Glasshouse Celery - Temperature Monitoring in Relation to Bolting

Low temperatures are the primary cause of bolting in early protected celery crops. Gary Jones of the ADAS South Coast Glasshouse and Mushroom Advisory Unit (Chichester) together with David Cribb and David Hand of IHR (Littlehampton) report on HDC-funded work to monitor temperatures on commercial holdings.

CELERY is popular with housewives and it is widely used both as a cooked vegetable and as a herb for flavouring soups. The crop is also highly prized as a decorative and edible constituent of raw salads. Nutritionally, celery contains little fat (0.2%) and comprises protein (1.3%), carbohydrates (3.7%), and minerals such as calcium (0.1%) and iron (0.01%), together with traces of essential vitamins. Climatic conditions on the South Coast of England are particularly suitable for producing early heated crops of the cultivars Celebrity and Loret, both selections of Lathom Self-Blanching. The crops are grown under glass during winter and spring, and harvested before the outdoor crops become available in July. Growers can make good returns during the crucial period of marketing from late April to June because consumer demand is strong, imports are weak, and supplies of English field celery are not yet available.

Background

Supplies of celery to the U.K. market totalled over 100,000 tonnes in 1987, with English protected and field crops accounting for 9% and 63% of the tonnage respectively. Imports (mainly from Spain, Israel and the U.S.A.) have risen by 15,100 tonnes during the past decade, and in 1987 totalled 27,900 tonnes (including those from The Channel Islands) with a market value of £9.7 million. There is clearly great potential for import substitution, especially from late April to June when about 2,750 tonnes of celery (mainly from Spain) enter the U.K. For all of this demand to be satisfied by English produce it would be necessary to expand the present area (139 hectares) of cropping under protected cultivation by about 30% (i.e. 40 hectares). In recent years, West Sussex and Surrey have become increasingly important for the early production

[Print A near here]

The temperature sensor comprises a YSI-type thermistor bead (3 mm in diameter) encapsulated in a moisture-proof coating. Protection from coarse dust particles is afforded by a cylindrical, fine-mesh nylon cap. Connection of the sensor to a socket at the rear of the integrator is made via a plug and extension lead of about 2 metres in length. It is not necessary to change the batteries during the growing season, and the temperature integrators will normally give six months of trouble-free use on growers' holdings provided that the units are kept dry and shielded from direct sunlight. To ensure meaningful readings the sensors were placed inside an aspirated screen sited above the crop at each location selected for monitoring temperature. In practice, the integrator's two registers accumulate counts at rates which are directly proportional to the elapsed time and to the temperature respectively. This means that the longer the elapsed time and the warmer the temperature the more counts that are accumulated in the registers and vice-versa. A formula is used to convert the readings to a mean temperature. Figure [1] shows a typical calibration obtained with an IHR temperature integrator.

[Figure 1 near here]

Plant measurements

Celery plants were taken from each site at fortnightly intervals, commencing at planting and ending a few weeks before the date of marketable harvest. Each sample comprised six representative plants which were selected from a central area of cropping within the glasshouse designated for the site. The plants were then transferred speedily to a laboratory at IHR Littlehampton for detailed assessment. In the first instance, the leaves of individual plants were removed in sequential order and their number recorded. A fine, dissecting needle and stereoscopic microscope (magnification 50 times) were used to aid detachment of the very young and small leaves. This procedure exposed the stem apex and meristematic tissue from which both leaf

[Print B near here]

and flower primordia are initiated. The apical diameter (as the diametric distance between the two most recently initiated leaf or inflorescence primordia on the stem apex) was measured by equipping the microscope with an eye-piece graticule of known calibration. Previous work at IHR Littlehampton has shown that there is a strong correlation between apical diameter and seven discrete stages in the development of the inflorescence. Measurements of apical diameter can therefore be used to assess the effects on flowering of environmental factors such as temperature. Furthermore, the technique allows the onset of flowering to be detected approximately six weeks before floral development is visible to the naked eye. Stem growth was assessed by measuring the height in mm from the apex to the base of the rosette.

Propagators' holdings

During a nine week period from mid January to mid March the two propagators achieved weekly, average 24-hour temperatures that were within the ranges 15-19C and 17-19C during 1987 and 1988 respectively. Precision of control varied with the propagators and, over the nine weeks of monitoring, there were differences of 3C in 1987 and 0.9C in 1988 between the average 24-hour temperatures achieved at the two sites.

Many celery growers prefer to obtain their plants from specialist propagators. The young seedlings (normally raised and supplied in peat blocks ranging from 43 to 50 mm in size) are competitively priced and allow growers to allocate all of their glasshouse area to production. However, claims are sometimes made that the performance of early celery crops (especially their potential for bolting) is strongly influenced by the 'quality' of the plants supplied by the propagator. Temperature is an important factor during propagation; it was therefore decided to compare plants supplied by the two commercial propagators and assess whether there were any real differences in bolting potential as the plants approached maturity. Replication over the two years of the project enabled a greater degree of certainty to be attached to the results.

Celery is normally ready for planting when four to five leaves have unfurled and the roots are just beginning to appear through the sides of the peat blocks. At the time of planting, the seedlings (cv. Loret) supplied by the two propagators were virtually identical in terms of apical diameter and the total number of leaves initiated. Also, there were no real differences between the two years.

[Insert Table near here]

Leaf number counts and measurements of the height of the main stem at various times after planting indicated that the potential for bolting was unaffected by the source of plant material. Environmental control and crop management techniques on the various commercial holdings were more important; the small differences in average 24-hour temperature between the two specialist propagators were seemingly of no practical significance.

Growers' holdings

From planting onwards the weekly, average 24-hour air temperatures under glass were generally within the range 11-14C during 1987 and 11-13C in 1988. However, site C was a notable exception for the first 6-8 weeks after planting. During this period in both 1987 and 1988 the grower at site C achieved weekly, average 24-hour temperatures that were from 1-5C below those recorded at the other sites.

[Insert Figure 2 near here]

It is encouraging that from early February to the end of March growers were collectively able to maintain an overall, average 24-hour temperature of 11.8C in 1987 and 11.3C in 1988 against mean outdoor temperatures of 5.5 and 7.1C for the same periods. However, these temperatures are too low to prevent vernalization and the celery crops grown on ALL the different holdings were inevitably prone to bolting in both years.

The progress curves for apical diameter in Loret celery grown on the various holdings showed that a maximum diameter of between 0.4 and 0.5 mm was attained towards the end of March, i.e. six to eight weeks after planting (late January/early February). Thereafter apical diameter declined, albeit at different rates which were associated with an individual grower's holding. During 1988, the slowest rates of decline were observed on the two holdings (sites G and H) which recorded the highest mean temperatures.

[Insert Figure 3 near here]

The onset of decline in the apical diameter is important because it seems to be indicative of floral induction and gives growers an early warning of impending bolting problems. Regrettably, the biochemical changes which occur in the apical meristem during the growing season are largely unknown. The mechanism by which the apex 'switches' from a vegetative to a reproductive state is also unclear. However, once the plants become reproductive the apical diameter declines rapidly to zero and by mid to late April the flower primordia can be clearly identified under a stereoscopic microscope. All of the celery plants sampled from the various sites showed that leaf initiation ceased shortly after the attainment of maximum apical diameter. Maximum leaf numbers were remarkably similar for the various holdings and ranged between 44 and 50. The ensuing loss of apical dominance promoted a rapid and exponential growth of the main stem. These phenomena were observed in both years and on all growers' holdings. Indeed, stem elongation rates as high as 2mm/day were recorded towards the end of each growing season.

All of the growers participating in the project were advised of the high risk of bolting occurring in their crops, especially if harvesting was delayed too long. Returns from a questionnaire showed that in 1988 the wastage of sticks due to bolting ranged from nil to 15% of the total crop, with several growers near the upper limit. Valid comparisons are however difficult to make because there was no standardisation in the stick weights at harvest. This is important because by cutting the sticks early a grower can mask bolting, though not flower initiation.

The project has been successfully completed and the results have corroborated recent research findings that post-planting temperatures averaging 14C or less are conducive for vernalization. During the period from planting to the vernal equinox, the mean 24-hour temperatures achieved on all the growers' holdings was too low to avoid floral induction. Indeed, the problem of bolting can be seen as the inevitable consequence of growing celery crops too cold. However, it may be difficult for growers to justify the costs of providing the extra heating needed to prevent vernalization. Basic studies are continuing at IHR Littlehampton and it is hoped that a cost-effective solution can be found to the problem. In the meantime, growers can use apical dissections, leaf number counts and stem height measurements to follow the development of their crops. This will enable them to predict the onset of flowering and to determine when their crops should be harvested to avoid unnecessary wastage due to bolting.

The authors gratefully acknowledge the financial support of the HDC and the help of local celery growers who co-operated in this joint ADAS/AFRC project. We are also indebted to Lindsay Stilwell (ADAS South Coast Glasshouse and Mushroom Advisory Unit, Chichester) who read and checked the temperature integrators at weekly intervals on the various commercial holdings throughout the project.

TABLE

Apical diameter and leaf number of Loret celery supplied by two propagators and planted on commercial holdings in West Sussex

Propagator	Apical diameter (mm)	Leaf number
X	0.20	14.9
Y	0.21	15.0

APPENDIX

List of Celery Growers Participating in HDC Project on Temperature Monitoring in Relation to Bolting

<u>1987 Season</u>

Site A Mr. M.J. Wake
28, Chalk Lane, Sidlesham, CHICHESTER, West Sussex.

Site B Mr. P. Evans
Linnet Nursery, Lockgate Road, Sidlesham, CHICHESTER, West Sussex.

Site C Mr. P.P. Allen
Chartswood Nursery, Sidlesham Common, CHICHESTER, West Sussex.

Site D Mr. N.T. Lill
111, Second Avenue, Batchmere, CHICHESTER, West Sussex.

Site E Mr. N. Vrijland
Leythorne Nursery, Runcton, CHICHESTER, West Sussex.

Site F Mr. N.J. Lee
Woodleigh Nursery, Third Avenue, Batchmere, CHICHESTER, West Sussex.

1988 Season

Site C Mr. P.P. Allen
Chartswood Nursery, Sidlesham Common, CHICHESTER, West Sussex.

Site D Mr. N.T. Lill
111, Second Avenue, Batchmere, CHICHESTER, West Sussex.

Site G Efford EHS
LYMINGTON, Hants.

Site H Mr. N.J. Bettridge
Appletrees Nursery, Keynor Lane, Sidlesham, CHICHESTER, West Sussex.

Site I Mr. N. Vrijland
West Cranleigh Nurseries, Alford Road, CRANLEIGH, Surrey.

Site J Mr. D.J. Hall, 113 Batchmere Estate, Birdham, CHICHESTER, West Sussex.

1987 and 1988 Seasons

Propagators Almodington Nurseries
Earnley, CHICHESTER, West Sussex.

Madestein UK Ltd
2, Leythorne Cottages, Vinnetrow Road, CHICHESTER, West Sussex.

Captions

Figure 1 Calibration for an IHR temperature integrator over the range 5 to 30 C.

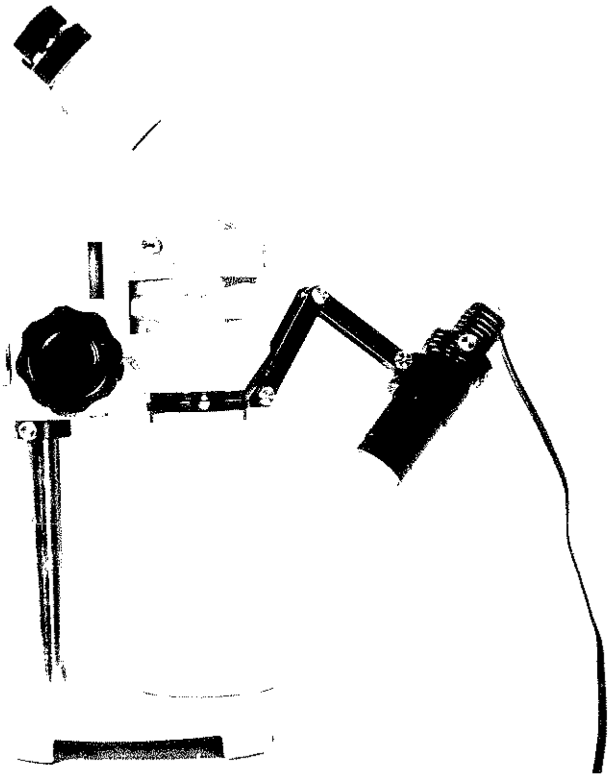
Figure 2 Weekly, average 24-hour temperatures recorded outside and on growers' holdings during 1987(a) and 1988(b).

Figure 3 Representative progress curves for apical diameter, leaf number and stem height in Loret celery grown on commercial holdings in West Sussex.

Print A IHR temperature integrator with 9 V batteries for powering elapse time (left) and temperature (right) counters. Thermistor-type temperature sensor is shown with protective cap, 2 metre extension lead and plug for inserting into socket located at the back of the unit. A push-button at the front of the integrator allows the counters to be re-set.

Print B Stereoscopic microscope for examining celery apices.

Print A IHR temperature integrator with 9 V batteries for powering elapse time (left) and temperature (right) counters. Thermistor-type temperature sensor is shown with protective cap, 2 metre extension lead and plug for inserting into socket located at the back of the unit. A push-button at the front of the integrator allows the counters to be re-set.



Print B Stereoscopic microscope for examining celery apices.

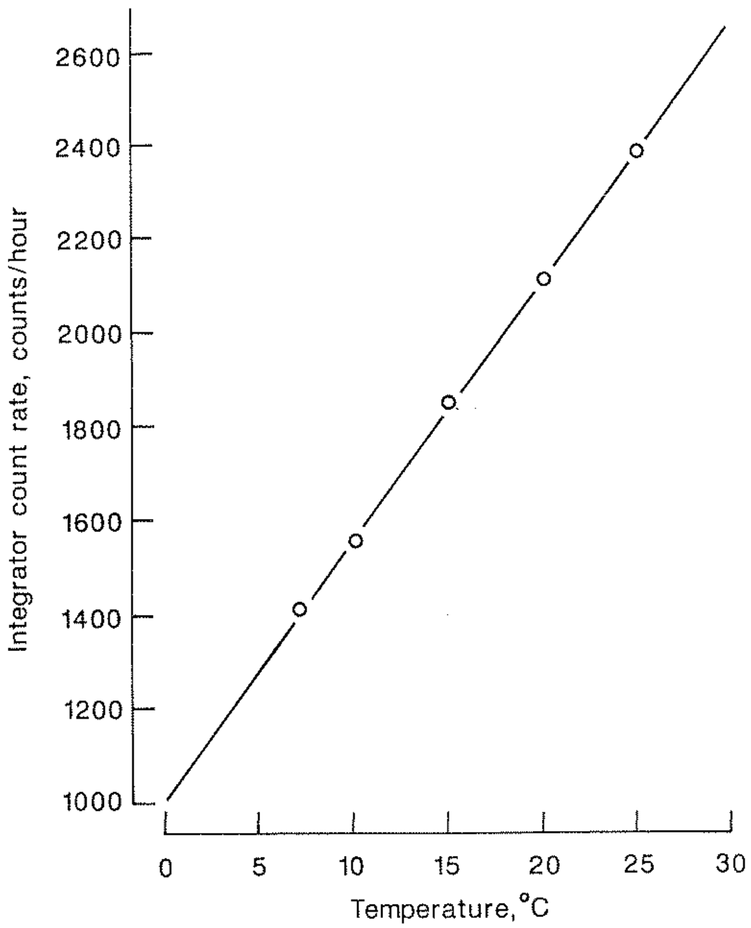


Figure 1 Calibration for an IHR temperature integrator over the range 5 to 30 C.

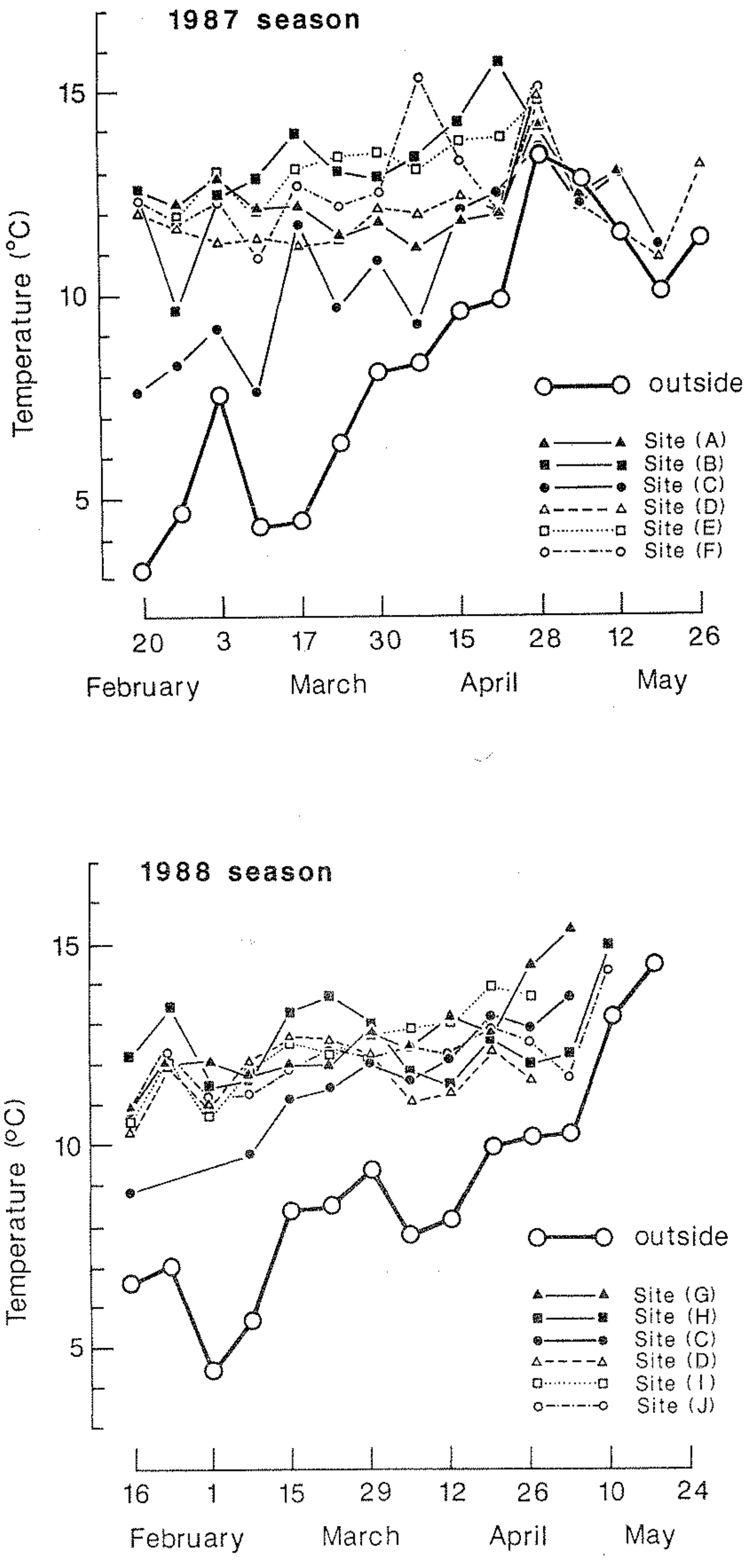


Figure 2 Weekly, average 24-hour temperatures recorded outside and on growers' holdings during 1987(a) and 1988(b).