INFLUENCES OF CERTAIN TRANSPLANT AND FIELD TREATMENTS ON EARLY YIELD OF TOMATOES

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INFLUENCES OF CERTAIN TRANSPLANT AND FIELD TREATMENTS ON EARLY YIELD OF TOMATOES

INTRODUCTION

The production of field grown tomatoes for processing and fresh market in the Willamette Valley is limited by the low yield obtained before early fall rains begin. These continued rains cause heavy losses of mature green and ripe fruits, largely as a result of cracking and rotting. It is especially important, therefore, to determine the effectiveness of various cultural treatments in influencing earliness of maturity and yields.

The experiments reported here were undertaken to study the influences of several transplant and field treatments on early yield of tomatoes. An attempt was made (1) to shorten the time from field transplanting to first harvest, (2) to increase the yield of tomatoes harvested early in the ripening period, and (3) to secure preliminary information on quality of processed tomatoes from certain of the treatments.

REVIEW OF LITERATURE

Earliness of tomatoes has been shown by Went (21, p.490) to be governed primarily by the time required to produce the first flower clusters and fruit. Time required to ripen the fruit after it has once set is less important. Casseres (3, p.287) stated that the first fruits to ripen on normal tomato plants were those borne on the first and second clusters. The number that ripened influenced the size of the early yield.

Factors which control time to first flower cluster may be genetic, climatic, or cultural, and it is the latter which may be altered to cause earlier formation of the first flower cluster.

Date of Seeding.

The date of seeding tomatoes to produce plants for transplanting, with respect to time of setting in the field, apparently has a direct effect on earliness. Casseres (3, pp.286-287) working with the Earliana variety in New York, in comparing plants 7, 11, and 15 weeks old, found a notable superiority in early yields from the 7-weeks-old plants. He further stated that plants which were 7 weeks old at transplanting produced a great many more fruit on the first two clusters than plants from earlier planting dates.

Sayre (18, p.369), using the variety John Baer at Geneva, New York, compared three dates of sowing the seed and found that where the plants are to be transplanted to the field about May 25 or later, there was no increase in early or total yield of tomatoes from sowing seed earlier than March 25, and that seed sown as late as April 8 may give as large or larger yields than earlier seeding.

It is the opinion of many workers that the young plants produce earlier maturing tomatoes because of the quicker recovery from transplanting and their ability to produce new growth. Casseres (3, p.287) stated that young and tender plants which were capable of quick growth resumption after field setting were factors associated with larger early yields.

Plants which were more than 8 weeks old, if grown under proper conditions, might become too large for handling and, to prevent this, they can be hardened to some extent to delay their growth. Comparing the effect of hardening on earliness of several early, medium, and late commercial tomato varieties, Porter (12, p.544) states that hardening tomato plants reduces the early yield of marketable fruits. The reduction was found to hold true regardless of variety used or time at which plants were set in the field.

From the results reported in the literature by most research workers, it is apparent that young, 7 to 8 weeks old, vigorously growing tomato plants are preferred for field planting to obtain early production.

Topping.

Topping of tomato plants (removal of the apical growing point) has been used in some areas in attempting to secure heavier early yields. Sayre (18, p.368), using the John Baer variety, compared topped (at a height of 8 to 9 inches) and untopped plants when they were transplanted at the normal time. In one area he found no significant differences in yields of either early or late fruit, while at another location he found that topped plants produced a significantly lower early yield than the untopped ones.

Westover (23, p.288), using Early Baltimore and Marvelous varieties at the West Virginia station, compared topped and untopped plants when the topping was done just above the second leaf and found that the topping treatment reduced the early yields of both varieties. However, as the season advanced, the yield difference decreased and lacked statistical significance.

In an earlier paper, Westover (22, p.521) using the same varieties but topping the plants when they were larger, (9 to 10 inches) found that the topped plants of the two varieties tended to yield a greater weight of early marketable fruits. These fruits were observed to be larger than those from the check plants. In each instance the topped treatment reduced the yields and the total fruit set for the entire season.

There is general agreement that topping of most tomato varieties, when set in the field at a "normal" date, has a detrimental effect on early production. If the plants must be held longer than normal, as Sayre (18, p.368) reported, topped plants might produce significantly heavier early yields than untopped plants.

Starter Solutions.

Brasher (1, p.13), working with the Rutgers tomato variety found that transplanting was a severe shock to the plant and checked growth for a period of time, depending upon environmental conditions. He believed that checking of plant growth was more serious than is generally believed. In addition to delaying maturity, it resulted in a hardening process which reduced yield in proportion to the severity of the hardening treatment. Starter solutions, made of a complete fertilizer high in phosphates, were used to lessen the effect of the shock of transplanting and to accelerate early plant growth. This resulted in increased early and total yields.

Sayre (16, p.909) further stated that the principal effect of a starter solution used in transplanting tomatoes is in enabling the plant to become established quickly. This results in a marked gain in early maturity. It may be particularly effective on plants which are low in minerals at time of transplanting.

Carrier and Snyder (2, pp.514-515), working with delphinium and snapdragon, found a significant increase in earlier flowering by treating these plants 5 to 10 days before transplanting with 25 cc per plant of a starter solution made of 2 parts by weight of mono ammonium phosphate to 1 part of potassium nitrate. They used 8 pounds of the mixture to 50 gallons of water. They also found that the time at which a starter solution should be applied to a plant in order to secure a maximum response varies with the particular plant. It was observed that length of time from treatment until plants became dark green was very closely associated with the earliness of flowering.

Mighton and Osborn (10, p.7), Rahn (13, p.309), and Sayre (16, p.905; 17, pp.490-492; 14, p.733 and 15, p.8) found that nitrogen and phosphorus were particularly important ingredients of a starter solution for stimulating earliness of tomatoes, with large amounts of available phosphoric acid being especially important.

Sayre (14, p.735) stated that sulphate of ammonia in the transplanting water had little effect on the early growth or early yields of the plants. A greater total yield was obtained from this treatment than with either a water of complete starter solution.

Hester (6, p.11), Sayre (17, p.493) and others found that soil fertility, and type and amount of commercial fertilizer used governs the results obtained with starter solutions.

Fertilizers.

It is a well-known fact that to produce a large vigorous plant, it must have a well-balanced nutrient supply. This concept of balance was well stated by Shear (19, pp.240-244) when he said that "all other factors being constant, plant growth is a function of the two variables of nutrition intensity and balance. As any element varies from its concentration at optimum intensity, the maximum growth possible within the new limits of supply of that element can result only when the concentration of all the elements have been brought into balance at the new level of intensity as determined by that element." These optima might come from the soil or be supplied by the addition of commercial fertilizers - either complete, or materials supplying the required amount of a given element.

Moore and Campbell (11, pp.19-20) working with tomatoes in the production areas of Mississippi, found that to realize maximum production and profit, a complete fertilizer containing 92 pounds N, 120 pounds available P_2O_5 and 70 pounds K_2O should be applied per acre.

Mighton and Osborn (10, p.7) working with commercial tomato varieties at Ontario, Canada stated that low temperatures early in the growing season will not allow rapid release of phosphorus from the soil. This is extremely important because of the prominent role phosphorus plays in early root growth and development. They further state that high analysis phosphoric fertilizer must be added to overcome this lack of availability.

A good explanation of the effect of phosphorus on earliness was given by Hepler and Kraybill (5, p.41) who stated that the effect of acid phosphate in hastening maturity of the tomato crop was due to a more rapid growth of the plants early in the season, as a result of which more blossom clusters, more blossoms, and more fruit were produced. They further stated (5, pp.28-33) that blossom clusters developed on growth that was from a week to two weeks old. Fruits ripened in 6 to 8 weeks after blossoming. Acid phosphate treatments resulted in larger sized plants early in the season. This in turn resulted in larger numbers of flower clusters available to set fruit and consequently a heavier early yield.

It is thus the opinion of most workers that a complete fertilizer containing a relatively high percentage of phosphorus is required to obtain maximum early production of tomatoes.

Paper Mulches.

It has been known for several years that black mulch paper has an effect on earliness of tomatoes. Comparing commercial varieties of tomatoes grown in mulch-paper and clean-cultivated plots, Thompson and Platenius (20, p.306) found that the mulch paper markedly increased early yield of tomatoes.

Hutchins (8, p.11) and Magruder (9, p.42) also found that black mulch paper had some beneficial effects on earliness of tomatoes; yet in some instances the increases were so small that they were not significant.

Hotcaps.

The use of hotcaps to secure earlier tomato production has been a debatable subject for some time. Hibbard (7, p.35) working with the commercial plant protector "Hotkap", states that the effect of protectors on early yields depended on all of the environmental factors involved. Working at Michigan State College for a period of six years, he found that protectors were of undoubted value one year, of doubtful value in two, and of no value in three years.

Comparing protected and unprotected plants, Hibbard (7, p.26) found that when plants which were unprotected were not frozen, their growth was slow for some time, and at the time of removal of protectors, the unprotected plants were generally inferior to protected ones. Two or three weeks later, however, it was difficult to detect any difference between them. Similarly, protected plants which had been partly etiolated appeared, within two or three weeks after removal of the protectors, to be similar to the other plants.

The major benefits of the protecters comes, as stated by Hibbard, (7, p.18), from accumulation of heat by hotcaps and this was more important, apparently, than the effect in checking radiations.

It is the opinion of most workers that hotcaps are of little value in increasing earliness of tomatoes except in years when late frosts kill unprotected plantings. The use of hotcaps depends on climate and it is obviously not possible to predict, from year to year, the last frost-free date. Hazards in some areas are, of course, greater than in others.

Irrigation.

Cordner (4, p.481), working in Oklahoma with commercial tomatoes, stated that tomato plants appeared to be rather sensitive to variations in soil moisture, and fruit set might be adversely affected by irrigation treatments that were highly favorable to growth of certain other vegetable crops. Light irrigations which undoubtedly caused marked variations in the surface soil moisture were especially detrimental to fruit set. In most instances increased yields induced by irrigating tomatoes were the result of increased plant size and were not due to improvement in fruit set. Water applied before harvesting began, appeared to be most beneficial to fruit production.

Irrigation may thus play an indirect but important role in earliness of tomatoes. Optimum water relations result in the early development of a large plant which is capable of supporting several flower clusters and this in turn results in heavier early yields.

MATERIALS AND METHODS

These studies were made during the growing season of 1951. Tomato seeds were germinated in sterilized soil and pricked out when about 2 inches high into 3x3 veneer plant bands. Plants were grown in the greenhouse until time for field transplanting. Night and day temperatures in the greenhouse were approximately 55° F. and 80° F. respectively.

Plants were vigorous and free of disease when set in the field. Plants were set 3 feet apart in the row and 6 feet between the rows. Each plot consisted of 3 plants and all treatments were replicated. Plantings were made on May 18 and 19 at the College Vegetable Farm to form 4 separate experiments.

Records were taken on early marketable, total marketable and total yields. Fruits harvested prior to September 10 constituted the early yield and fruit harvested between first picking and frost constituted the total yield. Pickings were made when sufficient red-ripe fruits were available to make a commercial picking practical. All fruit from the pink to red-ripe stages were harvested at each picking.

The tomatoes were counted, weighed and graded into marketable fruits and culls. Those which were greater than 2 inches in diameter, and free of blemishes, serious cracks and diseases were considered marketable.

Where fertilizer was applied either as a treatment or general application, it was placed by hand in a ring 3 inches from the plant and 3 inches deep at the time of field transplanting.

Experiment 1.

The variety Puck, an early, small-fruited determinate type of tomato, was arranged into 18 treatments and replicated 5 times in randomized blocks for this experiment. Treatments involved were as follows:

A. Dates of seeding.

1. March 17.
2. March 28.
3. April 7.

B. Starter solution rate - 1 pint per plant applied at time of field transplanting.

1. Water as a control.
2. Solution A - 2½ pounds ammonium sulfate plus 2½ pounds treble superphosphate dissolved in 50 gallons of water.
3. Solution B - 2½ pounds ammonium sulfate dissolved in 50 gallons of water.

C. Commercial fertilizer of 10-16-8 analysis placed in a band, as previously indicated, at the following rates:

1. 400 pounds per acre.

2. 1200 pounds per acre.

These treatments were completely randomized within each replication.

All treatments received uniform irrigations every 10 to 14 days during the growing period.

Experiment 2.

The variety Stokesdale, a standard commercial indeterminate-type tomato, was used for this experiment which consisted of 18 treatments replicated 5 times in randomized blocks. Treatments involved were as follows:

D. Dates of seeding.

1. March 17.
2. March 28.
3. April 7.

E. Starter solution.

1. 1 pint of water per plant at time of field transplanting as a control.
2. 1 pint of solution C per plant at time of transplanting made of 2 parts by weight of diammonium phosphate and 1 part potassium nitrate dissolved in water at the rate of 8 pounds of the mixture in 50 gallons water.

3. Solution C as above but applied at the rate of 25 cc per plant 7 days before field transplanting.

F. Topping.

1. Untopped plants as a control.

2. Topped plants (removal of tops above the 4th leaf except with the youngest plants which were topped above the 3rd leaf 1 week before field set).

All treatments were completely randomized within each replication.

All plants in this experiment received a uniform application of 400 pounds per acre of 10-16-8 commercial fertilizer placed in bands as previously indicated and received uniform irrigations every 10 to 14 days during the growing period.

Experiment 3.

The variety Stokesdale was used for this experiment which consisted of 12 treatments replicated 5 times in randomized blocks. Treatments were as follows:

G. Unperforated 36-inch black mulch paper.

1. Clean cultivated control.

2. Mulch paper.

H. Commercial frost protectors "Hotkaps".

1. Control.

2. "Hotkaps" for a period of 2 weeks.

I. 2,3,5-Trichlorophenoxyacetic acid with DuPont spreader sticker as entire plant spray.

1. Nothing.
2. 25 ppm sprayed on in 2 applications on August 1 and August 15.
3. 50 ppm handled as in the above treatment.

These treatments were completely randomized within each replication.

Plants were 9 weeks old and received a uniform application of 400 pounds per acre of 10-16-8 commercial fertilizer applied as previously indicated when field transplanted. All treatments received uniform irrigations at 10 to 14 day intervals during the growing season.

Experiment 4.

This experiment, using the Stokesdale variety, consisted of 2 major treatments and 3 minor treatments with 4 replications as follows:

A. Major treatments.

1. Control - no supplemental irrigation.
2. Supplemental irrigations supplied in furrows every 7 days.

B. Minor treatments - commercial fertilizer of 10-16-8 analysis banded as previously indicated.

1. Control - no fertilizer.

2. 400 pounds per acre.

3. 1200 pounds per acre.

These treatments were arranged in a split plot arrangement and were completely randomized.

Plants were 10 weeks old at time of transplanting to the field. Border row plants were set between each of the major treatments and border plants between each of the minor treatments. All plants received 2 pints starter solution (5 pounds 11-48-0 fertilizer in 50 gallons water) at time of field transplanting.

The effects of irrigation and fertilizers on color, flavor, and soluble solids of processed tomato juice was also determined. A sample of 40 uniform, mature red-ripe tomatoes was taken from 4 different treatments during the third picking. The following treatments were sampled:

1. Supplemental irrigations.
   a. Control - no fertilizer.
   b. 1200 pounds per acre of a 10-16-8 analysis commercial fertilizer.
2. Control - no supplemental irrigation.
   a. Control - no fertilizer.
   b. 1200 pounds per acre of 10-16-8 analysis commercial fertilizer.

With the cooperation of the Food Technology Department, the tomato samples were processed by commercial procedure. After a period of 7 months, 2-can samples from each treatment were opened and graded by a Production and Marketing Administration grader into their proper grades. At the same time, data were taken on color, flavor, pH and soluble solids. Color and flavor determination were made by comparison with a commercial standard. The pH was determined with a glass electrode pH meter and soluble solids readings were obtained with a hand refractometer.

Method of analysis.

All data obtained in the 4 experiments for early marketable yields of tomatoes were statistically analyzed for F values at .05 per cent level. Where a significant F value was obtained, the least significant difference was calculated at the 5 per cent level for each treatment.

EXPERIMENTAL RESULTS

Date of seeding effects on early yield of tomatoes.

The variety Puck, an early, small-fruited determinate type of tomato, showed a significant difference in mean yields between plants of different ages which were transplanted into the field at the same time. The results are shown in Table 1. The youngest plants grown from seeds planted on April 8 yielded 7.81 tons per acre while those seeded on March 17 and 28 yielded 5.57 and 5.42 tons per acre respectively. Yields of the youngest plants were thus significantly larger than those of the older plants.

The Puck variety, because of its varietal characteristics of early maturity, ripened all of its fruits before September 10, which was the date set for "early" versus "late" yields. The first harvest for this variety was July 21 and the final harvest was made on September 5. Because of this factor the total yields from Puck will be considered early yields.

The variety Stokesdale, an indeterminate medium-maturing type tomato, showed no significant increase in early yields between plants of different ages when transplanted on the same day as shown in Table 2.

The mean yield from plants grown from seed planted on March 17 was 9.27 tons per acre of early marketable fruit while the youngest plants, seeded April 7, yielded 8.84 tons, a difference of 0.43 tons

Table 1. Effect of date of seeding and starter solution on yield of Puck tomatoes. (Exp. 1)

Date of seeding	Yield* of tomatoes in tons per acre			
	Control 1 pt. water/ plant at set	Starter solution A** 1 pt./plant	Starter solution B*** 1 pt./plant	Means
March 17	5.48	5.25	5.99	5.57
March 28	5.17	5.39	5.72	5.42
April 7	7.83	7.82	7.81	7.81
Means	6.16	6.15	6.50	
Least significant difference at odds of 19:1				0.58[1]

* Average of 5 replications.

**A 2½ pounds ammonium sulfate plus 2½ pounds treble superphosphate dissolved in 50 gallons of water.

***B 2½ pounds ammonium sulfate in 50 gallons of water.

1 Analysis of variance shown in Appendix E.

Table 2. Effect of date of seeding and topping on early yield of Stokesdale tomatoes. (Exp. 2)

Date of seeding	Yield* of tomatoes in tons per acre.		
	Topped	Untopped control	Means
March 17	8.91	9.62	9.27
March 28	7.58	10.87	9.23
April 7	6.80	10.89	8.84
Means	7.76	10.46	
Least significant difference at odds of 19:1			NS[1]

* Average of 5 replications.

[1] Analysis of variance shown in Appendix F.

which is not significantly different.

The early yields of the Stokesdale variety consisted of two harvests, the first being on August 17 and the second harvest was made on September 3. A third harvest was made on September 15 which was included in the total yield. Before another harvest could be made the fruits were destroyed by rain.

Effect of topping on early yields of Stokesdale tomatoes.

The mean yields in tons per acre of early marketable fruits resulting from the topped and untopped treatments are presented in Table 3. The topped plants yielded 7.76 tons and the untopped controls resulted in a higher yield of 10.46 tons. From the analysis of variance (Table 3) it is seen that the topping treatment resulted in a significantly lower yield than the untopped control.

It can be seen from Table 2 that the topping of the youngest plants, grown from seed planted April 7, resulted in the greatest depression of early marketable yields. The mean yield for the topped plants, grown from seed planted April 7, was 6.80 tons as compared to 10.46 tons for the untopped plants of the same age. Although the differences appear quite large, they were not significantly different.

Table 3. Effect of topping and starter solution on early yield of Stokesdale tomatoes. (Exp. 2)

Topping	Yield* of tomatoes in tons per acre Control 1 pt. water at set	Solution G** 1 pint at set	Solution G 25 cc 7 days before set	Means
Topped	7.13	7.18	8.98	7.76
Untopped control	9.37	10.29	11.72	10.46
Means	8.25	8.73	10.35	
Least significant difference at odds of 19:1				0.82[1]

* Average of 5 replications.

** Solution G - 2 parts by weight of diammonium phosphate and 1 part potassium nitrate dissolved in water at the rate of 8 pounds of the mixture in 50 gallons of water.

1 Analysis of variance shown in Appendix F.

Starter solutions effect on early yield of tomatoes.

The Stokesdale variety showed significant responses in early market yield to starter solutions as shown in Table 4. Irregardless of other treatments, the control treatment of 1 pint of water at transplanting resulted in the lowest yield, 8.25 tons per acre. When 1 pint of starter solution "C" was applied at time of field setting, the mean yield was 8.73 tons per acre. The highest early yield, 10.35 tons per acre, was obtained from 25 cc of starter solution "C" applied 7 days before field transplanting. This treatment resulted in a significantly heavier early yield than the other treatments. Differences between the other two treatments were not significant.

It can be seen in Table 5 that on Puck tomatoes, starter solutions, at the rate of 1 pint per plant at time of field transplanting did not result in any significant increases in the yield of marketable tomatoes. The water control treatment yield was 6.16 tons per acre. Starter solution "A" yield was 6.15 tons per acre; the largest yield, 6.50 tons per acre, resulted from starter solution "B".

Effect of commercial fertilizer, 10-16-8 analysis, at two rates of application on early marketable yields of tomatoes.

The results of fertilizer treatments on the early marketable yields are presented in Table 6. With the variety Stokesdale the control treatment resulted in the lowest mean yield, 9.11 tons per acre; the 1200 pound commercial fertilizer treatment yielded 10.08 tons per acre and the heaviest mean yield, 10.31 tons per acre, was secured from the 400 pound commercial fertilizer treatment. Using analysis of variance, no significant differences were obtained.

It can be seen from Table 7 that fertilizer treatments did not show any significant increase in mean yield of marketable Puck tomatoes. The 400-pound fertilizer treatment yield was 6.46 tons per acre, while the 1200 pound fertilizer treatment yield was 6.06 tons per acre.

Although there was no significant difference between dates of seeding and rates of commercial fertilizer with the Puck variety, there was a significant difference on the interaction of dates of seeding and rate of commercial fertilizer as shown in Table 7. The oldest plants grown from seed planted on March 17 and treated with 400 pounds of commercial fertilizer gave a significantly larger mean yield, 6.16 tons per acre, than those treated with 1200 pounds fertilizer which yielded 4.97 tons per acre. At all other dates of seeding this interaction did not hold.

Table 4. Effect of starter solution and date of seeding on early yield of Stokesdale tomatoes. (Exp. 2)

Starter Solution Rates/plant	Yield* of tomatoes in tons per acre			
	March 17	March 28	April 7	Means
Control-1 pt. water at set	8.26	8.05	8.44	8.25
Solution C** 1 pt. at set	9.47	8.46	8.28	8.73
Solution C 25 cc 7 days before set	10.06	11.17	9.81	10.35
Means	9.27	9.23	8.84	
Least significant difference at odds of 19:1				1.01[1]

* Average of 5 replications.

** Solution C - 2 parts by weight of diammonium phosphate and 1 part potassium nitrate dissolved in water at the rate of 8 pounds of the mixture in 50 gallons water.

1 Analysis of variance shown in Appendix F.

Table 5. Effect of starter solutions and rate of commercial fertilizer applied on yield of Puck tomatoes. (Exp. 1)

Pounds of 10-16-8 fertilizer per acre	Yield* of tomatoes in tons per acre			
	Control 1 pt. water at set	Solution A** 1 pt./plant at set	Solution B*** 1 pt./plant at set	Means
400	6.35	6.50	6.60	6.48
1200	5.97	5.80	6.41	6.06
Means****	6.16	6.15	6.50	
Least significant difference at odds of 19:1				NS[1]

* Average of 5 replications.

** Starter solution A - 2½ pounds ammonium sulfate plus 2½ pounds treble superphosphate dissolved in 50 gallons of water.

*** Starter solution B - 2½ pounds ammonium sulfate in 50 gallons of water.

**** No significant difference.

1 Analysis of variance shown in Appendix E.

Table 6. Effect of irrigation and rate of commercial fertilizer on early yield of Stokesdale tomatoes. (Exp. 4)

Irrigation treatments	Yield* of tomatoes in tons per acre			
	Control	400 lbs. per acre 10-16-8 fertilizer	100 lbs. per acre 10-16-8 fertilizer	Means
Irrigated	14.25	17.44	16.88	16.19
Non-irrigated	3.97	3.18	3.38	3.47
Means	9.11	10.31	10.08	
Least significant difference at odds of 19:1				4.45[1]

* Average of 4 replications.

[1] Analysis of variance shown in Appendix H.

Table 7. Effect of date of seeding and rate of commercial fertilizer application in the field on yield of Puck tomatoes. (Exp. 1)

Date of Seeding	Yield* of tomatoes in tons per acre		
	400 lbs per acre 10-16-8	1200 lbs. per acre 10-16-8	Means
March 17***	6.16	4.97	5.57
March 28	5.20	5.65	5.42
April 7	8.08	7.55	7.81
Means**	6.46	6.06	

Least significant difference at odds of 19:1 0.58[1]

* Average of 5 replications.

** No significant difference between rates of fertilizers.

*** Least significant difference at odds of 19:1 for interaction of date of seeding and rates of commercial fertilizer 0.84[1].

1 Analysis of variance shown in Appendix E.

Effect of irrigation on early marketable yields of tomatoes.

The yield of early marketable tomatoes in tons per acre is presented in Table 6. With the irrigation treatment, the larger yield, 16.19, tons was obtained. The treatment without irrigation resulted in a yield of 3.47 tons. The difference was highly significant.

It can be seen from Table 6 that the fertilizer treatment tends to increase the early marketable yields only when irrigation is supplied. Comparing yields, the 400-pound rate of commercial fertilizer treatment, when irrigated, resulted in a larger yield, 17.44 tons, than the control, 14.25 tons. When compared without irrigation, the 400 pound rate of commercial fertilizer treatment yielded 3.18 tons which was smaller than the control, 3.97 tons. Although there is no significant difference between rates of fertilizer or the interaction of fertilizers and irrigation treatments, the tendency is evident.

Effect of mulch paper, hotcaps and 2,4,5-trichlorophenoxyacetic acid on early yields of Stokesdale tomatoes.

The mean yield of early market fruit in tons per acre resulting from mulch paper, hotcaps and 2,4,5-T treatment yields were as follows; control, 7.04 tons; 2 applications of 25 ppm, 6.12 tons.

Table 8. Effect of 2,4,5-trichlorophenoxyacetic acid, mulch paper and hotcaps on early yield of Stokesdale tomatoes. (Exp. 3)

2,4,5-T** treatments	Yield* of tomatoes in tons per acre: Mulch paper	Mulch paper & hotcaps	Hotcaps	Control	Means	Least significant difference at odds of 19:1
Control	9.27	5.95	4.44	8.54	7.04	
2 appli. 25 ppm	9.64	3.68	4.48	6.68	6.12	
2 appli. 50 ppm	8.58	5.14	4.06	6.43	6.05	
Means	9.16	4.92	4.32	7.21		0.85[1]

Least significant differences at odds of 19:1 0.74[1]

* Average of 5 replications.

** 2,4,5-trichlorophenoxyacetic acid.

[1] Analysis of variance shown in Appendix G.

The lowest yield resulted from 2 applications of 50 ppm, 6.05 tons. The two 2,4,5-T treatments were not significantly different but were both significantly lower than the control.

Comparing mulch paper and hotcap treatments, mean yields were as follows: mulch paper with the largest, 9.16 tons per acre; control, 7.21 tons per acre; mulch paper plus hotcaps, 4.92 tons per acre and the lowest, hotcaps alone, 4.32 tons per acre. The mulch paper treatment yield was significantly larger than the other 3 treatments and the control treatment yield was significantly larger than the treatments containing hotcaps which did not show significant difference. The large depression in early yields from the treatments containing hotcaps may have resulted from the size of the plants at the time of treatment. When the hotcaps were applied, the tomato plants had to be bent and forced under the hotcaps. Before they were removed the plants had become distorted and in some cases had broken through the hotcaps causing restriction in the stem of the tomato plants.

Treatment effect on total market and total yields of tomatoes.

The results for total market and total yields from each experiment were very similar to the early market yields. Therefore, they will not be presented in the text of the thesis. For the purpose of clarity and comparison, however, the results are presented in appendix A, B, C, and D. Analysis of variance was computed and "F" values obtained. If significance was indicated, least significant differences were calculated at the 5 percent level and are presented with each table.

Effect of irrigation and fertilizers on color, flavor, soluble solids and pH of processed Stokesdale tomato juice.

It can be seen from Table 9 that the color of the experimental product was inferior, irregardless of treatment, to the commercial standard. When comparing the results on flavor, they were found to be quite variable with no trend evident. The highest rating resulted from the non-irrigated and 1200 pound fertilizer treatment which had a rating of 34. This treatment resulted in a better flavor rating than both commercial standards which were 22 and 33. The non-irrigated, high fertilizer treatment resulted in the highest percentage soluble solids of 7.4 per cent followed by the non-irrigated control fertilizer treatment which was 7.0. All other treatments and the commercial standards had soluble solids readings of 6.0 per cent except the irrigated control fertilizer treatment which was 5.8 per cent.

The pH of the juice sample varied from pH of 4.3 to 4.1 with a possible relationship between percentage soluble solids and pH. The highest per cent soluble solids, 7.4, showed the lowest pH reading of 4.1. The lowest per cent soluble solids, 5.8, resulted in the highest pH reading which was 4.3.

These results were not from replicated trials; therefore, analyses of variance were not applied.

Table 9. Effect of irrigation and fertility on color, flavor, soluble solids and pH of processed Stokesdale tomato juice. (Exp. 4)

Sample Source	Color rating*	Flavor rating*	% soluble solids	pH	PMA grade
Irrigated no fertilizer	26	21	5.8	4.3	C
Irrigated 1200# per acre 10-16-8	26	28	6.0	4.2	C
Non-irrigated no fertilizer	26	27	7.0	4.1	C
Non-irrigated 1200# per acre 10-16-8	26	34	7.4	4.1	A
Commercial A	29	32	6.0	4.3	C
Commercial B	29	33	6.0	4.2	A

* Production and Marketing Administration grade rating points.

PMA grading points.

Factor	Grade	Points
Color	A	26-30
	C	23-25
	D	0-22
Flavor	A	33-40
	C	27-32
	D	0-26

DISCUSSION OF RESULTS

Varietal differences appear to effect the results of date of seeding on tomatoes. In one case the variety Puck, a determinate, early-maturing type tomato, showed a significant increase in yield when young, 7 weeks old plants were used instead of the older 9-and 10-weeks old plants. The Stokesdale variety, an indeterminate mid-season type tomato, did not show this difference. The increase in yield from the Puck variety may have come from its vegative condition at the time of field transplanting. The 9-and 10-weeks old plants had flower clusters formed and in some instances, fruit set when transplanted into the field. These older plants might have been unable to resume vagative growth to the same instances, fruit set when transplanted into the field. These older plants might have been unable to resume vegative growth to the same extent as the younger plants and, consequently, the lower yields of tomatoes.

The Stokesdale variety had not developed flower clusters in any age group at the time they were set in the field. It may be that the older plants were able to contimue vigorous vegetative growth to produce a large base plant to support enough flower clusters for a large early yield.

It appears from the results that topping of plants without regard to their size or age has a detrimental effect on early yields. This detrimental effect increases in severity as the plants become smaller. The depression in early yields caused by topping may have resulted from the delay in renewal of shoot growth and consequent later formation of the first flower clusters.

The increase in early yields of the Stokesdale variety, resulting from a pre-transplanting starter solution, was highly significant. The results may be due to the presence of a high analysis phosphorus material in relation to the remainder of the complete fertilizer in the starter solution. The application of the starter solution was made 7 days before transplanting while the tomato plants were in the greenhouse. Greenhouse day temperatures were relatively high making the phosphorus, as well as the remaining nutrients, available to the plant. Thus, as the time of field transplanting, the nutrients may have been already within the plant, resulting in a rapid root development. The same starter solution added to the plant at transplanting in larger quantities did not give a significant increase over the control treatments.

The lack of response to a "starter" solution in the field might be due to the low soil temperature resulting in the slow availability of the phosphorus. The starter solutions and controls on the variety Puck did not show any significant difference when the starter solution was applied at time of field transplanting.

The results of the fertilizer treatments were inconclusive and insignificant but the use of the highest rates, 1200 pounds per acre of 10-16-8 commercial fertilizer, tended to depress the yields of both the Stokesdale and Puck varieties. The lack of response may have been due to the native fertility of the soil. With the Stokesdale variety, the 400 pound rate tended to increase the yield of early marketable tomatoes. However, without a control on the Puck, this tendency could not be observed. It might be possible to use a lower rate of commercial fertilizer or a different analysis and obtain significant increases.

Although the results with the commercial fertilizers were not significant, the relationship of commercial fertilizer to supplemental irrigation was shown. When irrigation was applied, along with 400 pound per acre of 10-16-8 commercial fertilizer treatment, there was a tendency to increase the early marketable yield over the control. Without irrigation, the use of commercial fertilizer did not show this tendency.

The results from the irrigation treatments were highly significant, with an increased early yield of 3-fold when supplemental water was applied. This increase in early yield may result from the development of a larger plant, earlier, with more foliage and a greater number of flower clusters (possibly more flowers per cluster) than obtained on the non-irrigated control.

The results from the mulch paper treatment were highly significant in increasing the early marketable yields over the controls. This increase in early marketable yield may be due to the higher soil temperature under the mulch paper, which would result in increased availability of phosphorus and nitrogen and also increase the metabolism within the roots. This increased availability of the nutrients would result in a larger plant earlier in the growing season. Such a plant could support more and larger flower clusters. More and larger flower clusters, consequently, would result in heavier early yields. These results are in agreement with those reported in the literature. It is recognized that there are soil moisture, aeration, and micro-biological effects, also, which may enter into this picture.

The results obtained from the hotcap treatments are not in agreement with the results reported in the literature. The depression in early marketable yield, which was significant, when compared to the control, probably resulted from the large size of the plant at time of application. When applied, the plants had to be bent and forced under the hotcaps and after a period of 2 weeks, when they were removed, the plants were malformed and in a very poor vegetative condition. The results might have been more favorable if the plants were smaller on the date of transplanting or if they were transplanted at a time when protection from frost was required.

The results from the 2,4,5-trichlorophenoxyacetic acid treatment showed a significant depression of early marketable yield when compared with the control. The 2,4,5-T was used 2 weeks before fruit harvest to remove a portion of the foliage, which, conceivably, might increase the heat units within the fruit and hasten the maturity. It is apparent from the results that the time to first harvest was not shortened and the fruit apparently did not increase in size to the same degree as the control.

The inferior color of the processed Stokesdale tomato juice for the experimental treatments was striking when compared with the commercial samples. It was the general opinion of all of those who observed the juice samples that, irregardless of treatment, the color of the experimental samples was inferior to the commercial samples purchased on the local market.

The high fertilizer treatments resulted in an increased flavor rating in both the irrigated and non-irrigated treatments, with the irrigated high-fertilizer treatment being about the same as the non-irrigated, no-fertilizer treatment. No explanation is offered. It is considered that these results need further study.

Juice samples from the non-irrigated high-fertilizer treatments resulted in the highest per cent soluble solids. The per cent soluble solids from the non-irrigated treatments were significantly higher than from the irrigated treatments.

The pH readings for the irrigated treatments were similar to the commercial samples and were higher than for the non-irrigated treatments. Because limited data were taken on the pH of the processed tomato juice samples, the results should not be considered conclusive.

SUMMARY

Transplant and field treatments were applied to Stokesdale and Puck varieties of tomatoes in an attempt to increase early yields.

The use of 7-week-old Puck plants resulted in an increased early yield over 9-and 11-week-old plants. There was no difference in early yields of the Stokesdale variety between plants of the 3 ages.

The use of 25 cc of a starter solution (2 parts by weight of diammonium phosphate and 1 part potassium nitrate dissolved in water at the rate of 8 pounds of the mixture in 50 gallons of water) 7 days before field transplanting resulted in a significant increase in early yields of Stokesdale tomatoes. This treatment is considered to have possible important practical significance. The same solution applied at the rate of 1 pint per plant, or 1 pint of water alone per plant, at the time of field transplanting did not result in an increased early yield. Starter solutions used at time of transplanting Puck tomatoes resulted in no increase in early yield over the controls.

Commercial fertilizer, 10-16-8 analysis, at rates of 400 and 1200 pounds per acre resulted in no significant increase of early yields of either Stokesdale or Puck tomatoes.

Supplemental irrigation every 7 days for Stokesdale tomatoes resulted in a highly significant increase in early yields when compared with the non-irrigated treatment.

The topping of Stokesdale tomato plants resulted in a significant depression of early yields. This was true regardless of the age of the plant at the time of topping.

The use of 36-inch black paper mulch for Stokesdale tomatoes resulted in a significant increase in early yield. The use of hotcaps with mulch paper or hotcaps only under the conditions of this experiment resulted in highly significant depression in early yield of tomatoes.

2,4,5-trichlorophenoxyacetic acid used as a defoliant spray at concentrations of 25 and 50 ppm resulted in a depression in early yields of Stokesdale tomatoes.

Supplemental irrigation, no irrigation, high levels of a complete commercial fertilizer and no fertilizer did not show any effect on color of the processed Stokesdale tomato juice. The color in all cases was inferior to commercial standards.

The higher rates of commercial fertilizer resulted in a higher flavor rating of the processed Stokesdale tomato juice than did the non-fertilizer control treatments. The non-irrigated treatments also increased the flavor rating over the irrigated treatments. The flavor rating of the non-irrigated no-fertilizer treatment and irrigated high-fertilizer treatment was comparable.

The per cent soluble solids of the processed Stokesdale tomato juice from the non-irrigated treatment was significantly higher than from the irrigated treatment. The per cent soluble solids from the irrigated treatment was comparable to the commercial standard.

The pH of the processed Stokesdale tomato juice varied between 4.1 and 4.3. The higher pH apparently resulted from the irrigated treatments and the lower pH resulted from the non-irrigated treatments.

These data on color, flavor, soluble solids, and pH were considered to be preliminary in nature.

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Appendix A. Effect of date of seeding, starter solutions and rates of commercial fertilizer on total Puck yields. (Exp.1)

Date of seeding	Treatments: Starter solution 1 pt./plant at set	Treatments: Commercial fertilizer 10-16-8 lbs./acre	Yield* in tons/acre
	Control	400	9.8[1]
		1200	8.94
March 17	Solution D**	400	10.37
		1200	8.68
	Solution B***	400	10.21
		1200	9.41
	Control	400	8.82
		1200	9.65
March 28	Solution A	400	9.45
		1200	9.77
	Solution B	400	9.60
		1200	10.04
	Control	400	13.27
		1200	11.57
April 7	Solution A	400	13.11
		1200	11.94
	Solution B	400	12.45
		1200	12.28
Least significant difference at odds of 19:1			0.41[1]

* Average of 5 replications.

** 2½# $(NH_4)_2SO_4$ plus 2½# $Ca_3(PO_4)_2$ in 50 gallons water.

*** 2½# $(NH_4)_2SO_4$ in 50 gallons water.

1 Analysis of variance shown in Appendix A-1.

Appendix A-1. Analysis of variance for experiment 1. Puck variety.

Variation due to:	DF	Sum of squares	Mean squares	F
Replications	4	198.1572	49.5393	3.26
Treatments	17	1152.5094	67.7946	4.46**
Error	65	985.8650	15.1671	
Total	86	2336.5316		

Appendix B. Effect of date of seeding, starter solutions, and topping on total marketable and total yields of Stokesdale tomatoes. (Exp. 2)

Treatments			Yield* in tons/acre	
Date of seeding	Starter solutions	Topping	Total marketable	
March 17	1**	Topped	24.88	27.80
		Untopped	22.44	26.04
	2***	Topped	23.25	27.05
		Untopped	25.90	29.46
	3****	Topped	28.16	32.55
		Untopped	26.25	30.93
March 28	1	Topped	23.00	27.95
		Untopped	23.73	26.82
	2	Topped	22.52	25.24
		Untopped	23.82	28.36
	3	Topped	26.38	29.73
		Untopped	26.71	31.33
April 7	1	Topped	18.73	20.46
		Untopped	25.70	28.83
	2	Topped	18.49	21.36
		Untopped	24.42	28.30
	3	Topped	18.48	22.73
		Untopped	26.59	30.14
Least significant difference at odds of 19:1			4.89[1]	5.48[2]

Appendix B. (continued)

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* Average of 5 replications

** 1 pint water per plant at set

*** 1 pint starter solution C (2 parts diammonium phosphate and 1 part potassium nitrate dissolved in water at the rate of 8 pounds of the mixture in 50 gallons water) at set.

**** 25 cc starter solution C 7 days before set.

1 Analysis of variance for total marketable Stokesdale yield shown in Appendix B-1.

2 Analysis of variance for total Stokesdale yield shown in Appendix B-2.

Appendix B-1. Analysis of variance for total marketable yield experiment 2. Stokesdale variety.

Variation due to:	DF	Sum of squares	Mean squares	F
Replications	4	1434.5208	358.6302	3.92**
Treatments	17	4329.9146	254.7008	2.78**
Error	65	5941.4461	91.4068	
Total	86	11705.8815		

Appendix B-2. Analysis of variance for total yield experiment 2. Stokesdale variety.

Variation due to:	DF	Sum of squares	Mean squares	F
Replications	4	1203.2257	300.8064	2.63
Treatments	17	5720.2081	336.4828	2.94**
Error	65	7447.9425	114.5837	
Total	86	14371.3763		

Appendix C. Effect of mulch paper, hotcaps and 2,4,5-trichlorophenoxyacetic acid on total marketable and total Stokesdale yields. (Exp. 3).

Mulch paper and/or hotcap treatment	2 applications of 2,4,5-T in ppm	Yield* in tons per acre: Total marketable	Yield* in tons per acre: Total
Neither	0	23.31	28.01
	25	22.36	27.50
	50	21.63	27.38
Hotcaps only	0	19.15	23.78
	25	19.71	24.43
	50	19.04	23.65
Mulch paper plus hotcaps	0	21.44	25.12
	25	20.68	24.02
	50	25.21	29.72
Mulch paper only	0	24.23	29.21
	25	24.84	30.31
	50	24.02	29.71
Least significant difference at odds of 19:1		3.73[1]	3.69[2]

* Average of 5 replications.

1 Analysis of variance shown in Appendix C-1.

2 Analysis of variance shown in Appendix C-2.

Appendix G-1. Analysis of variance for total marketable yields experiment 3. Stokesdale variety.

Variation due to:	DF	Sum of squares	Mean squares	F
Replications	4	646.9720	161.7430	3.11*
Treatments	11	1586.0689	144.1880	2.77**
Error	44	2290.5042	52.0569	
Total	59	4523.5452		

Appendix G-2. Analysis of variance for total yields experiment 3. Stokesdale variety.

Variation due to:	DF	Sum of squares	Mean squares	F
Replications	4	1239.6365	309.9091	6.07**
Treatments	11	2193.4944	199.4085	3.90**
Error	44	2247.0753	51.0698	
Total	59	5680.2062		

Appendix D. Effect of irrigation and rates of commercial fertilizer on total marketable Stokesdale yields. (Exp. 4).

Irrigation treatments	Yield* of tomatoes in tons per acre			
	Rates of commercial 10-16-8 fertilizer in pounds/acre			Means
	0	400	1200	
Irrigated	20.15	26.04	27.12	24.43**
Non-irrigated	4.38	3.95	4.43	4.25
Means	12.26	14.99	15.77	
Least significant difference at odds of 19:1				2.93[1]

* Average of 4 replications.

1 Analysis of variance for total marketable yields experiment 4.

Appendix D. (continued)

Variation due to:	DF	Sum of squares	Mean squares	F
Replications	3	67.112	22.370	NS
Irrigation	1	14795.701	14795.701	473.144**
Error (a)	3	93.814	31.271	
Rate of fertilizer	2	327.989	163.994	1.2
Rate of fertilizer x irrigation	2	354.879	177.439	1.3
Error (b)	12	1640.114	136.676	
Total	23	17279.609		

Appendix B-1. Effect of irrigation and rates of commercial fertilizer on total Stokesdale yields. (Exp. 4)

Irrigation treatments	Yield* of tomatoes in tons per acre			
	Rates of commercial 10-16-8 fertilizer in pounds per acre			Means
	0	400	1200	
Irrigated	25.76	32.88	34.67	31.10
Non-irrigated	6.93	7.23	7.91	7.35
Means	16.34	20.05	21.29	
Least significant difference at odds of 19:1				3.65[1]

* Average of 4 replications.

1 Analysis of variance for total yield experiment 4.

Appendix D-1. (continued)

Variation due to:	DF	Sum of squares	Mean squares	F
Replications	3	204.042	68.014	NS
Irrigation	1	20470.952	20470.952	425.46**
Error (a)	3	144.346	48.115	
Rates of fertilizer	2	640.386	320.193	2.58
Rates of fertilizer x irrigation	2	446.427	223.213	1.795
Error (b)	12	1491.855	124.321	
Total	23	23398.008		

Appendix E. Analysis of variance for experiment 1.
Puck variety.

Variation due to:	D.F.	Sum of squares	Mean squares	F
Replications	4	255.4067	63.8516	7.77**
Treatments	17	788.6664	46.3921	5.64**
Starter solution	2	14.5100	7.2550	0.88
Date of seeding	2	653.3971	336.6985	40.98**
Rates of fertilizer	1	24.0974	24.0974	2.93
Starter solution x date of seeding	4	11.5835	2.8958	0.35
Starter solution x rates of fertilizer	2	6.0286	3.0143	0.36
Date of seeding x rates of fertilizer	2	61.3174	30.6587	3.73*
Starter solution x date of seeding x rates of fertilizer	4	17.7324r	4.4331	0.53
Error	65	534.0435	8.2160	
Total	86	1578.1166		

Appendix F. Analysis of variance from experiment 2. Stokesdale variety.

Variation due to:	D.F.	Sum of squares	Mean Squares	F
Replications	4	365.1176	91.2944	3.91**
Treatments	17	1898.8221	111.6954	4.75**
Starter solution	2	437.8356	218.9178	9.38**
Date of seeding	2	20.0208	10.0104	0.43
Topping	1	989.0966	989.0966	42.39**
Starter solution x date of seeding	4	97.9194	24.4798	1.05
Starter solution x topping	2	17.1046	8.5523	0.37
Topping x date of seeding	2	284.1296	142.0648	6.09**
Starter solution x date of seeding x topping	4	52.7155	13.1788	0.56
Error	65	1516.6546	23.3331	
Total	86	3780.6543		

Appendix G. Analysis of variance for experiment 3. Stokesdale variety.

Variation due to:	D.F.	Sum of Squares	Mean Squares	F
Replications	4	46.7654	11.6913	1.42
Treatments	11	1518.2440	138.0221	16.71**
2,4,5-T	2	74.8170	37.4085	4.52*
Mulch paper and hotcaps	3	1336.7758	445.5919	53.93**
2,4,5-T x mulch paper and hotcaps	6	106.6512	17.7752	2.15
Error	44	363.5026	8.2614	
Total	59	1928.5120		

Appendix H. Analysis of variance for experiment 4. Stokesdale variety.

Variation due to:	D.F.	Sum of squares	Mean of Squares	F
Replications	3	51.7681	17.2559	NS
Irrigation	1	2383.6143	2383.6143	203.15**
Error (a)	3	35.2000	11.7332	
Rates of fertilizer	2	15.9937	7.9966	NS
Irrigation x rates of fertilizer	2	44.6747	22.3371	NS
Error (b)	12	200.5857	16.7152	
Total	23	2731.8369		