CONTRACT REPORT

No. AR/92/4

Celery: Early production of green varieties under film covers undertaken on behalf of HDC.

HDC Ref No FV50

Year 3

ADAS

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Period of investigation: January - August 1992
Date of issue of report: December 1992
No. of pages in report: 20
No. of copies of report: 5 (2 held by ADAS)
This is ADAS copy No.: 1

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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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CONTENTS

Summary

Eighteen varieties of green celery were evaluated amongst a commercial crop for early outdoor production without bolting. The varieties were Claret, Fenlander, Greensleeves, Hopkins Fenlander, Multipak, N60, N65, RS664B, Tendercrisp, TZ 8827, TZ 8848, TZ 8849, TZ 8937, TZ 8940, TZ 9066, TZ 9145, TZ 9150 and Utah 1.

Varieties were sown in mid-January and propagated at either 16 or 21°C after pricking out. They were transplanted on 2 April 1992 and immediately covered with a double protective layer comprising perforated polythene over a fibrous film cover.

The earliest varieties, with a high percentage of marketable celery (>80%) on 11 July, were TZ 8848, TZ 9145, N65, Tendercrisp, TZ 8827, TZ 8849, TZ 8937, TZ 9066, TZ 9150 and Utah 1. Those varieties which showed no tendency to bolt were TZ 8848, TZ 9145, TZ 8937, TZ 9066 and Utah 1. Of these, TZ 8848 and TZ 8937 appeared to be the most promising varieties in terms of quality. For some varieties, risk of bolting was decreased by propagating at the higher temperature.

Introduction

UK production of green celery during the summer and autumn periods has been encouraged in recent years. Several new varieties have been evaluated alongside older varieties. In 1990 and 1991, eight and eleven varieties respectively were evaluated for their suitability to early outdoor production in experiments at ADAS Arthur Rickwood. In this third season (1992), eighteen varieties were raised at ADAS Arthur Rickwood and then transplanted into a commercial crop.

In 1990, earliest high yielding varieties were TZ 8848, TZ 8849 and Claret. In 1991, earliest high yielding varieties were TZ 8848, TZ 8849 and Greensleeves. In both seasons, two propagation temperatures (16 and

21°C) were compared; the 21°C regime reduces the risk of bolting following transplanting. In 1990, there was little merit in using the more costly 21°C minimum propagation temperature. However, in 1991, following colder temperatures in April and May, more bolting in celery crops occurred nationally, and in the experiment there was a benefit from using the 21°C regime.

The trial was repeated in 1992 to further test both varieties and propagation temperature regimes in a commercial crop of celery.

Objective

To identify which varieties produce high quality green celery in early July, and to examine the effect of two propagation regimes on the level of bolting.

Materials and Methods

Site

Celery was propagated at ADAS Arthur Rickwood and then transplanted on a grower's holding amongst a commercial crop. The soil type was a loamy peat 90 cm deep with 35% organic matter over fen clay. The site was located at Barway, Cambridgeshire OS N^{O} 548750.

Treatments

i) Temperature during propagation
   a) 16°C glasshouse thermostat setting
   b) 21°C glasshouse thermostat setting

ii) Varieties

a) Claret	Royal Sluis
b) Fenlander	Tozer
c) Greensleeves	Nickerson Zwaan
d) Hopkins Fenlander	Nickerson Zwaan
e) Multipak	Nickerson Zwaan
f) N60	Nickerson Zwaan
g) N65	Nickerson Zwaan
h) RS 664B (Greenlet)	Royal Sluis
i) Tendercrisp	Nickerson Zwaan
j) TZ 8827	Tozers
k) TZ 8848	Tozers
l) TZ 8849	Tozers
m) TZ 8937	Tozers
n) TZ 8940	Tozers
o) TZ 9066	Tozers
p) TZ 9145	Tozers
q) TZ 9150	Tozers
r) Utah 1	Tozers

Husbandry

All varieties were sown on 22 January except for Claret, TZ 8937 and TZ 8940 which were sown on 15 January. The seed was sown into Fisons F1 compost and germinated at 21°C. On 11 February, the seedlings were pricked out into 43 mm^3 peat blocks, made from Fisons B2 compost and grown on at either 16 or 21°C. The plants were transplanted by hand on 2 April, irrigated within five hours, and then covered with a double layer of plastic film covers comprising 500 hole/m^2 perforated polythene (Polycrop) over a fibrous non-woven cover (Agryl p17).

The polythene was removed in May but the non-woven cover remained on until harvest. The celery was grown to a high commercial standard (Appendix I), and harvested on 11 and 15 July.

Assessments

The site was observed regularly prior to cover removal. The percentage number of bolted plants was recorded on 12 June, 23 June and 9 July. At each harvest, the plants were cut, trimmed to a commercially acceptable presentation and then weighed. The celery were deemed marketable if their trimmed weight was at least 450 g and they were of high quality (Class I).

At each harvest, ten plants per plot were used for detailed quality assessment including lengths of petiole to the knuckle, petiole shape (transverse section), petiole smoothness, colour of petiole and presence of smaller side shoots between the petioles. Simple shelf life tests were also done. Weather data was recorded during the outdoor growing period at an experimental site, 8 miles away from the trial (Appendix II).

Design

The trial design was a randomised block with two replicates. There were 96 plants per plot arranged as 6 rows per 2.03-m bed width at 300 mm spacing. The in-row spacing was 200 mm. The data were subjected to analyses of variance, and angle transformed where appropriate.

Results

During propagation, there were no visible differences between the varieties in terms of leaf colour or plant size. At planting, however, there was a large difference in the plant growth habit from the two propagation temperature regimes. Those plants grown at 16°C from pricking out were green, upright and sturdy whereas those raised at 21°C were starting to go yellow, and to have weak, floppy foliage. These latter were more awkward to separate at planting and appeared more prone to disease attack once covered by the plastic films.

Bolting

The level of bolting, meaned for both propagation regimes and all varieties, increased from 0.06% on 12 June, when first recorded, to 2% on 9 July. There were significant ($P<0.001$) differences in bolting between the propagation regimes and varieties, and there were significant interactions (Table 1). There were more bolted plants from the 16°C than the 21°C propagation regime. There were many more bolted plants for Claret than any other variety. Most varieties produced no bolted plants when raised at 21°C. However, several varieties showed a particularly low tendency to bolt, by producing no bolted plants when raised at 16°C. These were the most promising for the early season of production.

Table 1. Percentage of bolted plants on 9 July.

Variety	Propagation regime		
	16°C	21°C	Mean
Claret	48.5	0.5	24.5
Fenlander	0	0.5	0.3
Greensleeves	0.5	0	0.3
Hopkins Fenlander	0	0	0
Multipak	0	0	0
N60	0	0	0
N65	0.5	0	0.3
RS 664B	2.0	0	1.0
Tendercrisp	3.0	0	1.5
TZ 8827	7.5	0	3.8
TZ 8848	0	0	0
TZ 8849	2.5	0	0
TZ 8937	0	0	0
TZ 8940	0	0	0
TZ 9066	0.5	0	0.3
TZ 9145	0.5	0	0.3
TZ 9150	10.0	0.5	5.3
Utah 1	0.5	0	0.3
Mean	3.95	0.1	2.0

SED (39 d.f.)	between propagation regimes (pr)	1.12
	between varieties	0.36
	between pr x varieties	1.59
CV(%)		79.0

Yield

At the first harvest 75.4% of celery harvested was marketable and weighed, on average, 556 g (Table 2). There was no significant difference in yield between the propagation temperatures. There were, however, significant ($P<0.01$) differences between the varieties. TZ 8848 and TZ 9145 had the highest percentage of marketable celery at this early harvest which weighed, on average, 649 and 669 g respectively. Other varieties which performed well at this early harvest were N65, Tendercrisp, TZ 8827, TZ 8849, TZ 8937, TZ 9066, TZ 9150 and Utah 1, all of which had over 80% of marketable celery.

At the second harvest, Greensleeves, Hopkins Fenlander, Multipak and N60 gave high percentages of marketable celery, showing that they have the potential for high yield but at a slightly later maturity date. With the exception of Claret, all varieties gave over 70% of marketable yield in mid-July.

Table 2. Percentage of marketable celery (angle transformed data in brackets for statistical comparison) and mean head weight (g) at both harvest dates meaned for propagation temperatures.

Variety	% Marketable celery		Mean head weight (g)	
	11 July	15 July	11 July	15 July
Claret	48.3 (39.8)	48.3 (39.8)	615	634
Fenlander	51.7 (46.1)	72.9 (58.8)	449	488
Greensleeves	76.7 (61.6)	80.0 (63.8)	512	533
Hopkins Fenlander	40.1 (37.5)	83.3 (69.0)	411	555
Multipak	54.2 (47.6)	87.9 (75.3)	468	542
N60	56.8 (49.6)	80.8 (71.7)	466	546
N65	82.5 (65.5)	82.5 (65.5)	563	560
RS 664B	77.5 (64.1)	77.5 (64.1)	527	535
Tendercrisp	82.5 (66.2)	82.5 (66.2)	604	606
TZ 8827	81.7 (66.0)	85.0 (71.3)	532	546
TZ 8848	96.7 (81.1)	97.5 (83.6)	649	692
TZ 8849	84.2 (69.9)	82.5 (68.9)	571	599
TZ 8937	81.7 (66.2)	87.1 (70.3)	574	614
TZ 8940	61.5 (51.9)	77.1 (62.3)	475	524
TZ 9066	83.3 (66.5)	90.8 (72.5)	587	674
TZ 9145	95.8 (79.9)	97.5 (83.6)	669	691
TZ 9150	83.0 (69.1)	88.3 (72.6)	552	566
Utah 1	87.5 (72.6)	87.5 (72.6)	608	610
Mean	75.4 (62.6)	83.7 (69.2)	556	590
SED (39 d.f.) between two variety means	9.36	8.10	45.7	39.6
CV(%)	21.0	16.4	11.6	9.5

Standing ability

The ability of the varieties to remain marketable, without bolting, five days after reaching their peak maturity, is given in Table 3.

Table 3. Standing ability in the field (assessed 5 days after the main harvest of each variety) and percentage bolting at two propagating temperatures (16°C and 21°C).

Variety	Standing Ability#		Bolting %	
	16°C	21°C	16°C	21°C
Claret	-	*	100	0
Fenlander	*	*	0	0
Greensleeves	*	*	0	0
Hopkins Fenlander	*	*	0	0
Multipak	*	*	0	0
N60	*	*	0	0
N65	-	*	50	0
RS 664B	-	*	50	0
Tendercrisp	-	*	25	0
TZ 8827	*	*	2	0
TZ 8848	*	*	0	0
TZ 8849	-	*	25	0
TZ 8937	*	*	0	0
TZ 8940	*	*	0	0
TZ 9066	*	*	0	0
TZ 9145	*	*	0.5	0
TZ 9150	*	*	4	0
Utah 1	*	*	0	0

* = good standing ability;
- = poor standing ability

At 21°C, all varieties stood well and none bolted when assessed 5 days after the main harvest. At 16°C, some varieties produced >25% bolters and had poor standing ability, i.e. Claret, N65, RS 664B and TZ 8849.

Shelf life

There was no significant difference between the propagation regimes, and no interactions. The data for the 21°C regime only are given in Table 4. Those varieties which retained their quality after three days in shelf life conditions particularly well (i.e. quality score >8.5) were Claret, Fenlander, Multipak, TZ 8848, TZ 8849, TZ 8937 and TZ 9150. There was tissue breakdown (possibly bacterial soft rots) for N60, N65, RS 664B and TZ 9066 but it is not clear why these varieties in particular were affected.

Table 4. Visual quality score after three days in shelf life conditions (for plants propagated at 21°C only).

Varieties	Quality score	Observations
Claret	8.7	Bright, attractive, smooth
Fenlander	9.0	
Greensleeves	8.3	Bright, attractive, stringy
Hopkins Fenlander	8.0	Long, attractive petioles
Multipak	8.8	Attractive, bright, smooth
N60	4.6	Dull, petiole rotting
N65	6.9	Bright, some petiole rotting
RS 664B	4.5	Attractive, petiole rotting
Tendercrisp	7.8	Attractive, bright
TZ 8827	8.0	Bright, pronounced ribs and rather stringy
TZ 8848	8.6	Attractive, pronounced ribs
TZ 8849	9.3	Attractive, smooth
TZ 8937	8.8	Attractive, pronounced ribs
TZ 8940	8.4	Attractive, bright
TZ 9066	6.5	Bright, pronounced ribs, some petiole rotting
TZ 9145	6.1	Bright, pronounced ribs, stringy, ugly
TZ 9150	8.8	Bright, attractive, rather stringy
Utah 1	7.0	Attractive, smooth.
Mean	7.6	
SED (35 d.f.) between two varieties	1.54	
CV(%)	28.8	

Quality

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Petiole quality parameters

The length, and scores for colour, smoothness and shape of the petioles are given in Table 5.

Length

The mean length of the petioles is shown in order of increasing height in Figure 1. There were significant differences ($P<0.01$) between the propagation temperature regimes with longer petioles from the plants raised at 16°C minimum temperature (mean 31.4 cm) compared with those raised at 21°C (30.4 cm). There were also differences ($P<0.001$) between the varieties. Several of the varieties from Tozers (TZ 8848, TZ 8849, TZ 8937, and TZ 9066) had particularly long petioles, but TZ 8940 proved much shorter.

Table 5. Petiole length (cm) and colour, smoothness and shape scores for celery varieties meaned for propagation temperatures.

Variety	length (cm)	colour score #	smoothness score *	shape score °
Claret	31.2	5.1	4.6	6.5
Fenlander	30.0	6.1	6.5	2.8
Greensleeves	30.0	5.8	5.1	5.5
Hopkins Fenlander	31.8	5.9	5.5	6.8
Multipak	28.9	4.9	4.6	4.8
N60	30.3	3.8	5.1	5.3
N65	31.6	5.3	5.4	5.8
RS 664B	31.1	5.9	3.7	4.0
Tendercrisp	30.9	5.1	3.2	5.8
TZ 8827	30.0	5.9	5.9	7.0
TZ 8848	32.0	4.7	5.2	6.0
TZ 8849	33.1	5.0	4.4	4.8
TZ 8937	32.6	5.5	6.4	4.3
TZ 8940	27.8	5.7	6.9	5.5
TZ 9066	32.2	5.5	6.5	4.5
TZ 9145	30.7	4.9	5.9	4.8
TZ 9150	29.9	5.9	4.7	5.0
Utah 1	31.8	5.8	3.5	5.5
Mean	30.9	5.3	5.1	5.2
SED (38 d.f.) between two varieties	0.89	0.53	0.45 (36 d.f.)	0.82
CV(%)	4.1	14.0	12.5	22.2

# colour score
0 = white/blanched
5 = apple green
10 = dark green

* smoothness score
0 = not ribbed
10 = ribs very pronounced

° shape score
0 = flattened in cross-section
10 = convex in cross-section

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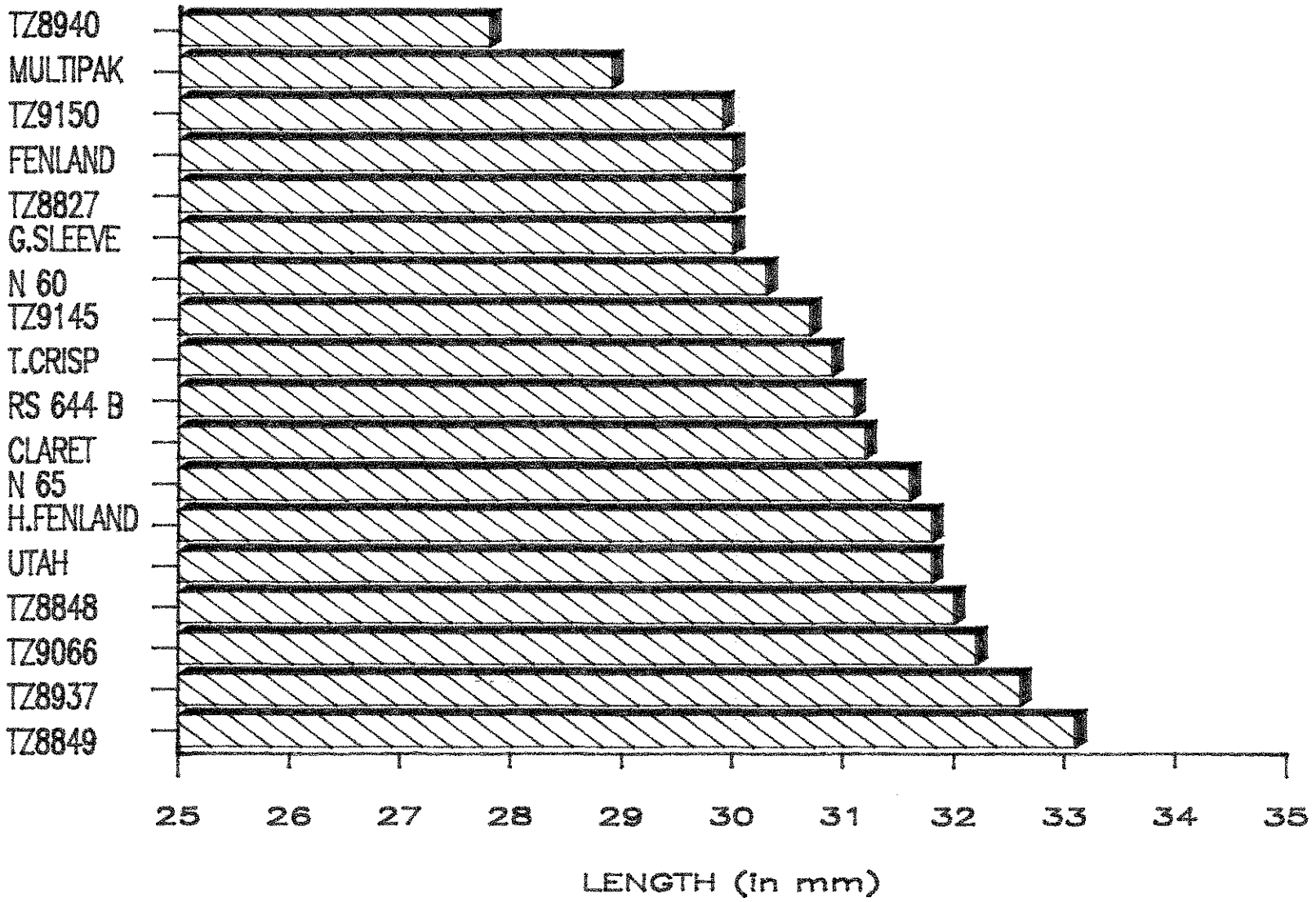
FIG.1: THE ORDER OF INCREASING PETIOLE LENGTH (in mm) IN DIFFERENT VARIETIES OF CELERY.



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Colour

The propagation temperature regimes gave similar mean colour scores. There were, however, significant differences ($P<0.05$) between the varieties as shown in Table 5 and in Figure 2. N60 was the palest variety and Fenlander the darkest green.

Smoothness

There was a significant difference ($P<0.05$) between the propagation regimes with smoother petioles where the plants were raised at 21°C compared with 16°C. There were also large differences ($P<0.001$) between the varieties with RS 664B, Tendercrisp and Utah having particularly smooth petioles. TZ 9066, Fenlander, TZ 8937 and TZ 8940 had pronounced ribs, but this did not indicate that their petioles were necessarily "stringy" when broken (or bitten). It was noted that TZ 8827, with a smoothness score only slightly above that of the mean was considered "stringy" in observations.

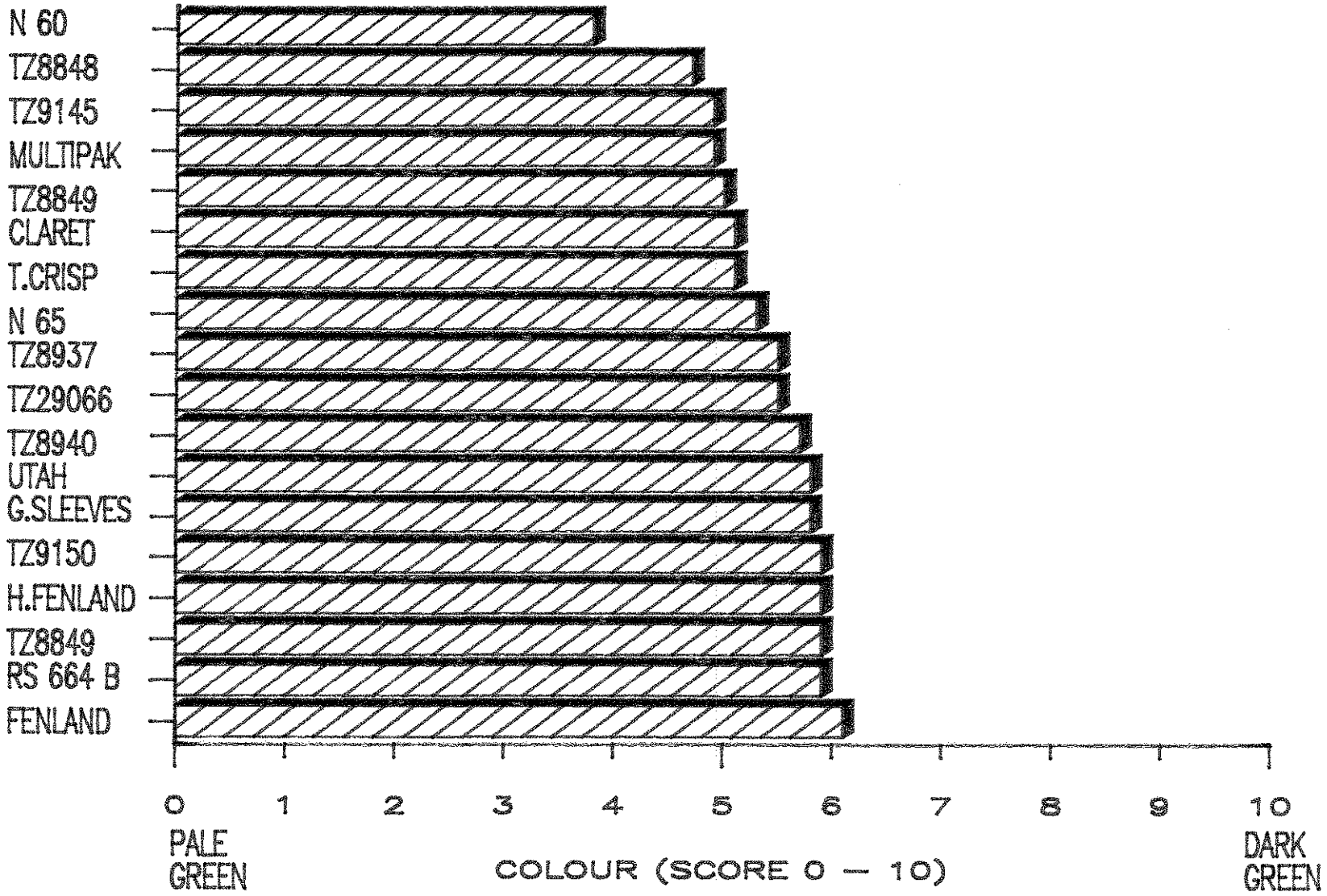
Shape

There was a significant difference ($P<0.001$) between the propagation temperatures with more convex petioles from 16°C compared with 21°C. There were also large differences ($P<0.01$) between the varieties. Fenlander had particularly flat petioles whereas Claret, Hopkins Fenlander and TZ 8827 had thick convex petioles.

Sideshoots

Greensleeves, RS 664B and TZ 8827 had small sideshoots between the petioles (Appendix III) which increased the time taken to trim them.

FIG.2: THE ORDER OF INCREASING GREENNESS IN DIFFERENT VARIETIES OF CELERY PLANTS



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Discussion

Varieties which had performed well at a research centre in 1990 and 1991 were tested amongst a commercial crop in 1992 and grown to a high standard with no pest or disease damage evident at harvest. The varieties had been propagated at either 16°C or 21°C glasshouse temperatures to determine whether the more costly high temperature is required to ensure that the crop matures without bolting when transplanted outdoors. (Some green types of celery are more prone to bolting than the self-blanching types, bred from Lathom self blanching.) Several varieties appeared particularly promising for inclusion in an early production schedule because they showed no signs of bolting following propagation at 16°C in spite of quite severe ground frosts during May (Appendix II). These varieties were Fenlander, Hopkins Fenlander, Multipak, N60, TZ 8848, TZ 8937 and TZ 8940.

The earliest varieties with the highest percentage (over 80%) of marketable celery were TZ 8848 and TZ 9145, followed by N65, Tendercrisp, TZ 8827, TZ 8849, TZ 8937, TZ 9066, TZ 9150 and Utah 1. Some of these showed either no or negligible bolting at 16°C proving less risky to use for early outdoor production; these were TZ 8848, TZ 9145, N65, TZ 8937, TZ 9066 and Utah 1. All of these, except N65, 'held' their quality for a further five days after peak maturity without bolting. All of the above short-listed varieties showed acceptable quality for this early market and none of them showed evidence of sideshoots protruding between the main petioles (Appendix III). There were, however, differences in their quality scores after a period in shelf life conditions, such that the preferred choice of varieties for this early production period is TZ 8848 and TZ 8937.

Conclusions

1. In general, plants raised at 21°C were shorter, less susceptible to bolting and had better standing ability than plants raised at 16°C.

2. All varieties, except Claret, gave over 70% of marketable celery in mid-July.

3. The earliest varieties with a high percentage of marketable celery (over 80%) were TZ 8848, and TZ 9145, followed by N65, Tendercrisp, TZ 8827, TZ 8849, TZ 8937, TZ 9066, TZ 9150 and Utah 1.

4. Those early, high-yielding varieties, which also showed the least tendency to bolt were TZ 8848, TZ 9145, N65, TZ 8937, TZ 9066 and Utah.

5. Those varieties which held well in the field for five days after reaching their peak maturity, and without bolting, were TZ 8848, TZ 9145, TZ 8937, TZ 9066 and Utah 1.

6. The most promising varieties overall were TZ 8848 and TZ 8937 for quality, and TZ 8848 and TZ 9145 for yield.

7. Other varieties with particular attributes, and worth consideration, were N60 (pale and attractive), TZ 8849 (long and attractive).

Acknowledgements

The provision of funding from the Horticultural Development Council for this experiment is acknowledged. The assistance of Messrs. John Shropshire, Jeremy Harwood and Peter Hooker of G S Shropshires & Sons, Hainey Farm, Barway, Ely, Cambridgeshire is also acknowledged.

Appendix 1

Management of the trial

Previous cropping winter wheat

Crop diary

Propagation

15 January	sow Claret, TZ 8937 and TZ 8940
22 January	sow other varieties
11 February	prick out all varieties
2 April	plant

Cultivations

30 December	disc harrow twice
2 January	plough
3 March	roll
15 March	mole drained
17 March	sub soiled and rolled
2 April	power harrowed

Herbicides

1 April	2.8 kg/ha ai chlorpropham as 5.6 l/ha cp CIPC in 250 l/ha water
17 April	0.48 kg/ha ai linuron as 1 l/ha cp Linuron FL in 250 l/ha water
28 April	Linuron as above
7 May	Linuron as above
20 May	0.9 kg/ha ai chlorpropham + 1.8 kg/ha ai pentanochlor as 6 l/ha cp Atlas Brown in 250 l/ha water

Fungicides

11 March	110 ml ai chlorothalonil as 220 ml cp Bravo 500 per 100 litres water (drenched onto plants)

Insecticides

5 June	0.14 kg/ha ai pirimicarb as 0.28 kg/ha cp Aphox in 600 l/ha water
15 June	Aphox as above
23 June	Aphox as above

Fertiliser

14 March	172 kg/ha K_2O
1 April	liquid nitrogen (200 kg/ha)

Trace elements

17 April	manganese sulphate at 3 kg/ha in 250 l/ha water
28 April	manganese as above
7 May	manganese as above
28 May	manganese as above
5 June	manganese as above
15 June	manganese as above
23 June	manganese as above

Irrigation

2 April	15 mm
9 April	15 mm
16 April	15 mm
23 April	25 mm per week

until harvest.

Harvest

11 July	first harvest
15 July	second harvest

Appendix II

Weather records taken during the period from transplanting until harvest at ADAS Arthur Rickwood research centre (approximately 8 miles from trial site).

Date Week beginning	Temperature (°C) Air (maximum)	Grass (minimum)	Rainfall (mm)
2 April	17.7	-5.7	4.4
9 April	17.9	-4.9	20.5
16 April	16.8	-1.7	2.6
23 April	16.9	-0.2	7.4
30 April	20.2	-1.0	7.1
7 May	21.2	-1.2	21.1
14 May	26.3	-1.2	0.7
21 May	27.7	2.8	0.1
28 May	24.8	3.7	26.0
4 June	23.5	5.9	13.7
11 June	26.8	4.8	0
18 June	21.2	2.0	8.6
25 June	30.0	4.4	5.3
2 July	21.2	4.2	13.1
9 July	22.5	3.8	37.1

Appendix III

Presence of sideshoots between the petioles.

Variety	Presence of sideshoots
Claret	-
Fenlander	-
Greensleeves	*
Hopkins Fenlander	-
Multipak	-
N60	-
N65	-
RS 664B	*
Tendercrisp	-
TZ 8827	*
TZ 8848	-
TZ 8849	-
TZ 8937	-
TZ 8940	-
TZ 9066	-
TZ 9145	-
TZ 9150	-
Utah 1	-

* = sideshoots present

- = sideshoots absent.