THE INFLUENCE OF DEFOLIATION AND FRUIT THINNING ON THE GROWTH OF TOMATOES

THESIS FOR THE DEGREE OF M. S.

Alton Millett Porter

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THESIS

Tomatoes

THE INFLUENCE OF DEFOLIATION AND FRUIT THINNING ON THE GROWTH OF TOMATOES

BY

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A Thesis

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THESIS

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INTRODUCTION

The tomato is probably grown under a greater diversity of conditions than any other vegetable crop. Furthermore, it is submitted to a greater variety of cultural treatments. It is but natural that it should show widely varying responses to those respective conditions and treatments. There is very little information, though obviously the matter is of fundamental importance, as to the amount of foliage that is required under different conditions for the developing and maturing of a given quantity of fruit. Unless there is some answer to this question, such practices as pruning, disbudding and fruit thinning cannot be employed understandingly.

Review of Literature

The advantages claimed for pruning tomatoes (Stuckey 13), (Olney 11), (Lloyd and Brooks 5), (Rosa 12) are: (a) earlier ripening, (b) larger fruits, (c) less disease, (d) larger yields, (e) cleaner fruit, (f) more convenient harvesting and (g) more effective spraying of the plants. The disadvantages are: (a) greater amount of labor and expense, (b) less total yield, (c) greater loss from blossom end rot, (d) more sunscald on the fruit and (e) a greater amount of cracking of the fruits. Some of these claimed advantages are more or less the opposite of the claimed disadvantages. The pruning of tomatoes increased the quality and size of ripe tomatoes according to Whipple and Schermerhorn (16), Olney (11) and Stuckey (13), but Lloyd and Brooks (5) found a very slight, if any, effect on the size of tomatoes from pruning. The yields of tomatoes were reduced about one third by pruning according to Stuckey (13), Olney (11), Lloyd and Brooks (5), Rosa (12), Whipple and Schermerhorn (16) and Hoffman (4).

The rate of food manufacture by the leaves of the plant is determined by the rate of photosynthesis. This in turn is influenced by the length of day or light intensity, according to Tincker (15). The factors that govern the effect of light on the tomato leaves are: (a) intensity of light, (b) quality of the wave length of radiation and (c) duration of the exposure (3).

Magness and Haller (7) found that the maximum size was reached in apples when they had forty leaves per fruit. It decreased when there were more or less than forty leaves per fruit. They found that the fruits with a large leaf area had a higher percentage of dry weight and ripened earlier than the fruits with a relatively small leaf area.

Winkler (17) working with grapes under the same light conditions for all the vines found that about sixteen leaves were required for the best development of size and quality of about forty berries. Increasing or decreasing this leaf area per forty berries reduced the size and quality of the berry.

Magness and Overley (6) working with apples and pears found the amount of leaf surface necessary to synthesize the organic foods utilized in the development of apples and pears. They explained the decrease in fruit volume as partly due to the greater concentration of carbohydrates in fruit growth with larger leaf area. There is a possibility that a greater accumulation of synthesized materials when a large leaf area is available tends to inhibit synthesis of organic foods in the leaves.

In Murneek's (10) experimental work on tomatoes careful observations were made for the purpose of finding the effects of fruiting on vegetative growth of both nitrogen-high and nitrogen-low plants. By defruiting plants grown during long-or short-day periods he found the foliage became darker in color, grew rapidly and the stems were larger and more firm than in normally fruiting plants. The long-day plants increased in heighth 13 to 20 per cent faster than the short-day plants. The developing of fruit on the normal and vegetative growth on the defruited short-day plants was leading to rapid exhaustion of the stored carbohydrates because the current synthesis was inadequate. Under such circumstances the carbohydrates would act as limiting factors in the normal development of the fruits. In every case a maximum crop of fruit had a strikingly retarding effect on the vegetative growth and development of the plant, but it was not as rapid on the defoliated plants. The less fruit that was permitted to develop the more the leaves, stem and fruit grew. The height growth of the plant declines in proportion to the amount of fruit set.

MacDougal (8) in Arizona found that cloudy weather caused a uniformly high rate of growth in foliage and fruit of the tomato, and that high temperatures did not accelerate growth unless they were accompanied with high relative humidity. This showed that there must be a balance between the water supply and transpiration of a highly succulent fruit to produce an increase in its volume.

North

A	F	C	H	E	B
B	G	D	A	F	C
C	H	E	B	G	D
D	A	F	C	H	E
E	B	G	D	A	F
F	C	H	E	B	G
G	D	A	F	C	H
H	E	B	G	D	A

Figure I.

Arrangement of plants in the plot.

A - 1 leaf per fruit

B - 2 leaves per fruit

C - 3 leaves per fruit

D - 4 leaves per fruit

E - 5 leaves per fruit

F - 6 leaves per fruit

G - 7 leaves per fruit

H - Check plants

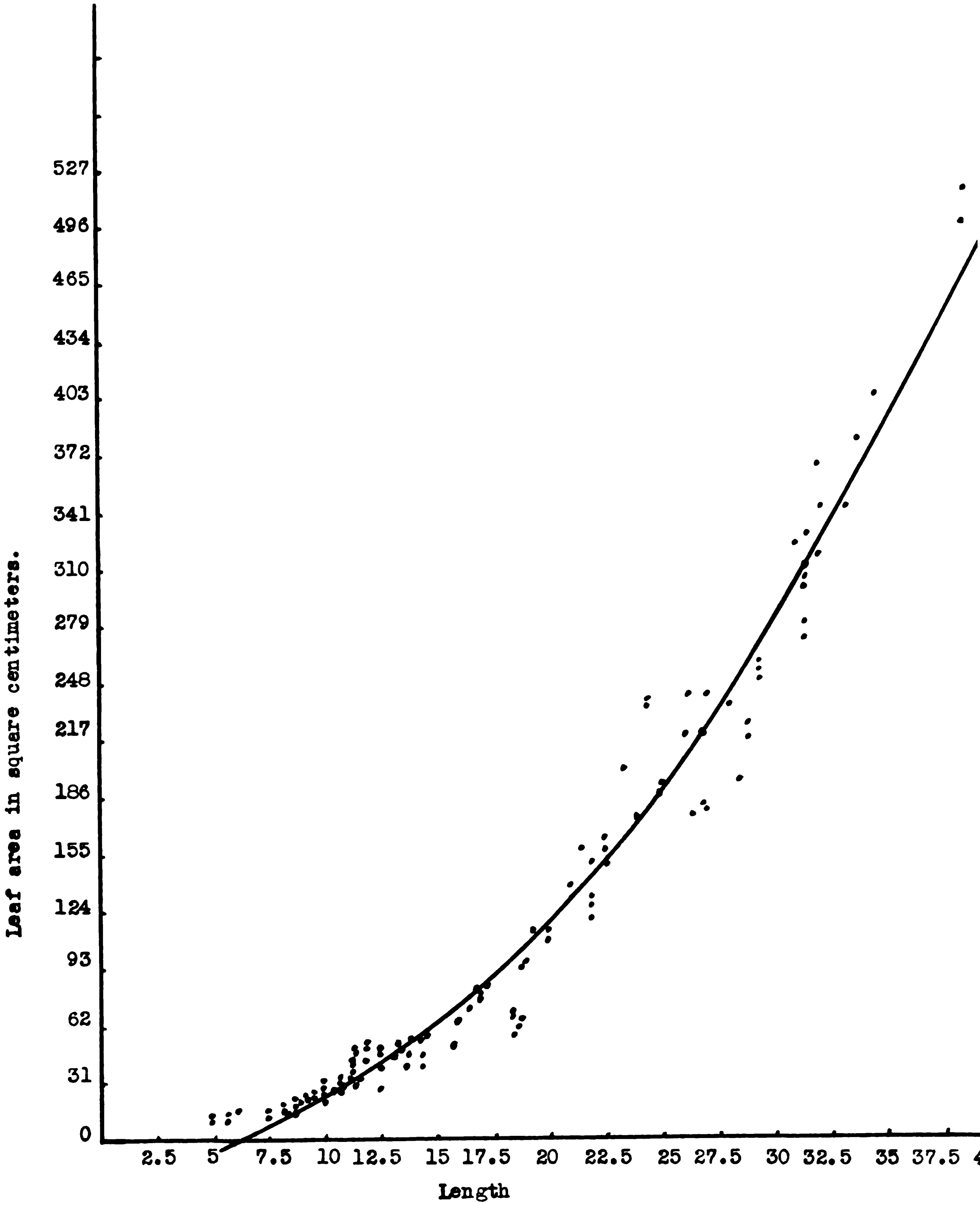

Figure 2. Showing relation between leaf area and length from basal leaflet to tip of leaf.

The rate at which the water is received is so little in excess of transpiration that a rise of 10 - 15°C may destroy the balance and stop fruit growth.

Objectives

The object of this investigation was to throw some light on the following questions:

1. The effects of defoliating and fruit thinning on the rate of tomato growth and total size of matured fruits.

2. The effects of defoliating and fruit thinning on the percentage of dry matter in the plants and fruits.

3. The difference between the leaf area required in the winter months to develop a certain quantity of fruit and that required by the same variety in the spring or summer under different light conditions.

Methods

At the outset it was necessary to devise a method of measuring leaf area. This method was developed from the correlation between the area and length of the leaf measured from the first basal leaflet to the tip. This correlation was found by taking one hundred thirty-four tomato leaves at random and outlining each on paper. These tracings were then measured with a planimeter to find the exact area of each leaf in square centimeters. The area of each of these leaves was then plotted against the length. (Figure 2). The equation for fitting a line to (Figure 2) was found to be $y = -3.16 + 4.17x + .307x^2$. The correlation between area and length was found to be

Table 1. The number of leaves and fruits on the treated plants.

Plants	Average leaves per fruit	Average fruits per plant		Total fruits per lot of plants	
		Fall	Spring	Fall	Spring
A	1	2.7	2.2	16	13
B	2	2.5	2.7	15	16
C	3	2.8	2.3	17	14
D	4	2.3	2.0	14	12
E	5	2.0	2.0	12	12
F	6	1.8	2.0	11	12
G	7	1.7	1.5	10	9

Table 2. The number of leaves and fruits on the check plants.

Week	Average leaves per fruit		Average fruits per plant		Total fruits per lot of plants	
	Fall	Spring	Fall	Spring	Fall	Spring
1	8.5	10	2	1.2	12	6
2	4.8	7.5	3.8	2.0	23	10
3	4.0	2.9	5.5	5.8	33	29
4	2.7	1.8	9.0	9.8	54	49
5	2.2	1.4	12.1	13.2	73	66
6	2.1	1.5	13.0	13.8	78	69
7	2.1	1.5	13.8	14.4	83	72

$.968 \pm .0018$. Accordingly length was used as the unit of measurement from which leaf area was computed. Length measurements were taken every seven days.

In order to control conditions as much as possible the experimental studies were made in the greenhouse, one crop being started at such a time that flower and fruit development took place during the short cloudy days of November and December; another crop was started at such a time that flower and fruit development took place during the long sunny days of April and May.

The Grand Rapids Forcing variety of tomatoes was used. The plants were trained to a single stem and grown two feet apart each way in a loam soil that was treated in the fall with 0-20-20 commercial fertilizer at the rate of 1500 lbs. per acre. These plants were watered by an overhead sprinkling system, except during the cloudy weather in the fall when a hose was used so as not to spread leaf diseases. There were no insect or disease attacks during the experiment to interfere with the progress of the work.

The fall crop was defoliated and defruited on November 21, 1931; the spring crop on March 20, 1932, and measurements of the leaf areas were taken every seven days for seven weeks in each case. The various lots of plants were set in the plot, as illustrated in figure 1 and all plants were defoliated and defruited, as shown in table 1. In table 2 is illustrated the natural development of the check plants. All the leaves were measured and their areas computed every seven days by the use of the equation developed for

Table 3. Average increase in leaf area per fruit per week in square centimeters.

Plant	Crop	Original area	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A-1	Fall	409.67	53.88	20.28	8.08	7.31	0	0	0
A-1	Spring	320.19	174.62	185.61	83.56	50.29	33.94	0	0
B-2	Fall	824.33	68.67	29.38	23.88	7.38	0	0	0
B-2	Spring	777.10	251.74	236.95	176.36	77.35	24.10	22.25	11.31
C-3	Fall	1280.99	80.25	35.40	16.80	16.87	2.96	0	0
C-3	Spring	964.30	392.43	386.66	199.51	121.12	24.75	15.20	11.31
D-4	Fall.	1763.71	142.82	57.54	37.55	33.91	16.73	0	0
D-4	Spring	1456.12	398.76	397.16	297.53	140.38	62.51	15.10	0
E-5	Fall	1847.54	169.31	87.21	53.42	53.84	0	0	0
E-5	Spring	1636.23	586.71	549.50	191.95	187.11	47.34	37.26	0
F-6	Fall	2055.96	247.51	113.40	60.32	58.48	11.38	0	0
F-6	Spring	2300.45	227.32	256.85	361.02	212.41	62.59	29.53	0
G-7	Fall	2933.18	182.26	78.40	41.75	36.15	0	0	0
G-7	Spring	2859.11	198.71	218.20	830.44	388.71	108.37	63.46	17.86
H	Fall	2030.77	291.31	110.90	47.00	13.55	6.48	3.59	2.73
H	Spring	555.62	262.83	179.36	64.37	27.27	30.32	29.74	19.37

Table 4. Total leaf area per fruit per week in square centimeters.

Plant	Crop	Original area	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A -1	Fall	409.67	463.55	483.67	491.76	499.08	499.08	499.08	499.08
A -1	Spring	320.19	494.81	680.42	763.98	814.27	848.21	848.21	848.21
B -2	Fall	824.33	893.00	922.83	946.71	953.09	953.09	953.09	953.09
B -2	Spring	777.10	1034.64	1271.59	1447.95	1525.70	1549.80	1572.05	1583.36
C -3	Fall	1280.99	1361.24	1396.64	1413.44	1430.31	1433.21	1433.21	1433.21
C -3	Spring	964.30	1356.73	1743.39	1942.90	2064.02	2088.77	2103.97	2115.28
D -4	Fall	1763.71	1806.53	1864.07	1901.62	1935.53	1952.26	1952.26	1952.26
D -4	Spring	1456.12	1854.88	2252.04	2549.57	2689.95	2752.46	2767.56	2767.56
E -5	Fall	1847.54	2016.85	2104.06	2157.48	2211.32	2211.32	2211.32	2211.32
E -5	Spring	1626.23	2223.04	2772.54	2964.49	3251.60	3298.94	3336.20	3336.20
F -6	Fall	2055.96	2303.47	2416.87	2477.19	2535.67	2547.05	2547.05	2547.05
F -6	Spring	2300.45	2527.77	2784.62	3145.64	3358.05	3420.64	3450.17	3450.17
G -7	Fall	2933.18	3115.44	3193.84	3235.59	3271.74	3271.74	3271.74	3271.74
G -7	Spring	2859.11	3057.82	3376.02	4206.46	4595.17	4703.54	4767.00	4784.86
H	Fall	2030.77	2322.08	1322.40	968.69	605.53	454.41	428.81	405.11
H	Spring	555.62	818.45	670.43	295.56	202.19	222.40	206.34	177.49

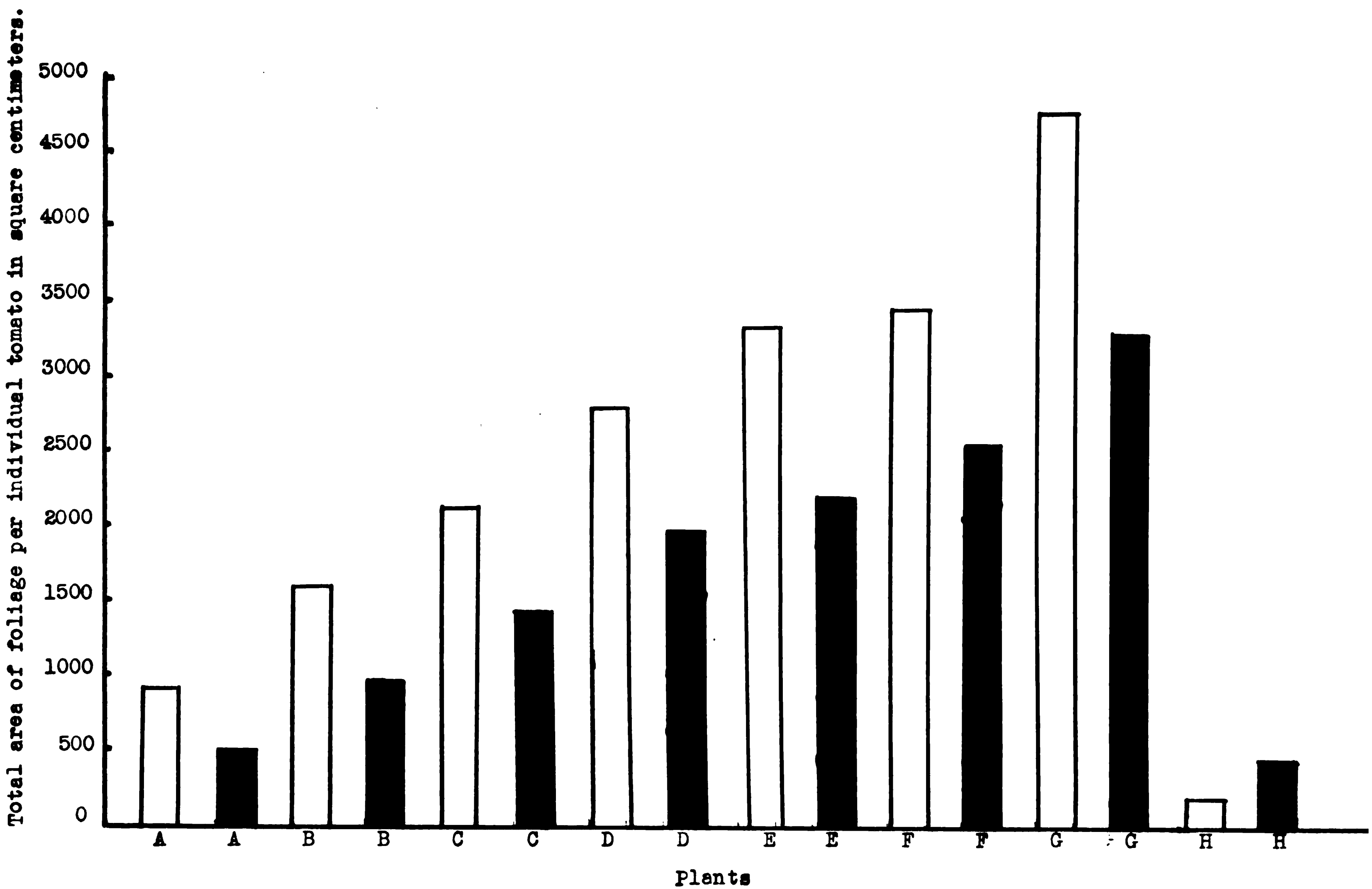

Figure 3. Average total area of foliage per fruit on each set of plants at ripening of crop.

measuring leaf area. The volume of the fruit was found every seven days by the water displacement method. This consisted in putting water in a cylinder calibrated in cubic centimeters and placing the tomato in it to find the number of cubic centimeters of water displaced.

An attempt was made to measure the solar intensity by means of comparing the absorbed and reflected energy. This was done by recording the difference every two hours between the readings on a black centigrade and a standard centigrade thermometer. (Table 12.)

The sunshine data were obtained from the United States Weather Bureau at East Lansing. (Table 12).

The methods used to determine the percentages dry matter in plants and fruits was by drying them in an oven at 90^{o}C for 48 hours.

Results

Foliage growth.

Both the fall and spring plants showed a rapid rate of foliage growth following either defoliation or defruiting. This rate decreased each week on all the plants except the F and G lots, where it increased for three weeks and then decreased the last four, and the H lot where it remained rather constant. As the leaves became more mature the total leaf area per tomato did not increase as rapidly except on the check plants where young leaves were continually forming and older ones maturing more rapidly than on the defoliated and defruited plants. (Tables 3, 4 and Figure 3).

Table 5. Per cent of area increase in foliage per fruit by weeks.

Plant	Crop	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A-1	Fall	11.6	4.1	1.7	1.4	0	0	0
A-1	Spring	55.5	27.2	10.9	6.1	4.0	0	0
B-2	Fall	7.6	3.2	2.5	0.7	0	0	0
B-2	Spring	24.3	18.6	1.2	0.5	0.1	0.1	0.07
C-3	Fall	5.9	2.8	1.1	1.1	0.2	0	0
C-3	Spring	28.9	22.1	10.2	5.8	0.1	0.07	0.05
D-4	Fall	7.9	3.1	1.9	1.2	0.8	0	0
D-4	Spring	21.5	17.6	10.1	5.2	0.2	0.05	0
E-5	Fall	8.4	4.1	2.4	2.4	0	0	0
E-5	Spring	26.4	19.8	6.4	5.7	0.17	0.11	0
F-6	Fall	10.8	4.9	2.4	2.3	0.5	0	0
F-6	Spring	8.9	9.2	11.4	6.3	0.18	0.08	0
G-7	Fall	5.8	2.4	1.2	1.1	0	0	0
G-7	Spring	6.4	6.4	19.7	8.4	2.3	1.3	0.3
H	Fall	12.5	8.8	4.9	2.2	1.4	0.9	0.7
H	Spring	32.1	21.9	21.7	13.4	13.6	14.4	10.9

Table 6. **Area of foliage per cubic centimeter volume of fruit at end of each week.**

Plant	Crop	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A -1	Fall	60.5	22.8	14.3	11.0	9.3	8.2	8.1
A -1	Spring	109.9	38.8	16.7	9.5	7.3	6.4	6.1
B -2	Fall	178.6	60.9	28.2	17.6	13.4	11.5	10.5
B -2	Spring	166.8	64.2	28.9	17.7	14.0	12.5	11.0
C -3	Fall	233.8	81.4	71.8	37.4	25.6	21.0	18.9
C -3	Spring	215.3	77.1	40.8	23.4	19.4	17.1	15.0
D -4	Fall	374.0	130.0	70.5	43.1	31.5	25.1	22.9
D -4	Spring	370.9	136.5	64.1	37.2	29.6	25.7	23.1
E -5	Fall	212.3	91.4	51.7	35.6	26.1	22.0	20.3
E -5	Spring	331.7	121.1	58.2	42.5	32.6	28.4	27.3
F -6	Fall	307.1	105.8	59.7	38.7	28.4	24.3	21.3
F -6	Spring	505.5	174.1	84.3	49.6	36.5	31.7	29.2
G -7	Fall	406.8	157.6	94.9	67.5	49.0	40.1	35.7
G -7	Spring	664.7	204.8	108.1	71.5	55.3	45.1	40.7
H	Fall	558.2	113.4	47.6	21.6	12.7	9.8	8.7
H	Spring	125.9	31.3	79.8	38.1	32.9	26.3	19.4

Table 7. Average amount of fruit growth per fruit per week in cubic centimeters.

Plant	Crop	Total growth	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A-1	Fall	66.6	7.66	9.5	10.0	11.9	14.1	11.0	2.5
A-1	Spring	138.0	4.5	13.0	28.0	40.0	29.5	17.0	6.0
B-2	Fall	90.2	5.8	9.6	17.0	17.3	21.3	13.6	7.0
B-2	Spring	143.7	6.2	13.6	30.2	36.0	24.7	15.0	18.0
C-3	Fall	88.3	6.0	11.0	13.6	16.2	19.8	15.0	6.6
C-3	Spring	141.0	6.3	16.3	25.0	40.5	19.2	15.7	18.0
D-4	Fall	83.8	4.8	9.5	12.6	17.0	17.8	17.5	7.5
D-4	Spring	119.3	5.0	11.5	23.3	32.2	20.5	14.5	12.0
E-5	Fall	108.1	5.0	9.6	19.5	20.3	24.2	17.1	11.0
E-5	Spring	122.1	6.7	16.2	28.0	25.5	24.7	16.0	5.0
F-6	Fall	109.0	7.5	14.2	18.2	23.6	24.2	16.6	5.8
F-6	Spring	118.0	5.0	11.0	21.3	30.4	26.0	15.0	10.0
G-7	Fall	93.0	7.2	14.4	14.0	14.0	17.0	15.2	10.0
G-7	Spring	117.6	4.6	11.8	22.5	25.3	20.8	20.6	12.0
H	Fall	49.8	4.1	7.5	8.6	7.6	7.8	7.3	6.6
H	Spring	88.7	6.5	14.9	15.6	16.0	14.4	11.1	10.2

The removal of the leaves had a stimulating effect on the rate of growth of all the plants, and the more foliage was removed the greater was the stimulus. (Tables 3 and 5). The leaves on the defoliated plants developed to much greater size and were much darker in color in both crops than they were on the check lot of plants. The leaves on the defoliated plants of the spring crop developed severe curling, but this did not seem to affect the foliage or fruit growth. (This is illustrated by the plates in the appendix.) Since the check plants did not develop this curling, it was believed to be due to the defoliating and defruiting of the plants. The increase in leaf area after defoliating or defruiting or both was much greater on the spring than on the fall plants, and this is true when figured either in terms of absolute area increase week by week or in terms of percentage increase. The percentage increase in leaf area week by week did not seem to be influenced materially by the number of leaves per fruit. That is, the percentage increase in leaf area was just about the same for a one-leaf-per-fruit plant as for a five-leaf-per-fruit plant.

Fruit growth.

The rate of fruit volume increase are presented in data on table 7. These show that the fruits in the fall reached their peak of volume increase one week later than those of the spring crop although the fruits on the spring plants were actually gaining in absolute weight faster throughout the entire growing period. The fall crop had a small increase in size just before maturity and

Table 8. Per cent volume increase of fruit per week per fruit in cubic centimeters.

Plant	Crop	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A -1	Fall	11.5	14.1	15.0	18.0	22.3	16.3	3.8
A -1	Spring	3.3	9.4	20.3	28.9	21.4	12.3	4.3
B -2	Fall	6.4	10.7	18.8	18.3	23.7	15.1	7.8
B -2	Spring	4.3	9.5	21.0	25.0	17.2	10.4	12.5
C -3	Fall	6.7	12.4	15.4	18.2	22.4	16.9	7.5
C -3	Spring	4.5	11.6	17.7	28.7	13.6	11.1	12.7
D -4	Fall	4.7	10.3	14.1	20.8	21.2	21.1	7.9
D -4	Spring	4.2	9.6	19.5	26.9	17.1	12.2	10.0
E -5	Fall	4.6	8.8	18.0	18.8	22.3	15.8	10.2
E -5	Spring	5.5	13.3	22.9	20.8	20.2	13.1	4.1
F -6	Fall	6.6	13.0.	16.6	21.7	22.1	15.2	5.3
F -6	Spring	4.2	9.3	18.1	25.7	22.03	12.7	8.5
G -7	Fall	8.2	15.4	15.0	15.0	18.2	16.3	10.7
G -7	Spring	3.9	10.0	19.1	21.5	17.7	17.7	10.2
H	Fall	8.3	15.0	17.4	15.3	15.8	14.7	13.4
H	Spring	7.3	16.7	17.6	18.0	16.2	12.5	11.5

Table 9. Volume of fruit in cubic centimeters per 100 square centimeters leaf at end of each week.

Plant	Crop	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A-1	Fall	1.65	3.54	5.52	7.83	10.65	12.84	13.34
A-1	Spring	0.90	2.57	5.95	10.50	13.55	15.56	16.26
B-2	Fall	0.65	1.68	3.61	5.05	7.29	8.72	9.45
B-2	Spring	0.59	1.55	3.45	5.63	7.14	7.99	9.07
C-3	Fall	0.44	1.22	2.16	3.27	4.65	5.69	6.16
C-3	Spring	0.47	1.29	2.44	4.26	5.13	5.84	6.65
D-4	Fall	0.26	0.76	1.43	2.34	3.01	3.91	4.21
D-4	Spring	0.20	0.73	1.56	2.68	3.37	3.87	4.32
E-5	Fall	0.23	0.73	1.62	2.50	3.61	4.39	4.88
E-5	Spring	0.30	0.82	1.71	2.34	3.06	3.50	3.66
F-6	Fall	0.32	0.83	1.60	2.50	3.38	4.04	4.27
F-6	Spring	0.19	0.57	1.18	2.01	2.73	3.15	3.42
G-7	Fall	0.24	0.71	1.10	1.52	2.08	2.53	2.84
G-7	Spring	0.15	0.48	0.92	1.39	1.80	2.21	2.45
H	Fall	0.17	0.89	2.09	4.62	7.88	10.05	12.29
H	Spring	0.79	3.19	12.51	26.20	30.30	38.04	49.97

Table 10. Average volume per fruit per week in cubic centimeters.

Plant	Crop	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A -1	Fall	7.6	17.2	27.2	39.1	53.1	64.1	66.6
A -1	Spring	4.5	17.5	45.5	85.5	115.0	132.0	138.0
B -2	Fall	5.8	15.5	35.0	48.2	69.5	83.2	90.2
B -2	Spring	6.2	19.8	50.0	86.0	110.7	125.7	143.7
C -3	Fall	6.0	17.2	30.6	48.8	66.6	81.6	88.3
C -3	Spring	6.3	22.6	47.6	88.1	107.3	123.0	141.0
D -4	Fall	4.8	14.3	27.3	45.3	58.8	76.3	83.8
D -4	Spring	5.0	16.5	39.8	72.3	92.8	107.3	119.3
E -5	Fall	4.8	15.5	35.0	55.3	80.0	97.1	108.1
E -5	Spring	6.7	22.9	50.9	76.4	101.1	117.1	122.1
F -6	Fall	7.5	20.2	39.8	63.5	86.3	103.0	109.0
F -6	Spring	5.0	16.0	37.3	67.7	93.7	108.7	118.0
G -7	Fall	7.6	22.8	35.6	50.0	68.2	83.0	93.0
G -7	Spring	4.6	16.4	38.9	64.2	85.0	105.6	117.6
H	Fall	4.2	11.6	20.3	27.9	35.8	43.2	49.8
H	Spring	6.5	21.4	37.0	53.0	67.4	78.5	88.7

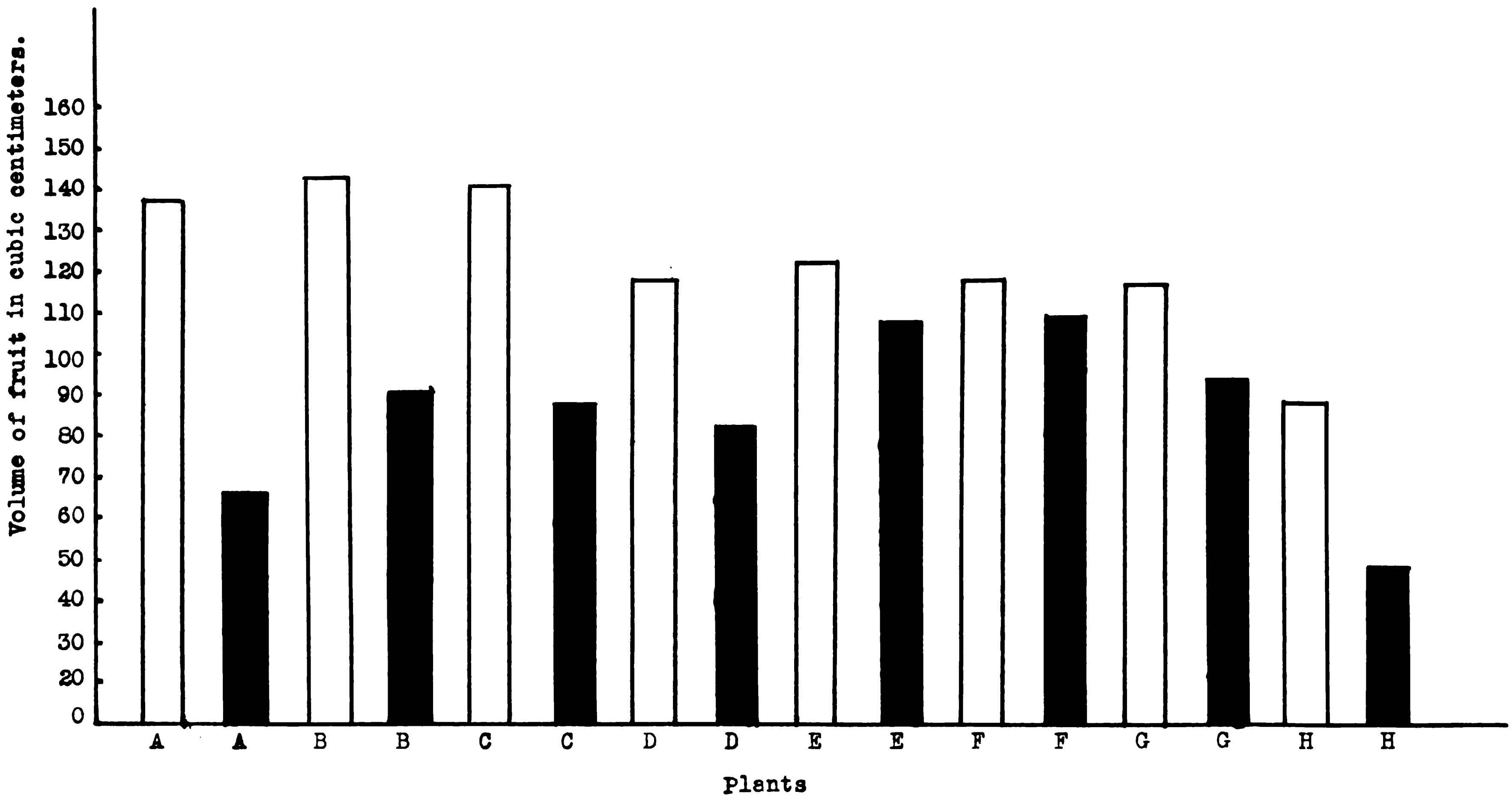

Figure 4. Average total volume of fruit on each set of plants at time of ripening of each crop.

■ Fall crop □ Spring crop

the fruits ripened very slowly, while in the spring the tomatoes increased in volume right up to maturity and ripened rapidly. All the fruits produced on the defoliated and defruited plants made a much larger size and matured earlier than the fruits on the check plants. (Table 10 and Figure 4).

In table 8 it will be noted that the plants with a large amount of foliage have a more constant increase, (on the percentage increase scale) of fruit over the period of seven weeks than any of the other plants considered in the experiment. The fruits on the E and F plants increased much more rapidly and reached a larger size on the fall crop than any of the other plants. On the spring crop the fruits on all the plants defoliated and defruited were larger than the maximum sized fruits on any of the fall crop, but the fruits on the A, B, and C plants were much larger than on any of the other plants. The fruits on the G plants were smaller than others on both crops. The fruits on the check plants did not grow large and they ripened at about one-third the size of those on the other plants. They were slow in growing and maturing, and due to the large number of fruits in a cluster and the small amount of leaf area per fruit they were small. (Tables 7, 8 and 10).

There was a steady rise in the rate of increase of fruit volume per unit of leaf area from the beginning to the end of the seven week period. This took place in both the fall and spring crop and is especially noteworthy in connection with the fall crop, for the period during which that crop was developing was characterized

Table 11. Average amount of fruit growth per plant per week in cubic centimeters.

Plant	Crop	Average total growth per plant	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week
A-1	Fall	178.5	20.4	25.3	26.6	31.7	38.6	29.3	6.6
A-1	Spring	296.0	9.7	28.0	60.0	86.0	63.1	36.3	12.9
B-2	Fall	229.5	14.6	24.2	42.5	43.3	53.3	34.1	17.5
B-2	Spring	383.0	16.5	36.2	80.5	96.0	65.8	40.0	48.0
C-3	Fall	249.5	17.0	31.0	38.7	45.8	56.1	42.1	18.8
C-3	Spring	328.6	14.7	38.0	58.0	94.5	44.8	36.6	42.0
D-4	Fall	202.5	11.2	22.1	29.4	40.0	41.5	40.8	17.5
D-4	Spring	238.0	10.0	23.0	46.6	64.4	41.0	29.0	24.0
E-5	Fall	213.4	10.0	19.2	39.0	40.6	48.4	34.2	22.0
E-5	Spring	244.2	13.4	32.4	56.0	51.0	49.4	32.0	10.0
F-6	Fall	201.3	13.7	25.9	33.2	43.2	44.2	30.4	10.7
F-6	Spring	237.4	10.0	22.0	42.6	60.8	52.0	30.0	20.0
G-7	Fall	158.8	12.0	24.0	26.4	26.4	28.3	25.1	16.6
G-7	Spring	174.1	6.9	17.7	33.7	37.9	31.2	30.9	18.8
H	Fall	438.1	8.2	28.7	47.6	70.9	94.9	95.3	92.5
H	Spring	644.7	6.5	23.8	75.4	130.6	158.4	127.6	122.4

by a steadily decreasing light intensity and an even more strikingly decreasing percentage of sunlight. This would seem to indicate either that (1) during the latter part of the period of development of the fruit when the fruits were growing most rapidly the leaves were functioning more efficiently, or (2) that during this same period the fruits were able to obtain a larger percentage of the products of photosynthesis. That this latter hypothesis is closer to the condition that actually existed is indicated by the fact that during this period of relatively slow growth of the fruits the leaf area was increasing rapidly, while later when the fruits were growing the more rapidly the leaves were growing but little. It is also significant that the volume of fruit per unit of leaf area, and likewise the increase in volume of fruit per unit of leaf area, was essentially the same in the fall as in the spring. The spring crop apparently should have a greater absolute increase in fruit size and fruit development from week to week than the fall crop because the plants developed larger leaves in the spring. The fact that maximum amount of fruit was produced by the unpruned and unthinned plants (table 11) and that the volume increase per unit of leaf area each week was greatest on these same plants in the case of both fall and spring crops indicate that from the standpoint of total fruit development the tomato plant will be most efficient when there is a very limited leaf area per individual fruit. On the other hand, when too many fruits set and start to develop for the leaf area possessed by the plant; the individual fruits are unable to attain commercial size. Therefore, some fruit thinning is

Table 12. Light intensity and percentage of sunlight.

Total Light intensity	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week	Average
Fall	16.8°C	18.1°C	27.1°C	13.5°C	13.1°C	11.9°C	13.4°C	16.30°C
Spring	47.2°C	55.0°C	56.4°C	49.1°C	62.0°C	36.7°C	44.0°C	50.05°C
Percentage sunlight								
Fall	28.7	25.3	59.1	10.4	26.5	8.1	9.4	24.41
Spring	49.8	28.7	62.0	54.7	98.5	49.4	55.7	56.50

Table 13. Average amounts of dry matter per 100 grams per plant.

Plant	Crop	Foliage & Stems	Fruit	Total plant
A-1	Fall	9.13	4.75	6.94
A-1	Spring	11.72	6.41	9.06
B-2	Fall	9.91	4.62	7.26
B-2	Spring	12.54	6.39	9.46
C-3	Fall	9.66	4.92	7.29
C-3	Spring	12.18	6.70	9.44
D-4	Fall	10.01	5.16	7.58
D-4	Spring	12.75	6.20	9.45
E-5	Fall	10.39	5.39	7.89
E-5	Spring	11.56	6.87	9.21
F-6	Fall	10.57	5.04	7.85
F-6	Spring	11.81	6.42	9.11
G-7	Fall	10.28	5.08	7.68
G-7	Spring	6.91	6.45	6.68
H	Fall	9.22	4.68	6.95
H	Spring	8.40	6.35	7.36

advisable, but more than enough to insure the minimum size or sizes that are satisfactory commercially is reasonably certain to reduce the efficiency of the plants.

The light intensity and per cent of sunlight are shown in table 12. The fruits do not ripen as evenly during the dark cloudy days of low light intensity in the fall as they do during the longer days of a higher light intensity in the spring.

The dry matter content of the tomatoes on the plants of different treatments is presented in table 13. It seems that the larger the tomato develops in size the more concentrated the nutrient material in the tomato becomes.

The foliage, stems and fruits of the fall crop have a lower percentage of dry matter than is true of the spring crop. (Table 13).

Table 14. Summary Table

Plant	Crop	Average total leaf area growth per plant during fruit growth	Average total leaf area per plant at fruit maturity	Average total fruit growth per plant	Average volume of fruit at maturity	Average amount of leaf area per cubic centimeter of fruit at maturity
A-1	Fall	238.42	1330.88	178.5	66.6	7.4
A-1	Spring	1144.04	1837.79	296.0	138.0	6.2
B-2	Fall	321.90	2382.72	229.5	90.2	10.2
B-2	Spring	2150.02	4222.29	383.0	143.7	11.0
C-3	Fall	431.44	4060.76	249.5	88.3	16.2
C-3	Spring	2685.62	4935.65	328.6	141.0	15.0
D-4	Fall	439.95	4655.27	202.5	83.8	23.0
D-4	Spring	2622.88	5535.12	238.0	119.3	23.2
E-5	Fall	727.56	4422.64	213.4	108.1	20.7
E-5	Spring	3419.94	6672.40	244.2	122.1	27.7
F-6	Fall	982.18	5094.10	201.3	109.0	25.3
F-6	Spring	2299.44	6900.34	237.4	118.0	29.1
G-7	Fall	677.12	6543.48	158.8	93.0	41.4
G-7	Spring	2888.62	7177.29	174.1	117.6	41.2
H	Fall	26554.33	29573.03	438.1	49.8	67.5
H	Spring	18302.97	19121.42	644.7	88.7	29.6

DISCUSSION

In tomato growing under glass it is generally considered that tomato plants maturing their fruit during the long brighter days of spring will set fruits more freely and they will grow to larger size than plants maturing their fruit during the shorter duller days of late fall and early winter. The differences in light intensity and percentage of sunshine correspond closely with the above differences. This variation in light supply may be the cause of the efficiency of the foliage per unit area, but it depends more on the total amount of foliage possessed by the plant at any time. This is indicated by the close correlation between rate and amount of fruit development and rate and amount of leaf development. From this information it seems that there must be a seasonal balance between the fruit number and leaf area in order to get maximum production of relatively large sized fruit. In the fall or early winter months of dull days and low light intensity it is evidently necessary to have a larger number of leaves per fruit than in the brighter days of late winter and early summer. When the fruit sets sparingly, this balance can be brought about by defoliating or pruning, but when the fruits set heavily, the proper balance can be more easily brought about by defruiting or fruit thinning.

The evidence presented also indicates that there must be a fairly definite ratio between leaf area and number of developing fruits in order to have most efficient foliage and maximum development of fruit of good size. This ratio will vary somewhat with different varieties, size of leaves and size of fruits that are desired.

The data presented suggests why directly opposite results were found in some of the investigations on pruning of tomatoes, cited in the Review of Literature.

SUMMARY

1. When various amounts of defoliating and defruiting were practiced, there was a distinct difference in rate of foliage and fruit growth and in total foliage and fruit growth.

2. The season of the year had a direct effect on the rates and totals in foliage and fruit growth. The light intensity and length of day had the greatest influence on this direct effect on the plants grown in the fall or early winter and late spring or early summer.

3. It was indicated that when the proper balance between leaf area and fruit volume was reached, the fruits developed more rapidly and became of a larger size than otherwise.

4. The percentages dry matter in the fruits and plants is regulated by the amounts of foliage developed and sunlight received in both crops.

5. It is evident that the light intensity and amount of sunlight had a greater effect on the growth of foliage and fruits than any other factor considered in the growth of a crop of tomatoes.

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APPENDIX

Explanation of Plates

Plate I. Comparative average size of tomatoes that were grown on the fall crop of plants. The letters at the side indicate the lot of plants each tomato represents.

Plate II. Comparative average size of tomatoes that were grown on the spring crop of plants. The letters at the side indicate the lot of plants each tomato represents.

Plate III. A plant of fall crop on left and A plant of spring crop on right. Note severe curling of foliage on the spring crop but there is more leaf area on the spring plant than on the fall plant.

Plate IV. B plant of fall crop on left and B plant of spring crop on the right. The fall crop had thicker stems but smaller leaves and fruit.

Plate V. C plant of fall crop on left and C plant of spring crop on the right. The large tomato second from the top on the left is the largest produced on the fall crop of C plants.

Plate VI. D plant of fall crop on left and D plant of spring crop on the right. Note the big difference of heighth of these two plants. This holds true on all lots of plants.

Plate VII. E plant of fall crop on left and E plant of spring crop on right. The tomatoes on the fall plant were the largest produced on the fall crop. Note how the plants differ in leaf curling.

Plate VIII. F plant of fall crop on left and F plant of spring crop on right. The results of a large amount of foliage in fall and spring is well illustrated in this plate.

Plate IX. G plant of fall crop on left and G plant of spring crop on right. This shows how small the tomatoes appear when there is an excess of foliage per fruit. Evidently the effect is greater in the spring than in the fall.

Plate X. H plant of fall crop on left and H plant of spring crop on right. This will give one an idea of the sturdy natural growth of the plants with a high light intensity and the spindly natural growth of the plants that have a low light intensity. It will be noted that there was very little curling on the plants that were allowed to grow naturally.

D H

C G

B F

A E

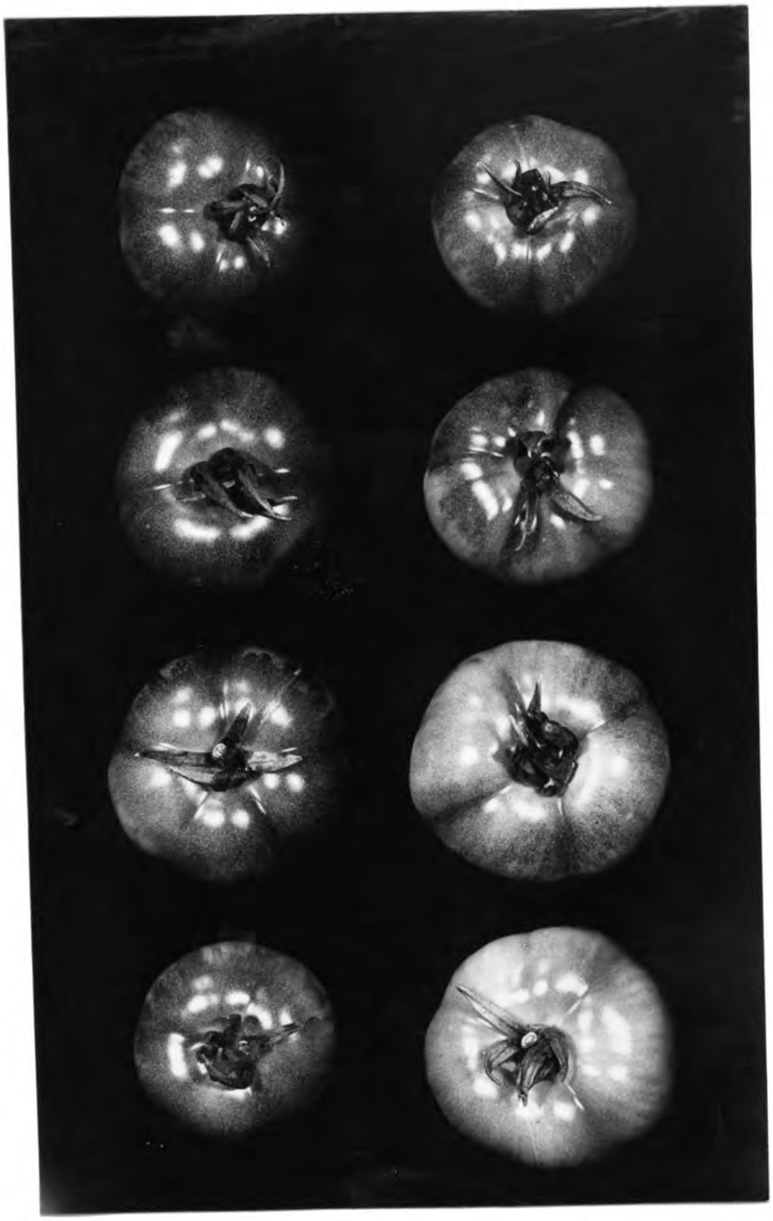

Plate I.

D H

C G

B F

A E

Plate II.

Plate III.

Plate IV.

Plate V.

Plate VI.

Plate VII.


Plate VIII.

Plate IX.

Plate X.