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HORTICULTURE RESEARCH INTERNATIONAL

STOCKBRIDGE HOUSE

A REVIEW OF CROP COVERS AND MULCHES FOR FIELD VEGETABLES

Commissioned by
The Horticultural Development Council

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November 1990

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Forward

The project sets out to review the use of low level plastics on field vegetables. It includes ADAS trials that have been undertaken and written up since 1978 and refers to appropriate research work worldwide. Gaps in horticultural and technical knowledge have been identified that may lead to research and development work. No attempt has been made to arrive at financial or political judgements or that HDC should necessarily provide funds for suggested projects.

Over the years terminology and jargon have occasionally lead to confusion, especially concerning the word 'mulch'. Reference titles do not always correlate with the subject title.

It was considered that for the purpose of this review early potatoes were outside the scope of this study.

Because of the number and the amount of cross referencing, references are listed under separate titles. This will enable quick searches to be carried out in the future on any aspect when deciding if further research is required.

Introduction

There are two main techniques used in the United Kingdom, these are mulches and crop covers. Combinations of these two and double skinning are occasionally used in special circumstances.

Crop Covers

Also known as floating mulches or covers; film covers; floating cloches or direct covers. These terms tend to cause confusion because 'mulch', 'cloche' and 'film' have a different meaning in another context, especially when translated into foreign languages. The material is laid over a crop from drilling or planting and is entirely supported by the crop.

Mulches

The technique of mulching in this context means laying plastics on the soil surface. The crop grows through slits or holes made at sowing or planting.

Mulch plus Crop Cover

Although mulches help the roots, the above ground part of the plant also requires protection to obtain full benefit, especially early in the season. A crop cover in addition to a mulch can be used to aid early growth of high value crops.

Double Skinning

To give extra protection early in the year for the establishment of high value crops. A polyethylene cover is laid on top of a polypropylene (nonwoven) cover. The polyethylene cover is normally removed after 3-4 weeks when temperatures begin to rise.

General information regarding husbandry, management and cultivations is explained in the following publications:

Rickard, P. C. (1979). Plastic mulches for vegetable production. Grower guide No 7.

Gerst, J. J. (1985). Growing vegetable crops under direct covers. Pub by Sodoca.

ADAS, (1984). Plastic film covers for vegetable production. Booklet 2434.

ADAS, Antill, D. (1985). Early vegetables under plastic covers. (Supplement to Booklet 2424). Leaflet P3010.

Antill, D. (1989). Low level plastics for vegetables crop management. ADAS leaflet P3205.

Antill, D. (1989) Low level plastics for field vegetables ADAS leaflet P3204.

Antill, D; Emmett, B; Greenfield A. J; Hadley, P; Davies, J. S; Birkenshaw, J E; Dyer, W. (1989) Conference proceedings, Stockbridge House EHS, April 1989.

Antill, D. (1989) The use of low level plastics on horticultural field crops. Professional Horticulture Vol 3, 83-87.

Antill, D. (1987) The use of fibrous materials on field vegetables in Great Britain. Index Conference proceedings B4.

Antill, D. (1990) Use of nonwovens on field crops in the United Kingdom. Index Congress proceedings B4.

ADAS. (1986) Commodity review. Low level plastics for field vegetables.

Wells, O. S; Loy, J. B. Intensive vegetable production with row covers. Hortscience 1985, 20:5, 822-826.

Benoit, F; Ceustermans, N. Review of the possibilities for applying temporary direct covering with perforated plastic to the growing of spring vegetables. 1985. Proefstation voor de Groenteteelt.

Henrikson, K. Covering vegetable seed-beds with plastic film. Meddedelse-Statens-Plantearlsporsug. 1985, 87: 1827.

Mayne, A; Rohlfing, H. R. Efficient utilisation of flat plastic cover systems in early vegetable field production. Plasticulture 1986, No 69, 1. 9-18.

Henrikson, K. Covering outdoor-grown vegetables with plastic sheeting. Gartner-Tidende 1986 102: 51, 1703-1705.

Gerst, J. J. Plastic sheeting: Diversification of applications. Infos-Paris 1989, No 52, 17-17.

Ressala, R. Plastic covering in vegetable cultivation out-of-doors. Nard-Jordbrugsforsk 1971, 53(1), 39-40.

Grudzeen, K; Rumpel, J. Speeded up production of early garden vegetables under flat covers of perforated plastic foil. Orrodnic two-Warsz 1977, 14(5), 123-126.

Fritz, U. Higher yields in vegetable cultivation by the use of plastic cover. DLG-Mitt-Dtsch-Landwirtsch 1978, 93(4): 156-196.

Agall, J; Stewart, K. Covering up for earlier harvests. Macdonald Est. Serv. Faculty of Agri, 1986, V47(2), p 34-37.

Christensen, M. W. The use of wide-width covers for vegetables in Europe. Proc-Natl-Plast-Congr. Pearid: National Agricultural Plastics Association 1986 (19th), 60-64.

Weels, O. S; Loy, J. B. Slitted plastic row covers for vegetable production. National Agricultural Plastics Association 1981 (16th) 124-128/.

Chou, -Lit-tuan: Technology of cultivating vegetables with plastic covers. K'uan-ming shih: Yun-nank' 0 chi ch'u pan she, 1988 2 39.

Hopper, R. R. The influence of ground mulch and row covers in the production of vegetable and fruit crops. National Agricultural Plastics Association 1987 v20 126-130.

Benoit, F. Direct covering of market garden crops. Experience acquired and future prospects. Revue-de-l'agriculture 1987, 40:2, 297-303.

ADAS. Courgettes, marrow and runner beans - Early production with plastic films. ADAS leaflet P3011.

ADAS. Early vegetables under plastic covers- Brassica crops. ADAS leaflet P3012.

ADAS. Early vegetables under plastic covers - Salad Crops. ADAS leaflet P3013.

Double Covering (double skinning)

Benoit, F; Ceustermans, N. Single and double flat covering of carrots. Acta-Horticulturae 1986, No 176 41-46.

Mayne, A. One week earlier with double cover. Gemuse 1986, 22:3, 100-102.

Benoit, F. Possibilities of using plastic film for the protection of overwintering vegetable transplants. Bulletin-Vyzkurnny-a-Slechtitelsky-Ustau-Zelinarsky-Olomoue 1988, No 32, 63-74.

Mayne, A. Effect of twofold flat plastic cover on yield and quality of vegetables. Acta Horticulturae 1986, No 187, 151.

Benoit, F; Ceustermans, N. Iceberg lettuce under single or double direct covering. (1986). Boer en de Tuinder, Vol 92 (7), 22.

History

The development of low level plastics as crop covers and mulches can be traced back to work carried out in Asia, America and Europe. Investigations on temperatures under plastic mulches were made in America in the late 1950's (Honma et el 1959) and (Clarkson 1960) and although it is difficult to find references, work must have been going on in Asia, particularly Japan which by the mid 1970's had over 200,000 ha. Low tunnels were the forerunner for crop covers and on the continent are still used fairly extensively and on specific crops in the UK. In Europe between the late 1960's and early 1970's plastics were used for the first time to cover soil by Dr Paul Seitz in West Germany (Gerst 1985). Development of crop covers continued in both France and Germany during the 1970's and commenced in the UK in 1978 (Rickard 1978 and 1979).

In the UK research and development took place rapidly from 1980 and accelerated with the introduction of nonwovens, often in parallel with America and other countries in Europe. Virtually all the ADAS Experimental Horticulture Stations were involved in development and testing of materials, techniques and husbandry on a wide range of crops.

Mulches and crop covers are cheap systems for providing earliness, improving yield and quality which can give better continuity. Some marginal crops have even been made into guaranteed ones. However the degree of success often depends on the experience and management skill of the grower (Antill 1989). The uptake of mulches and crops covers has been dramatic from the mid 1980's in the UK and is currently about 9500 ha annually (Antill 1989).

Honma, S; Mcardle, F; Carew, J; Dewey, D. H. (1959). Soil and air temperatures as affected by polyethylene film mulches. Mich Agr, Esp, Stn. Bull 41(4) 823-842.

Clarkson, V. A. (1960). Effect of black polyethylene mulch on soil and microclimate temperatures and nitrate level. Agron. J. 52 307-39.

Gerst. Growing vegetable crops under direct covers. 1985). Page 10.

Rickard, P. C. (1978). Perforated polythene for forwarding vegetable crops. Vegetable cultures: 847. S Cambridge ADAS.

Rickard, P. C. (1979). Plastic mulches for vegetable production. Grower Guide No 7.

Antill, D. (1989). The use of low-level plastics on horticultural field crops. Professional Horticulture. 1989 Vol 3, 83-87.

Antill, D. (1989). Covers and mulches for field vegetables. Conference proceedings April 1989, Stockbridge House EHS.

Uptake in the UK

The area of field vegetables grown under covers or with mulches has expanded from 650 ha in 1982 to 9500 ha in 1989. The vegetable industry then went through a difficult period and the total area of low level plastics used during 1989/90 is unlikely to have changed although use on individual crops has changed due to various factors. The following tables give an estimate of the present situation on areas, use of techniques and cost of materials.

	Hectares			
	1982	1985	1988	1989
Carrots and Parsnips	50	1200	2500	2000
Potatoes	200	1000	1400	1000
Sweetcorn	200	350	500	500
Lettuce, Celery	60	390	700	700
Chinese Cabbage, Cauliflower, Cabbage, Calabrese	-	300	1200	1600
Courgettes, Marrows, Squash, Melons, Beans	50	175	450	500
Beetroot, Turnip, Swede, Radish	-	60	300	300
Onions, Herbs, Tomatoes, Spinach, Leeks, Watercress	20	75	250	500
Weed Control, Storage, Seed Beds	20	90	600	800
Overwintering Crops	-	75	100	100
	600	3715	8000	8000
Jersey	50	400	1550	1550
Total UK Area	650	4115	9550	9550

D Antill (1989). Conference proceedings, April 1989, Stockbridge House EHS

Techniques and Use of Materials

	Area (ha)	% of Total Area	Tonne
Polyethylene	8500	89	2100
Nonwoven	1050	11	180
Covers	8250	86	
Clear Mulch	600	6	
Light Inhibiting Mulch	800	8	
Low Tunnels	100	1	
Mulch + Cover	100	1	
Double Cover	10	-	
Overwintering Beds	EHS's	-	

Costs

Material	Gauge	Width (m)	Pence/m^2
Polypropylene	17 g/m^2	2	8-10
Polypropylene	17 g/m^2	10-12	10-12
Polyester	25 g/m^2	10-12	20
Polyester	25 g/m^2	2	18
Polyethylene - Degradable	17 mu	1.4	4
Polyethylene - Perforated	35-40 mu	1.7-2 m	3.5-5
Polyethylene	50 mu	10 m	7
Black Polyethylene	50 mu	2.0	5
Black Nonwoven	25 g/m^2	1.8	8
Black/White	80 mu	1.4	11

Huss, H. M. Plastic covers for vegetables. Comparative cost of various systems. (1983). Deutscher Gartenbau, Vol 37 (18), 855-856.

Future Expansion

Whether the area of plastics increases in the future depends on:

* The profitability of early cropping, especially compared with imports.

* The price of polyethylene and polypropylene.

* The effectiveness of new ideas regarding the use of plastics to prevent weeds and damage by pests, enabling less dependence on pesticides. This could have important implications environmentally.

* The weather. Protection has not always been advantageous after two mild and dry winters and springs, especially on winter hardy vegetables. However severe winter weather may revive interest.

Types of Material

Plastics used for crop covers and mulches are made from the following raw materials. The nature and specification of the finished product depends on the method of manufacture. This can be controlled and specifications can be produced by using different polymers, for various circumstances. For example degradability, thickness, colour and thermal properties.

Polyethylene known as polythene		
Polyvinyl chloride known as PVC		
Polypropylene eg Agryl, Lutrasil	)	collectively
Polyamide eg Agronet	)	called
Polyester eg Reemay	)	nonwovens

Gerst, J. J. Plastic sheeting: Diversification of applications. Infos-Pass 1989 No 52 12-7.

Baudonnel, J; Sotton, A. Properties of textiles for agricultural and horticultural use. Plasticulture 1985, No 66, 45-46.

Gerst, J. J. Physical characteristics of agricultural plastic films (1985). Growing vegetable crops under direct covers.

Permeability

Polyethylene

Polyethylene for practical purposes is impermeable to water and air. In some circumstances this may be desirable eg when used as a mulch or as a crop cover to germinate seed or establish young seedlings. However, because of microclimate considerations polyethylene crop covers normally require perforating. Making precise perforation specifications for every situation is not practical because of cost. The most common size hole is 10 mm and the number per m^2 varies between 200 and 500. Making perforations increases the cost and this can be a limiting factor. In the early development of plastics a slitted polythene, Xiro, had the advantage of being able to expand as the crop grew and the slits widened allowing extra ventilation as the weather became warmer. However cost and strength were limiting in its general use. For narrow sheets that are laid by machine slits can be made as the mulch or cover is laid. Hand or mechanical tools are also available to slit sheets as the crop grows. The effect of perforating polyethylene can be summed up as follows:

* Prevents ponding of rain or irrigation on the surface.
* Reduces sucking effect of strong winds.
* Allows gas exchange.
* Prevent excessively high temperature build up.
* Crops are easier to wean at cover removal.
* Prevent excess condensation.

Nonwovens

Nonwovens have advantages regarding permeability:

* They allow a free gas exchange.
* Less temperature build up.
* Allow more even distribution of rain or irrigation through the crop cover.

Antill, D. 1989. The use of low level plastics on horticultural field crops. Professional Horticulture 1989 Vol 3, 83-87.

Mansour, N. S. Floating row covers give plants TLC. American Vegetable Grower. 1984 32 12, 8, 10.

Broek N van-den (1985). Advancing the time of harvest of spinach, lettuce, iceberg lettuce and endive. Groenten-en-Fruit 1985, 40: 27, 56-5.

Baudonnel, J: Scotton, M. Properties of textiles for agricultural and horticultural use. Plasticulture 1985, No 66, 45-46.

Loy, J. B: Wells, O. S. Use of spun bonded polyester as a plant row cover over vegetables. National Agricultural Plastics Association 1983 (17th) 54-62.

Kammerer, P. "Agronet". The lightest agricultural floating cover in the world. National Agricultural Plastics Association 1987 v. 20p 131-136.

Hournes, E. M. Polyester covers promote early harvests. American Vegetable Grower 1984, 32: 2,8.

Porcelli, S: D'Amone, R: Ficcadenti, N. "Agrotextiles" for semi-forcing in horticulture. Colture-Protette 1987, 16: 7, 33-37.

Strength and Stretchability

The materials need to be strong enough for handling or machine laying. Measurements of tensile strength and tear resistance can be made and some studies have been carried out (Gerst 1985). They need to be able to withstand the vagaries of the weather. It is important that a tear or accidental cut in the materials does not 'run'. Manufacturers are largely able to overcome problems relating to strength providing growers obtain the correct material for the purpose intended. It is important that growers do not buy cheap unproven one-off surplus quantities.

Gathering and re-winding for recycling is an important aspect, and the strength needs to be such that this can take place without difficulty.

Crop covers need to be able to stretch as the crop grows. Once the crop has grown to its maximum height the material should remain entire. Stretching of materials may be one of the difficulties regarding re-use, because materials do not retract to their former specifications. Often stretching weakens them making re-use impracticable.

Baudonnel, J; Sotton, M. Properties of textiles for agricultural and horticultural use. Plasticulture 1985, No 66, 45-56.

Gerst, J. J. Growing vegetable crops under direct covers. P 34.

Degradability

The nature of plastics is such that they will break down eventually when exposed to light. However, modern technology has overcome this as far as the grower is concerned. All plastics can be UV stabilised. Growers should not have problems of premature breakdown when plastics are exposed to light.

It has always been considered that the degradability of plastics should be turned to an advantage to save the problem of collection after use. Photodegradability can be controlled to a certain extent but because of the fickle weather in Britain it is unreliable. The edges buried in the soil to anchor the sheets do not degrade and often the plastics become brittle, and are scattered by the wind causing an environmental problem. Photodegradable mulches only have limited success.

Nevertheless interest by growers in having materials that will degrade after a given length of time remains, because of the cost of recovering and disposal after use. Biodegradability may eventually be the answer and this aspect requires further investigation.

Courter, J. W. Degradable plastic mulch films for vegetables. DSAC-Dixon-Springs-Agric-Cent. Jan 1976, 4: 201-204 also 1975, 3:41-45.

Anchorage

The most widely used method of holding crop covers or mulches in position is turning the edges under the soil. This can be inconvenient when it is necessary to remove the crop cover to carry out cultivations or if residual herbicides have been used, their effect is negated by soil disturbance at the edges.

Other methods have been tried, but expense and practical considerations confine their usefulness. The most usual alternatives are sandbags, straw bales, pegging or clipping edges to a wire at ground level. A new proprietary system from France that has yet to be proven uses plastic spikes on a handle to pin the edges to the soil.

Disposal

Careless use of plastics in the field can give rise to concern and environmentally is unacceptable. Heaps of plastics should not be left on headlands or burnt in the field and if it is breaking up through degradation the pieces should not be allowed to blow and scatter across the countryside.

The technology for recycling polyethylene is well known and is standard practice in some countries. It has been slow to be organised in the UK, but facilities are now being created for recycling. The main problem is collection but with over 8000 ha on the mainland it must be organised because environmentally other options are not acceptable.

Studies on the most economical way for disposal in collaboration with manufacturers are necessary.

Stall, W. M; Bryan H. H. Removal and disposal of plastic mulch in Florida. NationaL Agricultural Plastics Association 1981 (16th) 133-141.

Microclimate

The microclimate under crop covers and mulches has been the subject of many studies. Because of the difficulties of recording data in an environment which is not easily accessible there has also been much speculation.

As with any growing situation the microclimate is constantly changing. Not only is it dependent on prevailing weather but thickness of the crop cover, light transmission, permeability and growth stage are all factors that determine the microclimate. To obtain maximum benefits skilled management of the crops growing under crop covers or through mulches is dependent on intimate knowledge of the climate and differences between material types. Experience of prevailing weather and its effect on the microclimate will enable appropriate cultivations to be undertaken at critical times and crop growth stages.

Salman, H. M; Gorski, S. F. The effects of clear and black polyethylene mulches on the soil environment. Research Circular Ohio - Agricultural Research and Development Center 1985, No 288, 7-9.

Light Transmission

The transmissivity of the crop cover materials will directly affect growth. 1% loss in light equals 1% loss in yield. Some investigations have been carried out measuring visible transmission (Gerst 1985). A study on materials at Reading University (Merrick, unpublished data) showed the percentage of Photosynthetically Active Radiation (PAR) under clear polythene 38 microns was 84% and under a polypropylene nonwoven 80%. Both materials were commercial samples. Other factors such as condensation, pollution and dust on the crop covers will affect light transmission. In practice light has not appeared to be a factor of great importance except in the autumn, when using new material is advised (Gerst 1983). This is probably because outdoors other limiting factors, such as wind, and temperature, have greater influence than any reduction in light. However, there is lack of data to verify this and studies should be made to improve our understanding of how important light is under crop covers.

Niewhof, B. J. (1975). No light matter. Gardeners Chronicle/HTS 2 May 1975.

Gerst, J. J. (1985). Growing vegetable crops under direct covers. Table 7 Physical characteristics of agricultural plastic films.

Field, M. (1985). Reading University. Light transmission through covers. (Unpublished data).

Gilby, G. W. (1990). The use of plastics in agriculture. Proceedings of XI International Congress, New Dehli, India.

Gilby, G. W. (1990). Developments in film plastics for cladding greenhouses, Professional Horticulture 1990, Vol 4, 21-27.

Nutrition

Influence of Crop Covers and Mulches

There is evidence from studies in the UK and abroad that plants are able to use nutrients more efficiently under covers and that leaching of nitrogen is reduced especially when mulches are used. This could be economically important and save growers money. The increase in soil temperature is one of the factors that leads to greater nutrient uptake. Because of concern regarding nitrate levels in ground water and produce further studies and verification is required in order that firm guidelines can be established.

Whitwell, J. D. (1982). The potential for new techniques in field scale vegetable production. Scientific Horticulture 33: 44-59.

Clarkson, V. A. (1960). Effect of black polyethylene mulch on soil and microclimate temperatures and nitrate level. Agron. J. 52 307-39.

Benoit, F: Ceustermans, N; Rouchard, J; Vlansak, K. Influence of direct plastic covering upon the quality of carrots and lettuce. Acta Horticulturae (1984) No 154, 321-328.

Stockbridge House EHS. Antill, D. (1989-) VG28/010. Weed control using mulches.

Stockbridge House EHS. Hembry, J. (1990-) VG25/015. Mulches: Reducing nitrogen, rates of fertiliser.

Stockbridge House EHS. Senior, D. (1989) VG02/020. Early summer cauliflower - To evaluate the use of crop covers for continuity of cropping in late May and June.

Stapleton, J. J; Quick, T; Delaney, J. E. Soil solarisation: Effects on soil properties, crop fertilisation and plant growth. Soil Biology and Biochemistry 1985, 17:3, 369-373.

Everett, P. H. Influence of fertiliser rates and plastic mulch on the production of two cultivars of crisp head lettuce. Proc-Annu-Meet-Fla-State-Hortic-Soc s.l. The Society 1980 v93p, 243-245.

Hanlon, E. A: Hockmuth, G. J. Fertiliser recommendations for vegetables grown on polyethylene mulch. National Agricultural Plastics Association. 1984 (21st) 165-171.

Wien, H. C; Minotti, P. L. Growth, yield and nutrient uptake of transplanted fresh market tomatoes as affected by plastic mulches and initial nitrogen rate. (1987). Journal of the American Society for Horticultural Science, Vol 112 (5), 759-763.

Temperature

Recording temperatures under low level plastics has been carried out on numerous occasions at home and abroad.

Mulches

Trials have included investigations with coloured and thermal plastics; effects at various depths; accumulation of day degrees and solarisation. Of all the factors affecting microclimate temperature is one of the most important on which crops covers and mulches have influence. Some mulches are able to keep the soil cool which may be advantageous in summer. Surface temperatures also vary according to mulch type. The effects of mulches on soil temperatures may be summarised as follows:

Clear polyethylene gives the highest increase, but also has the greatest extremes.

Thermal mulches are able to raise soil temperature as well as controlling weeds.

White on black mulch keeps the soil and the surface of the mulch cool.

Black polyethylene acts more as an insulation with little effect on soil temperatures, but its surface can become so hot that plants and fruits are burnt.

Homma et al (1959). Soil and air temperatures as affected by polyethylene film mulches.
Clarkson (1960). Effect of black polyethylene mulch on soil and microclimate temperatures and nitrate level.
Knavel and Mohr (1969). Distribution of roots of four vegetables under paper and polythene mulches. Proc.Amer.Soc.Hort.Sci. 91: 589-597.
Rickard (1978). Perforated polythene for forwarding vegetable crops.
Antill (1985, 1987, 1989)

Crop Covers

When crop covers are laid after drilling or newly planted crops the effect on soil temperature will be similar to mulching with clear polyethylene. As the crop grows the canopy shades the soil but the gap between the material and soil widens providing insulation. Air and plant temperatures can become high on still days. Polyethylene can produce extremes to the point where plants are burnt. Nonwoven materials have the advantage that temperature extremes do not occur so readily and there are occasions when it may be cooler in hot weather than no cover. It is the steady increase in accumulated heat units that benefits plants rather than maximum temperatures. Temperature will also be affected by the amount of condensation and particular weather conditions.

The main types of crop cover have the following general effect:

Clear polyethylene gives the highest number of accumulated heat units, but has temperature extremes.

Standard nonwoven covers generate less accumulated heat units than polyethylene but more than no cover. They also have the advantage of less extremes.

Thin light-weight nonwovens and nets only show slight rises in temperature compared with uncovered crops.

Records are generally confined to soil and air temperatures. There is virtually no data on the temperature in the middle of plants eg the hearts of lettuce. Theoretical modelling of energy exchange and also experiments to establish what the temperatures are in the plants need to be done to help gain a better understanding of physiological problems, such as tip burn and the relationship between outside temperatures and those in plants. This may also lead to providing a more reliable guide to when crop cover removal should take place.

Insituut voor Twinbowwtechnick at Wageningen 1973. Applications in horticulture Hareslag 1973 pb 87: 123.

Henriksen, K. Influence of temporary covering with plastic on timing, yield and quality. Acta Horticulturae 122 1981, 61-75.

Gerst, 1985. Growing vegetable crops under direct covers.

Antill, D. 1985, 1987.

Birkenshaw, J. E; Dawson, E. M. Early outdoor lettuce production under perforated film plastic covers. Luddington Annual Review 1982.

Morrison, J. I. L; Green, W. T; Hadley, P. Energy exchange by plastic row covers. University of Reading.

Hadley, P; Livermore, D. A. (1989). The effects of carbon dioxide enrichment under plastic film crop covers on the growth of early outdoor crisp lettuce. The Grower 13 April 1989.

Baudonnel, J; Sotton, M. Properties of textiles for agricultural and horticultural use. Plasticulture No 66 45-56.

Benoit, F; Ceustermans, N: Colus, A. Single and double flat covering of carrots. Acta Horticulturae 1986 No 176 41-46.

Mayne, A. One week earlier with a double cover . Gemuse 1986, 22:3, 100-102.

Henrikson, K. Covering outdoor-grown vegetables with plastic sheeting. Gartner-Tidends 1986, 102: 51 1703-1705.

Antill, D. Runner beans; Early production with the aid of low level plastics - A review of work at Efford EHS 1977-1984, Efford Annual Review 1984.

Hill, D. E; Hankin, L; Stephens, G. R. Mulches: Their effect on fruit set timing and yields of vegetables. (1982). Bulletin; Connecticut Agricultural Experimental Station, New Haven (805), 15 pp.

Moisture

Under perforated polyethylene crop covers distribution of moisture from rain or irrigation is generally uneven. Water will run to the lowest point and, because of surface tension, will run over 10 mm perforations. As the crop grows tensioning the cover into a dome shape, much of the precipitation runs to the edges. On narrow sheets on a bed system slits can be made to direct moisture on to crop rows, but this is not possible on wide sheets. Directing the moisture to rows keeps the top soil in between rows dry which discourages weed growth. If plants are in small furrows so that in the early stages the crop cover is supported by soil in between the rows water will be directed to the plants. It has been observed that condensation will also be directed on to rows which may help seed germination.

Light inhibiting mulches will conserve moisture (Knavel and Mohr 1969). However it is important that the soil is moist when they are laid.

Applying mulches in dry conditions will keep the soil dry and hinder plant establishment. With long season crops transpiration will eventually use up soil moisture under mulches and irrigation applied in a suitable way may be necessary. Seep hose under the mulch can be used and making slits directly along the side of a row (on the wheeling side) will direct moisture to the rows.

Nonwoven crop covers and mulches allow rain or irrigation through more readily and more evenly making management of watering considerably easier. Because of their permeability there is less condensation.

Under all crop covers evaporation is reduced, and relative humidity increased (Kampe 1974). It appears that in certain conditions RH is at saturation point. This high humidity will reduce transpiration, growth and may induce Ca deficiency and increase tipburn (D W Hand and R I George). It has been suggested that large amounts of condensation are harmful to crops and that diseases are promoted. Trials in the UK have not substantiated this, providing disease was not present when the crop cover was laid.

It always appears that moisture dries out in the soil quicker under crop covers than with no crop cover. These observations were confirmed in trials at Luddington (Birkenshaw and Dawson 1982). The greater rate of growth leads to greater water loss (Knavel and Mohr 1969). Soil is therefore drier. These factors need compensating for when considering the SMD. However other observations have indicated that crops under covers are able to make better use of soil moisture providing cultivations are correct. The SMD at the time of covering may have an important influence on how well the crop grows. The effect of soil structure and SMD at covering on growth, physiological disorders eg normal tip burn, and quality requires investigation.

Runner beans 1986, Efford

Birkenshaw, J. E; Dawson, E. M. (1982). Early outdoor lettuce production under perforated film plastic covers. Luddington Annual Review 1982.

Klima, J. Effects of plastic foils on the variations in moisture contents of the soils under vegetable crops. Acta-Univ-Agric-Fac-Agron 1973 21 (1): 49-55.

Clough, G. H; Locascio, S. J; Olson, S. M. Continuous use of polyethylene mulched beds with overhead or drop irrigation for successive vegetable production. National Agricultural Plastics Association 1987 V 20 57-61.

Efford EHS. Antill, D. 1986 VE36/11362. Runner Beans - Weed control with mulches.

CO_2 Under Crop Covers

Summary

Earlier crops can be achieved by using crop covers, chiefly through higher temperatures and protection from wind. However to allow gas exchange for photosynthesis to take place polyethylene requires perforating. This reduces the potential temperature lift. It may be possible to overcome this by injecting CO_2 under non-perforated covers. The full temperature lift could then be exploited in the early season. Experiments have taken place on crisp lettuce. Although the technique advances the crop over conventional perforated crop covers and increases head weight, problems of knowing when to stop the CO_2, weaning of the plants, cover removal and hot weather remain. Further investigations are required to perfect the technique.

In general there is a lack of data on how crop covers influence levels of CO_2 in crops and whether yields and/or quality are effected. Investigations should be carried out to establish the facts.

Hadley, P; Livermore, D. A. (1989). The effects of carbon dioxide enrichment under plastic film crop covers on the growth and yield of early, outdoor crisp lettuce. Department of Horticulture, University of Reading.

Stockbridge House EHS. Antill, D; Hembry, J. VG06/019 (1989-). Lettuce, crisp: CO_2 under covers.

Frost Protection

Mulches do not give the above ground parts of plants any frost protection. Roots under the mulch are given considerable protection.

Crop covers give frost protection if the plants are not touching the cover, The amount of protection depends on the material. Most of the crop covers will prevent -5°C of radiation frost if there is an air gap between the plants and cover. However once the plants press on the material little protection is given with a single layer. Nonwoven materials will give down to -2°C of frost protection depending on weather conditions and thickness. Polyethylene will give no protection, and plants can be scorched through the cover on bright, frosty, sunny mornings.

Crop covers give considerable protection against wind frost and nonwoven materials are especially useful in winter and early spring during severe weather. Desiccation is prevented and harvesting is able to continue when non-covered crops are too frozen. However, data on the influence of crop covers and mulches on frost and the amount of protection offered is lacking and further studies are required.

Hournes, E. M. (1984). Polyester covers promote early harvests. American Vegetable Grower 32 2,8.

Mayne, A. One week earlier with double cover. Gemuse 1986, 22:3, 100-102.

Wiebe, H. J. Frost protection by winter covering 1987. Proceedings of a conference held in Hanover, German Federal Republic, 7-8 Oct 1987. Arbeitspapier 1987 No 125 131-136.

Wells, O. S. Overwintering of vegetables with spun bonded row covers. National Agricultural Plastics Association 1987 v 20p 258-263.

Fritten, D. D: Martsolf, J. D. Solar energy, soil management and frost protection plastic mulch. Hortsci Alexandria, va. American Society for Horticultural Science June 1981 v 16(3) 295-296.

Hockmuth, G. Frost protection pays off. American Vegetable Grower. February 1990, 54-56.

Solarisation

Laying clear non-perforated polythene over ridges or beds during summer may heat up the soil sufficiently to give partial sterilisation. Some weed seeds, pests and diseases may be killed or incidence reduced. Investigations are needed in this country to evaluate the potential and assess how the technique may fit in with an integrated low input programme.

Standifer, F. C: Wilson, P. W: Porche-Sorbet, R. Effects of solarisation on soil weed seed populations. Weed Science 1984, 32;5, 569-573.

Stapleton, J. J; Quick, T; DeVay, J. E: Soil solarisation - Effects on soil properties, crop fertilisation and plant growth. Soil Biology and Biochemistry 1985 17;3, 369-373.

Raymundo, S. A; Alcazar, J; Solas, R: Effects of soil solarisation, dazomet and bromoethane on root knot nematode. CMU - Journal of Agricultural, Food and Nutrition 1986, 8:2, 75-87.

Porter, I. J; Merriman, P. R. Evaluation of soil solarisation for control of clubroot of conifers and white rot of onions in South Eastern Australia. Ecology and Management of Soil Borne Plant Pathogens, 1985, 282-284.

Barbercheck, M. E; Broembsen, S. L. Von. (1986). Effects of soil solarisation on plant parasite nematodes and phytophthora cinnamoni in South Africa. Plant Disease, Vol 70 (10), 945-950.

Hariuchi, S; Hari, M; Takashi, S; Shimizu, K. Factors responsible for the development of clubroot suppressing effect in soil solarisation. (1983). Bulletin of the Chugoku National Agricultural Experment Station, E, No 20, 25-48.

Rubin, B; Benjamin, A. Solar heating of the soil: Effect on weed control and on soil incorporated herbicides. (1983). Weed Science, Vol 31 (6), 819-825.

Wind

One of the most important aspects is the protection crop covers provide from wind. Mechanical damage is prevented and evaporation reduced from the soil and plants.

If crop covers and mulches are laid properly only gales and unusual conditions cause problems.

In winter although plants may freeze in severe weather protection from the wind prevents desiccation.

Most crops grow taller when grown under covers because of the lack of exposure. It is difficult to study the direct effect of wind on crop covers and mulches and to assess exactly the net gain under covers due to the exclusion of wind. Observations have noted that in winter and early spring high winds will chaff covers on stones, soil and plants. It seems this can be prevented by using a double skin cover, but trials have not been carried out to confirm this. It is worth investigating the value of double skin covers to assess cost (two layers need not be more expensive than one thick one), amount of wind protection, light transmission, effect on temperature and frost.

Benoit, F; Ceustermans, N; Colus, A. Single and double flat covering of carrots. Acta Horticulturae, 1986, No 176, 41-46.

Cultural Operations

Crop Covers

There are certain husbandry techniques that need to be adopted for the successful cultivation of specific crops. Most species will support the crop cover once established. But it is preferable to transplant crops such as brassicas and courgettes into a small furrow 75-100 mm deep, so that initially the ridge of soil in between the rows supports the cover. This prevents the plants being pushed over, and gives frost protection until they touch the cover.

Field drilled crops should be sown into 50 mm deep mini furrows. This prevents very young seedlings sticking to the crop cover when condensation freezes on a cold night. The freezing may not kill them but a slight wind that moves the cover will pull the seedling out of the ground if they are frozen to it.

Lettuce should not be transplanted or drilled in furrows, because of physiological problems and hinderance to harvest.

To minimise edge effect row arrangements require consideration so that a reasonable distance is left between the outside rows and the edge of the crop cover.

Crop covers should be laid so that in a strong wind they ripple but not flap. Narrow widths up to 2 m wide are best laid by machine. Flapping will cause damage. Attention needs to be paid to achieving uniform tension when the cover is being secured at the edges. When the crop grows and pushes up the cover stretching needs to take place uniformly.

Gerst, J. J. 1985. Growing vegetable crops under direct covers. P 98.

Mulches

Besides achieving weed control, light inhibiting materials conserve moisture, (see under subject Moisture). Mulches only work efficiently when in close contact with the soil surface. They therefore must be laid tightly. To achieve this the bed needs to be slightly dome shaped. They should be 'drum-tight' to ensure maximum effectiveness. Mulches are inefficient if they flap or if there is an air gap between the plastic and soil. A loose mulch will also allow plants to slip underneath the mulch in windy conditions. The plants are unable to come back though the mulch without assistance.

Lamont, B. 1990. Bed preparation and cropping combinations. American Vegetable Grower. May 1990, 38-42 and June 1990, 44/50-51.

Successional Cropping

The cost of mulching with polyethylene or polypropylene is relatively high compared to many herbicides. Although this may be balanced in some circumstances by other benefits eg conservation of moisture, reduction in pest or disease, cleaner produce, or more efficient use of nutrients, it would be advantageous if more than one crop could be grown after a mulch has been laid. This would reduce the unit cost considerably. Techniques for multi use need developing.

Coffey, D. L; Ramsey, P. W. Sequential cropping on vegetables on black plastic. Tenn-Farm-House-Tenn-Agric-Exp-Stn, Knoxville, Tenn. The Station. Fall 1987 (144) 19-21.

Stockbridge House. Hembry, J. VG28/012 (1990-). Mulches, successional cropping of summer cabbage, crisp lettuce, broad beans, cauliflower.

Clough, G. H; Locascio, S. J; Olson, S. M. Continuous use of polyethylene mulched beds with overhead or drip irrigation for successive vegetable production. National Agricultural Plastics Association 1987 V20 57-61.

Cover Removal

One of the crucial management decisions regarding crop covers is removal. Polyethylene is more difficult to manage than nonwoven material. One of the most important advantages of nonwoven or net materials is that with many crops removal can be delayed until first harvest. However they are more expensive and not so warm in the early months. Many growers cause physiological problems to crops by leaving polyethylene on too long. Considerable experience and trials work has defined when these crop covers should be removed. Growth stage is important for some crops. However other criteria such as prevailing weather, soil moisture, nutrition and weed control may be the overriding factors. When any cover is removed it is best done in dull moist relatively calm conditions. In sunny weather it is advisable to remove the covers in the evening and then apply short bursts of irrigation the next day.

Efford. Antill, D. VE03 (1982). The production of early summer cabbage with polythene mulch.

Rosewarne. Treble, J. C. VG12/010 (1987-89). Turnips, Early production using polythene covers.

Rosewarne. Treble, J. C. VG13/012 (1986-88). Swedes, Early production under floating mulch: Removal date trials 1 and 2.

Arthur Rickwood. VG13/003 (198). Parsnips, First Early - Covering materials and removal date.

Arthur Rickwood. VG12/004 (198). Parsnips, First Early - Cultivar, drilling date, uncovering date and harvest date.

Arthur Rickwood. HDC project (198). Celery, Comparison of film cover materials and removal date for early production.

Efford. Antill, D; Hand, D: FV/29/87 HDC project (1987/88). Calabrese, Early production using crop covers.

ADAS Eastern Region VG03/10292 (1984). Calabrese, Uncovering date for crops under film cover.

Kirton. VG02/044 (198). Early summer cauliflower, Effect of crop cover removal date on earliness of harvest.

Luddington. Bell, P. HDC project (1987/88). Leeks, Production under crop covers.

Efford. Antill, D. VE04/10222 (1984-86). Lettuce, Iceberg - Early field production under film covers.

Luddington. Birkenshaw, J. E; Dawson, E. M. (1982). Early outdoor lettuce, Production under perforated film plastic cover. Luddington Annual Review.

Arthur Rickwood. Davies, J. VG13/007 (1987-89). Carrots - First early covering materials and removal date.

Arthur Rickwood. Davies, J. VG13/014 (198). Carrots - Autumn sown comparing crop density and polythene removal date from 2 sowings.

Rosewarne. Houghton, B. VE06/05564 (1981/82). Carrots - Early production under perforated polythene comparing 5 uncovering dates.

Arthur Rickwood. VE06/09092 (1983). Carrots - Comparisons of drilling dates for early production under floating plastic film covers of both autumn and spring sown crops.

Gerst, J. J. (1985). Growing vegetable crops under direct covers. 5.2 p. 63 and cultural notes on crops.

Benoit, F; Ceustermans, N. (1979). Morphogenis of early lettuce under temporary direct cover of perforated plastic sheeting. Phytotronic Newsletter. 20. 62-69.

Rickard (1979). Plastic mulches for vegetable production. Grower Guide NE7.

Kirton. Hiron, R. W. P. (1978). Use of Xiro as a polythene mulch.

Mayne, A. One week earlier with a double cover. Gemuse 1986, 22:3, 100-102.

Re-use of Crop Covers and Mulches

Re-using materials is normally confined to the wide crop cover sheets. The problems that prevent large scale re-use are damage when removing the cover, dirt, time to fold or roll neatly, storage and how much the material has been stretched by the crop. Both polythene and the nonwovens may be re-used at least once. Cost is an important factor in the equation whether re-use is worth while. At present it is doubtful for polythene, but worthwhile for the thicker nonwovens and essential for the expensive net type. However price rises could alter this view.

The strip cropping technique allows one sheet to be used over two or three crops in a season. This is by far the most practical and economic way for re-using materials. For mulches replanting in the same holes may allow more than one crop that will reduce the unit cost. Further trials are necessary to verify previous work, especially with newer materials.

Gerst, J. J. 1985. Growing vegetable crops under direct covers. Ageing and re-use of the cover. p 100, 7.3.3.

Eichin, R; Deiser, E; Buhl, R. Nets and covering membranes against vegetable flies. Deutscher-Gartenbau 1987, 41:4, 206-213.

Huber, P. Nonwoven fabrics and plastic nets for vegetable crop protection. Plasticulture 1989, No 81, 33-36.

The Overwintering Bed System

The technique involves preparing seedbeds in ideal soil conditions in October or November and covering with clear unperforated polythene. This gives ideal soil conditions for drilling without further cultivation from late January until April. Providing the wheelings between the beds are dry enough drilling can take place at any time and beds can be recovered after sowing to improve germination and emergence. The technique may have application for early transplanted crops. It is also possible to use light inhibiting mulches rather than clear polyethylene and plant through it in the spring.

The Polyflo

The Polyflo machine was designed and built by ADAS at Efford EHS. It is used to lift the clear polythene that has protected the soil over winter, drill a crop and replace the cover in one pass. With mechanical lifting and relaying shown to be feasible other advantages can be visualised. In addition to drilling other operations such as top dressing or applying pesticides can be carried out in one pass. The use of soil sterilants particularly for weed control on a field scale becomes more realistic. The Polyflo is able to act as a simple laying machine or to recover polythene from the field.

Benefits of the Overwintering Bed System

Trials have shown the following advantages:

* Better timing of field drilling in late winter or early spring.
* Field drilling in ideal soil conditions.
* Improved germination and emergence.
* Improved early protection of seedlings.
* Improved continuity of crops.
* Improved earliness.
* Provision of a longer growing season.

Weed Control

For some crops controlling weeds is one of the limiting factors for growing under crop covers. For crops such as carrots, sweetcorn, brassicas and beetroot conventional standard residual herbicides have generally proved efficient. Results have always been better if the herbicide has been applied to moist soil and laying of the crop cover delayed for up to 72 hours. This prevents the chemical being evaporated or vaporised too quickly. Only carrots have any formal label recommendations for herbicide use. The situation for other crops is in the process of being clarified. Trials on celery have investigated the possibilities of spraying through certain cover types.

However weed control still causes problems with many crops and further investigations are required, particularly in relation to application and the timing of laying of the crop cover. For some crops partial soil sterilisation and solarisation have shown promise. There is also the possibility of using mulches in conjunction with covers. Research has indicated that herbicides are more persistent under polyethylene covers.

Birkenshaw, J. E; Dawson, E. M. (1972). Early outdoor lettuce production under perforated film plastic covers. Luddington Annual Review 1982.

Efford, Antill, D. (1980/87). VE04/11205. Lettuce, iceberg, Herbicides under film covers.

Kirton (1986/87). VG28/002. Cauliflower, ES, Use of herbicides under polythene covers.

Arthur Rickwood. VG28/008. Chinese cabbage weed control.

Arthur Rickwood. HDC Project. Celery comparison of herbicide regimes for film covered crops.

Stockbridge House. Antill, D; Hembry, J. VG28/010 (1989-). Weed control using mulches on bulb onions, brussels sprouts and lettuce.

Stockbridge House. Hembry, J. VG25/014 (1990-). Weed control using mulches on organic/reduced input trial.

Stockbridge House. Hembry, J. VG28/012 (1990-). Mulches successional cropping of summer cabbage, crisp lettuce, broad bean, cauliflower.

Bond, W; Walker, A. Aspects of herbicide activity and persistence under low level polyethylene covers. Institute of Horticultural Research, Wellesbourne 1988.

Antill, D. Problems of herbicide use on field grown vegetables under low level plastics. British Crop Protection Conference 7B-1 617 1987.

Bond, W; Burch, P. J. (1989). Weed control in carrots and salad onions under low level polyethylene covers. Brighton Crop Protection Conference 1989.

Standifer, L. C; Wilson, P. W; Porche-Sorbet, R. Effects of solarisation on soil weed seed populations. Weed Science 1984 32, 5, 569-573.

Stapleton, J. J; Quick, J; DeVay, J. E. Soil solarisation - Effects on soil properties, crop fertilisation and plant growth. Soil Biology and Biochemistry 1985 17;3, 369-373.

Mayck, B. A. Oxyflourfen for weed control in vegetables transplanted through clear plastic mulch and protected by slitted row covers 1986. Proceedings 40th annual meeting of the Northearton Weed Science Society. 159.

Marlow, H; Zschau, K. New herbicides approved for use in vegetables. Nachrichlenblatt-far-den-Pflanzenschutz-in-der-DDR. 1986, 40:12, 237-239.

Benoit, F; Ceustermans, N. Spring leeks - Further findings with single and double covering. Boer-en-de-Tuinder 1987, 93: 50, 17.

Edinburgh School of Agriculture: Herbicides for calabrese under low plastic covers. 1987 Annual Review.

Gorshe, S. F. Chemical weed control programmes for selected vegetables on clear plastic mulches. National Agriculture Plastics Association. 1981 (16th) 142-148.

Vrabel, T. E; Schales, F. D. Herbicide safening effects of plastic row covers in vegetables. Proc-Annu-Meet-Northeast-Weed-Sci-Soc. Beltsville, Md: The Society 1987 V41 103-108.

Coffey, D. L; Ramsey, P, W. Sequential cropping of vegetables on black plastic . Tenn-Farm-Honne-Tenn-Agric-Exp-Stn. Knoxville, Tenn. The Station Fall 1987 (144) 19-21.

Derr, J. F. Use of herbicides in vegetables grown under plastic mulch. Extension Division, Virginia Polytechnic Institute and State University Dec 1987 (427-011) 2 p.

Jensen, K. I. N; Kimball, E. R; Rickitson, C. L. Effect of perforated plastic row covers on residues of the herbicide DCPA in soil and broccoli. (1985). Balletin of Environmental Contamination and Toxicology, Vol 35 (6), 716-722.

Rubin, B; Benjamin, A. Solar heating of the soil: Effect on weed control and on soil incorporated herbicides. (1983). Weed Science, Vol 31 (6), 819-825.

Greenfield, A. BCPC Conference proceedings, 1989.

Crops Grown with the Aid of Crop Covers and Mulches

Crop covers were first trialled in the late 1970's on early carrots, potatoes and runner beans while clear mulches were used with sweetcorn. Carrots, potatoes and sweetcorn accounted for nearly 70% of the area in 1985 and over 45% in 1990. Since the mid 1980's the techniques have been used more widely on other crops, notably lettuce, cauliflower and calabrese, courgettes, chinese cabbage and celery. In all plastics are now used on about 30 crops.

HRI, ADAS and growers have built up considerable experience in the management of crop covers and mulches. Some research and development workers have acquired particular expertise along with specialist growers who have special skills with individual crops.

The use of plastics for early production is summarised under crop headings in alphabetical order. Using crop covers and mulches for reducing damage by insect pests is dealt with in the next section.

Cabbage

Summary

Crop covers have been used firstly on early summer pointed and round headed types for early production. Up to 14 days earliness can be achieved. Secondly, spring cabbage has been covered in winter for protection against severe weather and to provide improved quality and continuity of production.

It has been shown that crop covers will reduce bolting in early round headed summer crops. Trials and observations using crop covers on spring cabbage show that it is a gamble. In severe winters much benefit can be gained but in mild conditions there is no advantage apart from protection against pigeons.

Efford. Antill, D. VE03 (1981-82). The production of early summer cabbage with polythene mulch.

Efford. Antill, D. VE03/1250 (1985-87). Spring greens under low level film covers.

Kirton. Paterson, C. (1990) VG02/069. Early summer cabbage under polythene.

Stockbridge House. Hembry, J. VG28/012 (1990-). Summer cabbage mulches, successional cropping.

Wiebe, H. J. Frost protection by winter covering. Arbeitspapier 1987, No 125, 131-136.

Calabrese

Summary

There tends to be a gap between imported produce and the early outdoor home grown in early summer. Crop covers have enabled growers to fill that gap. There is also the possibility of extending the season in the autumn. Covers are able to protect the spears against minor frosts. Plant density, varieties, types of material, propagation method and planting have been studied in trials and recommendations are available.

ADAS Midlands/Western. VE03/09086 (1984). Production of early crops under film cover.

ADAS Wye. Wood, M. B. VE03/10157 (1984). Early field production from modules under plastic.

Efford. Antill, D; Hand, D. FV/29/87 HDC project (1987/8). Early production using crop covers.

ADAS South East. VE03/10292 (1984). Uncovering date for crops under film cover.

Rosewarne. VE03/10162 (1984). Plant density in propagation cells for early production under film cover.

Rosewarne. (1986/87). Early crops under polythene.

Arthur Rickwood. Davies, J.
VG02/022 (1988-89). Early production under film covers.
VG02/015. Comparing module grown plants with direct drilling for early production with and without polythene cover.

Arthur Rickwood. Davies, J. VG02/021 (1987). Early production under film cover.

Kirton. Wood, M. B. VG02/038 (1987-89). Varieties, raising systems and sowing dates for early production under polythene.

Mayne, A. One week earlier with a double cover. Gemuse 1986, 22:3, 100-102.

Edinburgh School of Agriculture. 1987 Annual Review. Herbicides for calabrese under low plastic covers.

Kirton. Hanks, G; Wood, M. VG02/029 (1987-89). Use of polythene covers.

Arthur Rickwood. Davies, J. VG02/057 (1989-90). Spacing under film cover for early crops.

Carrots

Summary

Carrots were one of the first crops to be investigated using crop covers in 1978. The area of carrots grown under crop covers has expanded to about 2000 ha in 1990. The technique has enabled English growers to provide continuity all the year round and compete successfully with imports during late May to July. Early yields and quality have been improved. In the more favoured growing areas the earliest crops are obtained from drilling in the autumn and covering the plants over winter. This has been more reliable since the introduction of better, more vigorous and bolt resistant varieties. Trials have shown that crop cover removal of the autumn sown crop is not critical providing it is removed before the weather becomes too hot in late April or May. Spring sown carrots however require crop cover removal when the plants have reached about seven leaves. Weed control has been effective using standard herbicides.

Guidelines and recommendations are available for the growing of the crop.

Kirton. Hiron, R. W. P. V37 (1978). Use of Xiro as a polythene mulch.

Hiron, R. W. P. (1979). Herbicides application through plant protection films.

Arthur Rickwood. Rickard, P. (1979/80); Wood, M. B. (1981) VE06/05582. Early production from covered overwintered varieties.

Arthur Rickwood. Wood, M. B. (1980-83). Early production from fluid drilling and covering.

Arthur Rickwood. VE06/09092 (1980/83). Drilling dates for crops under mulch applied pre or post emergence.

Arthur Rickwood. (1982 and 1984). New materials for mulching.

Rosewarne. Houghton, B. (1981/82). VE06/05564. Early production under polythene film

Rosewarne. Houghton, B. (1985-87). Early production under polythene - Autumn sown.

ADAS Eastern Region. (1982-83) VE06/05619. Varieties and plant populations for 2nd early production.

ADAS Eastern Region. (1982-84). VE06/04278 and VE06/10179 (1984). 2nd early production, covering materials, methods, varieties and densities.

ADAS Eastern Region. (1983). VE06/09347. 1st early production, autumn sown, N top dressings.

Hari, Y; Arai, K and Toki. (1970). Studies on the effect of root temperature and its combinations with air temperature and nutrition of vegetable crops. II. Carrot, celery, pepper. Bull. Hort. Res. Stat. Hiratsuka, Kanagaura, Japan 9: 198-219.

McMillan, K. A and Hamilton, H. A. (1971). Carrot response to soil temperature and copper manganese, zinc and magnesium. Can. J. Soil Sci 51 293-297.

White, J. M. and Standberg, J. O. (1979). Physical factors affecting carrot root growth: water saturation of soil. J. Amer. Soc. Horti. Sci. 104 (3): 414-416.

Arthur Rickwood. Davies, J. (1987-89).

F/F3/VG13/007. First early - covering materials and removal date.

F/F3/VG13/009. Production systems first early, weed control, under perforated plastic film.

F/F3/VG13/014. Autumn sown comparing crop density and polythene removal date from 2 sowings.

Efford. Antill, D. (1986/87). F/F1/VG13/016. Overwintering under film covers, sowing date.

Stockbridge House. Senior, D. (1989/90). VG25/014. Overwintering beds.

Benoit, F; Ceustermans, N; Rouchaud, J; Vdassak, K. Influence of direct plastic covering upon the quality of carrots and lettuce. Acta-Horticulture (1984). No 154, 321-328.

Firch-Savage, W. E. The effects of fluid drilling and seed covering reduction on early carrot production under polyethylene mulch. Annals-of-Applied-Biology 1986, 108:2, 431-439.

Benoit, F; Ceustermans, N; Calus, A. Single and double flat covering of carrots 1986. Acta-Horticulture, No 176, 41-46.

Henrikson, K. Covering vegetable seedbeds with plastic film 1985. Meddedelse-Statens-Plantearlsforsog 1985, 87: 1827.

Ricketson, C. L; Thorpe, J. If. E. Row covers for advancing maturity of carrots and rutabages. 1985 Annual report, Research Station Kentville, Nova Scotia.

Eichin, R; Deiser, E; Buhl, R. Nets and covering membranes against vegetable flies. Deutscher-Gartenbau 1987, 41:4, 206-213.

Benoit, F; Ceustermans, N; Calus, A. The influence of the intensity of perforation of a plastic mulch and the duration of mulching on the morphogenus of early carrots. (1982). Revue de l'agriculture, Vol 35 (5), 2897-2904.

Early Summer Cauliflower

Summary

Using perforated polyethylene crop covers on early summer cauliflower has given 10-14 days earliness, improved quality and yield. Damage by birds and rabbits is avoided and the protection from wind and cold after planting out has improved establishment. Polyethylene crop cover removal should take place when the curds are 20-30 mm in diameter which is usually early May. Nonwoven covers can remain until first harvest. For the first early crop, trials have shown the chemical control of cabbage root fly is unnecessary especially if nonwoven materials are used. Propagation methods have been related to maturity and continuity in May and June. Weed control has generally been effective using conventional herbicides and not covering for one or two days after application. A cheaper method of production by overwintering the crop in the field under polyethylene crop covers on 1.8 m bed system has shown some promise. This technique can be fully mechanised. Guidelines and recommendations for growing the crop are available.

Luddington. Bell, P. VG02/018 (1986-89). To evaluate the use of crop covers for continuity of cropping in late May and June.

Stockbridge House. Senior, D. VG02/020 (1988-89). The evaluate the use of crop covers for continuity of cropping in late May and June.

Stockbridge House. Senior, D. VG26/005 (1988-89). Root fly control under perforated crop covers.

Luddington. Bell, P. VG25/004. Nitrogen fertiliser rates and timing for the covered crop.

Luddington. Bell, P. VG02/016 (1987). Effect of different module propagation systems under plastic covers for two varieties.

Luddington. Bell, P. VG02/017 (1987). Effect of plant nutrition and duration of covering for different crop cover materials.

Kirton. Paterson, C. VG02/025 (1986-90). Use of polythene covers to enhance harvest date.

Kirton. Paterson, C. VG28/002 (1987-89). Use of herbicides under polythene covers.

Luddington. Bell, P. VG02/044 (1988). Effect of crop cover removal date on earliness of harvest.

Stockbridge House. Senior, D. VG02/064 (1989-). Overwintering in the field.

Stockbridge House. Senior, D. VG02/065 (1990-). Planting date.

Henrikson, K. Covering outdoor grown vegetables with plastic sheeting. Gartner-Tidende 1986, 102:51, 1703-1705.

Kirton. Paterson, C. VG25/009 (1987-89). Starter Solution.

Kirton. Paterson, C. VG02/062 (1989). Polythene covers, the importance of planting in furrows.

Kirton. Paterson, C. VG02/066 (1989). Use of polythene covers and use of module type.

Celery

Summary

The use of crop covers has provided earliness, improved quality and a better continuity of production. Evaluation of weed control (recently including applying the herbicide through the crop cover), bolting and varieties have been carried out. Further studies are needed to prevent bolting of first early crops. Crop covers have also been trialled for field storage in the autumn to extend their season. Guidelines and recommendations are available.

Arthur Rickwood. Davies, J. VG21/011 EC10220 (1985-87). Light manipulation to reduce bolting in early planted crops.

Arthur Rickwood. Runham (nee Jones), S. (1978-84). Field storage under polythene.

Arthur Rickwood. Runham (nee Jones), S. VE04/08038 (1980-83). Field storage under protective materials using plants from different sowing/planting dates.

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Arthur Rickwood. HDC project (1988-89). Comparison of film cover materials and removal date for early production.

Arthur Rickwood. HDC project (1988-89). Comparison of herbicide regimes for film covered crops.

Arthur Rickwood. Davies, J. VG21/015. (1988-90). Module size for early outdoor crops.

Benoit, F; Ceustermans, N. 1985 Review.

Mayne, A. One week earlier with a double cover. Gemuse 1986, 22:3, 100-102.

Chinese Cabbage

Summary

Trials have been carried out on evaluating materials as crop covers, varieties, earliness and techniques for preventing bolting. Crop covers in conjunction with correct propagation temperatures and variety have enabled summer production to be achieved. Quality for early crops still causes problems and further trials are required.

Arthur Rickwood. Runham (nee Jones), S. (1984-8). Plastic mulching for early crops.

Arthur Rickwood. Runham (nee Jones), S. VE04/09934 (1983-86). Plastic mulching for early crops, part 1 - materials, part 2 - spacing.

Arthur Rickwood. VG20/003 (1985-87). Screening cultivars for early production.

Arthur Rickwood. Davies, J. VG06/013 (1988-90). Early production systems for maximising quality.

Arthur Rickwood. Davies, J. VG06/006 (1988-). Short day treatments to reduce bolting in early outdoor crops.

Arthur Rickwood. VG06/004 (1980-87). Effect of temperature during propagation on head quality.

VG28/008. Weed control.

Henrikson, K. Covering outdoor grown vegetable with plastic sheeting. Gartner-Tidende 1986, 102:51, 1703-1705.

Matthews - Gehringer, D; Hough - Goldstein, J. A. Physical barriers and cultural practices in cabbage maggot management on broccoli and chinese cabbages. Journal of Economic Entomology 1988, 81:1, 354-360.

Haseli, A; Konrad, P. Nets as an alternative vegetable production method. Landtechnick 1987, 42:9, 358-361.

Benoit, F; Ceustermans, N. (1986). Hastening a crop of chinese cabbage. Revue de l'agriculture, Vol 39 (5), 1111-1117.

Courgettes

Summary

Courgettes benefit from the use of crop covers and mulches. They respond to the increase in heat units as well as protection from wind. The techniques have made it possible to commence field cropping three weeks earlier when prices are high. Quality is also improved so that early English samples compete successfully with those from warmer countries. Weed control remains one of the most limiting factors, but following development work many growers find the crop is able to stand the cost of light inhibiting mulches or the use of dazomet to partially sterilise the top 100 mm of soil. Recommendations and guidelines are available.

Efford. Antill, D. (1983-85) VE04/09192. Early production under low plastics.

Efford. Antill, D. (1986/87) VG21/013. Weed control under covers and mulches.

Rosewarne. Houghton, B. (1985-87). Early crops under polythene.

Rosewarne. VG21/010. Effect of herbicide treatments on weed control and yield under plastic film.

Endive

Summary

Trials have evaluated cultural methods for early production, use of light inhibiting covers for blanching and temperatures during propagation.

Arthur Rickwood. Davies, J. VG06/003 (1987-90). Cultural methods for early production.

Arthur Rickwood. Davies, J. VG06/005 (1988). Treatments to increase blanching of head centres.

Broek N-van-Den (1985). Advancing the time of harvest of spinach, lettuce, iceberg lettuce and endive. Groenten-en-Fruit 1985, 40:27, 56-57.

Benoit, F; Ceustermans, N. 1985 Review.

Fennel

Summary

The objective has been to use crop covers to provide early production so that the season can be extended and give a longer continuity of supply. Bolting remains a problem and further investigations are required.

Arthur Rickwood. Davies, J. VG21/008 (1986-90). Early season production under film covers.

Benoit, F; Ceustermans, N. 1985 Review.

Leeks

Summary

In recent years the demand for leeks has increased, particularly for summer production and they are now in demand all the year round. Crop covers have been used to advance the harvest date of the transplanted crop so that harvesting can begin in July. Polyethylene crop covers are also being evaluated for improving establishment of field drilled crops. They are already being used successfully on seed beds for bare root transplanted crops. Verification of cultivations for the July crop is required. Tentative recommendations are available.

Kirton. Hiron, R. W. P. V37 (1978). Use of Xiro as a polythene mulch.
Luddington. VG11/037. Herbicides on transplanted crops under covers.
Luddington. VG11/039. Herbicides on transplanted crops under covers.
Luddington. Bell, P. VG11/004 (1988). Overwintering beds.
Stockbridge House. Senior, D. VG11/047 (1990). Early, production under crop covers.
Stockbridge House. Senior, D. VG11/048 (1990). Field drilled, establishment.
Luddington. Bell, P. HDC project (1987-89). Production under crop covers.
Benoit, F, Ceustermans, N. 1985 Review.
Mayne, A. One week earlier with a double cover. Gemuse 1986, 22:3, 100-102.
Henrikson, K. Covering vegetable seedbeds with plastic film. Meddedelse-Statens-Plantearlsforsog 1985, 87: 1827.
Henrikson, K. Covering outdoor grown vegetables with plastic sheeting. Gartner-Tidende 1986, 102:51, 1703-1705.
Wiebe, H. J. Frost protection by winter covering. Arbeitspapier 1987, No 127, 131-136.
Benoit, F; Ceustermans, N. Spring leeks - Further findings with single and double direct covering. Boer-en-de-Tuinter 1987, 93: 50, 17.

Lettuce

Summary

Trials have concentrated on varieties, time of crop cover removal and types of material for crop covers. The crop responds well to the technique providing management is skilled. Up to three weeks earliness with protection from some pests can be achieved and improved quality. However physiological problems frequently occur due to inadequate management and sudden changes in the weather. Weed control remains a problem, partly due to difficulties in obtaining label recommendations. Light inhibiting mulches or sterilisation with dazomet may be economic in certain circumstances. Investigations have also been carried out on the use of CO_2. Recommendations and guidelines are available.

Kirton. Hiron, R. W. P. V37 (1978). Use of Xiro as a polythene mulch.

Luddington. Birkenshaw, J. E; Dawson, E. M. (1982). Early outdoor lettuce, production under perforated film plastic covers. Luddington Annual Review 1982.

Luddington. Davies, A. C. W. VE04/01316 (1981-84). Crisp lettuce variety trial under polythene films.

ADAS Midland/Western (1981). VE04/07618. Spring production under polythene film of butterhead types.

ADAS Eastern Region (1983-84) VE04/09365. Early variety trial of butterhead and crisp under crop covers.

Efford. Antill, D. (1984-86) VE04/10222. Iceberg, early field production under film covers.

Efford. Antill, D. (1986/87)
VE04/11205. Iceberg, herbicides under film covers.

F/F2/VG05/003. Crisp lettuce, varieties under crop covers.
F/F1/VG05/005. Lettuce, iceberg varieties under film covers.

Stockbridge House. Senior, D. (1988/89) VG25/014. Overwintering beds - field drilled.

Hadley, P; Livermore, D. A. (1988). The effects of carbon dioxide enrichment under plastic film crop covers on the growth and yield of early outdoor crisp lettuce. Dep. of Hort. University of Reading.

Stockbridge House. Antill, D. (1989/90) VG06/019. CO_2 under covers.

Arthur Rickwood. Davies, J. HDC project (1988-). Red lettuce, comparison of film cover materials and removal date for early production.

Stockbridge House. Antill, D; Hembry, J. VG28/010 (1989-). Mulches for weed control.

Stockbridge House. Hembry, J. VG28/011 (1990-). Mulches and covers to reduce pests.

Stockbridge House. Hembry, J. VG28/012 (1990-). Mulches; Successional cropping.

Broek, N-van-den. (1985). Advancing the time of harvest of spinach, lettuce, iceberg lettuce and endive. Groenten-en-Fruit 1985, 40:27, 56-57.

Benoit, F; Ceustermans, N; Rouchaud, J; Vlassak, K. Influence of direct plastic covering upon the quality of carrots and lettuce. Acta-Horticulturae 1984, No 154, 321-328.

Mayne, A. One week earlier with a double cover. Gemuse 1986, 22:3, 100-102.

Everett, P. H. Influence of fertiliser rates and plastic mulch on the production of two cultivars of crisphead lettuce. Proc-Annu-Meet-Fla-State-Hortic-Soc s.l. The Society 1980 v93p, 243-245.

Benoit, F; Ceustermans, N. Iceberg lettuce under single or double direct covering. (1986). Boer en de Tuinder, Vol 92 (7), 22.

Guttormsen, G. Improving the microclimate with plastic. Gartneryrket, Vol 74 (9), 190-191.

Outdoor Tomatoes

Summary

Trials were carried out to evaluate production with the aid of mulches and crop covers including low tunnels with particular reference to PYO. Recommendations and guidelines are available.

Efford. (1979). Polythene mulch comparison.

Efford. Antill, D. VE04/01563 (1980-82). Production under polythene mulches.

Austin, R. B. (1964). Plastic mulches for outdoor tomato crops and a trial of varieties. Experimental Horticulture, No 11, 17-22.

Ochigbo, A. A; Harris, G. P. (1989). Effects of film plastic cover on the growth and yield of bush tomatoes grown in a bed system. Journal of Horticultural Science, 64 (1), 61-88.

Majek, B. A. Oxyfluorfen for weed control in vegetables transplanted through clear plastic mulch and protected by slitted row covers. Proceedings 40th annual meeting of the Northeastern Weed Science Society, 159.

Perry, K. B; Sanders, D. C. Tomato yield as influenced by plant protection systems. (1986). Hortscience, Vol 21 (2), 238-239.

Parsnips

Summary

The use of crop covers centres around production of early roots for a specialised market. Guidelines are available.

Arthur Rickwood. Rickard, P. VG13/004 (1984-87). Varieties and plant populations under plastic films for autumn sown.

Rosewarne. Houghton, B. VG13/013 (1986-87). Observation of maturity period and yield from autumn and spring sowings grown under polythene.

Arthur Rickwood. Rickard, P. VG13/003 (1987). Covering materials and removal date.

Runner Beans

Summary

Trials have been concerned with using clear polyethylene as mulches, crop covers to aid establishment and low tunnels to give earliness. Mulching gave the most consistent results in the South East but low tunnels were favoured in the West Midlands. Both systems give a longer cropping period with up to three weeks earliness compared to bare soil. To gain extra earliness planting out with modules was also studied. Generally the extra gain was not justified economically. Studies have also been carried out in to weed control using various herbicides, light inhibiting mulches and soil sterilants. Black polythene gave good yields and weed control. Under clear polythene a tank mix of diphenamid and chlorthal-dimethyl consistently gave good results. Pendimethalin also showed promise. However obtaining label recommendations may be a problem. A study of soil moisture under mulches was made in 1986. Guidelines and recommendations are available.

Antill, D. VG36/01554. Polythene mulches for extended season cropping. 1979-82.

Antill, D. VG36/05346. Herbicides under mulches 1980-81 and 1985-87.

Antill, D. VE30/07969. Production from modules with mulching techniques 1982-84.

Antill, D. Runner beans, Early production with the aid of low level plastics - A review of work at Efford EHS 1977-1984. Efford Annual Review 1984.

Swedes

Summary

The object of using crop covers was to extend the season by providing early roots for a specialised market. This has enabled continuity of the UK crop from July until March. Trials have been carried out on propagation, sowing/planting dates, varieties and cover removal. Guidelines are available.

Rosewarne. Houghton, B. (1986/87). Early production under polythene.

Rosewarne. Treble, J. C. VG13/012 (1986-88). Early production under floating mulch - Removal date trial 1 spacing and use of modules. Trial 2 removal date, planting date and use of modules.

Ricketson, C. L; Thorpe, J. H. E. Row covers for advancing maturity of carrots and rutabagas. 1985 Annual Report, Research Station, Kentville, Nova Scotia, 99-101. (Rutabagas = swedes).

Sweetcorn

Summary

Using clear polyethylene mulches to guarantee sufficient Ontario units to ripen the crop each year has become standard practice on suitable sites. The crop is one of the few where cheap photodegradable polyethylene can be used successfully. Up to three weeks earliness and a 50% increase in yield is obtained. The use of modules to give extra earliness by transplanting is doubtful economically. Weed control is effective with existing recommended herbicides. Guidelines and recommendations are available.

Efford. Antill, D. VE04/01555. Early production mulch trial 1979-82.

Antill, D. VE04/07853. Different propagation methods/transplanting 1982-84.

ADAS Eastern Region. VE04/05616. Effect of polythene mulching 1981.

ADAS Eastern Region. VE04. Transplanted/mulching/varieties 1983.

Antill, D. VE04/11250. Mulches for early production 1986.

Antill, D. Continuity production of sweetcorn. Efford Annual Review 1982 p 46.

Birdeen, C; Gaullen, A; Aloy, M; Verdu, A. M; Casanas, F; Bosch, L. Maize culture under plastic film. ITEA-Information-Tecnic-Ecnomica-Agrania 1988, 19:79, 7-16.

Izakovic, R. Effect of plastic mulch on the yield and some traits of maize lines. Roslinna-Vyroba 1989, 35:9, 973-980.

Andrew, R. H; Schlough, D. A; Tenpas, G. H. Plastic mulch aid sweetcorn and other vegetable crops on Northern Wisconsen. Des-Rep-Dis-Div-Coll-Agric-Life-Sci-Univ-Wis. Aug 1976, 2838.

Turnips

Summary

Early turnips have been a feature of market gardening under frames for many years. Trials have been carried out for field scale production under crop covers to reduce costs on suitable sites. The work has evaluated sowing date in relation to bolting, varieties and cover removal. Guidelines are available.

Rosewarne. Treble, J. C. VG13/010 (1987-89). Early production using polythene covers.

Other Crops: Trial Work Involving Crop Covers

Asparagus

Luddington. Davies, A. VG21/003 (198). Effect of polythene covers and straw burning on yield and earliness.

Brussels Sprouts

Kirton. Hiron, R. W. P. V37 (1979-80). Plant raising using plant protection films.

Wiebe, H. J. Frost protection by winter covering. Arbietspapier 1987, No 125, 131-136.

Celariac

Benoit, F; Ceustermans, N. 1985 Review.

Chicory

Benoit, F; Ceustermans, N 1985 Review.

Cucumbers - Ridge

Henrikson, K. Covering outdoor grown vegetables with plastic sheeting. Gartner-Tidende 1986, 102:51, 1703-1705.

Gherkins

Benoit, F; Ceustermans, N 1985 Review.

Kohlrabi

Mayne, A. One week earlier under a double cover. Gemuse 1986, 225, 3, 100-102.

Lamb's Lettuce

Benoit, F; Ceustermans, N 1985 Review.

Melon

ADAS Midlands/Western. VE04/04572 (1981-82). Outdoor production on mulches.

Majek, B. A. 1986. Oxyfluorfen for weed control in vegetables transplanted through clear mulch and protected by slitted row covers. Proceedings 40th annual meeting of the Northeastern Weed Science Society 159.

Wells, O. S; Loy, J. B. Intensive vegetable production with row covers. (1985). Hortscience, Vol 20, 822-826.

Onions - Bulb

Spring sown.

Efford. Antill, D.) VG11/044 (Overwintering
Stockbridge House. Senior, D.) (1986-90) Beds)
Stockbridge House. VG28/010. Mulches to control weeds (1989-).
Henrikson, K. Covering vegetable seedbeds with plastic film. Meddedelse-Statens-Plantearlsforsog 1985, 87: 1827.

Parsley

Henrikson, K. Covering vegetable seedbeds with plastic film. Meddedelse-Statens-Plantearlforsog 1985, 87, 1827.

Haseli, A; Konrad, P. Nets as an alternative vegetable protection method. Landtechnik 1987, 42:9, 358-361.

Radicchio

Arthur Rickwood. Davies, J. VG06/007 (1987-89). To examine cultural methods for early production.

Radish

Benoit, F; Ceustermans, N. 1985 Review.

Eichin, R; Deiser, E; Buhl, R. Nets and covering membranes against vegetable flies. Deutscher-Gartenbau 1987, 41:4, 206-213.

Rhubarb

Stockbridge House EHS (1980), VE04/01245. Early field forcing of Timperley Early in low tunnels using 3 types of plastic.

Spinach

Stockbridge House EHS. Harriman, M. VG21 (1989).

Broek, N-van-den (1985). Advancing the time of harvest of spinach, lettuce, iceberg lettuce and endive. Groenten-en-fruit. 40:27, 26-57.

Haseli, A; Konrad, P. Nets as an alternative vegetable protection method. Landtechnik 1987, 42 9:3, 58-361.

Other Crops on which Crop Covers are used

Beetroot
Coriander
Salad Onions
Marrows
French Beans

Use of Crop Covers to Prevent Pest Damage

The value of using polypropylene and net crop covers to reduce insect pest damage has been recognised in Europe and other countries for a number of years. For early planted crops polyethylene will also protect crops against birds and mammals.

In Switzerland trials commenced in 1982 with fine nets for summer cropping. The system was quickly taken up in Germany and there is also experience in France using polypropylene.

Pressure from environmental groups, public concern over residue levels and a diminishing range of insecticides that are approved for use on field vegetables have all increased the need to search for alternative methods of controlling or preventing attack by insect pests.

Nets are expensive, but will last up to four or five years; the task of rolling or folding up and keeping until next season is labour intensive and causes storage difficulties. The introduction of strong lightweight nonwovens which are cheaper has encouraged UK growers to give more consideration to using crop covers in order to reduce their dependency on chemicals.

Observations commenced at Efford in 1986 and more recently at Arthur Rickwood in 1988. In 1989 trials commenced at Arthur Rickwood, Stockbridge House and ADAS Cambridge evaluating the effectiveness of nonwoven crop covers in preventing damage by insect pests.

Provisional results regarding cabbage root fly, carrot fly and lettuce root aphid were promising. Trials were repeated and extended in 1990 and results continue to give encouragement.

Considerable further research and development is needed into types of material, effect on diseases, crop cultivations and husbandry, varieties, yields and quality of produce, before firm guidelines and recommendations can be made. However there is every indication that for specific insect pests and crops, crop covers could play an important roll in integrated programmes in the future.

Gerst, J. J. Growing vegetable crops under direct covers. 1985, page 68.

Natwick, E. T; Durazo, A. Polyester covers protect vegetables from whiteflies and virus diseases. California Agriculture 1985. 39: 7/8, 21-22.

Antill, D; Davies, J. The use of nonwoven crop covers to prevent insect pests on field vegetables. 1990 BCPC Mono No 45, Organic and low input agriculture.

Antill, D; Senior, D; Blood Smyth, J; Davies, J; Emmett, B. Crop covers and mulches to prevent pest damage to field vegetable. 1990 BCPC Conference on Crop Protection.

Matthews - Gehringer, D; Hough - Goldstein, J. A. Physical barriers and cultural practices in cabbage maggot management on broccoli and chinese cabbage. Journal of Economic Entomology 1988, 81:1, 354-360.

Eichen, R; Deiser, E; Buhl, R. Nets and covering membranes against vegetable flies. Deutscher-Gartenbau 1987, 41:4, 206-213.

Huber, P. Nonwoven fabrics and plastic nets for vegetable crop protection. Plasticulture 1989, No 81, 33-36.

Gerst, J. J. Plastic sheeting, diversification of applications. Infos-Paris, 1989, No 52, 12-17.

Haseli, A; Konrad, P. Nets as an alternative vegetable protection method. Landtechnik 1987, 42:9, 358-361.

Folster, E. The use of nets, films and foils. Gb -+- Gw 1988, No 83, 23-324

Gomez, C; Broun, J; Lambe, R. C. Crop row covers exclude insects that vector virus diseases of vegetables. National Agricultural Plastics Association 1989 (21st), 297-300.

Sorensen, K. A. Evaluation of plastic film and row covers for vegetable insect management in North Carolina. National Agricultural Plastics Association 1989 (21st), 222-227.

Use of Mulches to Reduce Damage by Pests, Diseases and More Efficient Use of Nutrients

Traditionally clear polyethylene mulches have been used to warm the soil in order to improve plant growth and light inhibiting mulches have been used to control weeds and conserve moisture. Other benefits have been observed such as cleaner crops (avoidance of mud splash), improved establishment, reduced damage by specific pests and diseases and less leaching of nutrients, especially nitrogen. With concern over residue levels of pesticides, nutrients and more stringent MRL's in produce and water interest in using mulches has dramatically increased.

Frit fly on sweetcorn, cabbage root fly on brassicas, various winged aphids on lettuce and brussels sprouts are examples where damage has been reduced when specific mulch types or colours have been used. It is also possible that the incidence of some diseases may be reduced if part of their life cycle relies on access to and from the soil surface.

In trials commenced at Stockbridge House EHS in 1989 polyethylene mulches reduced the leaching of nitrogen. There is promise that mulches could play an important role in integrated programmes that will reduce damage caused by certain pests, diseases and the more efficient use of nitrogen. The reduced leaching and saving of nitrogen fertilisers could be sufficient to be important economically. More research and development is required before firm guidelines and recommendations can be made.

Clarkson, V. A. (1990). Effect on black polyethylene mulch on soil and microclimate temperatures and nitrate level. Agron J. 52, 307-309.

Stockbridge House EHS. Antill, D. (1989-) VG28/010. Weed control using mulches.

Stockbridge House EHS. Hembry, J. (19900) VG25/015. Mulches: Reducing nitrogen rates of fertiliser.

Stapleton, J. J; Quick, T; Delaney, J E. Soil solarisation: Effects on soil properties, crop fertilisation and plant growth. Soil Biology and Biochemistry 1985, 17:3, 369-373.

Folster, E. (1988). The use of nets, films and foils. Gb + Gw 1988, No 8, 323-324.

Cai, S. Z; Chen, J. M. (1983 & 1984). Studies on the dry matter accumulation and absorption and distribution of nutrients in tomato with polyethylene film mulches. Journal of Soil Sciences No 5, 26, 33-36.

Comporota, P; Baudrand, M; Tanssig, C. Basal rot of lettuce caused by rhizoctonia solani, tests of treatment in the field (with mulches). Revue Horticole No 271, 33-38.

Schalk, J. M; Robbins, M. L. R. Reflective mulches influence plant survival, production and insect control in fall tomatoes. Hortscience 1987, 22:1, 30-32.

Recommendations for Future Research and Development

It is easy to make a long list of ideas for research and development by looking through the subject and crop sections. Many of the ideas are valid horticulturally and scientifically. However, the prime consideration for HDC is the growers' interest and any experiments that are commissioned need to be directly related to making the industry more efficient, better able to compete with imports, keeping abreast technically and profitable. Low level plastics have a part to play in these aims for field vegetable production and future research and development should concentrate on work in the following categories:

* Keeping abreast with new materials

* Solving cultivation and husbandry problems

* Developing new techniques and ideas

* Improving continuity and quality of produce

* Specific problems with individual crops

New Materials

As technology increases on the manufacturing of materials specifications change. It is in the growers interest that an on going programme monitors materials as new ones become available. Trials should be carried out on crop covers and mulches to evaluate:

* Degradability and durability

* Light transmission

* Re-use

* Handling and machinery compatibility

* Temperature, including frost protection

* The effect of various mulches on ground frost

Cultivations and Husbandry Problems

Good soil structure is essential for the success of crops under crop covers. Any soil problems are exaggerated and lead to physiological problems. For many crops weeds are a limiting factor and their control is often linked with soil cultivations. Establishment from field drilling of early crops also remains uncertain and can cause difficulty with continuity. There has been comparatively little research and development that has studied the relationship between soil structure, SMD and plant growth. In order to improve quality and make the most economically of crop covers further investigations are required. Experiments are envisaged under the following topics:

1. The effect of SMD, seed or plant bed cultivations and time of covering on weed control and crop performance.

2. The effect of seed bed cultivations and type of cover on the establishment of early field drilled crops.

3. Rates of fertiliser under crop covers, effect on yield and quality.

4. A study into ways and means of effecting disposal of plastics.

New Techniques and Ideas

The industry needs to keep abreast with innovations and new techniques and to be able to prove them under commercial field conditions before they are launched in to large scale production. It is very important that practical problems are overcome before large investment is made.

Because of pressure from environmental groups and a diminishing number of chemicals available to growers alternatives to pesticides need to be tried.

1. Reducing Damage by Insect Pests and Diseases

Field trials are necessary to evaluate crop covers and mulches to reduce damage by insect pests and diseases. Preliminary results are promising but further work is required on the following topics:

* Varieties
* Cultivations
* Costs
* Evolving integrated programmes
* Crop cover type

2. Using Less Nitrogen Fertiliser

Trials are necessary to evaluate mulches to reduce rates of nitrogen fertiliser.

3. Solarisation

Evaluating the potential of the technique in the UK. Solarisation requires investigation and verification in this country. The technique could play an important role in an integrated programme.

Continuity and Quality

1. Predicting maturity scheme requires extending to the relevant crops grown with crop covers:

    * Calabrese
    * Cauliflower
    * Lettuce

2. Microclimate studies required on:

    * CO_2 levels
    * Plant temperature
    * Light levels

The experiments need to relate to the quality of produce in particular and how the above factors effect physiological problems.

Individual Crops

Problems that require further trial work on individual crops:

Runner Beans	Weed control Comparison between mulches and low tunnels
Red Lettuce	Varieties Crop covers Nitrogen rates
Courgettes	Type of mulch Frost protection
Chinese Cabbage	Quality of early crops
Celery	Early production - Green varieties - Weed control - Aphid control
Leeks	Early production - Cover type
Rhubarb	Early Outdoor production from crop covers

Acknowledgments

I wish to record my thanks to Miss A Darley for typing and preparation of the report. To Dr D Grey and Mr M Wood for their help in editing the script.