12-1963

The effect of night temperature upon the vegetative and reproductive developments in lycopersicon esculentum

Biddanda P. Poovaiah

Recommended Citation

Poovaiah, Biddanda P., "The effect of night temperature upon the vegetative and reproductive developments in lycopersicon esculentum. " Master's Thesis, University of Tennessee, 1963.
https://trace.tennessee.edu/utk_gradthes/8768

To the Graduate Council:

I am submitting herewith a thesis written by Biddanda P. Poovaiah entitled "The effect of night temperature upon the vegetative and reproductive developments in lycopersicon esculentum." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Landscape Architecture.

B.S. Pickett, Major Professor

We have read this thesis and recommend its acceptance:

G.M. Campbell, H.D. Swingle, Gordon E. Hunt

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

December 11, 1963

To the Graduate Council:

I am submitting a thesis written by B. P. Poovaiah entitled "The Effect of Night Temperature Upon the Vegetative and Reproductive Developments in Lycopersicon esculentum." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Horticulture.

Major Professor

We have read this thesis and
recommend its acceptance:

George M Campbell
Gordon E Hunt
Homer D. Swingle

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

THE EFFECT OF NIGHT TEMPERATURE UPON THE VEGETATIVE AND REPRODUCTIVE DEVELOPMENTS IN *LYCOPERSICON ESCULENTUM*

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
B. P. Poovaiah
December 1963

ACKNOWLEDGEMENTS

The writer wishes to express his sincere gratitude to Dr. G. M. Campbell, Assistant Professor of Horticulture for his constant help and valuable guidance in conducting the experimental work and preparing this thesis.

The author is deeply indebted to Dr. B. S. Pickett, Head, Department of Horticulture for his advice, encouragement and suggestions in constructing this thesis.

The writer is grateful to H. D. Swingle, Associate Professor of Horticulture and Dr. Gordon E. Hunt, Professor of Botany, for reviewing this thesis and also for their valuable guidance throughout the period of graduate study.

He desires to express his great appreciation to Mrs. G. M. Campbell and Mrs. Bobby Austin for the help rendered during the course of this work and the preparation of the thesis.

Thanks are also due to the Agricultural Library Staff for their kind and considerate help in finding reference materials, and to the Department of Horticulture for providing the necessary facilities.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The tomato is one of the most sensitive plants, and yet one of the most tolerant and one of the most readily influenced by its environment. It thrives under a wide range of conditions, but the crop is not well adapted to regions where monthly mean temperatures are 80° F or higher.

The influence of temperature during the period preceding fruiting of tomatoes has been studied for some time. Various observations suggested that low temperature following establishment in the field might be responsible for rough fruits, poor fruit-set of the first clusters, poor pollination and other common low temperature effects. With the work of Went, Wittwer and others it seemed that some of these effects might not, in fact, occur but that other effects did take place.

Low temperature during seedling stage, provided it did not fall below 50° F seemed to encourage the development of flowers, and did not diminish fruit set.

With these bits of information, it seemed desirable to study the effect of low night temperature, beginning at 45° F, after the plants were set in the field. From the information which was at hand it became the object of this experiment to study the fruiting behavior of tomatoes through the flowering, fruit-setting and fruit development of the first three clusters.

If the idea that lower temperatures at night encourages more flowering and do not discourage fruit setting, could be extended to clusters beyond the first, perhaps a means of increasing total crop productions would be available. For field tomatoes a choice of location having a long growing season with relatively cool nights might have special value.

CHAPTER II

REVIEW OF LITERATURE

It has been known for some time that fruit set and plant development in tomato are sensitive to certain critical temperatures. Smith (21) explained this sensitivity on the basis of excessive style growth, reduced pollen viability and retarded pollen tube growth, all of which are known to be caused by unfavorable temperatures. Extremely high temperature causes styles to develop early and elongate abnormally, resulting in drying of the stigmatic surface before pollination; thus flowers fail to become fertilized and soon abscise. He observed poor germination of pollen at 100° F on tomato stigmas. Pollen tubes are short. Optimum temperature for pollen germination was about 85° F. It was a little less at 70° F. At 50° F it was somewhat better than at 100° F.

Studies reported by Leopold and Scott (14) indicated that temperature was a critical environmental factor for normal development of the tomato ovary.

Roberts'(19) observations revealed that, for a number of plants at least, temperature during the night rather than during the day is an especially important factor for blossom induction. Wittwer and Teubner's (37) work on tomato seedlings with different levels of night temperatures (50, 55, 60, 65, and 70° F) showed that exposure of seedlings to 50-55° F during a two week interval induced early flowering.

The number of flowers produced and number of fruit set was greater at 50 to 55° F than at 60 to 70° F. Early fruit production were also observed due to effect of cold treatment (50-55° F) during the seedling stage since the inflorescence occurred earlier. In general, they observed that the plants grown from seedlings subjected to 50-55° F were temporarily retarded; later they showed a superior growth; the leaves were close together and the plants were blockier, with first flower clusters appearing 2 to 3 inches lower.

Investigations by Went, et al. (17, 28, 30, 31, 34) established that night temperatures affected the fruit setting behavior of some varieties of tomatoes. For the varieties studied, the fruit setting optimum night temperature was found to range from 57° to 68° F. When the night temperatures were either increased or decreased above this range (57° to 68° F) fruit setting was reduced or completely terminated. Went's (29) work indicated that the size of the inflorescence varied with the night temperature, the warmer the night, the smaller the inflorescence and the flowers. Flower clusters were much larger at night temperatures of 41.4, 55.4 or 60.8° F than at 71.6, 79.7 or 86° F and were also observed to be much larger if the corresponding day temperature was 79.7° F rather than 64.4° F. His work also showed some varietal difference to a higher or lower range of night temperatures.

Curme (4) observed earliest maturity at higher night temperature of 79° F and progressively later maturation were found in stepwise sequence at each of the lower (73, 62, 50 and 45° F) night temperature treatments. He especially mentioned that response to the temperatures depend on the variety, since he observed varietal differences for fruit maturity at all the night temperatures tested.

Osborne (17) observed that tomato fruits were larger at maturity when grown at 50° F night and 62.6° F day temperatures.

Schaible (20) stated that within varieties listed, fruit size decreased as the night temperatures were decreased from 57° F to 80° F.

Went (28) observed that about 70 to 90 per cent of the daily growth of the tomato stems occurs during darkness, and the slowest growth rate for each day was found to be around noon. His investigations showed that during the day, the process which was essential for growth had an optimum temperature near 78.8° F, whereas at night a lower optimum temperature of 64.4° F was more favorable. The same types of temperature dependence was found for fruiting. Went (30) further found that warm days and nights stimulated vegetative growth of stems and leaves, but the roots were found heaviest after cool nights. The ratio of top-to-root weights steadily decreased with decreasing night temperature and was considerably lower where plants grew under cool day temperatures. Leaf size was slightly larger at the higher night temperature, but weights were highest at medium night temperature.

Trygve Kristoffersen's (26) work showed that the top-root ratio decreased with decreasing temperatures. It was interesting to note how important the night temperature was in determining the growth, especially the growth of the stem and the roots. As the plants grew the roots probably became relatively less and less efficient in supplying the rest of the plant with water and nutrients.

An interesting result was observed by Wittwer and Teubner (37). Following cotyledon expansion plants were subjected to different temperature treatments. These were continuous cold (50° F), continuous warm (70° F), and alternating cold and warm temperatures during the first and second weeks. Other treatments were cold days and warm nights during the first week with the conditions reversed for the second week and vice versa. None of these treatments showed striking effect for flower number. Apparently cold treatment was no more effective at night than during the day.

According to Lewis (15), tomato plants are sensitive to low temperatures between the eighth and twelfth day after cotyledon expansion. During this period a low temperature causes plants to initiate an increased number of flowers in the first inflorescence. He also stated that the temperature treatments given from the time of cotyledon expansion to the emergence of the first inflorescence have an effect which sometimes lasts to the fifth inflorescence. An effect to determine exactly when cold treatment affected flower number, a series of treatments were set up. One was of 3 days of low temperature (with a temperature of 60° F day and 50° F night), another 18 days of high temperatures (75° F during day with a 65° F night). He also used a treatment of 6 days low temperature followed by 15 days of high temperature. He found that during the first 9 days from cotyledon expansion the plant was not sensitive to low temperatures for flower number. From the ninth to twelfth or fifteenth day, it was sensitive for the flower number. In other experiments conducted at the low temperature of 57.2° F from the expansion of the cotyledon to the appearance of the first inflorescence; increased flower production was observed as compared with a treatment of 77° to 86° F. According to Calvert (3) the sensitive phase for flower number does not begin until approximately the ninth day after cotyledon expansion. This is in agreement with the findings of Lewis (15). Calvert (3) used low temperature (50° F night with 60° F day) and high temperature (60° F night and day) for six weeks from cotyledon expansion. After six weeks both the treatments received a constant 60° F. Flower numbers were increased for the first three clusters in low temperature treatment. He also stated that the continuation of the high temperature conditions for a number of weeks caused increased vegetative growth and this had the effect of hastening the development of the inflorescence after initiation.

Wedding's (27) experiment with three levels of day and night temperatures (86°/59°, 77°/59°, and 68°/50° F) for a six weeks period, while fruits were setting and developing revealed that the fruit size as indicated by diameter at the equator increased with an increase in temperature. The total soluble solids of the juice, an approximate measure of sugars and degree of sweetness, was found to decrease significantly with higher temperatures, as did acidity. There were neither cracked nor blossom-end rotted fruits from the low temperature treated plants. Pointedness of fruit was favored by lower temperatures. Puffiness, blossom-end-rot and growth cracks were associated with plants exposed to higher temperatures.

Considering the above mentioned facts, the effect of cold treatments on tomatoes depends on many factors such as variety, age of the plant, duration of temperature, level of temperature, time of occurrence and other factors related to plant developments.

Tiedjens and Schermerhorn (24) found the vigor of different plants to be reflected in their metabolic ratio. The fruitful types had a lower rate of respiration than the more vegetative ones, and the plants possessing a high rate of metabolism were more sensitive to temperature than the others. Klinker and Sweet (11) also detected a lower rate of leaf respiration in higher yielding plants. There was no correlation between dry weight of the top and fruit set.

According to Curme (4) the low temperature fruit set phenomenon might be associated with low metabolic activity in the plant. Kraus and Kraybill (13) and others (9, 10, 36) suggested that the deficiency of carbohydrates was usually correlated with low percentage of fruit set. Lowering the temperature has been known to reduce the rate of respiration and growth, thus favoring carbohydrate accumulation. They also found that fruit set can be improved by properly adjusting the carbohydrate level in the plant tissue.

Went (29) concluded that the decrease in growth rate of full grown tomato plants when subjected to night temperatures above 62.6°

to 64.4° F was due to insufficient translocation of sugars from the leaves. He stated that when seedlings were exposed to varying night temperatures, the higher optimum night temperature could be above 62.6° to 64.4° F and that translocation was less critical than in large plants. Based on several observations, he fixed 64.4° F as the optimal night temperature for tomato plants. He stated that above 64.4° F the rate of sugar translocation limited growth of stems as well as of roots and fruits, whereas below 64.4° F the rate of the growth process itself becomes a limiting factor. He also suggested that the optimal temperature for stem elongation was also optimal for fruit set and fruit growth (30).

Several investigations of Went (28, 29, 30) have shown decrease in sugar translocation at higher temperature.

Most workers agree that the optimum during the day is about 78.8° F for older plants.

Curtis and Herty (6) and others (29, 30, 8, 32, 33, 1) believed that the translocation of carbohydrates was a controversial problem and was not a process confined to the dark period. Went was of the opinion that the translocation of carbohydrates limited the growth and flowering processes at temperatures above 64.4° F and that translocation was favored by low temperatures.

The work of Curtis (5) on primary leaves of the red kidney bean showed that cooling the petioles to 32.9° to 40.1° F greatly retarded translocation of carbohydrates from leaf blades. If the plant was kept at 32° to 35.6° F for 17 to 20 hours translocation of carbohydrates was retarded significantly. At temperatures of 44.6° to 41.8° F, translocation appeared to be between the values found for low temperature and values for higher temperatures of 62.6° to 75.2° F.

Parker and Borthwick's (18) work on Biloxi soybean revealed that analysis of plants kept at temperatures of between 55° and 85° F demonstrate that sucrose, reducing sugars, and total sugars in the leaves and stems of plants could be increased with a decrease in temperature during the dark period.

Went (29) stated that there was no correlation between day or night temperature and auxin content. Neither was there a correlation between growth rate and auxin content. Studies by Borthwick _et al_. (2) on Biloxi soybean, where the petioles were cooled during a 4-day photoperiodic induction period showed an inhibition of flowering, apparently resulting from the influence of low temperature on the transport of flowers forming substances from the leaves.

Went (28) observed that stem growth and fruit set of tomatoes largely depends upon root temperature. Trygve Kristoffersen's (26) work indicated that root temperature could limit growth provided the soil temperature was lowered to 50° to 53.6° F. Lingle _et al_. (16, 7) have shown that the effect of relative air humidity and different levels of nutrients may be modified by the root temperature. The temperature effect was smaller at higher light intensities than at low. Higher temperature accelerated growth but lowered flower production.

Went (29) stated that temperature had little effect on suction force and practically no effect on stomatal opening.

Kramer (12) reported that the cause of decreased water absorption by plants at low soil temperature was the combined effect of decreased permeability of the root membranes and increased viscosity of the water itself.

Went (35) stated that relative humidity has only little influence on growth as long as the soil is kept moist. Nevertheless he pointed out an experiment with tomatoes where the effect of different temperatures could not be compared directly because the vapor pressure deficit was not kept constant.

The transpiration rate of the leaf depends on the gradient in water vapor pressure from the leaf to the external atmosphere. So, even a small rise in the leaf temperature increases the vapor pressure deficit according to Thames (23).

Trygve Kristoffersen (26) stated that low temperature could, to a certain degree, substitute for darkness. The water balance in the plant was improved by low night temperatures and darkness. The life span of the leaves could have been increased by subjecting the plant to low temperatures for a few hours daily according to his report. It was pointed out that plants could tolerate continuous light better at low temperature than at higher temperature. Furthermore, the roots were not able to supply the plant with sufficient water under continuous light at higher temperatures, even if parts of the roots were submerged in water.

Investigators have found it difficult to establish optimal conditions for the different plant organs when working with intact plants. Considering the numerous reactions that are going on in the plant and that all these reactions may differ somewhat in their temperature requirements, it is no wonder that the plant as a whole may react in a rather complicated way.

Since the tomato is a heat sensitive plant, the temperature under which it grows in its natural habitat can be used as one criteria for determination of its requirements for optimum growth and development. The optimal temperature for the best integration of these processes has been studied extensively by many investigators, but there is still a wide diversity of opinion concerning temperature effects on the tomato plant.

CHAPTER III

MATERIALS AND METHODS

Vigorous 21-day-old Rutgers tomato plants were selected for uniformity in size and transplanted into 10-inch pots on April 17. The plants were then divided into three groups containing eight plants each. All three groups grew under prevailing seasonal conditions in the field during the day. At night the three groups of plants were separated and placed in rooms at temperatures of 45° F, 55° F and 65° F, respectively, for twelve hours.

Plants were staked, pruned to one stem and suckered. No artificial means were used to stimulate flowering or fruit set.

Production records were kept on the first three flower and fruit clusters. Data were recorded for the plants contained in the three temperature treatment groups as follows: (1) Earliness of flowering; (2) Total number of flowers produced per plant; (3) Total number of fruit set; (4) Days required for maturation; and (5) Average size and weight of fruit produced per plant for plants placed under the three separate night temperatures.

The plant's vegetative response to night temperature was studied by measuring internode length, fresh weight of top and roots, and calculating top-to-root ratio for all plants in the three night temperature treatments.

All data collected were analyzed statistically according to Snedecor's (22) Statistical Methods of Analysis, using a system of analysis of variance.

CHAPTER IV

RESULTS AND DISCUSSION

Night temperature manifested marked effect on earliness of flowering for plants subjected to the three different levels of night temperature (Table I). Flowers formed and developed most rapidly when plants were exposed to 65° F night temperature through the fourth flower cluster. When the experiment was terminated, night temperature was limited to 55° F or 45° F; more days were required for flowering. The difference in number of days observed between the two treatments, 45° and 55° F for the first and second clusters were found to be non-significant, whereas for the third and fourth clusters the data were highly significant. The first and second flower clusters were probably initiated before the plants were subjected to different night temperature treatments, whereas the initiation of flowers in the third and fourth clusters probably occurred after the plants were subjected to different night temperature treatments. The response in the 45° and 55° F treatment was perhaps due to the rate of initiation and the rate of development, whereas the rate of development alone was a factor in the first and second clusters. Therefore it appears that the rate of flower initiation is significantly influenced at night temperatures between 45° and 55° F as well as the rate of development of flowers. It appears that plants held under 65° F had opened flowers faster in all four clusters.

TABLE I

THE EFFECT OF NIGHT TEMPERATURE ON EARLINESS OF FLOWERING[a]

Night Temperature (degrees F)	Days from Transplanting to First Flower			
	First Cluster	Second Cluster	Third Cluster	Fourth Cluster
45	31.1	43.2	58.0	69.9
55	29.9	41.3	47.9	58.8
65 (control)	21.5	30.4	40.0	43.0
LSD at 5%	3.11	1.86	3.65	2.49
LSD at 1%	4.71	2.82	5.52	3.78

[a] Plants were 21 days old when the experiment was begun.

Data reported in Table II indicate that plants flowered more profusely during the first month when placed under the 65° F temperature at night. No more flowers appeared on the first three clusters after the sixth week where the night temperatures were held at 65° F or after the eighth week at 55° F. A single flower appeared for the ninth week, after the first flowers appeared on the plants held at 45° F (see Table II).

During the first month plants receiving the 55° F and 45° F temperature did not flower abundantly. They did, however, flower over a longer period of time than plants exposed to the 65° F temperature. No significant difference was noted for the total number of flowers produced on the three flower clusters recorded.

It was interesting to note from the three levels of night temperatures tested, early flowering was much favored by increasing temperatures but in no way influenced the total flowers initiated.

There was a difference in the number of fruits set per plant between those subjected to the 65° F and 55° F night temperature when measured at 10 per cent level of significance as shown in Table III. These data also show a highly significant decrease in the number of fruits set per plant for plants under the 45° F night temperature.

The per cent fruit set was highest for plants given the 55° F night temperature treatment.

Low night temperatures produced a drastic effect on the days required for fruit maturation (Table IV). This was apparent for all three

TABLE II

THE EFFECT OF NIGHT TEMPERATURE ON NUMBER OF FLOWERS PRODUCED PER PLANT FOR THREE CLUSTERS

Night Temperature (degrees F)	Weeks--May 9 through July 11									Grand Total
	1	2	3	4	5	6	7	8	9	
	Mean Weekly Counts of Flowers Produced Per Plant									
45	0	2	2	4	3	4	3	3	1	22
55	1	2	3	5	5	2	1	1	0	20
65 (control)	5	5	4	5	2	1	0	0	0	22

TABLE III

THE EFFECT OF NIGHT TEMPERATURE ON FRUIT SET PER PLANT FOR THREE CLUSTERS

Night Temperature (degrees F)	No. of Flowers Produced	No. of Fruits Set	Per Cent Fruits Set
45	21.9	4.5	20.5
55	19.9	15.2	76.4
65 (control)	22.5	13.4	59.5
LSD at 10%	NS	1.52	
LSD at 5%	NS	1.92	

TABLE IV

THE EFFECT OF NIGHT TEMPERATURE ON THE NUMBER OF DAYS REQUIRED FOR MATURATION

Night Temperature (degrees F)	Days from Fruit Set to Harvest		
	First Cluster	Second Cluster	Third Cluster
45	60.0	59.6	60.0
55	54.6	52.0	52.4
65 (control)	44.6	44.1	43.6
LSD at 5%	0.93	1.22	1.24
LSD at 1%	1.41	1.85	1.87

clusters of fruit harvested. Fruit maturation was much more rapid on plants which were given the 65° F night temperature. Fruits ripened more than a week earlier when subjected to the 65° F night temperature, as compared to those given the 55° F night temperature. Although few fruits actually ripened on plants placed under the 45° F night temperature; those maturing ripened 16 days later than those on the control plants. In conclusion for all the three clusters, it was evident that the number of days required for ripening of fruits decreased with increasing night temperatures. The night temperature levels could be one of the important factors responsible for maturation of fruits. Figure 1 shows the effect of temperature on maturation of fruits.

Night temperature treatments also influenced the quality and yield of fruits. Table V shows these treatmental differences. Greater average fruit weight, more marketable fruits with fewer culls and greater overall fruit productions occurred with the 55° F night temperature treatment. This may be attributed to the increased fruit size and more fruits. Wedding's (27) results are in agreement with the results of this experiment, although his maximum night temperature of 59° F might not be high enough to reduce the fruit size. It is possible that as the night temperature is increased from the bare minimum to optimum the size of the fruit would be increased. In this study, above optimum temperature levels were associated with a reduction of fruit size. Osborne's (17) work is also in agreement with this study.

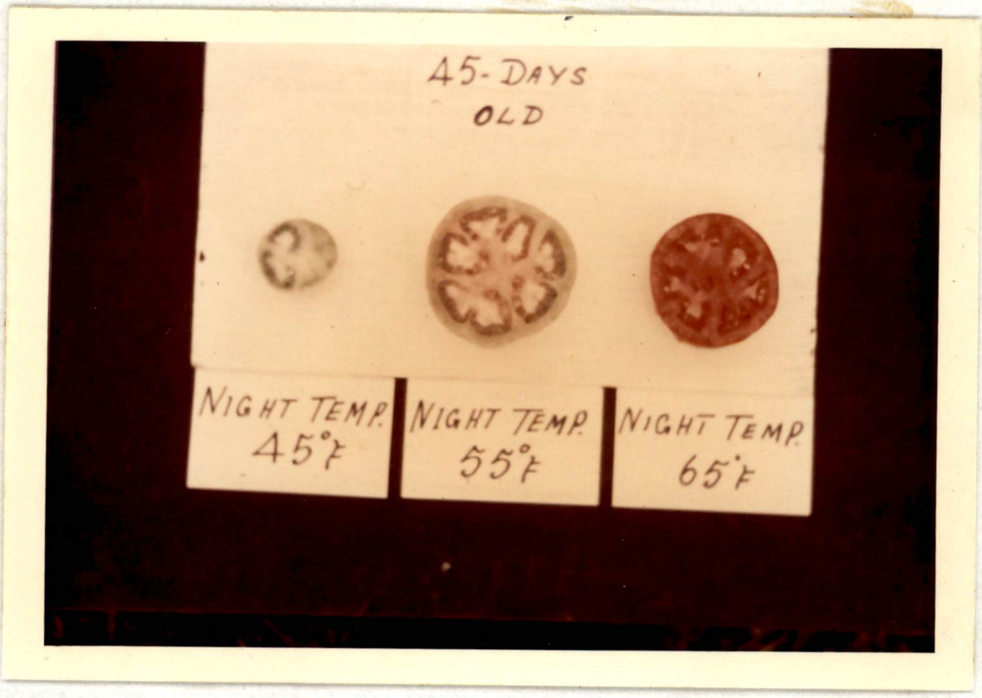

Figure 1. Effect of temperature on maturation of fruits.

TABLE V

THE EFFECT OF NIGHT TEMPERATURE ON FRUIT QUALITY AND YIELD

Night Temperature (degrees F)	Average Fruit Weight (grams)	Fruit Yield - Weight per Plant		
		Marketable (grams)	Culls (grams)	Total (grams)
45	66.0	132.0	76.0	208.8
55	153.0	1745.3	49.3	1794.6
65 (control)	131.1	1226.4	212.8	1439.2
LSD at 5%	19.33	285.81	61.27	267.46
LSD at 1%	29.28	432.98	92.82	405.17

Plants receiving the 45° F night temperature produced a very low marketable yield made up of small fruits of poor color. Plants receiving 65° F night temperatures produced the largest amount of cull fruits which was chiefly due to blossom-end-rot and radially cracked fruit. These weighed less than those from plants grown under the 55° F night temperature.

Differences in vegetative growth were reflected in stem, internode length, and diameter and total top and root growth as shown in Table VI and VII. Where the night temperature was held at 55° F, internode length and root weights were significantly longer and heavier than for other treatments. The total top (vegetative and reproduction) weight for the plants at 45° F night temperature averaged only 604 grams, approximately 2000 grams less than the tops produced by plants at 55° F and 65° F.

The length of internode and top weights appeared to be directly associated with the extent of top and root growth or fruit yield and size since these measurements were highest for plants grown under 55° and 65° F night temperature which seemed to be best suited to fruit production. Figure 2 shows the differences in vegetative response due to night temperature.

TABLE VI

THE EFFECT OF NIGHT TEMPERATURE ON STEM GROWTH

	Description of Internodes[a]	
Night Temperature (degrees F)	Average Length (centimeters)	Average Diameter (centimeters)
45	2.98	1.14
55	4.18	1.49
65 (control)	3.51	1.63
LSD at 5%	0.26	NS
LSD at 1%	0.39	NS

[a] Description based on mean measurements made from four internodes taken above the third fruit cluster from each of eight plants.

TABLE VII

THE EFFECT OF NIGHT TEMPERATURE ON TOP AND ROOT GROWTH

Night Temperature (degrees F)	Weight in Grams[a]		Top/Root Ratio
	Top Growth	Root Growth	
45	604	95	6.4
55	2793	182	15.3
65 (control)	2655	201	13.2
LSD at 5%	337.22	26.18	
LSD at 1%	510.86	39.66	

[a] Top and root growth based on total fresh weights including fruits.

Figure 2. Effect of temperature on vegetative growth.

CHAPTER V

SUMMARY AND CONCLUSIONS

The influence of night temperature (45°, 55°, 65° F) was studied on the growth and development of the Rutger tomato variety, between the period beginning 21 days after seedling emergence and the harvesting of the third fruit cluster.

At 65° F the plants grew taller, flowered earlier and fruits ripened faster than at 55° F or at 45° F night temperature.

At 55° F the fruit set was greater, the quality in terms of smoothness and size was better, and the number of grams of fruit produced was greater than at either the higher temperature level of 65° F or the lower temperature level of 45° F.

Plants held at a night temperature of 45° F were dwarfed and produced fewer fruits, which were smallest. Only a few of the fruits ripened.

The three levels of night temperature studied had no effect on flower number. These results suggested that high night temperatures tend to reduce fruit size, increase radial cracking, blossom-end rot and encourage losses due to other causes.

The data suggest that areas having cool night temperatures lying below 65° F and above 45° F, may have an advantage for tomato production. The literature suggest that the low night temperature level should approach 55° F.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Bohning, R. H., A. W. Kendall and A. J. Linck. 1953. Effect of temperature and sucrose on growth and translocation in tomatoes. Amer. J. Bot. 40:150-153.

2. Borthwick, H. A., M. W. Parker and P. H. Heinze. 1941. Influence of localized low temperature on Biloxi Soybean during photoperiodic induction. Bot. Gaz. 102:792-800.

3. Calvert, A. 1957. Effect of early environment on development of flowering in the tomato. Jour. Hort. Sci. 32:9-17.

4. Curme, J. H. 1962. Effect of low night temperatures on tomato fruit set. Campbell Soup Company Plant Science Symposium Proceedings, pp. 99-108.

5. Curtis, O. F. 1929. Studies on solute translocation in plants experiments indicating that translocation is dependent on the activity of living cells. Amer. J. Bot. 16:154-168.

6. Curtis, O. F., and S. D. Herty. 1936. The effect of temperature on translocation from leaves. Amer. J. Bot. 23:528-532.

7. Davis, R. H., and J. C. Lingle. 1961. Basis of shoot response to root temperature in tomato. Plant Physiol. 36:153-162.

8. Hewitt, S. P., and O. F. Curtis. 1948. The effect of temperature on loss of dry matter and carbohydrate from leaves by respiration and translocation. Amer. J. Bot. 35:746-755.

9. Howlett, F. S. 1936. The effect of carbohydrate and nitrogen deficiency upon microsporogenesis and the development of the male gamatophyte in the tomato. Ann. Bot. 50:767-803.

10. Howlett, F. S. 1939. The modification of flower structure by environment in varieties of Lycopersicum esculentum. Jour. Agri. Res. 58, No. 2, 79-117.

11. Klinker, J. E., and R. D. Sweet. 1949. An investigation of the yield performance of several tomato varieties. Proc. Amer. Soc. Hort. Sci. 54:253-260.

12. Kramer, P. J. 1940. Root resistance as a cause of decreased water absorption by plants at low temperature. Plant Physiol. 15:63-79.

13. Kraus, E. J., and H. R. Kraybill. 1918. Vegetation and reproduction with special reference to the tomato oregón. Agril. Exp. Sta. Bul. 149.

14. Leopold, A. C., and F. I. Scott. 1952. Physiological factors in tomato fruit set. Amer. J. Bot. 39:310-317.

15. Lewis, D. 1953. Some factors affecting flower production in the tomato. Jour. Hort. Sci. 28:207-220.

16. Lingle, J. C., and R. H. Davis. 1959. The influence of soil temperature and phosphorus fertilization on the growth and mineral absorption of tomato seedlings. Proc. Amer. Soc. Hort. Sci. 73:312-322.

17. Osborne, D. J., and F. W. Went. 1953. Climatic factors influencing parthenocorpy and normal fruit-set in tomatoes. Bot. Gaz. 114: 312-322.

18. Parker, M. W., and H. A. Borthwick. 1940. Effect of variation in temperature during photoperiodic induction upon initiation of flower primordia in Biloxi Soybean. Bot. Gaz. 101:145-167.

19. Roberts, R. H. 1943. The role of night temperature in plant performance. Science 98:265.

20. Schaible, L. W. 1962. Fruit setting responses of tomatoes to high night temperatures. Campbell Soup Company Science Symposium Proceedings, pp. 89-98.

21. Smith, O. 1935. Pollination and life history studies of the tomato. Cornell University Agri. Exp. Sta. Memoir 184.

22. Snedecor, G. W. 1956. Statistical Methods. Iowa State College Press, Ames, Iowa.

23. Thames, J. L. 1961. Effect of wax coatings on leaf temperatures and field survival of _Pinus_ _taeda_ seedlings. Plant Physiol. 36:180-182.

24. Tiedjens, V. A., and L. G. Schermerhorn. 1938. Classification of tomato varieties according to physiological response. Proc. Amer. Soc. Hort. Sci. 36:737-739.

25. Tracy, W. W. 1923. Tomato culture. Orange Judd Publishing Co., Inc., New York.

26. Trygve Kristoffersen. 1963. Interactions of photoperiod and temperature in growth and development of young tomato plants. Physiologia Plantarum Supplementum I:1-98.

27. Wedding, R. T., and H. M. Vines, N. 1959. Temperature effects on tomatoes. Cal. Ag. Exp. Cal. Ag. 13:13N.

28. Went, F. W. 1944. Plant growth under controlled conditions. II. Thermoperiodicity in growth and fruiting of the tomato. Amer. J. Bot. 31:135-150.

29. _______. 1944. Plant growth under controlled conditions. III. Correlation between various physiological processes and growth in the tomato plant. Amer. J. Bot. 31:597-618.

30. _______. 1945. Plant growth under controlled conditions. V. The relation between age, light, variety and thermoperiodicity of tomatoes. Amer. J. Bot. 32:469-479.

31. _______, and L. Cosper. 1945. Plant growth under controlled conditions. VI. Comparison between field and air-conditioned greenhouse culture of tomatoes. Amer. J. Bot. 32:643-654.

32. _______, and M. Carter. 1948. Growth response of tomato plants to applied sucrose. Amer. J. Bot. 35:95-106.

33. _______, and H. M. Hull. 1949. The effect of temperature upon translocation of carbohydrates in the tomato plant. Plant Physiol. 24:505-526.

34. _______. 1950. The climatic control of flowering and fruit set. The American Naturalist 84:161-170.

35. _______. 1957. The experimental control of plant growth. Chronica Botanica Co. 17:202-295.

36. Withrow, A. P., and R. W. Withrow. 1947. Plant growth with artificial sources of radiant energy. Plant Physiol. 22:494-513.

37. Wittwer, S. H., and H. G. Teubner. 1956. Cold exposure of tomato seedlings and flower formation. Proc. Amer. Soc. Hort. Sci. 67:369-376.