditions)

Conclusions

- The degradable crop covers trialled on early carrots in 2006 season produced crops equivalent to those produced under perforated polythene, the industry standard.
- The soil temperature records for both types of cover were similar to the industry standard.
- Difficulty was encountered with matching cover and bed; vegetable growers need wider degradable crop covers – e.g. 2m and 2.3m for early carrots.
- Mater – bi has potential for soil incorporation after harvest but Envirocare degrades more slowly and it is likely that this material would have to be removed for composting elsewhere.
- After removal, composting in a 7 day closed composting system with organic municipal waste was not a suitable method of disposal for the degradable crop covers used in this demonstration.

Technology transfer

A site open day was held on 26 June 2006.

Results were presented at the HDC/BCGA technical seminar for carrot growers on 25 January 2007

References

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

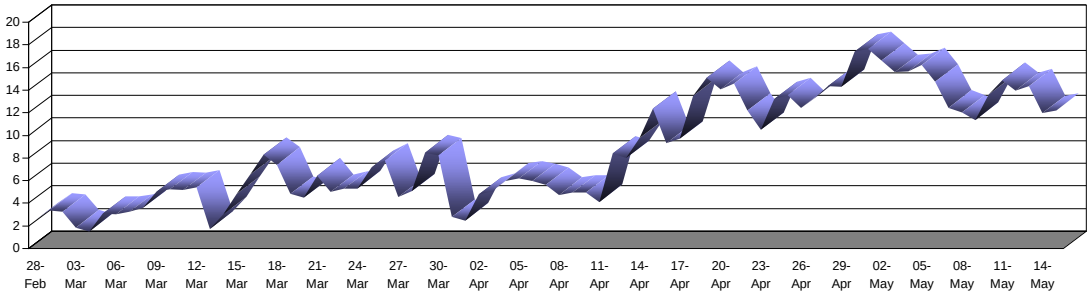
HDC Project, FV 280, The Scope for Bio-degradable Crop Covers in Vegetable Production, April 2006.

Appendix 1 Soil temperatures recorded (2006)

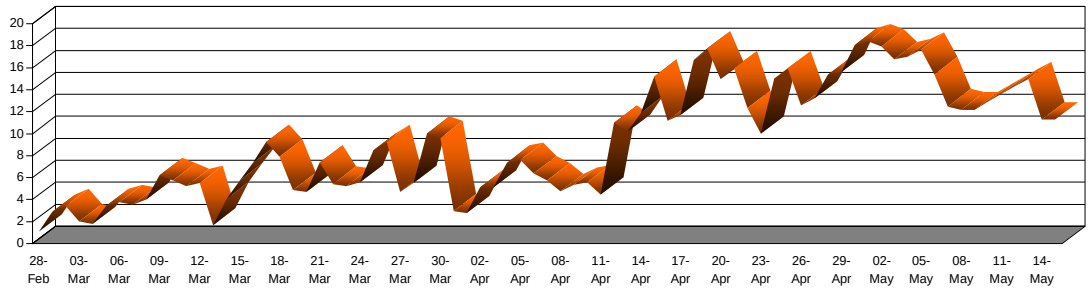
Demonstration of Biodegradable Covers on Field Vegetables
Carrots - Herringswell 2006

Sensor on soil surface (under mulch)
Day degrees above 2° Centigrade

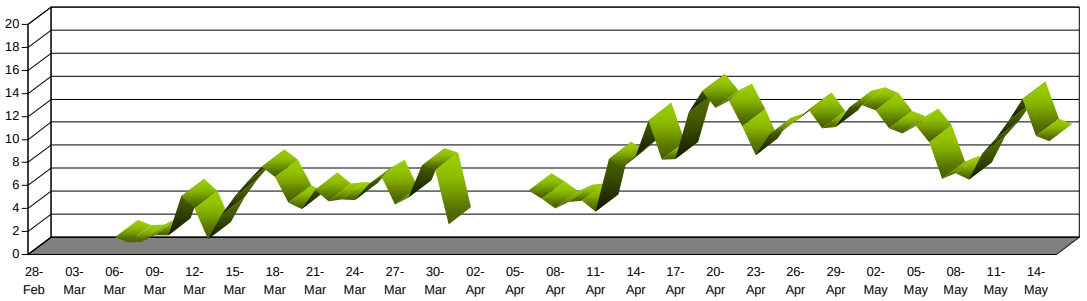
Mater-bi 1



Standard perforated polythene 1



Envirocare 1



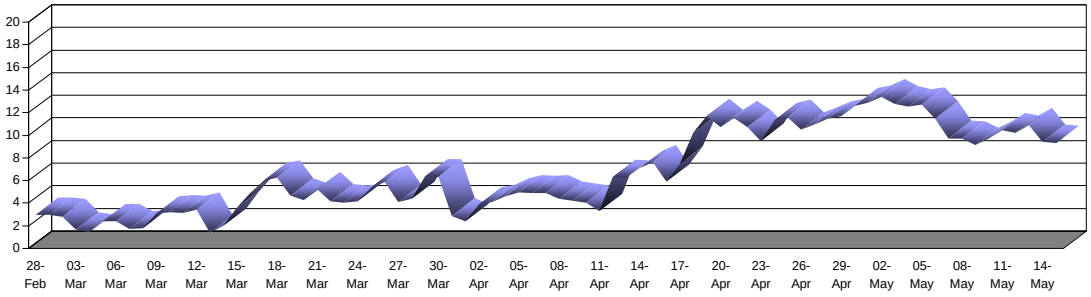
Demonstration of Biodegradable Covers on Field Vegetables

Carrots - Herringswell 2006

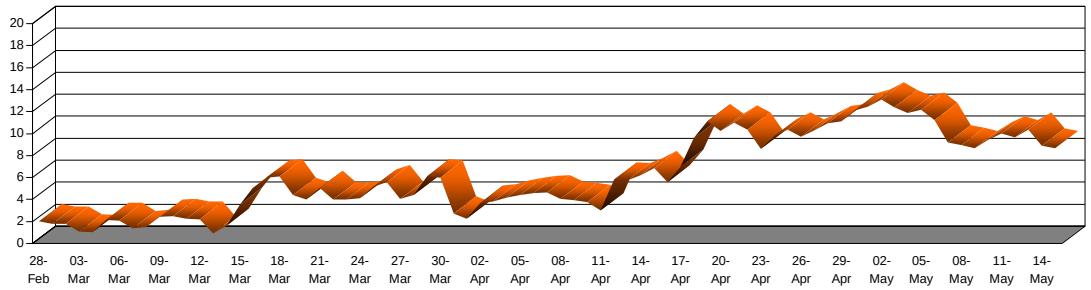
Sensors at 2cm depth under mulch - mean of 2

Day degrees above 2° Centigrade

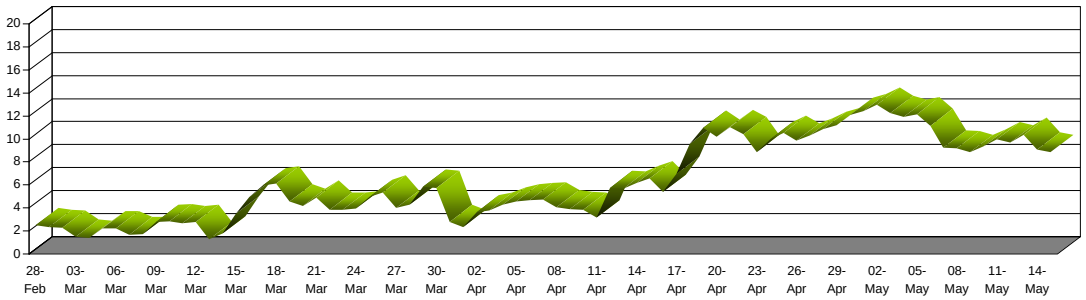
Mater-bi 2



Standard perforated polythene 2



Envirocare 2



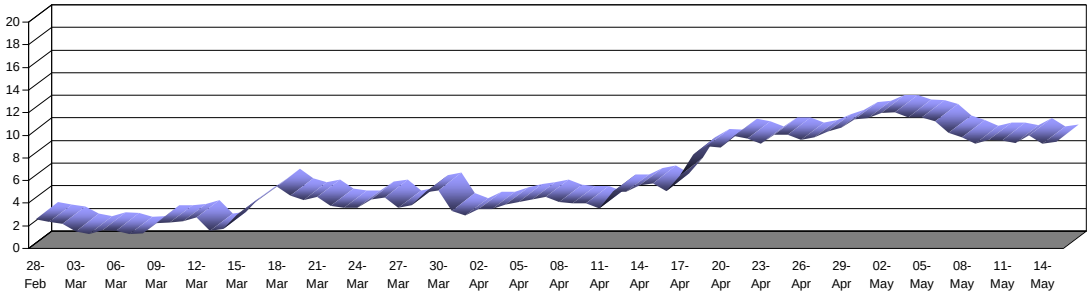
Demonstration of Biodegradable Covers on Field Vegetables

Carrots - Herringswell 2006

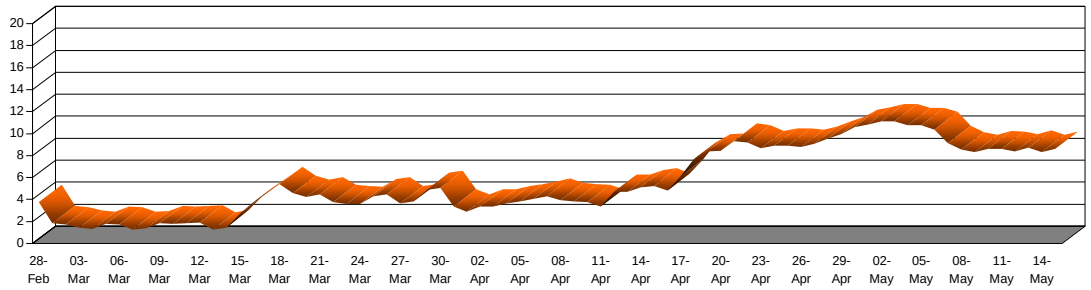
Sensors at 12.5cm depth under mulch

Day degrees above 2° Centigrade

Mater-bi 3



Standard perforated polythene 3



Envirocare 3