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HORTICULTURAL DEVELOPMENT COUNCIL

BLINDNESS IN BRASSICAS
Contract No: FV 113

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Project Number:	FV 113
Project Title:	Blindness in Brassicas
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Project Co-ordinator:	Arthur Whitlock
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Index

Relevance to growers and practical application

Application

The object of this work has been to determine the factor or factors causing blindness in brassicas in order that plant raising and/or production techniques can be modified to minimise its occurrence.

Although several treatments including specific cold treatments did not induce blindness the level of blindness in plants raised with no heat in general exceeded that in plants with frost protection. In batches of calabrese plants raised during the winter in a polyethylene tunnel blindness varied from nil to 80% and high levels of blindness were predominantly associated with low light intensity in the period just before plants went blind. This suggests that supplementary light during dull weather might help to prevent the problem.

Summary

This project has concentrated on studying the effects of many different stresses on the level of blindness found in the blindness susceptible calabrese variety Marathon.

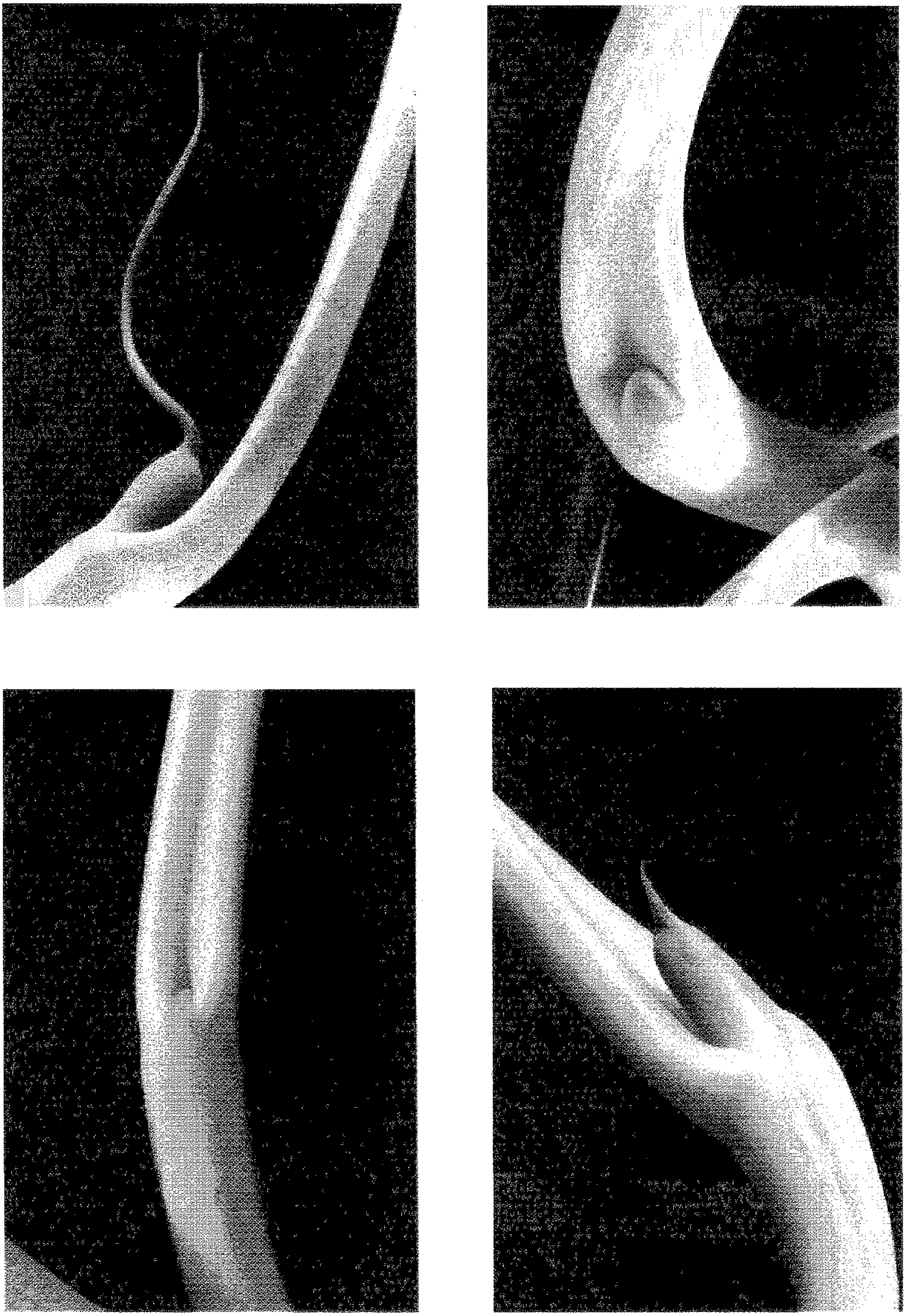
'Blindness' in brassicas occurs because the plant stops cell division at its apex and therefore stops producing leaves. If blind plants have fewer leaves than the mean number of leaves on a sample of plants at transplanting then the blindness was caused during plant raising. If the number of leaves on blind plants exceeds that at transplanting the blindness was caused in the field.

Blindness was not induced by specific cold treatments and there were no effects of shading, daylength or moisture stress during plant raising. There was a small effect of seed ageing in producing 4% blindness but this was obvious before transplanting and seed germination had to be reduced to 66% for this to happen.

However, in batches of plants of the calabrese variety Marathon, raised from a range of sowing dates during the winters of 1992/93 and 1993/94, levels of blindness varying from zero to 80% were produced. High levels of blindness were predominantly associated with low levels of light in the period immediately before plants went blind suggesting that supplementary lighting during winter brassica raising might help to reduce the incidence of blindness. There were indications that temperature does have an effect and may interact with solar radiation to affect blindness at low

light levels but because of the difficulties of separating the two effects this is as yet unproven.

Figure 1. Blind plants



Experimental section

Introduction

'Blindness' is the death of the growing point and at a low incidence occurs in all brassica crops, irrespective of when grown. It only becomes apparent when it is obvious that the plant has stopped producing leaves and this is usually not until some time after transplanting. It is estimated that blindness can affect up to 20% of early calabrese crops alone with a consequent annual crop loss of about £500,000. Blindness has been a considerable problem in recent seasons with levels of up to 95% reported in calabrese and 60% in cauliflower.

The time at which plants go blind can be identified approximately by counting the number of leaves on blind plants. This is usually less than the number of leaves on plants at transplanting and the problem is therefore normally associated with conditions during plant raising. If the conditions causing blindness can be determined and the problem prevented there will be considerable financial benefits for calabrese and other brassica species. The objective of this work has been to determine the conditions causing blindness in brassicas in order that plant raising conditions can be modified to minimize any problem.

In 1992 a literature review (Wurr, Smith & Hambidge, 1992) of work associated with blindness concluded that temperature was the most important factor but that blindness had been reported to be associated with low temperatures, molybdenum deficiency, insect damage, scorching by fertilizer and pesticide, daylength, light intensity, moisture stress and seed quality. However, the scientific evidence for these is patchy. Blindness shows itself in various ways and would appear to be caused by a lack of cell division at the plant apex rather than anything causing tissue death and necrosis.

Since a lot of the evidence for blindness pointed towards effects of low temperature, much of the work since April 1992 has concentrated on this area. Considerable use has been made of a temperature-controlled cabinet designed to operate between -20 and +30°C. Treatments applied during the spring, summer and autumn of 1992 and 1993 studied the effect of many factors on the level of blindness: the stage of growth when low temperature was imposed, the temperature, the length of the cold period, the rate of cooling, the daylength during plant raising, shading during raising, seed quality, moisture stress before a cold treatment and moisture stress after transplanting. However, the highest level of blindness recorded was only 4% and this was achieved by drastically 'ageing' seed such that its germination was only 66%. The mean number of leaves on these blind plants was fewer than two, so that any problem would have been easily seen at transplanting, and the high levels of blindness occurring in commerce are most unlikely to have been caused specifically by seed quality or indeed by any of the applied stresses. However, when batches of calabrese plants of the variety Marathon were raised during the winter of 1992/93 from sowings made between October and January, blindness levels of up to 50% were observed (Wurr, Smith & Hambidge, 1993).

Materials and methods

The results from 1992/1993 were investigated further during the 1993/94 winter with nine batches of plants of the calabrese variety Marathon sown at 14-day intervals from 27 October 1993. From emergence, plants were raised and treated in a ventilated polyethylene tunnel. The treatments were all combinations of two light regimes: natural irradiance (open) or irradiance reduced by about 50% for 28 days from 49 days after sowing (shaded); and two temperature regimes: ambient temperatures (ambient) or 12 days with temperatures cycling from 2°C in the day to -1°C at night, from 63 days after sowing (freezer). After treatment plants were transferred to a glasshouse with frost protection until they were sufficiently large to be potted up. Regular 10-plant samples were taken during raising to determine the number of leaves. Sixty plants of each treatment were transplanted into FP7 pots containing Levington M2 compost, were put in a glasshouse with frost protection on capillary matting and fed with a standard nutrient feed. Individual plants were assessed for blindness approximately 28 days after transplanting by removing leaves and inspecting the plant apices.

Results

Table 1 shows, for every treatment of each batch, the percentage blindness and the number of leaves produced by blind plants. It also contains estimates of the day numbers when the final leaf was produced and when the next leaf would have been produced. This information was then used to inspect the environmental conditions leading up to the failure to produce that leaf. Table

Table 1. Percentage blindness, number of leaves on blind plants and estimates of when the final leaf was produced and the next leaf would have been produced.

	Batch	Sown	% blind	Number of leaves	Day when final leaf produced	Day when next leaf would have been produced
Ambient open	1	27 Oct	80	5.7	9	24
	2	10 Nov	48	6.3	36	52
	3	24 Nov	57	5.6	42	63
	4	8 Dec	62	5.5	51	67
	5	22 Dec	28	4.9	54	67
	6	5 Jan	20	5.3	65	79
	7	19 Jan	10	4.5	59	72
	8	2 Feb	0	-	-	-
	9	16 Feb	5	2.5	65	74
Ambient shaded	1	27 Oct	62	6.2	18	32
	2	10 Nov	22	6.6	40	54
	3	24 Nov	47	6.4	51	66
	4	8 Dec	45	6.1	62	77
	5	22 Dec	20	4.7	50	64
	6	5 Jan	7	6.0	78	90
	7	19 Jan	5	4.5	58	72
	8	2 Feb	0	-	-	-
	9	16 Feb	7	4.0	72	83
Freezer open	1	27 Oct	60	5.7	15	32
	2	10 Nov	17	6.4	48	69
	3	24 Nov	72	5.5	39	56
	4	8 Dec	50	5.1	44	59
	5	22 Dec	25	4.9	56	71
	6	5 Jan	38	5.1	66	81
	7	19 Jan	3	5.0	68	84
	8	2 Feb	0	-	-	-
	9	16 Feb	10	2.5	46	60
Freezer shaded	1	27 Oct	72	5.8	15	32
	2	10 Nov	23	6.0	36	53
	3	24 Nov	53	5.5	39	55
	4	8 Dec	22	5.4	51	66
	5	22 Dec	25	5.6	67	82
	6	5 Jan	18	5.5	75	89
	7	19 Jan	5	3.7	48	63
	8	2 Feb	0	-	-	-
	9	16 Feb	8	4.4	67	83

1 shows that, in general, percentage blindness was highest from the earliest sowing and declined with later sowing. There were no blind plants recorded for batch 8 in any treatment and blindness levels were relatively low for batches 7 and 9. For ambient open plants (those raised in a polyethylene tunnel without shading or additional cold treatment) blindness varied from 0 to 80% and although the level of blindness from the ambient open treatment consistently exceeded that from ambient shaded plants the differences were minor compared with those between different times of sowing. Batches 1-6 went blind after they were shaded and batches 7 and 9 before they were shaded. The effect of cold treatment for 12 days in the freezer was negligible and while batches 1-6 went blind after cold treatment, batches 7 and 9 went blind before cold treatment. As a result of the limited effects of shading and cold treatment, further analyses of the data concentrated on those open batches raised in the polyethylene tunnel which relate more easily to plants raised in commerce. Figure 1 shows some of the ways in which blindness expresses itself.

The number of leaves produced by blind plants declined slightly with later sowing, suggesting that there is no specific growth stage at which plants go blind. The crops at greatest risk of blindness (here batches 1-4) are those sown in late autumn which experience the longest periods of adverse conditions. In order to explore the conditions associated with blindness data are considered in terms of the periods during which specific leaves were produced. The mean values of maximum temperature, minimum temperature, mean temperature, amplitude of temperature change (the difference between maximum and minimum temperature) and solar radiation were calculated for half of the time period during which the leaf that did not appear due to blindness would have been produced, subsequently referred to as the 'blind' period. Figure 2 then shows the percentage of blind plants plotted against both mean daily solar radiation, measured in mega-joules per m^2 (MJ/m^2) and mean daily temperature (°C) in this period. It shows how the level of blindness declined as solar radiation increased during the 'blind' period. It also indicates how blindness declined with increased mean daily temperature in the 'blind' period and shows that this relationship is poorer than that with solar radiation.

Figure 3 indicates the duration of the 'blind' period and shows that plants apparently went blind in January (batch 1), mid February (batch 2), late February (batch 3) and March (batches 4, 5, 6, 7 and 9). Figure 2 also shows the daily radiation and mean daily temperature over the whole of this time. Solar radiation levels started to increase in early March while mean temperatures in mid and late January were higher than during most of February. Thus blindness in batches 4, 5, 6 and 7 occurred as solar radiation levels were rising. This suggests that it is not just the absolute level of solar radiation which causes blindness but that temperature may interact with solar radiation to allow expression of blindness.

Figure 2. Relationships between percentage blindness, mean daily solar radiation and mean daily temperature in the period from half a leaf before blindness occurred (ambient open only).

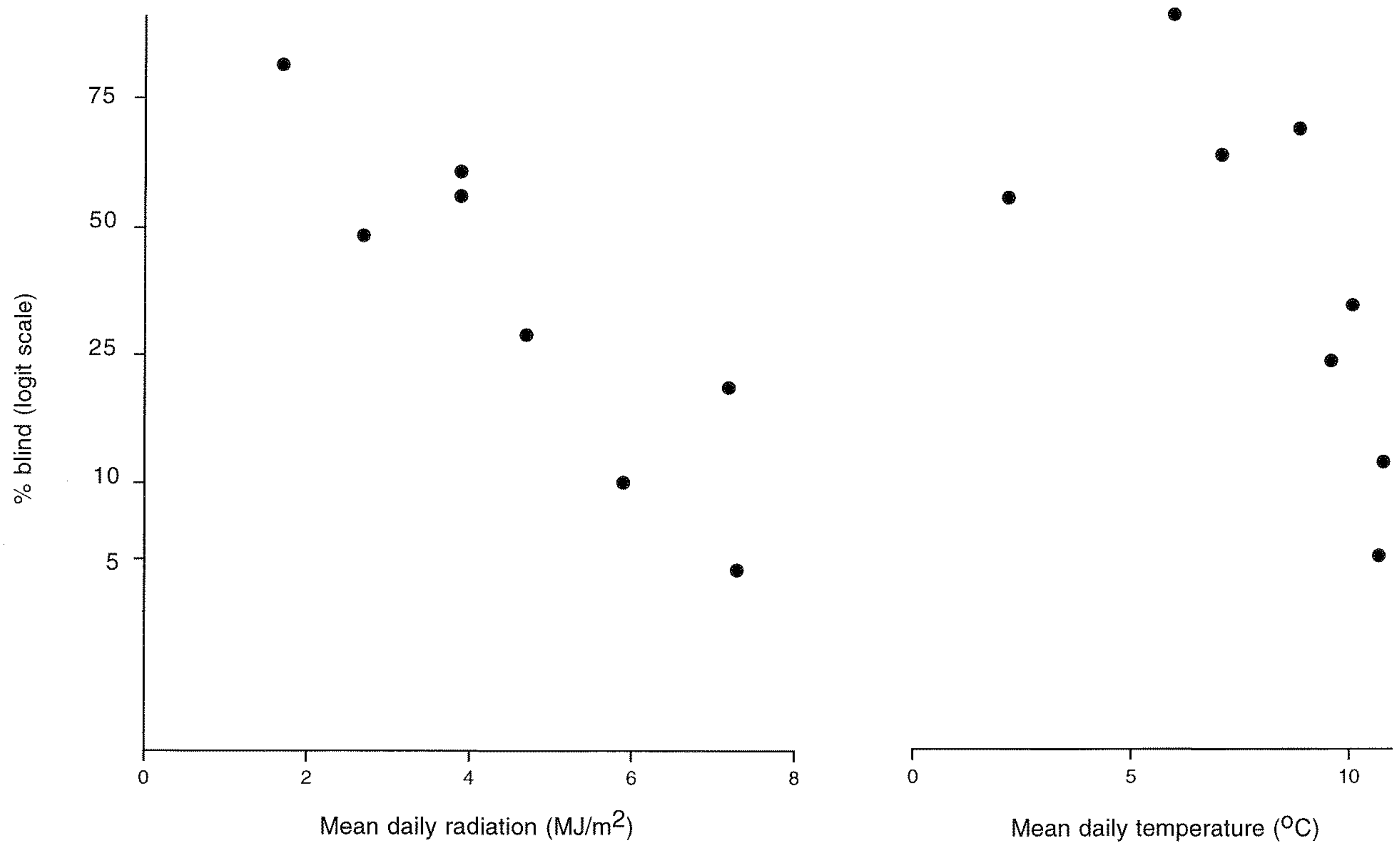
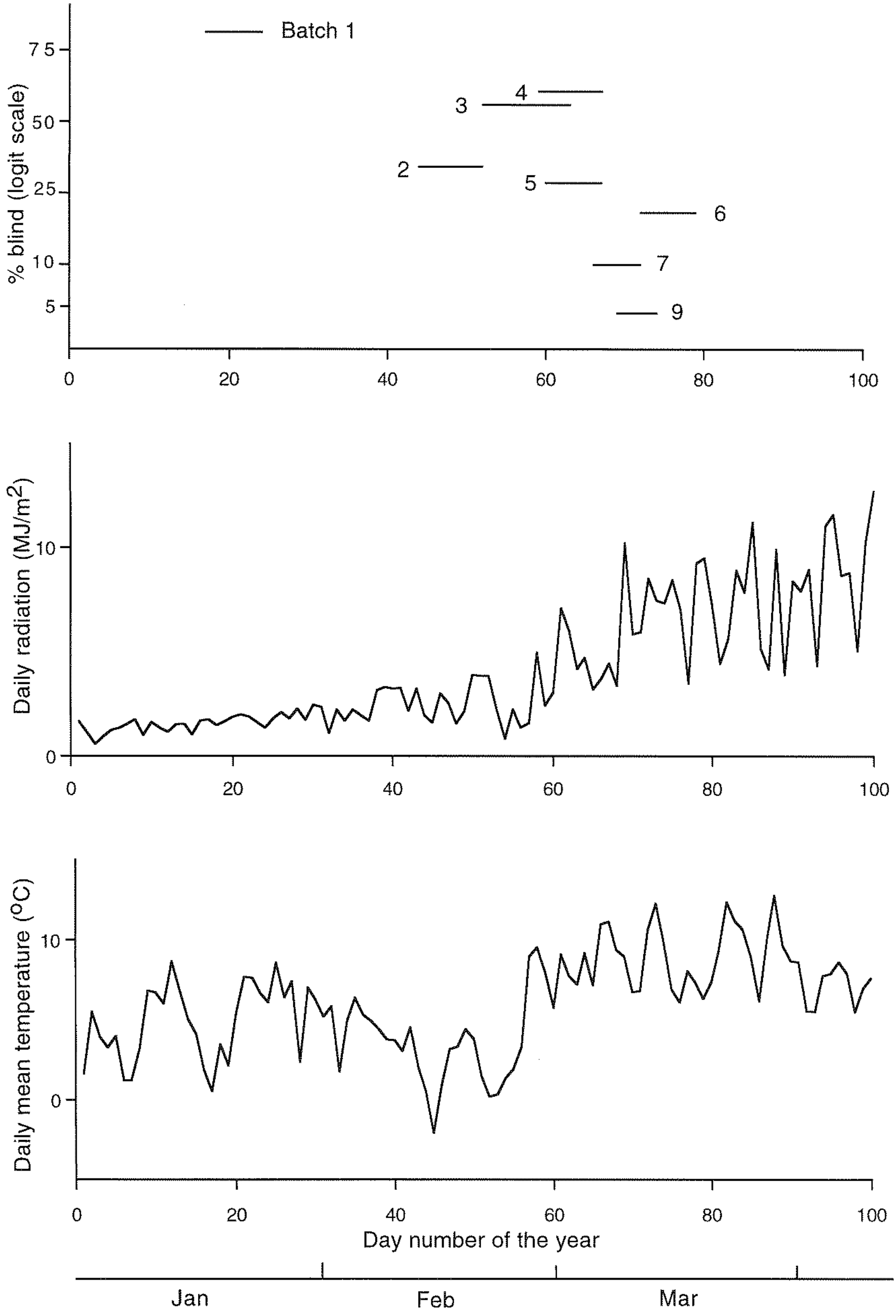


Figure 3. The timing of the period from half a leaf before blindness occurred, together with percentage blindness, daily solar radiation and daily mean temperature (ambient open only).



Conclusions

The wide range of temperature, light, moisture stress and seed quality treatments applied during the spring, summer and autumn of 1992 surprisingly failed to produce any appreciable level of blindness despite some apparently severe treatments. For these experiments the cold stress was applied with the lid of the temperature-controlled cabinet shut and consequently plants received stress in the dark and were moved into a glasshouse compartment kept at approximately 15°C in the day. It was thought that this regime might have had some effect on blindness expression and consequently, all subsequent experiments were conducted in the cabinet with a triple-skinned polycarbonate lid fitted in order to keep plants in the cabinet continuously and allow them to receive natural lighting while being treated. The experiments in the summer of 1993 applied cold stress over a long period of time but still did not cause any marked blindness. There was a small effect of seed quality but those plants which went blind either had no true leaves or a very low number of leaves and commercially would have been discarded at transplanting. Although negative, all these results were useful because they clearly demonstrated, in well replicated experiments, that the stresses imposed were insufficient to account for the levels of blindness known to occur in practice. They suggested that the stresses which cause blindness are either more severe than those applied in the summer and autumn of 1992 and the summer of 1993 or were not present in the right combination to trigger expression of blindness.

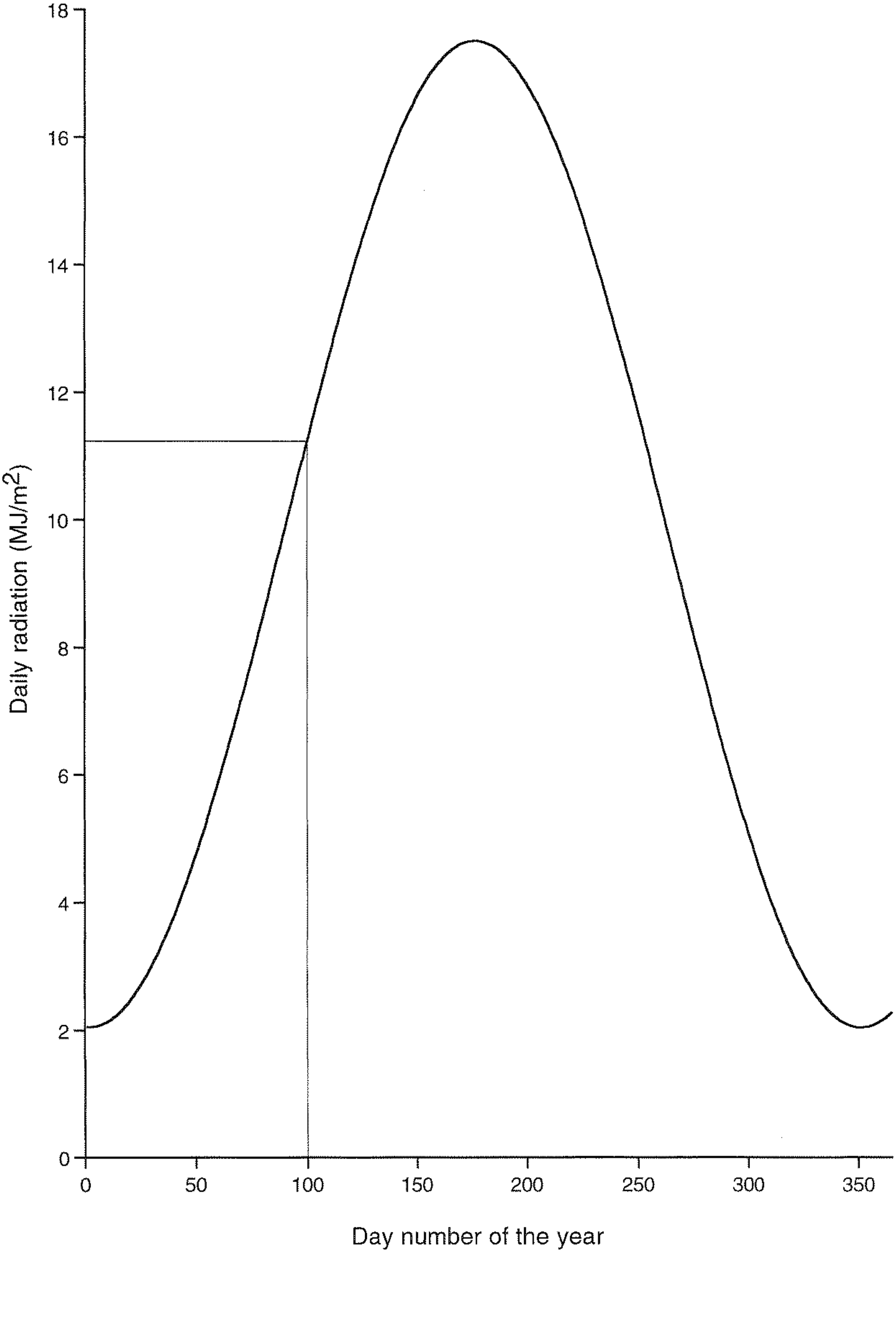
It was considered that light might be an important factor since levels during the winter are a fraction of those during the summer (Fig. 4) and cold stresses applied under low light conditions might have a different effect to those applied under summer light levels. Thus the work conducted in the winters of 1992/93 and 1993/94 looked at blindness under low light and low temperature conditions. It was thought that continuous temperatures at or below 0°C in the light might be necessary to induce blindness.

In 1992/93 the data showed that:

1) The level of blindness in plants raised with no heat always exceeded that in plants with frost protection.
2) Plants never experiencing temperatures below 5°C still showed up to 14% blindness
3) The number of leaves on blind plants declined with successively later sowings so there was no specific growth stage at which plants were affected.
4) All batches of plants appeared to have gone blind at a similar time during late February/early March.

This suggested that blindness may be associated with some combination of light and temperature during plant raising, irrespective of growth stage. This hypothesis was explored further in the winter of 1993/94 when the major differences were between the batches from different sowing dates, with levels of blindness varying from zero to 80%. The number of leaves on blind plants varied slightly suggesting that there was no specific

Figure 4. Long term average values of solar radiation at Wellesbourne in $MJ/m^2/day$. (The box indicates the time period in Figure 3.)



growth stage at which plants were susceptible. The results show that high levels of blindness were associated with low light intensities in the period just before plants went blind. However, it is too early to be sure that this is causal because light levels during the winter are closely associated with maximum, minimum, mean temperature and the amplitude of temperature and the data also suggest that temperature has some effect. Certainly low light cannot be the sole cause of blindness because in 1993/94 the level of blindness in the polyethylene tunnel on open plants exceeded that on shaded plants. However, the major treatment differences were between batches and, as Fig. 4 shows, levels of irradiance change dramatically between January and March and then double again to midsummer values.

Because it has not been possible to separate the effects of temperature and solar radiation we can only speculate as to how temperature may still influence blindness even though specific cold treatments had no effect. The fact is that most batches of plants went blind from mid-February onwards when light and temperature levels were increasing. It is suggested that competition for assimilates may be the cause of the problem and that at low light levels a small change in temperature may be sufficient to stimulate leaf growth but because photosynthesis is limited by the low light levels the next leaf to be produced does not get sufficient assimilates to support it. This explains why blindness is rare in summer when light levels are high, yet still occurs in late winter when plants are protected from frost. It may explain why in 1992/93, plants raised at ambient temperatures in a polyethylene tunnel had a higher level of blindness than those with frost protection in the glasshouse, which themselves showed up to 14% blindness. Data presented by Wurr, Smith and Hambidge (1993) show that maximum temperatures in the polyethylene tunnel were higher than in the glasshouse and may have encouraged leaf expansion without solar radiation being high enough to support the growth of the next leaf.

The likely conclusion from these experiments is that blindness is predominantly caused by low light conditions so that in practice the use of supplementary lighting during dull weather may reduce the incidence of blindness.

There is often uncertainty as to whether blindness was caused during plant raising or during growth in the field but this can be determined by the grower counting the number of leaf scars and leaves up to the point of blindness. If there are fewer leaves than the total number of leaves at transplanting, (in calabrese on average about eight) then the blindness was caused during plant raising. If the number of leaves on blind plants exceeds that at transplanting, then the blindness was caused in the field.

Recent studies of petunia and geranium plants with so called 'leaf distortion', which can occur irregularly in sequences of batches of plants of these and other bedding plant species, have suggested that the problem is similar to blindness in brassicas. Close inspection of plants showed that the leaf distortion was associated with the loss of the main growing point or points and indeed the plants, although checked, were able to recover by continuing growth from axillary buds. It is possible that the environmental cause of blindness in brassicas is also responsible for 'leaf distortion'.

There is clearly scope for further experimentation to study the effects of supplementary lighting on blindness, to separate out the effects of low light and temperature and to explore the effects of such treatments on leaf distortion in bedding plant species.

References

Wurr, D.C.E., Smith, G.P. & Hambidge, A.J. (1992). Blindness in brassicas. *1992 Annual Report for Horticultural Development Council*. 23 pp.

Wurr, D.C.E., Smith, G.P. & Hambidge, A.J. (1993). Blindness in brassicas. 1993 Annual Report for Horticultural Development Council. 12 pp.

conditions causing blindness and varietal differences in the stage of growth at which plants are sensitive are not known. An initial investigation of this problem could be made by HRI using a programmable environmental cabinet, which can operate between +20°C and -30°C, to mimic any cooling and warming conditions during plant raising. The price of this cabinet is estimated to be a maximum of £6000, and is included in the costs for Year 1.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

The only known work in this area was a small study by Dr Peter Salter, reported in Nature in November 1957. It applied to the cauliflower variety Finneys 110 and found that plants were particularly sensitive to a period of low temperature when approximately seven leaves had been initiated.

6. DESCRIPTION OF THE WORK

In Year 1 it is proposed that plants of a susceptible variety of calabrese are subjected to 'thermal stress' as follows:

Initially -

At different numbers of leaves

Cooled to different temperatures

A series of experiments could then be conducted examining the following factors and perhaps others:

Plants cooled at different rates

Cooling regime repeated for different numbers of days

Temperature from which cooled

Time spent at minimum temperature

Light conditions during daytime

This approach needs a series of experiments, for which the treatments will depend upon the previous experiment. It is estimated that up to 5 such experiments could be conducted during the growing season.

Before and after treatment, plants would be held in a glasshouse at a controlled temperature. They would need to be planted out in the field at the same time so that blindness assessments could be made without plant dissection.

Once the approximate conditions causing blindness can be identified, investigations in subsequent years could be

Contract No: FV/113

TERMS AND CONDITIONS

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.......[signature].........
	Position.. Commercial & Marketing Manager.
	Date.......23.12.91.........
Signed for the Council	Signature.......[signature].........
	Position.......CHIEF EXECUTIVE.........
	Date.......17.12.91.........

extended to other varieties of calabrese and to other brassica crops.

7. COMMENCEMENT DATE AND DURATION

January 1992 for 3 years.

8. STAFF RESPONSIBILITIES

Project Leader:	Dr D C E Wurr
Other staff:	0.5 ASO plus some assistance from permanent staff when necessary.

9. LOCATION

HRI Wellesbourne

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