Research Summary 34 April 1969

Greenhouse Vegetable Research 1969

V180 +
new OARDC

91337

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER

Wooster, Ohio

CONTENTS

* * * *

A Preliminary Report on Supplemental Lighting for Tomato, by Dale W. Kretchman -- 1

The Relation of Frequency of Pollination on Fruiting of the Greenhouse Tomato--A Preliminary Report, by Dale W. Kretchman and Freeman S. Howlett ----------------- 5

Characterizing Tomato Fruit Growth, by Dale W. Kretchman -- 9

The Relationship of Incident Light and CO_2 Enrichment to Yield of Spring Crop Greenhouse Tomatoes, by Dale W. Kretchman and Freeman S. Howlett ----------------- 11

Relation Between Soil Test for Phosphorus and Potassium and Leaf Composition for the Same Elements in the Greenhouse Tomato, by Freeman S. Howlett and Dale W. Kretchman -- 13

Relation of Nitrogen and Potassium Applications and Leaf Composition to Fruit Cracking--Spring 1968 Greenhouse Tomato Crop, by Freeman S. Howlett and Dale W. Kretchman ---- 17

Relation of Added Nitrogen and Potassium and Leaf Composition to Puffiness in the Spring 1968 Greenhouse Tomato Crop, by Freeman S. Howlett and Dale W. Kretchman -- 19

Relation of Nitrogen and Potassium Application and Leaf Composition to Yield of Greenhouse Tomato in Spring and Fall Crops, 1968, by Freeman S. Howlett and Dale W. Kretchman -- 21

Correlations of Nutrient Elements Within Leaves of Major Significance in Greenhouse Tomato, Spring and Fall Crops, 1968, by Freeman S. Howlett and Dale W. Kretchman -- 25

Disease Problems of Occasional Importance in Greenhouse Tomatoes, by Robert E. Partyka ------------------------------ 29

DISCOVER DEVELOP DISSEMINATE

4-69-3.2M

A PRELIMINARY REPORT ON SUPPLEMENTAL LIGHTING FOR TOMATO

Dale W. Kretchman
Department of Horticulture
Ohio Agricultural Research and Development Center

Fruit set of the first cluster of the greenhouse tomato during the spring crop in Ohio requires very skillful management of temperature, nutrition, and watering in relation to the available light. Light intensity usually is quite low during November and December when the transplants for the spring crop are being produced and after transplanting during January and February when the early clusters are setting.

Fruit set on the first cluster is quite critical because failure on this cluster frequently results in difficulty with setting on the second and perhaps even the third cluster. There is, therefore, some interest in producing a transplant which is developed sufficiently and which contains adequate carbohydrates to favor setting of the first cluster after transplanting. Light, which is essential to carbohydrate production and is usually limited during spring crop plant growing, was considered for study to determine its potential for use in producing greenhouse tomato transplants.

METHODS

Seeds of W-R 25 were sown in vermiculite on December 16, 1967. After transferring the small seedlings to 4-inch clay pots on December 26, the plants were divided into three lots. One lot was placed in the greenhouse plant growing compartment and the other two in an environment-controlled growth chamber. Temperatures in both growing areas were maintained at 70° F. daytime and 60° F. at night. Light intensity in the growth chamber initially was about 3,000 ft. candles but due to aging of the fluorescent tubes, intensity had decreased to nearly 2,000 ft. candles by the end of the growing period. Lights were on for 12 hours each day.

Plants in the greenhouse were exposed to normal winter light intensities and normal day length.

All plants were cared for in accordance with standard practice. Transplanting of one set of plants from the chamber occurred on January 25, 1968. The second set from the growth chamber and the plants grown in the greenhouse were planted 2 weeks later on February 8. Growing practices after transplanting were in accordance with recommended procedures.

Yield and fruit quality data were collected according to standard practice for all greenhouse tomato research of the Department of Horticulture.

RESULTS AND DISCUSSION

Plants grown in the growth chamber (Figures 1 and 2) were advanced by 2 weeks in comparison to plants grown in the greenhouse. The plants

Fig. 1.--A comparison of plants grown under normal greenhouse conditions (left) and those grown in the growth chamber (right) on January 25, 1968.

Fig. 2.--Plants growing in the growth chamber ready for transplanting on January 25, 1968.

were also of better quality for transplanting, especially those transplanted on January 25.

Plants held in the growth chamber until the first blossoms on the first cluster were in bloom and transplanted on February 8 were somewhat hardened. The mass of roots had the appearance of being potbound. These plants were also very subject to moisture stress for several weeks after transplanting and did not develop the vigorous appearance of good quality tomato plants until several weeks after transplanting. Further, when these plants were pulled at the end of the season, most of the root system was still confined to a somewhat enlarged pot-ball, with very few roots extending out into the soil mass.

Plants from the growth chamber planted on January 25 and those from the greenhouse grew normally after transplanting. Fruit set was generally very satisfactory on all plants, primarily because of the later than normal transplanting and the very favorable light intensity during February 1968. Nevertheless, the plants grown under the relatively high intensity light under a longer day length in the chamber appeared to have more fruit set on the first cluster than those from the greenhouse. Fruit set data were not taken in 1968 but are being recorded in the 1969 light studies.

Total yield and fruit quality data are presented in Table 1. No statistically significant differences were found between treatments for any of the data collected. This is not too surprising because of the very favorable light conditions during February after the late transplanting. It will be interesting to compare these results with those from the 1969 crop, which was planted at the more normal time in early January. These data will be included in a subsequent report.

Table 1- The influence of growing transplants in the growth chamber vs. the greenhouse on yield and fruit quality of tomatoes.

	Growing Location		
	Greenhouse Transplanted - 2/8	Chamber 1/25	Chamber 2/8
Number of Fruit /Plant	46.17	47.46	45.63
Total Fruit Weight- lbs /Plant	17.09	17.73	16.93
Average Fruit Size- lbs	0.3702	0.3736	0.3710
Number of Defects /Fruit	0.2900	0.2575	0.2100
% Puffy Fruit	12.75	10.25	9.00
% Cracked Fruit	8.50	7.25	6.50
% Off-Shaped Fruit	3.50	3.50	2.25
% U.S. No.1 Fruit	88.0	87.5	91.0

THE RELATION OF FREQUENCY OF POLLINATION ON FRUITING OF THE GREENHOUSE TOMATO--A PRELIMINARY REPORT

Dale W. Kretchman and Freeman S. Howlett
Department of Horticulture
Ohio Agricultural Research and Development Center

Greenhouse tomatoes will produce high yields only if a good set of fruit occurs. Hand pollination with a mechanical vibrator is the only presently known method for assuring good fruit set. It is generally recommended that pollinating be done on a daily basis. This is a costly procedure in terms of labor usage.

With escalating labor costs, a decreasing labor supply, newer cultivars, and the use of CO_2 enrichment, it was desirable to re-examine the possibility of reducing the frequency of the pollinating process. A study was initiated in the late fall of 1967 to determine the effects of reduced frequency of pollination on yield and quality of the greenhouse tomato. The preliminary results are reported here.

METHODS

Fall Crop 1967: Starting with the bloom on the fifth cluster, the following treatments were imposed: 1) flower clusters vibrated every day; 2) flower clusters vibrated every second day; 3) flower clusters vibrated every fourth day. Each treatment was replicated four times, with 12 plants of W-R 25 used for each treatment. A commercial electric vibrator was used. The pollinating was done between 1:00 and 2:00 p.m. each day of pollination. The treatments were continued until the plants were topped. An average of three clusters per plant was produced on the plants during this study.

At harvest, data were taken on fruit numbers, weight, and fruit quality defects, including puffiness, cracks, and off-shape. The fruit was graded according to U.S. grade standards.

Spring Crop 1968: Frequencies of pollinating treatments for this crop were: 1) clusters vibrated every day; 2) clusters vibrated every third day; 3) clusters vibrated every fifth day. The treatments were imposed at the beginning of bloom on the first cluster and continued until topping out after 13 to 14 clusters had developed. The remaining conditions were similar to the previous fall crop.

RESULTS AND DISCUSSION

Data obtained for the fall crop (Table 1) indicate that greater numbers of fruit, larger sizes, and greater total yield were obtained from the plants pollinated daily. No differences between any of the treatments were found with respect to fruit quality defects.

Results of the spring crop 1968 were similar except that average fruit size was not affected by pollination treatment.

An examination of the data reveals an apparent relationship between CO_2 enrichment and frequency of pollination. Part of these

Table 1- The influence of frequency of pollination on yield and fruit quality of greenhouse tomatoes during the fall crop, 1967. Treatments were imposed starting with the fifth cluster.

	Pollination Frequency		
	Every Day	Every Second Day	Every Fourth Day
Number of Fruit /Plant	11.17	11.20	10.70
Total Weight of Fruit /Plant -lbs.	4.00	3.87	3.65
Average Fruit Weight -lbs.	0.358	0.347	0.342
Number of Defects per Fruit	0.496	0.481	0.493
% Puffy Fruit	26.63	25.25	25.19
% Cracked Fruit	4.06	4.38	4.50
% Off-Shaped Fruit	11.06	10.69	11.44

Table 2- The influence of frequency of pollination on yield and fruit quality of greenhouse tomatoes during the spring crop, 1968.

	Pollination Frequency		
	Every Day	Every Third Day	Every Fifth Day
Number of Fruit /Plant	48.57	45.59	45.02
Total Weight of Fruit /Plant- lbs.	17.0	16.1	15.7
Average Fruit Size- lbs.	0.350	0.352	0.347
Number of Defects /Fruit	0.294	0.294	0.315
% Puffy Fruit	8.63	7.63	8.13
% Cracked Fruit	9.13	9.63	11.63
% Off-Shaped Fruit	4.88	4.75	4.63
% U.S. No.1 Fruit	86.25	86.88	85.38

Table 3- Relation of CO_2 enrichment and frequency of pollination to yield of greenhouse tomatoes - Spring crop, 1968.

Pollination Frequency	Total Yield $-CO_2$	Lbs./Plant $+CO_2$	% Change due to $+CO_2$
1- Every Day	16.318	17.690	+ 8.41
2- Every Third Day	15.360	16.833	+ 9.59
3- Every Fifth Day	14.685	16.660	+ 13.45
Difference between Treatment 1 & 3	1.633 lbs.	1.030 lbs.	

data concerning total yield is given in Table 3. Although total yields declined as the interval between pollination increased from 0 to 4 days, the decline was less for plants receiving added CO_2 (1.030 lb./plant) than those exposed to normal levels of CO_2 (1.633 lb./plant). Further, the percentage increase from added CO_2 increased as the pollination interval increased.

This supports previous studies[1/] showing that CO_2 enrichment improves fruit setting of the greenhouse tomato, especially during the spring crop when additions are made during early plant growth and blossom and fruit development.

Nevertheless, data obtained thus far from this study indicate that greenhouse tomatoes should be pollinated daily for maximum yields.

[1/] Kretchman, D. W. and F. S. Howlett. 1966. The relationship of day temperatures and CO_2 enrichment to fruit set and yield of greenhouse tomatoes. OARDC, Res. Summary 8, p. 5-9.

This page intentionally blank.

CHARACTERIZING TOMATO FRUIT GROWTH

Dale W. Kretchman
Department of Horticulture
Ohio Agricultural Research and Development Center

The growth of many fruits generally can be classified into two patterns: 1) rapid growth during the early stages after bloom with a gradual slowing of growth rate until fruit ripening; and 2) rapid early growth after bloom followed by a period of near cessation of growth and then a rapid increase in size as maturity and ripeness approach. In type 1, most of the growth has taken place before the fruit has reached physiological maturity, although some increase usually occurs until the fruit is eating ripe as long as it remains on the plant. In pattern 2, a very rapid flush of growth occurs near maturity and continues until the fruit is ripe. In this case, considerable yield increase can be obtained by permitting the fruit to remain on the plant until nearly ripe.

Because of the relation of total yield and fruit size to favorable economic returns of greenhouse tomatoes, and because most greenhouse tomatoes are harvested in the "early pink" stage, it is desirable to know the fruit growth pattern, especially during late maturation and ripening.

Information on fruit growth was obtained as an incidental part of the study on fruit cracking as it pertains to CO_2 enrichment. A linear displacement transducer, exciter-demodulator and strip-chart recorder was used to measure the growth rate of tomato fruit on the plant from the time the fruit was about 1/2 inch in diameter until complete ripeness.

The growth pattern obtained is illustrated in Figure 1. It is very similar to that described as type 1. Growth was quite rapid early in development, followed by a gradually decreasing rate until the appearance of the first sign of pink color on the blossom end of the fruit. After this, practically no increase in size occurred.

Although the general growth pattern appears to be a smooth, even type curve, it actually is not completely so. Figure 2 shows that fluctuations in growth occur as the fruits mature and ripen. In each of these cases, the first color developed between days 1 and 2. Note the relatively steep rate of size increase just prior to color break and the almost complete leveling off of growth afterwards.

These data clearly show that maximum fruit size was not obtained until the tomato fruits had reached and were slightly past the color break. After this stage of development had been reached, very little size increase occurred. It should be noted, however, that no data were obtained on fruit weight changes. It is entirely possible that weight could increase after color break due to an influx of water, even though fruit size remains relatively constant.

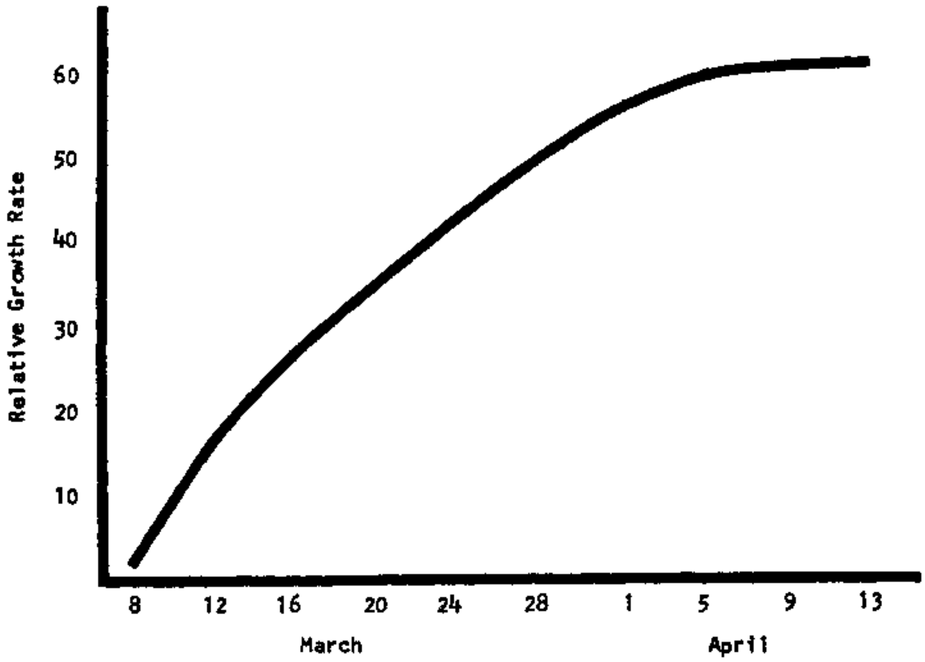


Fig. 1.--Seasonal growth pattern of the greenhouse tomato during the early spring crop. The fruit was about 1/2 inch in diameter on March 8 and was about 2-1/2 inches in diameter when ripe on April 13. Color break occurred April 5.

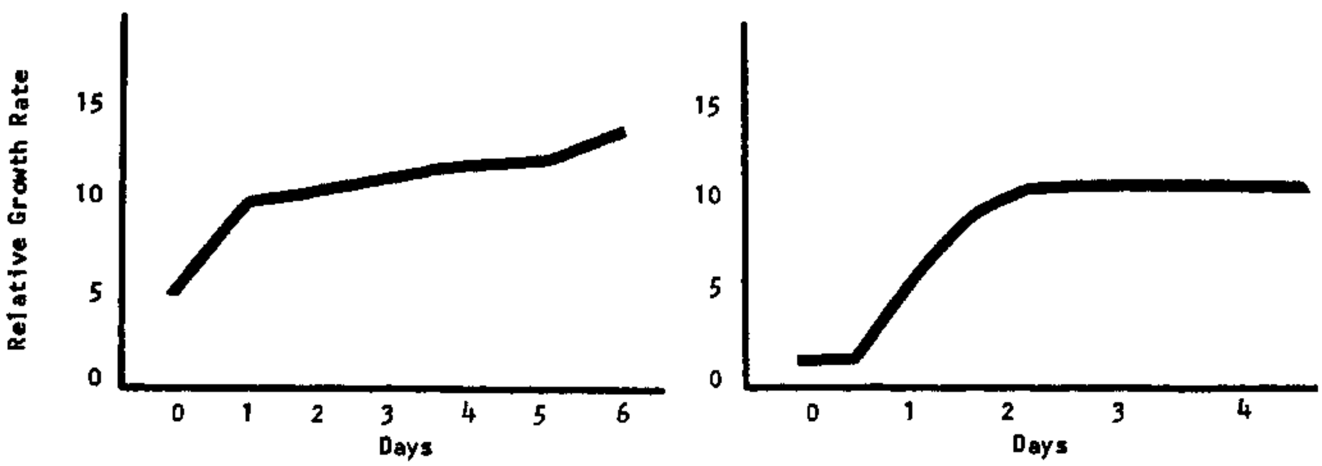


Fig. 2.--Fluctuations in fruit size of the greenhouse tomato during ripening. Color break occurred between days 1 and 2.

Greenhouse Vegetable Research--1969. Research Summary 24, Ohio Agricultural Research and Development Center, Wooster, Ohio. April 1969.

THE RELATIONSHIP OF INCIDENT LIGHT AND CO_2 ENRICHMENT TO YIELD OF SPRING CROP GREENHOUSE TOMATOES

Dale W. Kretchman and Freeman S. Howlett
Department of Horticulture
Ohio Agricultural Research and Development Center

Sufficient data have been gathered from CO_2 enrichment studies to re-examine the general physiological principle of light-CO_2 relationship as applied to spring crop greenhouse tomatoes. It is generally accepted that light intensity is the prime factor limiting plant growth during the winter months and that CO_2 at normal atmospheric levels (300 ppm.) is not limiting.

Ohio results present an interesting challenge to this concept (Table 1). CO_2 enrichment of three to five times the normal atmospheric concentration provided the greatest percent increase in total yield of fruit during the season, with the lowest accumulated light during the critical fruit setting months of January and February. Further, as the light intensity increased during this period, the response to CO_2 enrichment diminished.

It should be noted that the 1964 crop was a "short crop" due to later-than-normal planting and early plant removal. Nevertheless, the light-CO_2 response appears to hold true.

There is no doubt that types of plants vary in their light saturation level and certainly the greenhouse tomato has been selected to produce well under low light conditions. In addition, conditions for optimum plant growth may or may not be optimum for fruit setting and development on fruiting plants. Although these concepts may be only of academic interest, the results strikingly point out the importance of CO_2 enrichment for the greenhouse tomato, even during the dull days of winter under central Ohio conditions.

Table 1- The relation of CO_2 enrichment and light intensity to yield of spring crop greenhouse tomatoes.

Year	Total light accumulation during January and February (gm cal. /cm^2)	Total Yield * (lbs /plant) $-CO_2$	$+CO_2$	% Change due to $+CO_2$
1964	14,948	11.10	11.70	5.4
1965	12,518	13.80	16.36	18.6
1966	11,627	14.22	17.48	22.8
1967	10,525	13.96	17.36	24.3
1968	13,467	16.32	18.20	11.5

* - CO_2 refers to normal atmospheric levels of near 300 ppm.; $+CO_2$ is enriched 3 - 5 times the normal level.

RELATION BETWEEN SOIL TEST FOR PHOSPHORUS AND POTASSIUM AND LEAF COMPOSITION FOR THE SAME ELEMENTS IN THE GREENHOUSE TOMATO

Freeman S. Howlett and Dale W. Kretchman
Department of Horticulture
Ohio Agricultural Research and Development Center

The relation between soil test values and leaf composition has been of major interest to producers of horticultural crops since analysis of leaves became a major management tool. The research specialist is equally concerned with the relationship between the phosphorus and potassium found in the soil and the percentage of these elements in the leaves. Frequently the correlations between the results with several vegetable crops have not been satisfactory. Large amounts of phosphorus or potassium found in the soil have not always resulted in as large amounts in the leaves as expected and the reverse has equally been true.

Since initiation of the nitrogen-potassium nutritional study in greenhouse No. 1 at OARDC in 1964, phosphorus and potassium soil tests have been taken immediately before and after each fall and spring crop. These tests have been conducted in cooperation with the Soil Testing Laboratory of the Cooperative Extension Service at The Ohio State University, Columbus. The values have been obtained utilizing the same methods as used for grower samples. Averages of the soil tests at 6 and 12-inch depths are given in Table 1.

In examining correlations between leaf composition in percentage and soil test values (Tables 2 and 3), it must be kept in mind that the same potassium treatments have been applied to the same plots throughout the period from 1964 through 1968. Each plot contains 80 square feet. Eighteen plants have been utilized in each plot with the exception of the fall 1968 crop. Leaf samples have usually been taken every 3 weeks.

Table 1.-- Average Soil Phosphorus and Potassium Test Values. Greenhouse Tomato Spring Crop, 1968.

	Average Soil Test Values at Depth Indicated			
	Phosphorus		Potassium	
	6"	12"	6"	12"
Before Planting	361	346	371	246
After Planting	218	208	383	235

Tables 2 and 3 give the correlation coefficients between soil tests and leaf composition values for leaf phosphorus and potassium at each sampling date during the spring 1968 and fall 1968 crops.

Table 2 shows significant positive correlations between soil phosphorus and leaf phosphorus at certain sampling dates. There were positive correlations at the 12-inch level in only three instances. Furthermore, no particular difference occurred between the two cultivars.

Table 3 shows that the correlations between soil potassium and leaf potassium were significant at every sampling date at both soil levels. Furthermore, the values in certain instances were very high. No particular difference occurred between the two cultivars. The

Table 2.-- Correlation Between Soil Phosphorus and Leaf Phosphorus. Spring Crop, 1968. *

Date of Sampling and Cluster Order and Cluster No.	Correlation Coefficients at Soil Depths Indicated			
	Before Planting		After Planting	
	6"	12"	6"	12"
		Ohio WR 25		
Feb. 19 Cluster 1	.335		.379	
Feb. 28 Cluster 2				
Mar. 21 Cluster 3	.345			
April 10 Cluster 4	.352			
April 30 Cluster 5				
May 20 Cluster 6		.436		
June 10 Cluster 3				
June 10 Cluster 7				
		Ohio-Indiana Hybrid 0		
Feb. 19 Cluster 1			.348	
Feb. 28 Cluster 2				
Mar. 21 Cluster 3			.368	
April 10 Cluster 4				
April 30 Cluster 5				.382
May 20 Cluster 6				.397
June 10 Cluster 3	.366			
June 10 Cluster 7	.362			

*Correlation coefficients were entered only where they were statistically significant.

results clearly show fairly high positive correlations between potassium leaf composition and soil test values at all sampling dates between February 19 and June 10. Furthermore, there was little difference between the 6 and 12-inch depths, either before planting or after harvest.

The experiment does not involve the addition of increments of phosphorus, as is the case with potassium. Despite this fact, the leaf phosphorus of both the spring and fall crops ranged from low to high. It should be noted that the soil test values given for phosphorus in Table 1 were fairly high and were actually greater than those which might have been expected for potassium.

Table 3.-- Correlation Coefficients Between Soil Potassium and Leaf Potassium. Spring Crop, 1968.

Date of Leaf Sampling and Cluster Order		Correlation Coefficient at Soil Depths Indicated			
		Before Planting		After Planting	
		6"	12"	6"	12"
			Ohio WR 25		
Feb. 19	Cluster 1	.806	.779	.660	.656
Feb. 28	Cluster 2	.631	.515	.644	.568
Mar. 21	Cluster 3	.479	.442	.547	.531
April 10	Cluster 4	.800	.789	.679	.678
April 30	Cluster 5	.714	.657	.695	.675
May 20	Cluster 6	.653	.628	.750	.764
June 10	Cluster 3	.373	.387	.421	.416
June 10	Cluster 7	.634	.588	.686	.671
			Ohio-Indiana Hybrid 0		
Feb. 19	Cluster 1	.814	.812	.698	.743
Feb. 28	Cluster 2	.492	.493	.474	.456
Mar. 21	Cluster 3	.407	.406	.543	.537
April 10	Cluster 4	.415	.459	.443	.483
April 30	Cluster 5	.650	.647	.709	.727
May 20	Cluster 6	.659	.665	.784	.767
June 10	Cluster 3	.695	.665	.740	.715
June 10	Cluster 7	.602	.587	.709	.695

CONCLUSIONS

These results indicate that even with the roots confined to a rather small area, there were few correlations between soil phosphorus and leaf phosphorus. On the other hand, the comparable correlations with potassium were very satisfactory within the same small plots. These results indicate that the soil test values for potassium obtained in a greenhouse soil give a better indication of what can be expected in the leaves than is true for soil test values for phosphorus.

RELATION OF NITROGEN AND POTASSIUM APPLICATIONS AND LEAF COMPOSITION TO FRUIT CRACKING--SPRING 1968 GREENHOUSE TOMATO CROP

Freeman S. Howlett and Dale W. Kretchman
Department of Horticulture
Ohio Agricultural Research and Development Center

Fruit cracking has been the major fruit defect associated with the nitrogen fertilizer applications made during the nitrogen-potassium experiment at the Ohio Agricultural Research and Development Center. Almost invariably since the spring of 1964, cracking has shown an increase with added nitrogen. Furthermore, leaf nitrogen has been correlated positively with cracking. The higher the leaf nitrogen, the greater has been the quantity of fruits showing this disorder.

EFFECTS OF ADDED NITROGEN AND POTASSIUM

Both the nitrogen and potassium applications showed an increase in fruit cracking with Ohio W-R 25. Cracking was definitely higher at the two highest potassium applications with Ohio-Indiana Hybrid O. An interesting interaction occurred between nitrogen and potassium. At the lower potassium levels, cracking increased with added nitrogen and then decreased. At the higher potassium levels, cracking showed uniformly large amounts with added nitrogen.

RELATION TO LEAF COMPOSITION

With both cultivars at all sampling dates, the higher the leaf nitrogen, the greater the amount of cracked fruit. An interesting development was found between number of fruits per cluster and cracking. From cluster 6 and above in Ohio W-R 25, there was a positive correlation between number of fruits to a cluster and the amount of cracking. Practically the same relationship existed with Ohio-Indiana Hybrid O. In other words, cracking was definitely related to amount of fruits produced in these clusters.

SUMMARY

The data show definitely that both nitrogen and potassium applications affected the amount of fruit cracking. In addition to the increase due to nitrogen, excessive potassium application also increased fruit cracking. Potassium reached 8 to 9 percent in the leaves of both cultivars at the April 30 sampling date and 10 percent occurred in some samples. This quantity is considerably above the amount required and must be considered in the high to excessive categories.

Greenhouse Vegetable Research--1969. Research Summary 34, Ohio Agricultural Research and Development Center, Wooster, Ohio. April 1969.

RELATION OF ADDED NITROGEN AND POTASSIUM AND LEAF COMPOSITION TO PUFFINESS IN THE SPRING 1968 GREENHOUSE TOMATO CROP

Freeman S. Howlett and Dale W. Kretchman
Department of Horticulture
Ohio Agricultural Research and Development Center

During the spring and fall greenhouse tomato crops, nitrogen and potassium were applied in increasing increments. The plots were the same as those utilized previously for spring and fall crops beginning with the spring 1964 crop. The treatments were thus superimposed on the same plots during this period, although the amounts varied somewhat. The results of the 1967 treatments were presented in the 1967 Research Summary (No. 19, April 1967). This report presents the effects of the nitrogen and potassium soil applications during the spring crop of 1968. In addition, the relation of leaf elements to puffiness is considered.

Puffiness is a very intriguing disorder since it is known to be affected by several environmental factors and is also related to the effectiveness of pollination. Among the environmental influences are high day and low night air temperatures, excessive water applications, low light intensity, and excessive nitrogen. One of these factors may be largely responsible at one time, while under other circumstances another one may be operative.

RESULTS WITH PREVIOUS CROPS

In previous crops, the amount of puffiness has been affected by both added nitrogen and potassium. Generally it increased with added nitrogen. Some data have become available indicating that at times potassium had a marked effect on puffiness. This disorder was less at the higher levels of applied potassium.

RESULTS WITH SPRING CROP 1968

Two cultivars were utilized--Ohio-Indiana Hybrid O and Ohio W-R 25. Added nitrogen resulted in an increase in puffiness in both cultivars. There was no increase of puffiness with added nitrogen only at the median potassium level. Definite interrelationship existed between added nitrogen and potassium and puffiness in Ohio W-R 25 but not in Ohio-Indiana Hybrid O. Puffiness was lowest in the lowest (zero potassium) treatment in Ohio W-R 25.

CORRELATIONS WITH LEAF COMPOSITION

Puffiness was not significantly correlated with leaf nitrogen in either Ohio W-R 25 or Ohio-Indiana Hybrid O. Strangely enough, at practically all sampling dates leaf phosphorus was positively correlated significantly with puffiness. Phosphorus was rather high in all leaf samples taken during this period. The relation of this element to the incidence of puffiness is not explainable.

CONCLUSIONS

Added increments of nitrogen generally tended to be associated with increased puffiness. Since total number and weight of fruits per plant tended to increase at first with added nitrogen and then showed a significant decrease, the unfavorable effects of excessive nitrogen applications on yield were definitely indicated. Furthermore, both added potassium and leaf phosphorus were definitely related to puffiness. The positive correlation of leaf phosphorus with puffiness is unexplainable.

RELATION OF NITROGEN AND POTASSIUM APPLICATION AND LEAF COMPOSITION TO YIELD OF GREENHOUSE TOMATO IN SPRING AND FALL CROPS, 1968

Freeman S. Howlett and Dale W. Kretchman
Department of Horticulture
Ohio Agricultural Research and Development Center

The spring and fall 1968 tomato crops represent the sixth and seventh produced in the nitrogen-potassium experiment. The objectives have included determining the effects on fruit yields and quality of applying five increments of each element. As expected, the effect of a low supply of nitrogen has been very pronounced but the plants receiving no potassium have been indistinguishable from those receiving various amounts of potassium. On the other hand, the effect of high potassium has occasionally been pronounced, particularly with reference to certain defects.

This report presents the relationships of nitrogen and potassium applications to yield. The correlations of leaf nitrogen and potassium with yield are also indicated in those instances where they are statistically significant.

TIME AND AMOUNT OF APPLICATION

Spring Crop 1968: Nitrogen and potassium were applied on the following dates: February 2, February 29, March 22, April 11, May 1, and May 22. The total amounts of elemental nitrogen and potassium applied in pounds per acre were:

Nitrogen	Potassium
0	0
120	228
390	750
660	272
780	500

Leaves were sampled on February 19, February 28, March 21, April 10, April 30, May 20, and June 10. Both Ohio W-R 25 and Ohio-Indiana Hybrid O were utilized in this crop.

Fall Crop 1968: One fertilizer application was made on October 9, 1968. This consisted of the following amounts of elemental nitrogen and potassium in pounds per acre:

Nitrogen	Potassium
0	0
24	46
78	150
132	254
156	300

Leaves were sampled August 27, September 9, September 23, October 7, October 21, November 4, November 18, and December 2. Only Ohio-Indiana Hybrid 0 was utilized in this crop.

EFFECTS OF APPLICATIONS ON YIELD

SPRING 1968

Number of Fruits per Plant: In both Ohio W-R 25 and Ohio-Indiana Hybrid 0, there was a definite tendency for the number of fruits to increase at first and then decrease with added nitrogen. The overall effect was a decrease in number of fruits at the higher nitrogen applications.

Weight of Fruits per Plant: In both Ohio W-R 25 and Ohio-Indiana Hybrid 0, the weight of fruits increased with added nitrogen applications, followed by an outstanding decrease.

FALL CROP 1968

Both number and weight of fruits per plant showed a significant increase with added nitrogen, followed by a small but significant decrease.

CORRELATIONS OF LEAF CONTENT WITH YIELD

SPRING CROP 1968

Ohio W-R 25: Leaf nitrogen was positively correlated with yield at several sampling dates. This result does not negate the fact that increased increments of added nitrogen resulted in a decrease in number and weight of fruits per plant after a certain level of nitrogen had been attained. The minus nitrogen plants generally produced a lower yield than those receiving nitrogen applications.

Ohio-Indiana Hybrid 0: A similar result was obtained with this cultivar as with Ohio W-R 25.

FALL CROP 1968

The number and weight of fruits per plant were positively correlated with leaf nitrogen on the following sampling dates: September 27, October 7, and December 2. Leaf potassium was not correlated with yield at any time.

SUMMARY

The number and weight of fruits per plant showed a pronounced increase with added nitrogen, followed by a definite decrease. This latter result developed following application of nitrogen at the higher levels. Potassium applications had no effects on yield.

In view of the low nitrogen level in the minus nitrogen treatment, a significant positive correlation with leaf nitrogen and yield developed. The interactions between applied nitrogen and potassium upon yield were of minor consequence. The results presented in another report of this series indicated that such interactions were important when fruit quality defects were considered.

CORRELATIONS OF NUTRIENT ELEMENTS WITHIN LEAVES OF MAJOR SIGNIFICANCE IN GREENHOUSE TOMATO, SPRING AND FALL CROPS, 1968

Freeman S. Howlett and Dale W. Kretchman
Department of Horticulture
Ohio Agricultural Research and Development Center

Analysis of leaves at different sampling dates in both the spring and fall crops showed statistically significant correlations between various elements. Some of these relationships have been commonly observed in connection with other leaf analysis results and others have no ready explanation at present. For example, the effect of potassium and magnesium can be explained in view of the effect of soil potassium in reducing the rate of magnesium entering the plant. On the other hand, the positive correlation between phosphorus and boron found in every vegetable plant is unexplainable.

Certain combinations were identical in the leaves of both spring and fall 1968 crops and are presented in Table 1. It should be noted that this list includes some elements such as sodium, silicon, strontium, barium, and aluminum which are not essential for plant growth but which are commonly found in soils and plants.

These positive and negative relationships of one minor element (micronutrient) to another may not be found in all vegetable crops. However, the relationships between the major nutrients such as nitrogen, phosphorus, potassium, calcium, and magnesium are quite commonly observed and are of physiological significance in the greenhouse tomato.

Table 1.--Significant Positive and Negative Correlations Between Leaf Nutrients. Spring and Fall Crops, 1968.

Element	Element with which correlated: Positive	Negative
Nitrogen	sodium	
Phosphorus	boron molybdenum	potassium
Potassium		calcium magnesium sodium manganese boron molybdenum
Calcium	magnesium sodium silicon manganese iron boron aluminum barium molybdenum	
Magnesium	sodium silicon manganese iron boron molybdenum	
Sodium	manganese boron molybdenum	
Silicon	manganese iron aluminum	
Manganese	iron boron aluminum molybdenum	

Table 1.--(cont'd)

Element	Element with which correlated	
	Positive	Negative
Iron	boron copper zinc aluminum molybdenum	
Boron	copper molybdenum	
Copper	zinc aluminum molybdenum	
Zinc	aluminum	
Aluminum	silicon barium molybdenum	
Strontium	barium	
Barium	molybdenum	

This page intentionally blank.

DISEASE PROBLEMS OF OCCASIONAL IMPORTANCE IN GREENHOUSE TOMATOES

Robert E. Partyka
Extension Plant Pathologist
The Ohio State University

Greenhouse tomato growers are aware of the many diseases which may attack their crop at various times of the year. Some diseases are a continuous threat to the crop and control measures are generally employed during the cropping period. Growers can cope with such disease problems if they follow the necessary procedures.

Several diseases of greenhouse tomatoes are considered to be minor problems. However, when ideal conditions exist for one of these diseases to develop, a grower may suffer great losses in his crop.

Virus Streaks: Several diseases result in streaks in the tomato stem, leaf necrosis, and fruit distortion. These all appear to be associated with tobacco mosaic plus other viruses and cause various degrees of crop losses.

Glasshouse streak or single virus streak produces large, elongated lesions on the stem which vary from the short, narrow lesions found with the double virus streak. Small necrotic or dead spots may appear on certain leaves at certain levels on the plant. Stems showing severe streaking often show internal browning in the pith. Only a small number of plants are affected in the greenhouse and spread is little to none. Affected fruits have dark lesions and tend to be rough and mis-shaped.

The exact cause of glasshouse streak is unknown. There is some indication that tobacco mosaic virus is involved. Potash deficiency has been mentioned as a contributing factor but this is difficult to say with the high potash levels found in most Ohio greenhouse soils. Sunlight and temperature have been mentioned as having an effect on plant symptoms. The severity of tobacco mosaic virus, plant vigor, growing conditions, and rapid temperature changes during ventilation may be involved with this disease.

There are no control measures. Since this disease is difficult to distinguish from some of the other virus diseases in the greenhouse, it is recommended that infected plants be destroyed and that sanitary measures for virus disease control be employed.

Double virus streak (tobacco mosaic virus and potato virus X combination)is by far the most serious of the virus streaks. Depending on the strain of potato virus X, losses may run as high as 50 percent. The severity of the disease and its effects on crop yield vary, depending on the age of the plant, time of year, amount of sunlight, and the form of the virus present.

The symptoms of this disease appear on the fruit, leaves, and stems. Stems show necrotic spots which vary from 1/8 to 1/4-inch in width and up to 1 inch or more in length. The spots may run together and form large necrotic lesions on the stem. Individual lesions which are separate and distinct are often referred to as pencil lines. There is no discoloration of the pith area with this disease.

Fruit lesions are small, approximately 1/4-inch in diameter, but may run together to form larger areas. They are dark brown and glassy looking and may occur any place on the fruit. The lesion is superficial, discoloring a shallow layer of tissue, but is enough to make the fruit unmarketable. Rapidly growing fruits are most susceptible to the fruit spotting symptoms.

Affected young leaves often curl downward, resulting in a spiraling of the leaf. Small, brown necrotic spots may appear on the leaves almost overnight. These may combine and form rather large lesions. Only the young leaves of the plant are affected. Mature leaves appear to be resistant when infection takes place.

If infection occurs when plants are large and sunlight conditions are good, fruit spotting is at a minimum and the loss is small. However, with young plants and low light intensity, fruit spotting is more severe and losses may be large. When plants are first infected with the combination of these two viruses, growing fruit becomes spotted and unmarketable. After the plants have been affected for a period of time, they tend to recover and later maturing fruits are often marketable.

This disease is highly infectious. A worker handling one infected plant may spread the disease to many other plants as he prunes or pollinates. Thus, the control of the disease is based on early recognition, removal of the infected plants, isolation, and sanitation.

Growers should grow plants free of tobacco mosaic virus but this has been almost impossible in most cases. Plants free of TMV would not be affected by the introduction of potato virus X. But since TMV is so prevalent, the best procedure at present is to keep potatoes away from the tomato plants. No potatoes should be grown near a tomato greenhouse. Workers should not handle potatoes before working with tomato plants. Clean coveralls should be worn in the greenhouse and hands should be washed with warm soapy water. Insects and small animals may be carriers in some cases.

When infected plants are found in the greenhouse, the area should be isolated immediately. The plants should not be worked in any manner and not even pollinated. Remove the diseased plants in a manner so they do not infect other plants. Place them in a container of some type and close the lid. A waiting period of 2 weeks is necessary to insure that all recently exposed plants have time to show symptoms of infection before any further work is done in that area.

Isolating the plants and waiting for the disease to develop in infected plants is necessary to insure complete freedom from this disease. Otherwise, it will crop up again and move through the rest of the planting.

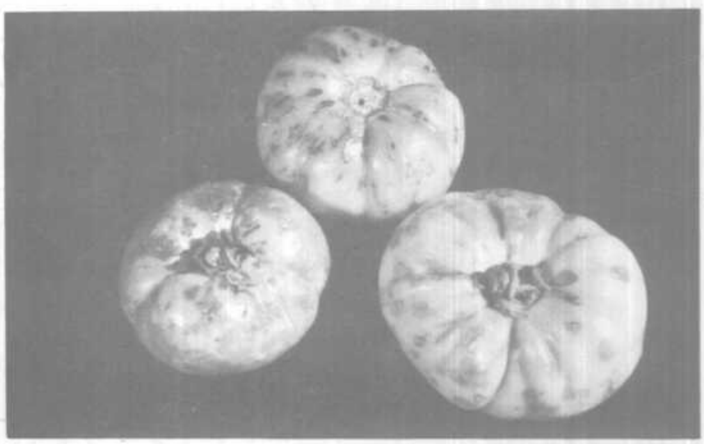
<u>The tobacco and cucumber mosaic combination</u> appears occasionally in greenhouse tomatoes. Symptoms of this disease are marked stunting

Single virus streak--internal discoloration of pith area plus brown lesions on the stem.

Double virus streak--overall greenhouse symptoms. Note leaf curling.

Double virus streak--shallow brown to black lesions on the stem.

Double virus streak--fruit lesions--shallow brown areas.



of the plant, with a tendency for a rosette to form at the growing point, and a general yellowing of the top portion of the plant. In a few cases, necrotic spots develop on the leaves. Fruit set stops and young fruits on the plant become gnarled, mis-shapen, and are worthless.

This disease is not as severe in greenhouses because it does not spread as rapidly as the tobacco and potato virus combination. Control is dependent on elimination of the cucumber aphid and roguing out the infected plants. Since the disease does not spread rapidly, removal of infected plants usually is sufficient to keep it in check.

Bacterial canker has occurred in a few greenhouses. At one time this disease was a severe problem in Ohio greenhouses. The main symptoms are stunting and wilting of the plants. An important diagnostic symptom of the disease is a granular disintegration of the tissue just below the epidermis. Thus, the outer portions of the tissue may be separated easily from the inner portion of the stem tissues. As the disease continues, the pith turns yellow and mealy in appearance, cavities form, and later an open canker develops.

This disease can spread rapidly during the pruning and suckering procedures in the greenhouse. By the time it is detected, many plants can be infected. Infected plants must be isolated and the area worked separately. All equipment should be kept in the infected plant area. Use seed which has been treated by acid extraction. However, if the bacteria are within the seed, acid extraction will not destroy them. Seed should come from plots where inspection and roguing are standard procedures.

Sterilizing the soil in the greenhouse between crops will kill the bacteria. However, some bacteria can live over on the equipment used in the greenhouse. So it is necessary to disinfect all equipment as well as to steam the soil if this disease appears.

Bacterial soft rot appears as an elongated light brown lesion on the stem. Often when it is found the stem is completely broken down and the plant is wilting. The problem is found under gutters and moist places and is most common during the fall months. The bacteria are found in most soils and gain entrance to the main stem from injured leaf petioles. If the stem is cut lengthwise, it is found that the pith has disintegrated for a considerable distance both above and below the point where the lesion is visible on the outside of the stem.

There is no definite control program for this disease. However, infected plants should be removed and the humidity should be lowered. Careful watering will help with disease control by reducing splashing of soil onto the plants. Leaking gutters and other leaks in the greenhouse should be fixed. Spraying the lower portion of the plants with fixed copper at 4 lb. per 100 gallons will help to reduce spread of the bacteria on healthy plants.

Timber rot or Sclerotinia stem rot shows up occasionally on tomato plants. When this disease is noticed, the plant is wilting and a large lesion can be found at the base of the plant. A tan or brown scar may be found on the stem. Upon splitting this open, masses of white mold

Bacterial canker--wilted leaves on plant.

Bacterial canker--stem lesion in advanced stage of the disease.

Bacterial soft rot--soft mushy pith area and hollow stem when disease is advanced.

Timber rot--stem lesion and external sclerotium.

Timber rot--external fungus growth and black sclerotia.

and black sclerotia may be found in the stem. The black sclerotia are the resistant structures which carry the fungus over from one crop to another.

In some cases, this disease may be introduced into the greenhouse on soybean, alfalfa, or clover hay used as a mulch. In other cases, the sclerotia can survive from one crop to another if a poor job of disinfestation has been carried out.

Steam sterilization of the soil is the best control for this disease. However, if the fungus was introduced on a mulch and the problem develops later in the growing season, it may be possible to obtain a degree of control by spraying the mulch and the lower portion of the plant with Botran. This material can be used for Botrytis control. Research indicates that the Sclerotinia fungus which attacks a number of other crops has been controlled by Botran. Botran should be applied to the lower stem at the rate of 1 lb. of the 75 percent wettable powder per 100 gallons. Several applications will be necessary. Infected plants should be removed and destroyed to eliminate the sclerotia which may be carried over to the next crop.

The State Is the Campus for Agricultural Research and Development

Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations. Thus, Center scientists can make field tests under conditions similar to those encountered by Ohio farmers.

Research is conducted by 13 departments on more than 6200 acres at Center headquarters in Wooster, ten branches, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Jackson Branch, Jackson, Jackson County: 344 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Marietta, Washington County: 20 acres

Western Branch, South Charleston, Clark County: 428 acres