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Celery: early production of green
celery under film covers.

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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.

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CELERY: EARLY PRODUCTION OF GREEN CELERY UNDER FILM COVERS

Summary

Eleven varieties of green celery were propagated in two different temperature regimes, planted in late March, and then assessed for yield and quality during the growing season and at harvest. The varieties Claret, Darklet, Deacon, Greensleeves, Multipak, RS664B, Tall Utah, TZ8848, TZ8849, TZ8937 and Utah were sown on 14 January and raised at 21°C. The seedlings were pricked out on 8 February into 43 mm peat blocks and then grown on at either 16 or 21°C minimum propagation temperature. The trial was planted on 26 March and covered with a double protective layer comprising perforated polythene over a fibrous film cover.

At planting there were only minimal differences in size between the batches of plants from the two propagation regimes. At the removal of the fibrous film cover in early June there was leaf damage by *Septoria apiicola* despite seed treatment. A routine fungicide spray programme commenced from early June.

The earliest treatments were cut on 11 July when the majority of heads in those plots had reached a minimum head weight of 450 g. The first varieties to mature were Claret, Greensleeves, TZ8848 and TZ8849. Both TZ8848 and TZ8849 produced over 96% of marketable heads, Greensleeves produced 80% when raised at 21°C and Claret 59% averaged over the two propagation regimes. The varieties TZ8937 and Utah also performed well following propagation at 21°C but were slightly later to mature. Latest harvest date was 23 July.

The levels of bolting were higher than observed in 1990 with levels in this trial ranging from 0 to 34%. The 21°C propagation regime reduced the number of bolted heads when compared to where a minimum of 16°C had been used.



The quality of the heads was generally good particularly for those harvested in mid July. Both TZ8848 and TZ8849 produced long petioles which were 'apple green', the colour favoured by the market, and moderately smooth. RS664B also had long petioles but there were high numbers of heads with internal side shoots which reduced the attractiveness of this variety.

The varieties were assessed for their field standing ability but the re-appearance of Septoria within the trial probably adversely affected this. Both TZ8848 and Greensleeves stood well in the field for about 8 days after harvest; slightly longer than TZ8849 and TZ8937. The varieties RS664B and Utah had very limited field standing ability due to a rapid deterioration in their outer petioles.



Introduction

UK production of green celery during the autumn has recently been encouraged: green varieties already account for a large proportion of imported celery during the winter months. The supermarkets are now requesting that green celery, as with self blanching, be supplied for a longer period of the year. Summer production in the UK could fill this need, given reliable data on techniques and varieties.

Most green types have been bred from the Tall Utah strains which originate from California. These varieties are generally very susceptible to bolting but advances in plant propagation and the film crop cover technique make early production a possibility. Also several of the new varieties do include some different genotypes and are thus considered more reliable than some of the older varieties.

The aim of the trial, now in its second year, was to evaluate early field production of a range of both named and numbered varieties following propagation at either 16 or 21°C minimum. An early planting date was used in order to provide a severe test of resistance to bolting. In 1990 eight varieties were grown with TZ8848, TZ8849 and Claret producing excellent quality heads in early July. There was no consistent effect of propagation regime on either date of maturity or yield. The number of bolted plants was very low. The trial was repeated in 1991 to test the bolting susceptibility and performance in a second season.



Objective

To assess the potential of a range of varieties to produce high quality green celery in late June or July and to examine the effect of two propagation regimes on the level of bolting.



Materials and Methods

Site

The trial was conducted on House Ground field at the ADAS Arthur Rickwood, Mepal, Ely, Cambridgeshire. The soil type is a loamy peat 90 cm deep with 35% organic matter over Fen clay. (Adventurers' Shallow).

Design

The experiment was of a randomised block design with two replicates. Plot size was 7.6 m² with 5 rows 250 mm apart per 1.68 m bed and a spacing of 300 mm between the plots. Each plot consisted of 70 plants with 25 plants cut and assessed at harvest.

Treatments

Temperature during propagation

- a. 16°C minimum glasshouse temperature
- b. 21°C minimum glasshouse temperature

Varieties

- a. Claret (Royal Sluis)
- b. Darklet (Royal Sluis)
- c. Deacon (Elsoms)
- d. Greensleeves (Nickersons)
- e. Multipak (Nickersons)
- f. RS664B (Royal Sluis)
- g. Tall Utah (Nickersons)
- h. TZ8848 (Tozers)
- i. TZ8849 (Tozers)
- j. TZ8937 (Tozers)
- k. Utah (Elsoms)

Husbandry

Seed of all the varieties was sown on 14 January into Correx trays which contained Fisons F1 compost and germinated at 21°C. On 8 February the



seedlings were pricked out into 43 mm peat blocks made of Fisons B2 compost and grown at either 16°C or 21°C minimum temperature according to treatment. Liquid feeding according to ADAS recommendations commenced from pricking out and was continued until planting.

At planting a spacing of 300 x 250 mm was used and the double cover of Polycrop 500 over Covertan (17 g/m²) laid. The film cover was removed for hoeing on 2 May and only the fibrous cover relaid until 6 June. The trial received a commercial insecticide and fungicide programme thereafter until the final harvest (Appendix I). No herbicides were applied, with weeds controlled by hoeing.

Assessments

Each plot was regularly assessed from early July for the number of bolted plants. The treatments were harvested when the majority of heads were of the correct size (minimum trimmed weight of 450 g). At harvest 25 heads/plot were cut, field trimmed and then weighed. The quality assessments undertaken included stick length, shape, colour of petioles, presence of internal basal side shoots and petiole smoothness. A simple taste test in the field was also carried out.

Note

A minimum head weight of 450 g had been used in 1990 and it was therefore also adopted in 1991 as the parameter for fixing harvest date. However in the meantime supermarket specifications were altered so that a minimum of 400 g is now acceptable. Consequently results are presented in this report showing marketable heads as being over 400 g providing they were of good quality.

Results and Discussion

The vigour of the plants prior to transplanting was assessed. Those which appeared most vigorous were TZ8848 and Tall Utah, followed by TZ8937, RS664B, Utah and Deacon.

At planting there with no visible differences between the two propagation regimes.

In early June the fibrous cover was removed due to the presence of Septoria on the plants. An assessment was made of each plot prior to commencing a fungicide spray programme. The results are shown in Appendix II.

The varieties appeared to differ in their susceptibility to Septoria despite all receiving the standard seed treatment prior to seed despatch. The more susceptible ones included Multipak, Tall Utah and TZ8937.

The first heads were cut on 11 July. The harvest dates for the varieties and propagation treatments are given in Table 1.

Table 1. Harvest dates.

Variety	Propagation regime 16°C Min	21°C Min
Claret	11 July	11 July
Darklet	23 July	19 July
Deacon	*	23 July
Greensleeves	*	11 July
Multipak	*	*
RS664B	19 July	19 July
Tall Utah	*	23 July
TZ8848	11 July	11 July
TZ8849	11 July	11 July
TZ8937	*	15 July
Utah	23 July	15 July

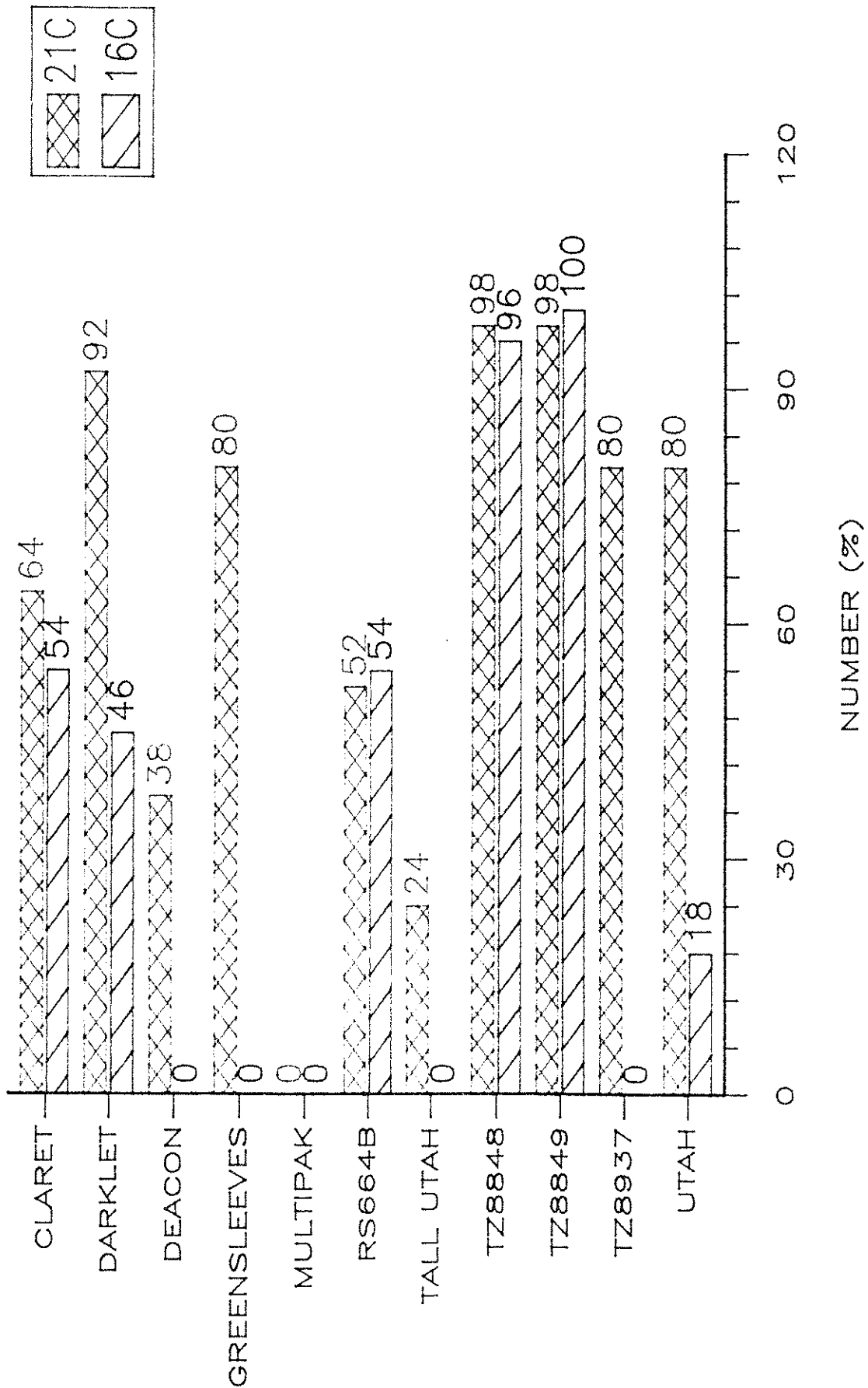
* not harvested due to poor vigour

The earliest varieties to mature were Claret, Greensleeves, TZ8848 and TZ8849. Those varieties which were intermediate in their maturity were RS664B, TZ8937 and Utah. Several of the varieties propagated at 16°C failed to develop properly. The reasons for this are unclear but may have been due to the early planting date which was 2 weeks earlier than 1990.

Overall there appeared to be an advantage from propagating the plants at 21°C as they generally matured a few days earlier than those raised at 16°C, although this was not always the case with the earlier varieties. However, this contrasts with the results obtained in 1990.

The number of marketable heads over 400 g is given in Figure 1, with the number of marketable heads over 450 g given in Appendix III.

Fig 1 : NUMBER OF MARKETABLE HEADS (%)



The varieties which produced the highest number of marketable heads were TZ8848, TZ8849 and Darklet, but this latter variety took longer to mature. The varieties Greensleeves, TZ8937 and Utah performed very well following propagation at 21°C, but badly when raised at 16°C.

The main head defects were lack of weight (below 400 g), poor shape and bolting as detailed in Table 2. The poor head shape was mainly due to the twisting of either the petioles or the heads having an 'open' habit.

Table 2. Head defects (%).

Variety	Small (%)			Poor shape (%)			Bolted (%)		
	16°C	21°C	Mean	16°C	21°C	Mean	16°C	21°C	Mean
Claret	22	32	27	0	0	0	22	4	13
Darklet	52	4	28	0	2	1	2	2	2
Deacon	100	54	77	0	0	0	0	8	4
Greensleeves	100	20	60	0	0	0	0	0	0
Multipak	100	100	100	0	0	0	0	0	0
RS664B	32	46	39	2	2	2	12	0	6
Tall Utah	100	60	80	0	0	0	0	16	8
TZ8848	4	0	2	0	0	0	0	2	1
TZ8849	0	2	1	0	0	0	0	0	0
TZ8937	100	12	56	0	8	4	0	0	0
Utah	42	2	22	6	4	5	34	14	24

The average number of small heads was higher than observed in the 1990 trial but this reflects the failure of some treatments to mature. The relatively high numbers of small heads for Claret and RS664B tend to indicate that the harvest date was too early. The varieties Claret and Utah were most susceptible to bolting although raising the plants at 21°C did reduce the levels of bolting. The levels of bolting in this trial were far higher than observed in 1990.

A description of each variety is given in Appendix IV.



The quality-related assessments were meaned for both propagation regimes and are given in Table 3.

Table 3. Quality assessment taken at harvest on marketable heads.

Variety	Mean stick length (mm)	Colour (1-9)*	Smoothness (1-9)*	Internal leafiness (%)#
Claret	241	3.4	2.9	33
Darklet	218	3.1	3.2	4
Deacon	201	3.0	2.9	40
Greensleeves	238	3.5	2.7	20
RS664B	257	3.3	3.3	59
Tall Utah	205	3.0	3.6	15
TZ8848	263	3.3	3.3	15
TZ8849	269	3.3	3.0	16
TZ8937	260	3.8	3.7	13
Utah	250	3.5	3.4	9
Mean	240	3.3	3.2	22

* 1 = very light/smooth
9 = very dark/very ribby

number of heads with side shoots at base of head

The two propagation regimes gave similar mean stick lengths. The varieties TZ8849 and TZ8848 produced the longest petioles which probably contributed to the earlier harvest date. TZ8937, RS664B, Greensleeves, Utah and Claret were slightly shorter than these but longer than Darklet, Deacon and Tall Utah.

Most of the varieties produced heads which were pale green in colour. TZ8937 produced slightly darker sticks. The petioles were generally less smooth than in the 1990 trial. Greensleeves, Claret, Deacon and TZ8849 produced petioles which were particularly smooth. The varieties Claret, Deacon and RS664B all had a tendency to produce side shoots between the outer and inner petioles, probably unacceptable to some markets.



At each harvest sticks were selected, trimmed and the petioles tasted. A comprehensive comparison was felt inappropriate due to the range of maturity and harvest date. However, all the varieties included in the trial had a pleasant flavour with no very strong or off-tastes found.

The field standing ability was assessed 8 days after each harvest. The varieties Greensleeves and TZ8848 held well in the field during this period with negligible pithiness. The varieties TZ8849 and TZ8937 held rather less well and would need to be harvested close to optimal maturity. The varieties RS664B and Utah had very poor field standing ability with rapid internal deterioration in the outer petioles and pithiness developing respectively. The other varieties had a tendency to become stringy when overmature but with no internal petiole tissue breakdown observed.



Conclusions

1. This trial confirms that high quality green celery can be produced in early July.
2. The propagation regimes exerted a slight effect on both date of maturity and marketability. The levels of bolting for some varieties was reduced following propagation at a minimum of 21°C.
3. The varieties which were the most promising were TZ8848 and TZ8849 due to their early maturity, long stick length, smoothness of the petioles and ease of trimming. The varieties Claret and Greensleeves, which were also early maturing, performed less well due to bolting and lack of vigour following propagation at 16°C respectively.
4. All the varieties generally had a poor field standing ability except Greensleeves and TZ8848.



Recommendations

1. The trial has indicated that the minimum temperature during propagation does have an effect on the levels of bolting at harvest. The levels of bolting in 1990 were very low but higher in 1991. The use of 21°C minimum appeared to reduce bolting in some varieties but not in others. The interaction between propagation temperature and variety therefore warrants further study.
2. The influence of propagation temperature on date of maturity also requires further study as it may be possible to advance crop maturity using a minimum of 21°C during plant raising. In both 1990 and 1991 the 21°C propagation treatment did advance maturity of some varieties by several days.
3. More detailed taste assessments should be carried out to determine whether any varieties develop off-flavours after harvesting.



Storage of data

The raw data will be stored by ADAS at ADAS Arthur Rickwood for a period of 10 years. The Horticultural Development Council will be consulted before disposal.



Appendix I

Field	House Ground	
Soil type	Loamy peat (90 cm) with 35% organic matter over Fen clay (Adventurers' Shallow).	
Previous cropping	1990	Sugar beet
	1989	Winter wheat
	1988	Winter wheat
Crop diary		
Cultivations	20 December	plough and furrow press
	21 March	cultivate using Kuhn powered rotary harrow
Propagation	14 January	seeds sown into Correx trays @ 21°C
	8 February	pricked out into 43 mm blocks @ 21°C or 16°C minimum
	25 March	plants moved to ambient glasshouse
Husbandry	26 March	planted and covered
	2 May	hoed and perforated polythene not replaced
	30 May	hoed
	6 June	fibrous cover removed
Insecticides	2 July	0.14 kg/ha ai pirimicarb as 280 g/ha cp Aphox in 400 l/ha water
Fungicides	6 June	0.55 kg/ha ai benomyl as 1.1 kg/ha cp Benlate + 1.0 kg/ha ai chlorothalonil as 2.0 l/ha cp Bravo in 1000 l/ha water
	14 June +	1.0 kg/ha ai chlorothalonil as 2.0
	21 June	l/ha cp Bravo in 1000 l/ha water
	2 July	1.0 kg/ha ai chlorothalonil as 2.0 l/ha cp Bravo in 1000 l/ha water
	16 July	0.55 kg/ha ai benomyl as 1.1 kg/ha cp Benlate in 1000 l/ha water
Fertiliser	4 December	157 kg/ha P ₂ O ₅ + 314 kg/ha K ₂ O
	25 March	160 kg/ha N
	18 June	30 kg/ha N



Trace elements	7 May	9 kg/ha MnSO_4 in 250 l/ha water
	14 June	as above
	28 June	as above
Irrigation	26 March	25 mm
	10 April	25 mm
	22 April	20 mm
	29 April	10 mm
	7 May	20 mm
	21 May	20 mm
	4 June	25 mm
	12 June	25 mm
	20 June	25 mm
	6 July	25 mm
	8 July	15 mm
	10 July	25 mm
	12 July	15 mm
	17 July	25 mm
	6 August	20 mm
13 August	25 mm	
Harvest dates	11 July	
	15 July	
	19 July	
	23 July	



Appendix II

Score for leaf damage caused by *Septoria apiicola* on 6 June.

Variety	Score (0 = nil, 10 = severe)		Mean
	16°C Min	21°C Min	
Claret	4.0	3.0	3.5
Darklet	5.0	3.5	4.3
Deacon	6.0	5.0	5.5
Greensleeves	4.0	3.5	3.8
Multipak	7.0	6.0	6.5
RS664B	6.0	1.5	3.8
Tall Utah	7.0	8.0	7.5
TZ8848	4.5	2.5	3.5
TZ8849	4.0	1.0	2.5
TZ8937	7.5	3.5	5.5
Utah	5.5	1.5	3.5
Mean	5.5	3.5	4.5



Appendix III

Number (%) of marketable heads over 450 g.

Variety	Propagation regime 16°C Min	21°C Min
Claret	38	46
Darklet	26	82
Deacon	-	12
Greensleeves	-	66
Multipak	-	-
RS664B	30	46
Tall Utah	-	16
TZ8848	92	98
TZ8849	92	92
TZ8937	-	60
Utah	10	74



Appendix IV

Description of each variety.

- Claret** A fairly early maturing variety but with a tendency to bolt unless raised at 21°C. Lack of vigour reduced marketability from this planting date. Moderate stick length and acceptable colour with good petiole smoothness. This variety did appear prone to producing internal side shoots. Field standing ability was poor due to bolting.
- Darklet** Later maturing variety producing heads with a wide base which made it look 'chunky'. Stick length was rather short but the petioles were apple green in colour and smooth. The petioles appeared to be glossy and this improved the appeal of the variety.
- Deacon** A later maturing variety which did not perform very well. It had a slight tendency to bolt. The petioles were very short and, although they were very light green, the attractiveness of the variety was reduced due to its fairly open habit.
- Greensleeves** Early maturing variety which performed well following propagation at 21°C. It had good shape and good stick length but did not perform as well as some of the numbered varieties. The field standing ability was good.
- Multipak** Performed badly with low vigour leading to small heads following this early planting date, even when raised at 21°C.



- RS664B A medium-maturing variety producing sticks which were long and fairly smooth. The heads tended to be quite ribby at the base and some were slightly misshapen but this was not noticeable after sleeving. Levels of bolting were fairly high at 16°C.
- Tall Utah A later maturing variety which performed poorly. The stick length was poor and the heads never really reached full maturity. The heads tended to be quite open.
- TZ8848 An excellent early maturing variety following propagation at both 16 and 21°C. The sticks were of good length, colour and shape. The heads were very easy to trim. The petioles were not as smooth as those observed in 1990. The field standing ability was good.
- TZ8849 All excellent early maturing variety with good stick length, colour and smoothness at both temperatures. The shape was better than that observed in 1990 when some of the heads had slightly kinked inner petioles. The field standing ability was good.
- TZ8937 A medium early variety which performed well following propagation at 21°C only. Stick length was good but the petioles tended to be quite dark green in colour and ribby. The heads looked quite attractive.
- Utah A later maturing variety which performed well following propagation at 21°C. The variety had a tendency to bolt particularly at 16°C. The base of the petioles was quite thick and this reduced the attractiveness of the variety.



Appendix V

Results from observation plots.

In addition to the main trial extra plots of some other named and numbered varieties were grown following propagation at 16°C. These plots received identical inputs to the main trial. The results are summarised below.

Table C. Variety performance and characteristics.

Variety	Harvest date	Number marketable (%)	Number small (%)	Number bolted (%)	Mean stick length (mm)	Colour (1-9)*	Smoothness (1-9)*	Internal leafiness# (%)
N30	18 July	44	56	0	198	3.7	3.4	4
N35	18 July	44	56	0	206	3.6	2.5	0
N40	18 July	84	16	0	270	3.1	2.9	8
N45	18 July	80	20	0	254	3.2	3.1	24
TZ8827	11 July	72	21	7	257	3.5	3.3	11
TZ8943	18 July	76	24	0	275	2.8	3.4	50

* 1 = very light/smooth
9 = very dark/very ribby

number of heads with side shoots at base of head

The varieties N40 and N45 looked promising in terms of their high numbers of marketable heads (over 400 g). The stick length was good for both of them with the petioles apple green in colour. N40 appeared more attractive than N45 due to a lower number of heads which had internal side shoots. The varieties N30 and N35 were short and darker in colour, but this could be due to a premature harvest date. Both TZ8827 and TZ8943 were early to mature but TZ8943 did suffer badly from internal side shoots which reduced the attractiveness of the heads.

Appendix VI

Weather data recorded during the trial.

Week commencing	Air temperature			Soil temps (10 cm)	Accumulated day degrees		Rainfall (mm)
	Max	Min	Mean		1991	1990	
25 March	14.2	-3.2	7.3	6.4	15		0.0
1 April	15.1	0.8	9.5	7.8	22		7.7
8 April	21.3	3.9	11.6	9.4	25	18	0.0
15 April	10.6	-1.2	6.7	7.1	9	16	12.0
22 April	16.2	-3.0	9.8	7.8	19	33	1.9
29 April	12.2	0.2	7.6	7.9	14	68	26.0
6 May	18.3	-2.6	12.6	9.6	27	37	1.3
13 May	20.3	5.3	12.9	12.6	37	46	4.5
20 May	23.6	5.3	13.1	15.2	56	40	0.7
27 May	15.2	0.9	11.3	13.3	31	59	0.4
3 June	19.3	0.2	12.4	12.6	41	39	14.5
10 June	20.2	4.7	14.6	13.7	51	49	14.0
17 June	20.8	5.3	12.7	13.7	50	60	18.4
24 June	22.5	7.5	15.9	15.1	68	82	39.2
1 July	25.7	10.7	19.9	19.4	89	61	1.3
8 July	28.2	9.9	19.6	20.1	87	79	0.0
15 July	23.1	8.5	17.6	18.4	77	93	6.9
22 July	14.2	6.1	27.8	18.5	83	72	18.5
Total					801	852	167.3

1. The mean air temperature are measured at 09.00 GMT.
2. The accumulated day degrees are based on a temperature of 6°C and give a useful indication of growing conditions for comparison with other years.

