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GROWTH AND TRANSPIRATION OF TOMATO IN RELATION TO NIGHT TEMPERATURE UNDER CONTROLLED CONDITIONS

by

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1. INTRODUCTION

The effect of a constant air temperature on growth and water requirement of tomato was previously investigated. It is of special interest, however, to study separately the effect of day and night temperature since literature in connection herewith is not very extensive. It is also of importance to investigate the relation between transpiration and growth as influenced by night temperature.

2. MATERIAL AND METHODS

Tomato seeds were sown in wooden boxes and the seedlings transplanted 12 days afterwards into small metal containers, 20 cm high and 10 cm in diameter. Each of these containers was filled with 2 kg of loamy soil. Fifteen days after transplanting, the tomato plants were all exposed to the same day temperature (25.3 °C) and, in series of four plants, to different night temperatures (25.3°, 20.0°, 15.6° and 9.2°C respectively). During 12 hours in every 24 hours the pots were in a compartment illuminated by "daylight" fluorescent tubes at an intensity of 7.6×10^4 erg. sec.$^{-1}$cm^{-2} ⌀ sphere, measured with a spherical radiation meter. Then each set of four plants was transferred to a dark compartment, kept at a constant temperature for the remaining 12 hours. The mean relative humidity of the air during the whole period of the experiment was approximately 60 %. The soil moisture was maintained between 100 and 80 per cent of the maximal available water content which range previously had been shown to be optimal for growth (1).

The water loss was measured each day, by weighing. Once every week, the soil in the pots was covered with plastic sheets for 24 hours in order to measure the amount of water, transpired by the plants. For further methodical details see ABD EL RAHMAN and BIERHUIZEN (1). The height of the shoot was measured

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once a week, during the experiment (28 days). At the end, fresh and dry weight of shoot, total leaf area, number of leaves, and dry weight of roots[1]) were measured.

3. Results and Discussion

A. *Growth measurements*

Some investigators have discussed the effect of night temperature on the growth of plants. According to Went (5), the optimal temperature for stem elongation in young plants is 25 °C during day and night. Verkerk (4) mentioned that under fauvorable light conditions the stem growth increased with increase of day and night temperatures. Under low light intensities this was less obvious. Loomis (2) observed that growth is often correlated with temperature during the night, and with the relative humidity during the day.

Thomas (3) found translocation of sugar to increase with a decrease in temperature. Because of this, 18 °C was considered a more favourable temperature than 26 °C. Lower temperatures gave an unfavourable effect because they decreased too much the rate of other processes, involved in growth. According to Went (5), so called thermoperiodicity in tomatoes is due to the interaction of two processes, one occurring in the dark, the other in the light, of which the dark process should have a much lower temperature optimum than the process in the light.

In the present investigation growth varies in relation to night temperature as is shown in plate 1. The height of shoot shows a reduction to 63 % with the night temperature falling from 25.3° to 9.2 °C (fig. 2) which was due to a difference in rate of elongation (fig. 1). After seven days, the difference in height

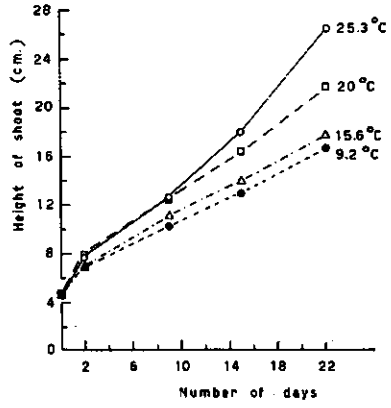

Fig. 1. The rate of stem growth of tomato plants at different night temperatures.

between the various treatments was not significant, it increased gradually with age (fig. 1).

The total leaf area varies irregularly with the different treatments. It seems that night temperature, in the range of temperatures studied, has only a minor effect on leaf area. The dry weight of the leaf decreases regularly – though rather

[1] Dry weight of roots was not measured in the experiments, described in (1), furtheron it has always been recorded.

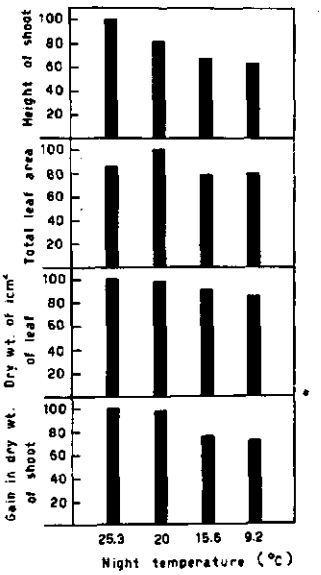

FIG. 2.
The variation in height of shoot, total leaf area, dry weight of 1 cm² of leaf and gain in dry weight of shoot at different night temperatures. The values are expressed as percentages of maximum.

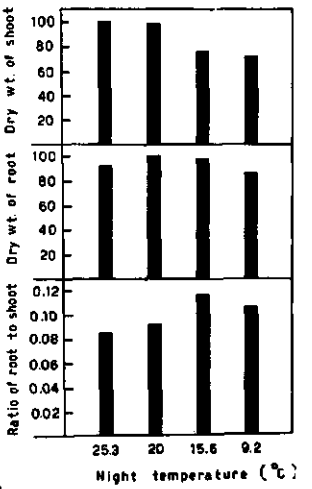

FIG. 3.
The variation in dry weight of shoot, of roots, and of the ratio of roots to shoot at different night temperatures. The values are expressed as percentages of maximum, except the ratio of root to shoot.

little – with decrease in night temperature, it shows a reduction to 85 % in the night temperature range from 25.3° to 9.2 °C (fig. 2).

The variation in total dry matter production of the shoot does not depend primarily on the variation in leaf area, but mainly on the growth of the stem and the dry weight of the leaf. The dry weight of the shoot decreases from 100 % to 98, 76, and 73 % in experiments at night temperatures of 25.3°, 20.0°, 15.6°, and 9.2 °C respectively. The gain in dry weight of roots varies only slightly at the various treatments (fig. 3). It is evident, from these results, that low night temperature favours a high ratio of root to shoot (fig. 3 and Table 1). The rise in night temperature from 15.6° to 25.3 °C is accompagnied by a reduction in the ratio from 0.117 to 0.085 (or to about 73 %). The difference in ratio between 15.6° and 9.2 °C is insignificant.

B. *Transpiration*

During the last seven days of the experiment, transpiration was measured during day and night separately, while the obtained data were calculated per unit leaf area. It is evident from fig. 4 and Table 1 that a reduction in day transpiration rate is significant only in plants with a night temperature of 9.2 °C. The night transpiration rate at 20.0 °C night temperature is only 56 % from that at 25.3 °C. At still lower night temperatures, the transpiration rate remains almost the same. The large decrease in night transpiration observed may be due to a decrease in the vapour pressure deficit at the lower temperatures. Since the transpiration rate during the day was roughly 5 times that during the night, the mean transpiration rate per 24 hours showed a significant reduction only at 9.2 °C night temperature, *viz.*, to about 76 %.

TABLE 1. Effect of night temperature on growth, transpiration and water requirement of tomato

Night temperature in °C	25.3°	20.0°	15.6°	9.2°
Height of shoot (cm)	26.4 ± 0.7	21.7 ± 0.7	17.7 ± 0.3	16.6 ± 0.3
Mean length of internodes (cm)	3.8 ± 0.2	3.3 ± 0.2	2.7 ± 0.1	2.6 ± 0.1
No. of leaves	10.4 ± 0.4	11.2 ± 0.4	10.4 ± 0.3	10.2 ± 0.2
Mean length of mature leaves (cm)	17.3 ± 0.2	18.4 ± 0.5	16.6 ± 0.1	16.0 ± 0.4
Mean area of mature leaves (cm^2)	60.9 ± 4.5	70.0 ± 3.1	58.7 ± 2.1	52.0 ± 2.1
Total leaf area (cm^2)	344 ± 17	401 ± 19	314 ± 7	320 ± 14
Mean dry wt. of 1 cm^2 leaf surface	3.73	3.65	3.41	3.18
Gain in dry weight of shoot (g)	1.73 ± 0.15	1.70 ± 0.10	1.31 ± 0.08	1.26 ± 0.06
Gain in dry wt. of root (g)	0.143 ± 0.005	0.155 ± 0.007	0.152 ± 0.008	0.133 ± 0.006
Gain in dry weight of shoot + root (g)	1.88 ± 0.14	1.86 ± 0.11	1.46 ± 0.09	1.39 ± 0.06
Ratio of root(g)shoot(g)	0.085 ± 0.006	0.092 ± 0.005	0.117 ± 0.007	0.107 ± 0.008
Mean transpiration of a single plant (g/day)	31.8 ± 3.3	31.2 ± 0.8	25.1 ± 1.0	21.6 ± 1.1
Transpiration by day ($g/dm^2.h$)	0.603 ± 0.030	0.597 ± 0.040	0.643 ± 0.017	0.522 ± 0.014
Transpiration at night ($g/dm^2.h$)	0.224 ± 0.015	0.126 ± 0.010	0.112 ± 0.005	0.110 ± 0.008
Mean transpiration rate of the whole day ($g/dm^2.h$)	0.414 ± 0.020	0.362 ± 0.025	0.378 ± 0.010	0.316 ± 0.007
Water requirement (shoot)	512 ± 17	523 ± 42	600 ± 39	481 ± 9
Water requirement (shoot + roots)	473 ± 17	479 ± 34	486 ± 26	435 ± 9

Although during the period of illumination (representing the day period), the plants belonging to different treatments were placed in a chamber at the same air temperature (25.3 °C), the soil temperature in the pots exposed to lower night temperatures required some hours to attain the same temperatures as those continuously exposed to 25.3 °C, and the more so, inasmuch as the difference in temperature was larger. This may be of considerable importance. The temperature of the soil in the former case was 24 °C. The soil in pots exposed to night temperaturres of 20.0°, 15.6° and 9.2 °C required approximately 2, 5 and 6 hours, respectively, to arrive at a soil temperature of 24 °C (fig. 5). Of course, it is also important that the soil subjected to a low night temperature took a similar period of adaptation to the low temperature. It is clear that the discussed effects have the largest amplitude at the night temperature of 9.2 °C. On the other hand, relatively quickly the temperature of the soil is within only a few degrees from that of the air.

As the soil in the pots was 20 cm deep, it represents about the layer of soil in which the greatest number of the roots grow. It is evident from these data that the night temperature gives a large after-effect on the day temperature of the

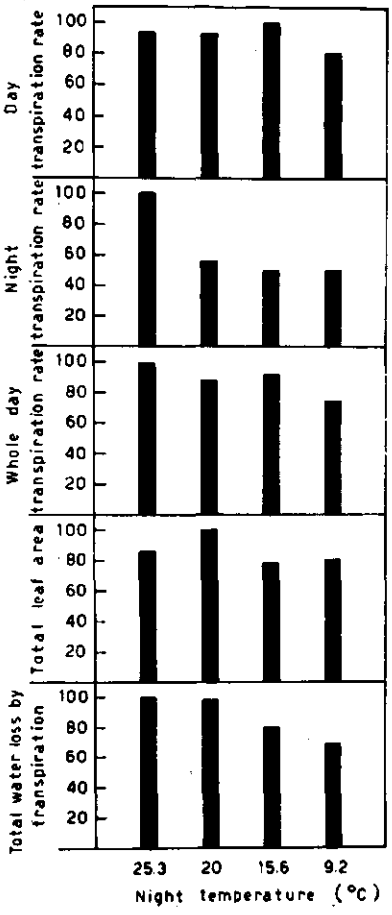

FIG. 4.
The variation in day and night transpiration rate, and the transpiration rate during the whole day at different night temperatures. The values are expressed as percentages of maximum.

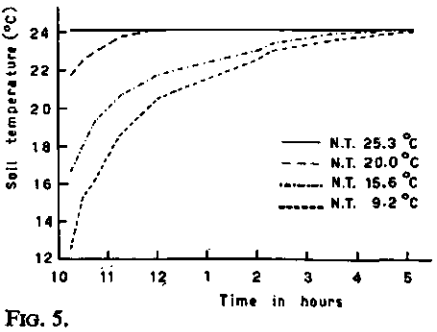

FIG. 5.
The change in soil temperature of pots transferred from the different night compartments to the day chamber at 25.3 °C, at 10 am.

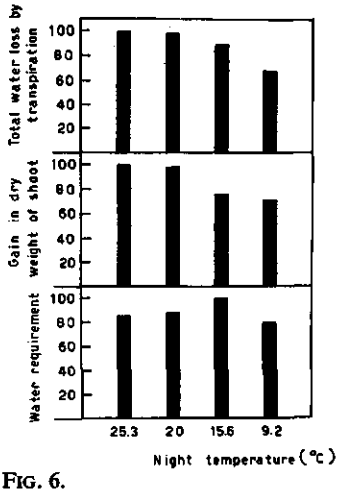

FIG. 6.
The variation in total water loss by transpiration, gain in dry weight of shoot and water requirement, at different night temperatures. The values are expressed as percentages of maximum.

soil. Since the latter has a noticeable effect on the rate of water absorption, the night temperature may influence the day time transpiration by means of the soil temperature.

C. *Water requirement*

The water requirement is determined by calculating the amount of water transpired in g per g dry matter produced. According to Table 1 and fig. 6 the total amount of water transpired, and the gain in dry matter produced at the different treatments show approximately the same procentual change. The difference in night temperature from 25.3° to 9.2 °C is accompagnied by a decrease in the total water transpired to 68 %, and in the gain in dry weight of shoot to 73 %. As the difference between the two percentages is not very great, the water requirement does not show appreciable variation.

4. Summary and Conclusions

Tomato plants were grown in metallic containers and, during a period of 28 days, placed at a constant temperature of 25.3 °C under "daylight" fluorescent tubes for 12 hours in every 24 hours. In the night period (12 hours) one set was kept in the same chamber at 25.3 °C and the others transferred to compartments of various temperatures (20.0°, 15.6° and 9.2 °C respectively).

The growth rate of the stem is lower at lower night temperatures. A decrease in night temperature from 25.3° to 9.2 °C resulted in a reduction to 63 % in the height of shoot. The total leaf area does not show a regular variation, but the dry weight of 1 cm^2 leaf shows a regular decrease to 85 % in the series with a night temperature of 9.2 °C. The reduction in both the height of shoot and the dry weight of leaves result in a reduction to 73 % in total dry matter of shoot. The various effects of night temperature may, at least partly, be ascribed to the time lag of soil temperature occurring after lower night temperatures.

The transpiration rate per unit area during the whole 24 hours decreases significant only with a night temperature of 9.2 °C, namely to 76 %, which was due to a decrease in day transpiration. The night transpiration was approximately one fifth of that during the day, and decreases to 56, 52, and 50 % with a decrease in night temperature from 25.3° to 20.0°, 15.6°, and 9.2 °C respectively. The decrease in night transpiration may be due to a decrease in the vapour pressure deficit at the lower temperatures.

The water requirement does not show a regular variation in relation to night temperature, which may be attributed to similar procentual changes in transpiration and dry matter production.

Acknowledgement

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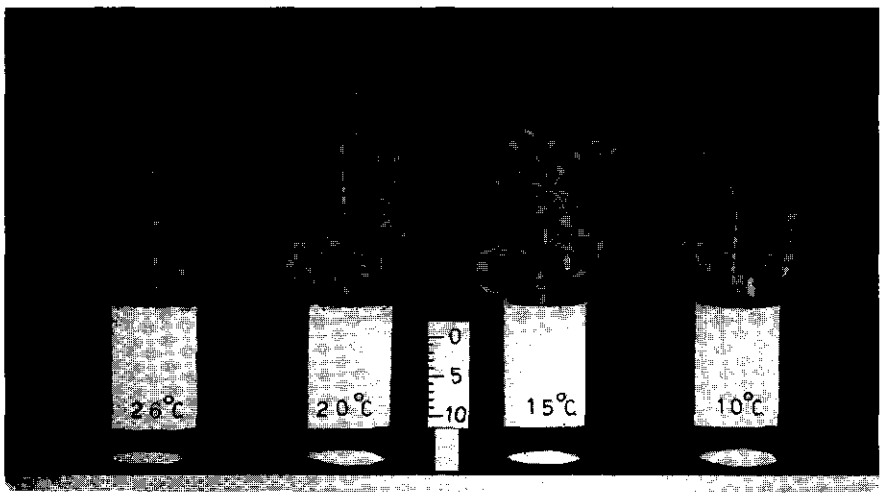

PLATE 1. Growth of tomato plants, kept for a period of 28 days at different night temperatures (From left to right: 25.3°, 20°, 15.6°, and 9.2°C).