Agricultural Development and Advisory Service

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CONTRACT REPORT

No. FV 2a/29/87

Early calabrese production

using crop covers

Undertaken for HDC

PRINCIPAL WORKERS

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AUTHENTICATION

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

.....R F Clements.....

Signature

R F Clements
Director Efford EHS
October 1988

Report authorised by: .....R F Clements.....

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CONTENTS

EARLY CALABRESE PRODUCTION USING CROP COVERS (1988)

Summary

The trials were undertaken at Efford EHS on the production of early calabrese. The objectives of the main trial were to evaluate two types of covering material and two cover removal dates for improvements in the earliness, yield and quality of two varieties of calabrese when compared with a bare soil control crop. A range of plant densities were also assessed. A second smaller trial assessed the suitability of four varieties for production under crop covers again using two materials but with a standard removal date and crop density.

The use of either nonwoven or perforated polythene crop covers gave an improvement in earliness of 17 days over bare soil, with the nonwoven cover producing a slightly higher marketable yield.

There was no further gain in earliness yield or quality by delaying cover removal beyond a head diameter of 10 mm. Cropping at the closest spacing of 30 x 20 cm resulted in a highly significant mean increase in yield of 0.75 t/ha across both the varietiieies used in the trial. The increased yield was not to the detrement of quality although the size of individual heads were reduced at the closest spacing.

Results from the variety trial were inconclusive as a high level of bolting produced low marketable yields in all but one of the four varieties under test, the exception being the variety Primer 70.

Introduction

Demand for calabrese has risen steadily over recent years. The natural season for home production is from the middle of June until frost curtails the crop in the autumn. Whilst imports satisfy demand overwinter and early spring, quality is often inadequate during early summer, at a time when many other vegetables are in short supply in the gap between overwintered and summer crops. Clearly there is a need to produce high quality early calabrese to extend the English season.

As a general technique previous ADAS trials have indicated that the correct use of low level crop covers could advance the season by up to 14 days so that cropping in southern areas could begin in early June.

An extensive trial to evaluate the use of crop covers for the production of early calabrese was undertaken during 1987 by ADAS on behalf of the HDC. The trial which was located at Efford EHS clearly demonstrated the improved earliness that could be achieved by the use of crop covers; covered plots cropping 11 days earlier than bare soil plots. Cover type and removal date in relation to the stage of development of the crop were also investigated during 1987 as was plant density. During 1988 a further two trials were undertaken at Efford EHS both to confirm and expand on the previous years findings. These trials are subsequently referred to as the 'Main trial' and 'Variety trial'.

The main objectives of these trials were:-

Main trial

(i) to compare the use of crop covers with bare soil for earliness, yield and quality.

(ii to evaluate 2 types of covering material; a nonwoven and perforated clear polythene.

(iii) to determine the optimum growth stage for cover removal.

(iv) to compare 3 plant densities and their effect on earliness, yield and quality.

Variety trial

(i) to assess the suitability of four varieties for early production using 2 cover types (as ii above) with a single cover removal date and crop density.

The findings of these studies are reported here.

Materials and Methods

Site

Both main and variety trials were carried out at Efford Experimental Horticulture Station, Lymington, Hampshire.

The soil on which the trial was sited was a very slightly stony sandy silt loam of the Waterstock series.

Husbandry

Seed for both trials was direct sown into Hassy 308 trays at a rate of one seed per cell, on the following dates:

Main trial	**15 February 1988**
Variety trial	**22 February 1988**

subsequent propagation and growth in the field was as near to standard commercial practice as possible. (For a full crop diary and cultural notes refer to Appendix II page 32).

Treatments (Main Trial)

Varieties

1. Mercedes
2. Southern Comet

Environments (crop covers)

1. Perforated clear polythene (Coverall, 500 x 10 mm holes/m^2, 50 microns

Removal of crop covers

1. Cover removal 1 at a head diameter of 10 mm.
2. Cover removal 2 at a head diameter of 20-30 mm.

Note: The stages of growth at which covers were removed detailed above differ from those in year one (1987) of this trial.

In 1987 cover removal 1 coincided with a head diameter of 20-30 mm (as 2 above) whilst cover removal 2 in 1987 was at or close to the point of first harvest.

In 1988 cover removals 1 and 2 were therefore at earlier stages of development.

Spacings

A standard 5 rows per 1.83m bed was used with 30cm between rows. Within row spacings were as indicated.

1. 30 x 20 cm
2. 30 x 30 cm
3. 30 x 37 cm

Treatments (Variety trial)

Varieties.

1. Southern Comet
2. Dixie
3. Packman
4. Primer 70

Environments (crop covers).

1. Perforated clear polythene (Coverall, 500 x 10 mm holes/m^2, 50 microns thick, 10m wide).
2. Nonwoven (Agryl, 16g/m^2, 10.5m wide)

Removal of crop covers.

Only one cover removal date was used coincident with a mean head diameter of 20-30 mm (equivalent to removal 2 from the main trial).

Spacing.

A standard spacing of 30 x 37 cm was used.

Experimental design

Both main and variety trials used a split plot design with all treatments having 3 replicates (for trial plan refer to Appendix III page 35).

Assessments

The following assessments were made for each treatment in both main and variety trials:-

Total yield (t/ha) and graded yield based on head diameter in the following categories < 50mm, 50-75mm, 75-100mm and > 100mm. All spears were trimmed to a length of 100mm prior to recording.

Waste as a % of the total.

Distribution of butt diameters in size grades < 15mm, 15-30mm, 45-60mm and > 60mm expressed as a % of the total.

Distribution of head diameters in size grades < 50mm, 50-75mm, 75-100mm and 100mm expressed as a % of the total.

In addition to these quantitative records certain qualitative assessments were made in relatioion to head characteristics, these were:- bud size, bud colour (variety trial only), Head shape, Cluster separation and angle of branching (for a key to these characteristics refer to Appendix IV page 38).

Note: The number of harvests per plot were restricted to three. The first and second harvests were to clear the bulk of the primary heads. The third harvest, if required was designed to take any missed primary heads and any secondary heads exceeding 100mm in length. However, an insignificant number of secondary heads were harvested and therefore not recorded.

Soil and air temperature data were also collected using a Squirrel data logger (Grant Instruments Ltd).

Statistical analysis

All data were subjected to a full analysis of variance.

Results: Main trial

Cover removal

The use of perforated clear polythene as a crop cover resulted in more rapid early growth of the crop. The stage of growth designated for removal one (head diameter of 10 mm) was therefore achieved two days earlier under polythene when compared with the nonwoven cover (Table 1).

Table 1. Date of cover removal

	Clear polythene	Nonwoven
Removal 1 (head diameter 10 mm)	22 May	24 May
Removal 2 (head diameter 20/30 mm)	31 May	31 May

The growth stage required for removal 2 (head diameter 20-30 mm) was achieved on the same date using both polythene and nonwoven covers (table 1).

The rapid early growth under polythene was probably attributable to the higher air temperatures experienced by the crop (Table 1b). Although the nonwoven cover resulted in slightly higher soil temperatures, both cover types were significantly warmer than bare soil plots.

Table 1b. Accumulated Day Degrees > 6^0C from 20 April to 21 June

Environment	Soil (75 mm deep)	Air/ground interface
Bare soil	481	507
Nonwoven	585	581
Polythene	575	603

First harvest

The use of crop covers advanced the date of first harvest by 17 days compared with bare soil (Table 2).

Table 2. Date of first harvest

	Polythene		Nonwoven		Bare soil
Variety	Removal 1	Removal 2	Removal 1	Removal 2	
S. Comet	3 June	3 June	3 June	3 June	20 June
Mercedes	3 June	3 June	3 June	3 June	20 June

The growth stages at which the covers were removed however had no effect on the date of first harvest. There was also no effect of variety or within row spacing on first harvest dates.

Marketable and Unmarketable yield

Varieties: The variety Southern Comet gave the highest total marketable yield and the lowest unmarketable yield (Table 3) when considered as the average of all treatments.

Table 3

Total marketable and unmarketable yields (t/ha) for each variety averaged across all treatments.

Variety	Marketable yield	Unmarketable yield
S. Comet	4.2	0.31
Mercedes	3.8	1.30
SED = (d.f. = 40)	0.15	0.18

The unmarketable material was almost totally attributable to bolting within the crop. The level of spear rot within the trial was negligible; possible reasons for a reduction in the incidence of spear rot compared with the level recorded in the first year of this trial are discussed later (see page 21).

Environments: The use of a nonwoven cover produced higher marketable yields than either bare soil plots or those with polythene covers. With the variety Southern Comet the highest yield was achieved if the nonwoven cover was removed when the crop had an average head diameter of 10 mm (Removal 1, Table 4).

Table 4

Comparison of environments: Total marketable yield (t/ha) of primary heads. (means of spacings)

Environment	Variety	
	Southern Comet	Mercedes
Nonwoven		
Removal 1	4.85	4.02
Removal 2	4.34	4.05
Polythene		
Removal 1	4.29	3.76
Removal 2	3.43	3.47
Bare soil	4.08	3.73

SED = 0.263

(d.f = 40)

The same trend was evident when using polythene covers on the variety Southern Comet. The time at which either nonwoven or polythene covers were removed from the variety Mercedes had no significant effect on yield (table 4).

Spacings: The closer spacing of 30 x 20 cm consistently gave higher total marketable yields in both varieties Southern Comet and Mercedes (Table 5).

Table 5

Comparison of spacings: Total marketable yield (t/ha) of primary heads (means of environments)

Spacing (cm) Between x within row	Variety	
	Southern Comet	Mercedes
30 x 20	4.91	4.36
30 x 30	3.95	3.81
30 x 37	3.74	3.25

SED (Between spacings) = 0.281 (d.f. = 40)

SED (Between varieties) = 0.258 (d.f. = 40)

However, as the plant density increased the proportion of heads falling within the smaller size grades (< 50mm and 50-75mm) increased, with few, if any heads in the largest category of > 100mm.

Note:

A full comparison of both graded and total marketable yields for all the treatments can be found in tables A and B for varieties Southern Comet and Mercedes respectively (Appendix V page 40-41).

Distribution of butt and head diameters within size grades

Butt diameter: In general the distribution of butt diameters within the size grades was not significantly influenced by the treatments. However, within the smallest size grade (butt diameter < 15 mm) the largest proportion was attributable to plants grown at the closest spacing of 30 x 20 cm. Whilst this result may have been anticipated it should be interpreted with caution as few if any butts fell within the larger size grades. A full comparison of the effect of all treatments on butt diameter is given in tables C and D for varieties Southern Comet and Mercedes respectively (Appendix V page 42 and 43).

Head diameter: As with butt diameter the distribution of head diameters within the size grades was not consistently influenced by the treatments. Growing the crop at the widest spacing of 30 x 37 cm did however, result in a larger number of heads in the 75-100 mm category. A full comparison of the effect of all treatments on head diameter is given in tables E and F (Appendix V page 44 and 45).

Qualitative assessments of head charactertistics

Bud size: When considered across all treatments Southern Comet tended to produce larger buds than the variety Mercedes. Plants grown on bare soil plots also tended to produce larger buds than those covered by either a nonwoven or polythene cover. The small influence of cover removal date and within row spacing on bud size was not consistent across the trial. A full set of treatment comparisons can be found in Appendix V tables G and H for varieties Southern Comet and Mercedes respectively, (page 46 and 47).

Cluster separation: The variety Southern Comet produced fewer bud clusters than Mercedes. A high incidence of bud clustering was evident when the variety Mercedes was grown at a spacing of 30 x 37 cm under polythene and the polythene was removed when the crop attained an average head of diameter of 20mm (Removal 2). The value of 3.6 recorded from this treatment (Appendix 5 table H, page 47) was significantly lower than that for any other treatment and should therefore be viewed with caution. No further significant treatment effects on cluster separation were recorded (see tables G and H page 46 and 47).

Head shape: When grown at the closest spacing of 30 x 20 cm the variety Southern Comet produced deeper heads than Mercedes. In both varieties deeper heads tended to be produced at the closer spacings. Whilst bare soil plots generally produced shallower heads than either polythene or nonwoven covers, removal 2 of the polythene cover produced the shallowest heads in both varieties. (see tables G and H pages 46 and 47).

Angle of branching: Branching within the primary heads was widest in the bare soil plots. (tables G and H). This is consistent with the finding that the bare soil crop had shallower heads. No further consistent effects of treatment on the angle of branching were recorded (see tables G and H).

Results: Variety trial

Preparation of the trial site and transplanting the trial was preceeded by one of the wettest periods in April at Efford EHS. The day on which the heaviest rainfall occurred was that of transplanting itself (20 April) when 18.4 mm fell later in the day (see APPENDIX VI). Site conditions were therefore poor at transplanting as was subsequent crop establishment with a high incidence of bolting in certain varieties. Marketable yields were therefore depressed by comparison with the earlier sown (**main trial**). This is best demonstrated by comparing the total marketable yield of 1.38 t/ha for Southern Comet achieved in the **variety trial** (table 6) with an average figure for the same variety of 4.2 t/ha recorded in the **main trial** (table 3).

Table 6.

Graded and total marketable yields of primary heads (t/ha)

Cover type	Variety	Graded yield/head diameter(mm) < 50	50-75	75-100	> 100	Total marketable yield	Waste as a % of total
Polythene	S.Comet	0.11	0.36	0.63	0.28	1.38	67.3
	Dixie	0.73	1.51	0.63	0.06	2.94	38.2
	Packman	0.06	0.90	0.85	0.20	2.01	58.5
	Primer 70	0.47	1.80	1.36	0.00	3.64	0.0
Nonwoven	S.Comet	0.22	0.79	0.65	0.07	1.72	61.4
	Dixie	0.74	1.87	0.78	0.09	3.48	23.6
	Packman	0.09	1.89	0.41	0.00	2.39	55.3
	Primer 70	0.57	2.55	1.00	0.00	4.13	0.0
SED (d.f = 12) =		0.089	0.390	0.323	0.119	0.509	6.50
Except when comparing means with the same cover then SED =		0.100	0.411	0.366	0.103	0.549	7.50

Marketable and Unmarketable yield

A first harvest date of 6 June was common to all four varieties under both nonwoven and polythene covers.

The use of a nonwoven cover gave rise to higher marketable yields with all four varieties when compared to yields achieved using polythene, differences however, were not always statistically significant. The highest yields by far were achieved with the variety Primer 70 which consequently produced no recordable waste. This was in stark contrast to Southern Comet where yields were poor with an average of 64% being waste (table 6). The waste being almost totally attributable to bolting.

Distribution of Butt and Head diameters within size grades

Butt diameter: The variety Dixie had a high percentage of spears within the smallest category (< 15mm) when grown under a polythene cover. This was not the case when considering the nonwoven, where Southern Comet produced the largest number of spears of butt diameter 15 mm or below (table 7). The majority of spears from all four varieties fell within the size grade 15-30 mm. Within the larger size grade (30-45 mm) the greater percentages were attributed to Southern Comet and Dixie grown under polythene and the varieties Dixie and Primer 70 under a nonwoven cover. No butts exceeding a diameter of 45 mm were recorded (table 7).

Table 7.

Distribution of butt diameters in various size grades expressed as a % of the total.

Cover type	Variety	Butt diameter (mm) < 15	15-30	30-45	45-60	>60
Polythene	S.Comet	19.0	49.9	21.1	0.0	0.0
	Dixie	25.1	57.8	18.8	0.0	0.0
	Packman	13.2	76.8	0.0	0.0	0.0
	Primer 70	5.3	76.8	8.3	0.0	0.0
Nonwoven	S.Comet	23.3	66.7	0.0	0.0	0.0
	Dixie	12.6	60.0	26.7	0.0	0.0
	Packman	16.6	73.4	0.0	0.0	0.0
	Primer 70	6.1	65.3	22.5	0.0	0.0
SED (df = 12)	=	8.73	8.84	11.75	0.0	0.0
Except when comparing means with the same type of cover then SED	=	9.24	8.82	10.51	0.0	0.0

Head diameter: The variety Dixie had the highest percentage of heads in the smallest size grade of < 50mm, when grown under both polythene and nonwoven crop covers. The largest number of heads for all four varieties felol within the size range 50-75mm this was most evident with the variety Primer 70. Little significant difference between varieties was recorded when comparing the % of heads in grade 75-100 mm with the exception of Primer 70 grown under polythene which was slightly higher than the average at 29% (table 8). Few heads exceeded a diameter of 100mm.

Table 8

Distribution of head diameters in various size grades expressed as a % of the total.

Cover type	Variety	Head diameter (mm) <50	50-75	75-100	>100
Polythene	S.Comet	12.3	19.3	20.3	8.9
	Dixie	43.1	34.2	16.1	3.0
	Packman	11.4	30.4	22.7	7.3
	Primer 70	28.8	46.0	29.3	0.0
Nonwoven	S.Comet	22.5	28.1	19.4	3.0
	Dixie	40.7	37.3	18.4	3.0
	Packman	8.2	44.4	15.8	0.0
	Primer 70	29.5	51.1	22.4	0.0
SED (d.f = 12)	=	4.96	6.10	4.74	4.10
Except when comparing means with the same type of cover then SED	=	5.31	6.88	5.36	3.46

Qualitative assessments of head characteristics

Bud colour: The use of polythene produced buds of a slightly lighter colour in the varieties Dixie and Primer 70 (table 9).

Bud size: When comparing all four varieties the smallest buds were produced by the variety Dixie; those under polythene being significantly smaller than when using a nonwoven cover. Southern Comet also produced smaller buds when grown under polythene.

Cluster separation: The level of cluster separation was greater in heads of the variety Dixie when grown under polythene (table 9). No further significant differences in the level of cluster separatioan were recorded.

Head shape: When covered with either polythene or a nonwoven cover the variety Primer 70 produced the shallowest heads (table 9). The variety Dixie produced significantly deeper heads when grown under a nonwoven cover.

Angle of branching: The narrowest angle of branching was measured in the variety Southern Comet grown under polythene. When grown under a nonwoven cover however, the angle of branching was significantly wider. The same effect of cover type was also recorded for the variety Dixie.

Table 9

Qualitative assessments of head characteristics

Cover type	Variety	Bud colour	Bud size	Head shape	Cluster separation	Angle of branching
Polythene	S.Comet	7.0	6.7	5.9	6.7	3.6
	Dixie	6.9	3.0	5.7	5.1	6.8
	Packman	6.9	6.5	5.1	5.1	6.4
	Primer 70	6.8	6.8	4.8	6.9	6.6
Nonwoven	S.Comet	6.9	7.3	5.6	7.4	5.3
	Dixie	7.2	3.6	6.8	6.5	8.1
	Packman	6.9	6.2	4.6	5.8	6.4
	Primer 70	7.1	6.6	4.6	6.7	6.8
SED (d.f. = 9)	=	0.13	0.35	0.26	0.65	0.59
Except when comparing means within the same type of cover; then SED	=	0.16	0.39	0.25	0.61	0.54

(For a key to quality characters see APPENDIX IV page 38).

Discussion

Main trial:

The total rainfall for January 1988 recorded at Efford EHS was some 170.9mm compared to the much drier (15.8 mm) colder January of 1987. (APPENDIX VI). Despite this very heavy rainfall early preparation of the trial site was able to proceed as planned. Soil conditions however, prevented the site being worked to the desired level, with the result that conditions were not ideal at the time of transplanting. The absence of many ground frosts in the latter part of 1987 and during January 1988 also gave rise to a poorer soil structure.

All nitrogen was applied in the base at the presence of covers prevented the top dressing of the majority of treatments. Unlike the first year of this trial (1987) where the same procedure was adopted no nitrogen deficiency symptoms were observed in the crop.

A high incidence of hollow stem recorded in 1987 was attributed, at least in part, to low Boron levels in the soil. Whilst the presence of hollow stems may be influenced by a range of climatic and soil conditions an application of Solubar at a rate of 10 kg/ha prior to transplanting in 1988 resulted in only three hollow stems being recorded. In all respects the crop showed normal growth.

Both Polythene and Nonwoven covers produced a taller, more lush growth habit than the bare soil plots. Early growth was slightly faster under the perforated polythene cover with these plants achieving a head diameter of 10mm (Removal 1, table 1) two days earlier than those grown under the nonwoven cover. This observation was probably as a result of the higher temperatures experienced by the plants under the polythene (table 1b). No difference in the time taken to achieve the growth stage for Removal 2 (head diameter 20 mm) or the date of first harvest. As both removals 1 and 2 gave an excellent result, with the first harvest being 17 days earlier than that on bare soil plots.

There would appear to be no advantage gained by leaving the covers on beyond a head diameter of 10mm. Removal of the covers at earlier stages of growth (page 5) appeared to reduce the incidence of spear rot which had been a problem in 1987 particularly when covers were left on until first harvest. The high level of spear rot encountered in the first year of the trial was probably due to high humidity levels under the covers resulting from their later removal. When required, irrigation was used after cover removal to help wean the plants.

Environments: Whilst the use of Nonwoven covers generally resulted in slightly higher marketable yields this benefit must be set against the additional cost incurred when using materials of this type. The cost in materials of covering 1ha would typically be:

Nonwoven (Agryl)	£1,196
Perforated polythene (coverall)	£ 758

The cost of labour must be added to this. It has been estimated that on average a gang of four people could cover an acre to acre and a half in 1 hour (1 ha = c. 3 hours). It must also be remembered that a cost will be incurred for cover removal that may be equal to or greater than that for laying the covers. This will depend on whether covers are to be re-used or simply destroyed. As with any operation of this type the individual grower will need to undertake a full economic appraisal before proceeding. The use of Nonwoven covers does however allow a greater degree of flexibility as increased air movement reduces the possible effect of high humidities and excessive day temperatures normally experienced close to cover removal. Timely removal of nonwovens although important is perhaps therefore not or critical as when using perforated polythene as a crop cover.

Spacings: The closest spacing of 30 x 20 cm resulted in a significant increase in marketable yield. Taken as a mean of the two varieties the increase above that achieved at a spacing of 30 x 30 cm was 0.75 t/ha. This result is highly consistent with that of the previous year where at the closest spacing of 30 x 30 cm a mean increase in yield of 0.8 t/ha was recorded above that for 30 x 37 cm. The increased plant density at 30 x 20cm did not significantly influence quality although individual spears tended to have smaller butt and head diameters; a result which may have been anticipated.

Variety trial:

Poor soil conditions at transplanting have already been cited as the most likely cause of the high incidence of bolting and hence low marketable yields recorded in this trial (see page 13). A few general observations however may be made.

The first harvest date of 6 June was common to all four varieties under both nonwoven and polythene covers. However, as all four varieties were under one cover, management of the crop could not be tailored to the needs of individual varieties. The use of a nonwoven cover, as with the main trial, resulted in an increase in marketable yield. Under the poor conditions described the variety Primer 70 performed the best with the highest marketable yields and a negligible level of bolting.

Conclusions

This trial served to confirm and expand on the findings reported for the first year of this study: The following general conclusions may be drawn.

1. The use of either nonwoven or perforated polythene crop covers advanced the date of first harvest by 17 days over that for bare soil.

2. The nonwoven cover resulted in slightly higher marketable yields.

3. No advantage was to be gained in terms of yield, earliness or quality by leaving covers in place beyond an average head diameter of 10mm (Removal 1).

4. The closest spacing of 30 x 20cm produced a highly significant mean increase in yield of 0.75 t/ha. Spacing had no effect on earliness or any consistent influence on quality over and above a mean reduction in butt and head diameter.

5. Adopting the techniques described here with a suitable early variety should allow the production of high quality calabrese to begin in the last week of May.

Recommendations for 1989

Whilst the current study has been completed under the terms of the original contract the following recommendations for future work are made:

1. In order to exploit covers to their maximum varieties need to be covered independently.

2. A range of newer varieties should be evaluated as to their suitability for early home production under crop covers.

APPENDICES

Storage of Data

The raw data will be stored by the Director at Efford EHS, Lymington, Hants, SO41 OLZ for a period of ten years. HDC will be consulted before disposal.

Contract between ADAS (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

PROPOSAL

1. Title of project FV/2a/87.

Calabrese. Use of plastics to extend marketing season.

2. Background

3. Objective of this project

To evaluate types of film cover, removal time and compare early varieties for early production of calabrese.

4. Potential benefit to the Industry

5. Closely related work already completed or in progress

6. Description of the work

Treatments: Film covers Perforated clear plastic 500 x 10mm holes/m^2. Fibrous 16 g/m^2.

Mulch Clear polythene; crop planted through.

Removal of Film Cover At curd initiation. 10-7 days from harvest (clear polythene) at first harvest (fibrous).

Spacing (split plot) 375 mm x 300 mm (4 rows per 1.83 m bed)

300 mm x 300 mm (5 rows per 1.83 m bed)

Control Bare soil.

Varieties Mercedes
Southern Comet
SG1

Layout: Three replicates with a randomised design.
Film covers to be wide sheets. Used in blocks of three plots to cover the three varieties at once.
40 recordable plants per sub plot.

Culture: Transplants to be raised in Hassy 308 modules, 1 seed per cell, sowing mid February for planting early April.
Base fertiliser: 250:150:150 kg/ha NPK according to soil analysis Herbicide. Propachlor + chlorthal-dimethyl post planting and pre-mulching (pre planting).

Records: Diary.
Stage of growth scores; 3 and 6 weeks after planting.
Yield data. Totals in t/ha. Crop to be graded according to market standards.
Temperature data.

7. Commencement date and duration

Start 1.2.87, duration two years.

8. Staff responsibilities

Project leader D N Antill. Supported (see 10) by SO, ASO and farm staff.

9. Location

Efford EHS.

10. Costs

The following schedule of costs has been agreed:

	Per day rate £	Man Days	£
Technical Officer	110	8	880
SO	87	5	435
ASO	56	32	1792
-Farm Staff Foreman	45	9	405
-Chargehand	41	14	574
-Craftsman	38	30	1140
-Tractor Driver (machinery operations)	41	2	82
Materials			353
			£5661

11. Payment

On each Quarter-day the Council will pay the Contractor in accordance with the following schedule:

Project year	1	2	3
	£5,661	£5,661	
Quarter/Year	1987	1988	1989
1	944	1,415	472
2	1,415	1,415	
3	1,415	1,415	
4	1,415	1,415	

12. The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s) Signature.....
Position.....
Date.....

Signed for the Contractor(s) Signature.....
Position.....
Date.....

Signed for the Council Signature.....
Position.....
Date.....

TERMS AND CONDITIONS

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1. The work to be done and the dates and amount of payment are set out on the first pages of this form and in the attached schedule.

2. MAFF cannot undertake to provide services of this type for you alone.

3. The customer will be free to publish the results generated by his sponsored treatments together with data from standard treatments without requiring MAFF permission, but any mention by you of MAFF must be approved in advance in its context by MAFF and you will not make any reference to MAFF without obtaining such approval. MAFF will not publish the results of the customer's sponsored treatments without obtaining approval from the customer.

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6. If any payment is not made on the due date MAFF reserves the right to cease work and if it thinks fit terminate the contract. The customer forfeits all rights to the receipts of the results if payment is not made as agreed.

7. If there is more than one party providing finance for the work, MAFF's agreement to do the work is conditional upon agreement being reached with all parties.

8. Any notices to be issued shall be in writing to the addresses at Section 5 on the front of this form and if sent by prepaid first class post shall be deemed to be served on the second business day after posting.

9. The charges quoted on this form are exclusive of VAT unless specified to the contrary.

10. This contract may be terminated by either party on three months' notice. On such a termination payment will be made in respect of the period up to termination, pro rated on a cost basis or, if necessary, on a time basis.

11. MAFF shall be entitled to the copyright in respect of any working papers and any report(s) produced. You will be entitled to publish the report subject to the provisions of condition 3. If any patentable discovery is made in the course of the work MAFF and the customer shall attempt to negotiate terms for the exploitation of that discovery, sharing the benefit as may be reasonable in the light of their respective contributions to the making of the discovery and the expected expenses of the exploitation. If agreement cannot be reached the terms shall be determined by a barrister agreed by MAFF and the customer or in default of agreement by the President of the Law Society and such barrister shall act as an expert and not as arbitrator.

12. If the work involves your employees attending MAFF premises, you will remain responsible for their salaries and all other associated costs. You will procure that such employees sign the Official Secrets Acts if required by MAFF. You will procure that such employees comply with MAFF security regulations whilst on MAFF premises. You will hold MAFF indemnified against any claim made against it as a result of any tort committed by the employee whilst on MAFF premises. MAFF may at any time at its absolute discretion refuse to accept or continue to accept any particular employee on its premises. MAFF is under no obligation to allow your employees to witness work being done.

13. You will provide accurate information as to the composition of any materials supplied by you, and will give MAFF notice of any hazards in their use known or suspected by you.

14. Our agreement will be subject to English law and we both hereby submit to the jurisdiction of the English courts.

Signed by
on behalf of MAFF date .....

R F Clements, Contract Manager

Agreed by
on behalf of
customer date .....

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE

SCHEDULE OF WORK FOR:-

Early calabrese production using crop covers

Name and address of customer

Horticultural Development Council

18 Lavant Street

Petersfield, Hampshire

GU32 3EW

Name and address of MAFF/ADAS Unit

Efford Experimental Horticulture Station

Lymington, Hampshire

SO41 OLZ

OBJECT: To evaluate types of crop cover, removal date, and crop density in 2 varieties of early calabrese. To undertake an assessment of four varieties under 2 cover types at a standard density.

TREATMENTS:	Cover:	perforated clear polythene 500 x 10mm holes/m2 Nonwoven 16g/m2
	Cover removal	1. head diameter 10 mm 2. head diameter 20 mm
	Spacing	(between x within row) 30 x 20 cm 30 x 30 cm 30 x 37 cm
	Control	bare soil
	Varieties	Southern Comet Mercedes

TREATMENTS

(Variety trial)

Covers	perforated clear polythene 50 x 10mm holes/m2 Nonwoven 16g/m2
Cover removal	head diameter 20mm
Spacing	30 x 37 cm
Varieties	Southern Comet Packman Dixie Primer 70
Trial design:	Both main and variety trials are of the split plot design with each treatment replicated three times.
Records:	Full crop diary Total and graded marketable yield in t/ha % waste Distribution of butt and head diameters within size grades. Qualitative assessments of head characters. Temperature data

APPENDIX II

Crop diary and cultural notes

Main trial

15 February	Seeds of the varieties Southern Comet and Mercedes were direct sown into Hassy 308 trays. Temperatures for germination and emergence were 18^0C day and night. Over a period of 2 weeks seedlings were weaned to cold glasshouse temperatures.
3 March	Elvaron spray programme commenced.
16 March	Plants moved to propagation site to continue weaning.
30 March	Base fertilizer applied to field site 260:91:195 kg/ha NPK plus solubor at 10 kg/ha.
11 April	Trial planted. Plants placed in 100mm deep furrows to prevent bending by crop covers. Standard cabbage root fly control applied to all plants (Birlane granules). Propachlor (as Albrass) at 9 l/ha plus Chlorthal-dimethyl (as Dacthal) at 6 kg/ha applied.
13 April	Trial Irrigated (8 mm). Heavy rain fell on 15 April (14.7 mm) and delayed the laying of crop covers.
18/19 April	All covers laid. Bare soil plots netted to afford protection from birds.

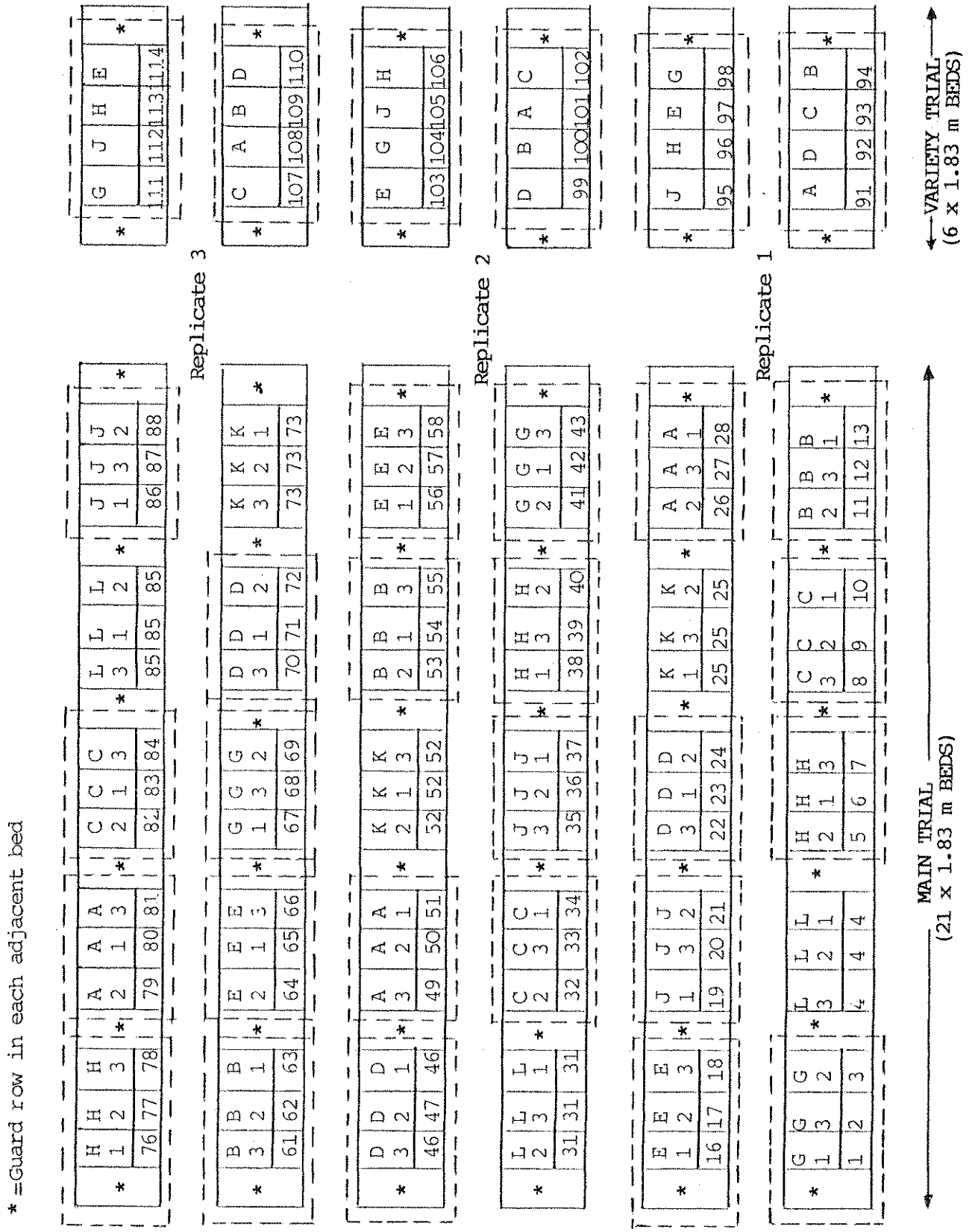
20 April	Grant squirrel data logger activated allowing temperature in the different environments to be recorded at 90 minute intervals.
17 May	Trial irrigated (16 mm).
22 May	Cover REMOVAL 1 for all polythene treatments.
24 May	Cover REMOVAL 1 for all nonwoven treatments.
31 May	Cover REMOVAL 2 for both polythene and nonwoven treatments. All nets removed from bare soil plots.
3 June	1st Harvest from both polythene and nonwoven covered plots.
7 June	2nd Harvest from both polythene and nonwoven covered plots.
9 June	3rd and final harvest from covered plots.
20 June	1st Harvest from bare soil plots.
23 June	2nd Harvest from bare soil plots.

Variety trial

24 February	Seed of all four varieties was direct sown into Hassy 308 trays.
10 March	Elvaron spray programme commenced.
24 March	Plants moved to propagation site to continue weaning.
20 April	Variety trial planted, soil conditions quite wet. Plants placed in 100 mm deep furrows to prevent bending by crop covers. Standard cabbage root fly control applied to all plants (Birlane granules). Propachlor (as Albrass) at 9 l/ha plus Chlorthal-dimethyl (as Dacthal) at 6 kg/ha applied.
22 April	All covers laid.
31 May	All polythene and nonwoven covers removed.
6 June	1st Harvest from all plots.
9 June	2nd Harvest from all plots.
14 June	3rd and final harvest from all plots.

Feeding and general husbandry during propagation was as detailed in ADAS leaflet 909 'Vegetable propagation in Cellular trays'.

CALABRESE - EARLY PRODUCTION UNDER CROP COVERS
(HDC TRIAL - 1988)



KEY TO PLOT CODES

Main trial treatments	Plot code
Polythene (coverall)	
S. Comet, Removal 1, 30 x 20.	A1
" " 30 x 30.	A2
" " 30 x 37.	A3
Mercedes. Removal 1, 30 x 20.	B1
" " 30 x 30.	B2
" " 30 x 37.	B3
S. Comet, Removal 2, 30 x 20.	C1
" " 30 x 30.	C2
" " 30 x 37.	C3
Mercedes. Removal 2, 30 x 20.	D1
" " 30 x 30.	D2
" " 30 x 37.	D3
Nonwoven (Agryl)	
S. Comet, Removal 1, 30 x 20.	E1
" " 30 x 30.	E2
" " 30 x 37.	E3
Mercedes. Removal 1, 30 x 20.	G1
" " 30 x 30.	G2
" " 30 x 37.	G3
S. Comet, Removal 1, 30 x 20.	H1
" " 30 x 30.	H2
" " 30 x 37.	H3
Mercedes. Removal 2, 30 x 20.	J1
" " 30 x 30.	J2
" " 30 x 37.	J3

Bare soil

S. Comet,	30 x 20.	K1
"	30 x 30.	K2
"	30 x 37.	K3
Mercedes,	30 x 20.	L1
	30 x 30.	L2
	30 x 37.	L3

Variety trial treatments

Polythene (coverall)	**Plot code**
S. Comet	A
Dixie	B
Packman	C
Primer 70	D

Nonwoven (Agryl)	
S. Comet	E
Dixie	G
Packman	H
Primer 70	J

all spaced at 30 x 37 cm.

Single plot (1.83 x 7m)

Spacings:-

30 x 20 = 5 rows x 35 plants = 175 plants/plot

30 x 30 = 5 rows x 23 plants = 115 plants/plot

30 x 37 = 5 rows x 19 plants = 95 plants/plot

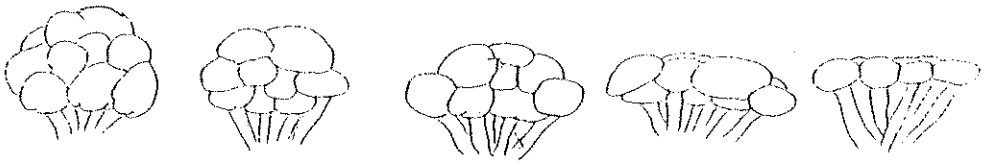
For all plots 14 plants were harvested from each of the three centre rows. The recordable area therefore changed with crop density.

Spacing	Recordable area m^2
30 x 20	2.52
30 x 30	3.78
30 x 37	4.66

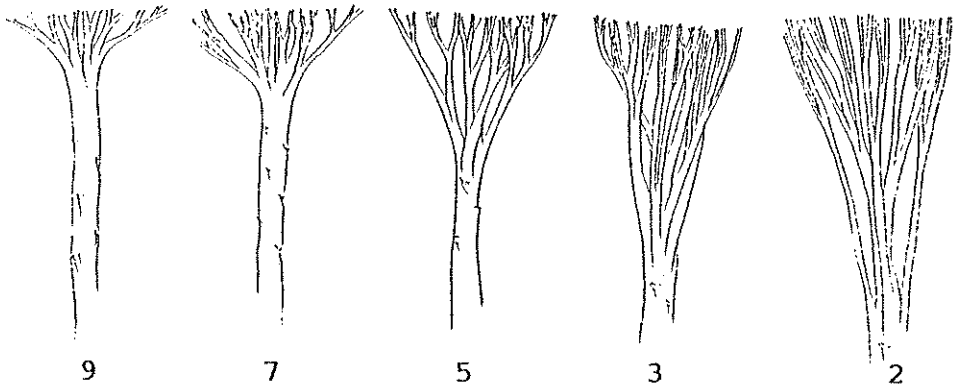
APPENDIX IV.

QUALITY CHARACTER SCORING FOR CALABRESE

Head shape



Angle of branching



Top - Diagrammatic representation of primary heads of calabrese showing deep heads (9) and shallow heads (1).

Bottom - Diagrammatic representation of branching within primary heads. Wide angle branching (9), narrow angle branching (1).

Bud size

Description	Score
Large	9
Medium	5
Small	1

Bud colour (variety trial only)

Description	Score
Dark green	9
Medium green	5
Pale green	1

Cluster separation

Description	Score
No bud clusters	9
Cluster of buds on perimeter of head	5
Obvious bud clusters over whole surface of head	1

APPENDIX V

Table A Graded and total marketable yields of primary heads (t/ha): var Southern Comet.

Cover type x Removal	Spacing(cm) between within row	Graded yield/head diameter(mm) <50	50-75	75-100	>100	Total marketable Yield	Waste as a % of Total
Nonwoven							
Removal 1	30 x 20	0.42	3.50	1.62	0.00	5.55	8.3
	30 x 30	0.35	2.30	2.05	0.09	4.78	2.5
	30 x 37	0.35	1.81	1.93	0.13	4.22	3.3
Removal 2	30 x 20	0.36	3.95	1.01	0.00	5.33	3.3
	30 x 30	0.35	2.76	0.69	0.00	3.80	5.8
	30 x 37	0.12	2.58	1.19	0.00	3.89	1.9
Polythene							
Removal 1	30 x 20	0.54	3.92	0.49	0.00	4.96	1.6
	30 x 30	0.25	3.65	0.47	0.00	4.37	5.0
	30 x 37	0.22	2.47	0.85	0.00	3.55	1.6
Removal 2	30 x 20	0.66	2.91	0.44	0.06	4.08	3.3
	30 x 30	0.31	2.04	0.53	0.00	2.88	11.6
	30 x 37	0.28	1.56	1.36	0.13	3.33	6.6
Bare soil	30 x 20	1.23	1.69	1.51	0.18	4.62	5.0
	30 x 30	0.37	2.58	0.78	0.19	3.98	1.0
	30 x 37	0.22	1.99	1.42	0.07	3.69	6.0
SED (d.f. = 40) (same spacing level) =		0.217	0.502	0.489	0.219	0.577	-
SED (d.f. = 40) (between spacings) =		0.211	0.509	0.497	0.232	0.629	-

Table B

Graded and total marketable yields of primary heads (t/ha): var Mercedes

Cover type x Removal	Spacing(cm) Between x within row	Graded yield/head diameter(mm) < 50	50-75	75-100	>100	Total Marketable yield	Waste as a % of total
Nonwoven							
Removal 1	30 x 20	0.61	2.47	1.12	0.00	4.21	14.2
	30 x 30	0.24	2.27	1.52	1.86	4.23	15.0
	30 x 37	0.15	1.69	1.61	1.88	3.64	10.8
Removal 2	30 x 20	0.42	2.52	1.95	0.00	4.90	19.5
	30 x 30	0.23	2.72	0.98	0.00	3.93	9.2
	30 x 37	0.12	1.78	1.11	0.31	3.32	21.7
Polythene							
Removal 1	30 x 20	0.81	2.99	0.76	0.00	4.56	7.5
	30 x 30	0.27	1.56	1.92	0.05	3.80	9.2
	30 x 37	0.25	1.17	1.41	0.07	2.91	10.8
Removal 2	30 x 20	0.57	2.56	0.89	0.00	4.01	18.3
	30 x 30	0.29	1.76	1.44	0.08	3.57	12.1
	30 x 37	0.51	1.15	1.10	0.06	2.82	10.8
Bare soil	30 x 20	0.52	2.10	1.26	0.24	4.11	28.3
	30 x 30	0.38	1.32	1.51	0.32	3.54	22.5
	30 x 37	0.34	1.19	1.35	0.67	3.54	4.3
SED (d.f. = 40) (same spacing level) =		0.217	0.502	0.489	0.219	0.577	-
SED (d.f. = 40) (between spacing) =		0.211	0.509	0.497	0.232	0.629	-

Table C

Distribution of butt diameters in various size grades expressed as a % of the total: var Southern Comet

Cover type x Removal	Spacing (cm) Between x within row	Butt diameter (mm) <15	15-30	30-45	45-60	>60
Nonwoven						
Removal 1	30 x 20	8.7	25.0	0.0	0.0	0.0
	30 x 30	3.7	33.7	0.0	0.0	0.0
	30 x 37	1.3	37.0	0.3	0.0	0.0
Removal 2	30 x 20	7.7	24.3	3.3	0.0	0.0
	30 x 30	5.3	32.3	0.0	0.0	0.0
	30 x 37	3.7	25.7	6.3	0.0	0.0
Polythene						
Removal 1	30 x 20	13.7	16.3	3.3	0.0	0.0
	30 x 30	2.7	30.0	0.0	0.0	0.0
	30 x 37	4.0	35.3	0.0	0.0	0.0
Removal 2	30 x 20	19.3	19.3	0.0	0.0	0.0
	30 x 30	10.3	23.0	0.0	0.0	0.0
	30 x 37	2.7	32.3	0.0	0.0	0.0
Bare soil	30 x 20	8.0	26.3	0.0	0.0	0.0
	30 x 30	4.0	33.3	0.0	0.0	0.0
	30 x 37	1.3	33.7	0.0	0.0	0.0
SED (d.f. = 40) (Comparison of spacings)	=	6.48	7.18	5.68*	-	-
SED (d.f. = 40) (Other comparisons)	=	6.57	6.98	5.22*	-	-

* not valid

Table D

Distribution of butt diameters in various size grades expressed as a % of the total: var Mercedes

Cover type x Removal	Spacing (cm) Between x within row	Butt diameter (mm) <15	15-30	30-45	45-60	>60
Nonwoven						
Removal 1	30 x 20	14.3	20.0	0.0	0.0	0.0
	30 x 30	3.3	30.7	0.0	0.0	0.0
	30 x 37	5.3	29.3	1.0	0.0	0.0
Removal 2	30 x 20	9.7	23.0	0.0	0.0	0.0
	30 x 30	7.0	29.3	0.0	0.0	0.0
	30 x 37	1.7	29.0	0.3	0.0	0.0
Polythene						
Removal 1	30 x 20	13.3	20.6	1.0	0.0	0.0
	30 x 30	4.7	31.3	0.0	0.0	0.0
	30 x 37	4.0	28.7	0.6	0.0	0.0
Removal 2	30 x 20	24.7	21.3	0.0	0.0	0.0
	30 x 30	8.3	25.0	0.0	0.0	0.0
	30 x 37	10.3	25.3	0.0	0.0	0.0
Bare soil	30 x 20	8.3	20.3	0.0	0.0	0.0
	30 x 30	3.7	25.0	0.0	0.0	0.0
	30 x 37	2.3	30.0	0.0	0.0	0.0
SED (d.f. = 40) (Comparison of spacing)	=	6.48	7.18	5.68*	-	-
SED (d.f. = 40) (Other comparisons)	=	6.57	6.98	5.22*	-	-

* Not valid

Table E

Distribution of head diameters in various size grades expressed as a % of the total: var Southern Comet

Cover type x removal	Spacing (cm) Between x within row	Head diameter (mm) <50	50-75	75-100	>100
Nonwoven					
Removal 1	30 x 20	7.3	20.7	5.7	0.0
	30 x 30	7.7	18.0	11.3	0.3
	30 x 37	6.0	18.0	14.0	0.7
Removal 2	30 x 20	5.7	25.0	4.7	0 0
	30 x 30	6.7	26.3	4.7	0.0
	30 x 37	4.0	24.0	7.7	0.0
Polythene					
Removal 1	30 x 20	8.0	24.0	1.3	0.0
	30 x 30	4.3	23.0	5.3	0.0
	30 x 37	6.0	27.0	6.3	0.0
Removal 2	30 x 20	11.0	24.3	3.0	0.3
	30 x 30	7.3	21.7	4.3	0.0
	30 x 37	5.3	17.7	11.3	0.7
Bare soil	30 x 20	8.7	18.0	7.3	0.3
	30 x 30	6.7	23.7	6.3	0.7
	30 x 37	6.7	18.3	9.7	0.3
SED (d.f. = 40) (Comparison of spacings)	=	5.66	6.15	5.99	4.96
SED (d.f. = 40) (other comparisons)	=	5.46	6.19	6.15	4.46

Table F

Distribution of head diameters in various size grades expressed as a % of the total: var Mercedes

Cover type x removal	Spacing (cm) between x within row	Head diameter (mm) <50	50-75	75-100	>100
Nonwoven					
Removal 1	30 x 20	10.3	19.0	5.0	0.0
	30 x 30	5.0	19.3	9.0	0.6
	30 x 37	5.0	17.7	12.0	1.0
Removal 2	30 x 20	8.7	14.0	8.0	0.0
	30 x 30	6.0	23.7	6.7	0.0
	30 x 37	3.3	19.0	7.7	1.3
Polythene					
Removal 1	30 x 20	12.0	19.7	3.0	0.0
	30 x 30	5.7	18.7	11.3	0.3
	30 x 37	7.3	16.3	9.3	0.3
Removal 2	30 x 20	8.3	20.0	4.3	0.0
	30 x 30	7.3	16.7	9.0	0.3
	30 x 37	12.3	14.0	9.0	0.3
Bare soil	30 x 20	7.7	14.0	6.3	0.7
	30 x 30	7.3	11.0	9.0	1.3
	30 x 37	7.7	12.7	10.0	2.0
SED (d.f. = 40) (Comparison of spacing) =		5.66	6.15	5.99	4.96
SED (d.f. = 40) (Other comparisons) =		5.46	6.19	6.15	4.46

Table G

Qualitative assessments of head characteristics : var Southern Comet

Cover type x removal	Spacing(cm) Between x within row	Bud size	Head shape	Cluster separation	Angle of Branching
Nonwoven					
Removal 1	30 x 20	6.6	5.3	6.9	6.3
	30 x 30	6.7	6.0	7.4	5.9
	30 x 37	6.8	5.9	8.4	6.4
Removal 2	30 x 20	6.6	5.9	7.6	6.5
	30 x 30	6.4	5.7	7.3	6.5
	30 x 37	6.4	6.3	7.9	6.7
Polythene					
Removal 1	30 x 20	6.8	5.8	7.8	6.7
	30 x 30	6.2	6.1	6.9	6.6
	30 x 37	7.6	6.5	8.1	6.1
Removal 2	30 x 20	6.5	4.9	7.0	6.7
	30 x 30	6.7	5.0	7.4	7.0
	30 x 37	6.3	5.4	6.1	5.9
Bare soil	30 x 20	7.4	4.9	7.0	7.4
	30 x 30	7.4	4.7	7.1	7.2
	30 x 37	7.3	5.0	6.9	6.5
SED (d.f. = 40) (Comparison of spacings)		= 0.26	0.44	0.81	0.50
SED (d.f. = 40) (Other comparisons)		= 0.30	0.46	0.86	0.50

for a key to quality characters see APPENDIX IV page 38

Table H

Qualitative assessments of head characteristics: var Mercedes

Cover type x removal	Spacing (cm) Between x within row	Bud size	Head shape	Cluster separation	Angle of branching
Nonwoven					
Removal 1	30 x 20	6.6	5.2	5.7	6.5
	30 x 30	6.6	5.6	5.6	5.6
	30 x 37	6.3	4.6	5.5	6.2
Removal 2	30 x 20	6.7	5.9	6.3	5.9
	30 x 30	6.5	5.8	5.3	5.9
	30 x 37	6.5	4.9	4.8	6.0
Polythene					
Removal 1	30 x 20	6.5	5.2	6.3	6.5
	30 x 30	6.4	6.5	6.3	6.1
	30 x 37	6.2	5.6	6.3	6.9
Removal 2	30 x 20	6.5	4.3	5.6	6.1
	30 x 30	6.5	4.5	5.2	6.2
	30 x 37	5.8	4.8	3.6	5.3
Bare soil	30 x 20	6.6	4.7	6.5	7.0
	30 x 30	7.1	5.2	6.0	6.9
	30 x 37	6.9	4.8	6.5	6.9
SED (d.f. = 40) (Comparison of spacings)		0.26	0.44	0.82	0.50
SED (d.f. = 40) (Other comparisons)		0.30	0.46	0.87	0.50

for a key to quality characters see APPENDIX IV page 38

APPENDIX VI

Comparison of climatic conditions in 1987 and 1988

		Total Rainfall (mm)	Total sunshine (hrs)	Air frost (days)	Ground frost (days)	Temp (^{0}C) min	Temp (^{0}C) max	Light Integral (daily mean) g/cal/cm^2
Jan	1987	15.8	66.1	19	20	-9.2	10.3	68
	1988	170.9	61.2	3	9	-1.0	11.5	66
Feb	1987	60.4	83.0	10	15	-3.5	13.0	131
	1988	47.3	132.8	4	18	-2.1	12.0	162
Mar	1987	95.7	122.2	11	17	-4.8	11.9	210
	1988	82.0	105.1	4	10	-3.2	12.6	202
April	1987	69.1	200.4	0	8	0.2	19.7	356
	1988	39.5	194.6	2	9	-1.1	15.8	379
May	1987	19.3	240.8	0	9	1.8	22.4	448
	1988	27.9	248.5	0	2	3.1	23.7	482
June	1987	54.4	173.7	0	1	2.7	24.3	419
	1988	34.3	183.1	0	0	6.0	26.2	410