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Report no. 2104

Negative DIF: The effect of temperature drop prior to daybreak on internode length of young tomato seedlings

Negativ DIF: Virkningen af temperaturfald før solopgang på internodielængden af tomat frøplanter

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Summary

It has been generally accepted that the change from night temperature to day temperature regimes has to coincide with daybreak, to obtain a maximum growth retarding effect of negative DIF (low day/high night room temperature) under commercial conditions.

However, investigations under controlled environmental conditions at the Department of Horticultural Engineering, have proven that the internode length of tomato seed plants can be significantly reduced when the low temperature regime is started two hours prior to daybreak. Irradiation with red light during these hours did not alter this result.

From this we conclude that the tissue temperature at daybreak is more important than a coincidence of temperature reduction and daybreak.

Furthermore the results may indicate that a red light induction of the phytocrome system from two hours prior to daybreak is not crucial for the effect.

The aspects of applying negative DIF under commercial conditions have, due to this observation, become more feasible, as the reduction in room temperature can take place in the dark period prior to daybreak.

Key words: Negative DIF, red light irradiation, tomato plants, pot plants, growth retarding.

Resumé

For at opnå den størst mulige reduktion i internodielængden ved dyrkning af potteplanter i erhvervsgartnerier ved anvendelse af negativ DIF (lav dagtemperatur/høj nattemperatur), har man troet, at temperaturfaldet om morgenen skal ske samtidig med daggry som en naturlig forudsætning for at opnå det bedste resultat.

Men undersøgelser i fytotronen udført på Laboratorium for Gartneriteknik har vist, at internodielængden hos tomatplanter kan reduceres signifikant, selv om temperatursænkningen sker to timer før daggry. Belysning med lav intensitet af rødlys havde ingen indflydelse på dette resultat.

Heraf vil vi slutte, at vævstemperaturen ved daggry, er mere vigtig end sammenfaldende tidspunkter for temperaturfald og daggry, og at dette temperaturfald gerne må ske nogle timer før daggry.

Endvidere tyder resultatet på, at en påvirkning af fytokromsystemet med rødlys i to timer før daggry ikke er nødvendig for at opnå internodieforkortelse.

Disse iagttagelser vil have stor betydning for anvendelsen af negativ DIF i erhvervsgartnerier. Perioden før daggry kan bruges til sænkning af temperaturen, så en eventuel ventilation for at få temperaturen hurtigt ned kan undgås.

Nøgleord: »Negativ DIF«, rødlysbestråling, tomatplanter, potteplanter, internodielængde.

Introduction

The growth retarding effect of low day/high night time room temperature regimes (negative DIF) on several greenhouse cultures has been reported by various authors (4, 5, 6, 7). Also the importance of this temperature strategy for energy saving has been stressed (1, 2, 3). It is generally assumed, however, that the effect on internode length depends on a drop in room temperature at daybreak. Furthermore it seems inevitable that the reduction from night towards day temperature has to occur immediately or at least within a very short time. This may be explained by the fact that many experiments so far have been performed in phytotrons or controlled environment rooms where room temperature changes can take place within a very short time or where small trays with plants can be easily moved from one compartment to another.

If a quick change in room temperature is important for a maximum retarding effect, a considerable decrease in room temperature can only be obtained by ventilation with an inevitable loss of energy as a consequence. Furthermore it may be difficult to obtain an adequate reduction in room temperature in summer time just after sunrise. The application of additional supplementary irradiation at night provides difficulties as the temperature decrease coincidence with a sudden very high energy input when lamps are switched on.

All this may severely restrict the utility of negative DIF in commercial nurseries. However there has been found an interaction between light quality (R/FR ratio) and DIF (6). *Campanula* plants respond only to DIF, when the plants were exposed to light with a high R/FR ratio during day extension as compared to an identical treatment with low R/FR ratio. This may explain the importance of the coincidence of temperature drop and daybreak. In this experiment we want to separate temperature drop and daybreak. But to secure the red light effect from sunrise we treated the plants with red light irradiation starting at temperature drop before daybreak.

The crucial question for a practical adoption of the method will therefore depend on whether coincidence of sunrise and temperature change is necessary or a temperature change prior to sunrise, possibly with manipulation of the phytochrome system by red light irradiation, will suffice.

It is the aim of this paper to demonstrate that coincidence of temperature drop and daybreak is not always necessary and that the results of our observations promote an easy application of negative DIF in commercial nurseries.

Materials and methods

The experiments were carried out in a phytotron at the Department of Horticultural Engineering in Årslev, Denmark. In the phytotron each daylight compartment is connected to three dark rooms. Plants can be automatically moved on trollies between the dark room and the day-light compartment.

The day temperature is a minimum temperature control where solar irradiation may increase room temperature until ventilation set point. During the day only natural daylight conditions prevail.

In the experiment the change in room temperature occurred when the trollies left the darkroom. The additional red light irradiation was supplied in the daylight compartment two hours prior to daybreak (table 1, treatment 2.3). The light treatment was performed with Philips TLD 36W/15

fluorescent tubes with a R/FR ratio (660/730 nm) of 7.29 (8).

The tube was mounted 1.5 meter over the plants and the irradiance amounts to 0.8 micromoles /m^2·s.

Ten tomato seedlings (*Lycopersicon esculentum* cv. 'Matador'), three weeks old, were used in three replications (see Table 1).

Table 1. The average internode length in millimeter of tomato seedlings grown with positive and negative difference between day and night temperature, respectively.

	Treatments		Internode length, mm
1	positive DIF 21°/19°	+2	
1.1	shift at daybreak		52***
2	negative DIF 14°/22°	−8	
2.1	shift at daybreak		19
2.2	shift two hours prior to daybreak		18
2.3	shift two hours prior to daybreak + additional irradiation with red light		18

*** statistical difference at 99.9 percent level.

The internode length was measured approx. 4 weeks after the commencement of the treatments when the experiment was terminated. The experiment was repeated three times from November 1989 until February 1990.

Results

The average internode length of the seedlings is shown in Table 1. There is a pronounced effect while changing from positive DIF to negative DIF in the internode length (Table 1).

The moment at which the room temperature drops does not affect the overall results of negative DIF.

The irradiation with red light which could have simulated daybreak when the temperature decrease occurs two hours earlier does not alter this.

Similar results has been obtained in this experiment for *Aster novi-belgii* cv. 'Freda Ballard' and cv. 'Royal Blue', *Dendranthema grandiflora* cv. 'Garland' and cv. 'Surf', *Fuchsia* × *hybrida* cv. 'Beacon' and *Rosa* × *hybrida* cv. 'Victory Parade'.

Discussion

The results of this experiment will have an important effect upon the question whether to apply negative DIF techniques under commercial conditions (2, 4, 6 and 7). But in most experiences quoted, it has been an implicit condition that temperature decrease should occur at sunrise. Because the results of this experiment show that the coincidence of daybreak and drop in temperature is not important, the commercial application of negative DIF is greatly improved.

A temperature decrease prior to daybreak will overcome one of the bigger problems of greenhouse nurseries connected to district heating and the occurrence of energy consumption peaks at sunrise (2).

The irradiation with red light (treatment 2.3, Table 1) showed to be without effect as compared to the treatment without red light before daybreak (treatment 2.2, Table 1). This may indicate the existence of two pools of phytochrome (Pfr I and Pfr II) as reported by *Takimoto* and *Saji* (9). Pfr I is unstable and rapidly disappears after transfer to darkness. Pfr II is stable in darkness and the amount is assumed to be unchanged. In the case of this experiment, the concentration of stable Pfr II has obvious been sufficient to secure the growth retardant effect of negative DIF (treatment 2.2, Table 1). An increase in concentration of Pfr I, induced by the two hours red light irradiation before daybreak did not improve the results.

The results on tomato plants in particular may be of importance to suppress vigorous growth in the early spring shortly after plants are placed in the greenhouses. The delayed yield as reported by *Heuvelink* (5) may be overcome if the nutrient concentration is reduced.

Conclusion

To obtain a growth retarding effect we may conclude that:

1. The change in room temperature at daybreak is not crucial for the growth retarding effect of negative DIF.
2. The decrease in room temperature may come before or at daybreak to obtain the growth retarding effect of negative DIF.
3. Additional irradiation with red light before daybreak does not enhance the growth retarding effect of negative DIF.

4. For commercial use in greenhouses the decrease from high night temperature to lower day temperature may therefore start before daybreak and will avoid greatly the occurrence of energy consumption peaks at dawn.

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Manuscript received 27 August 1990.