GROWING TOMATOES UNDER GREENHOUSE CONDITIONS IN THE VICINITY OF MOSCOW, IDAHO.

A THESIS

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

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BY

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INTRODUCTION

For several years the forcing of tomatoes has been practised with more or less success thruout the eastern states, especially the New England and the North Central groups. Instances are recorded where the work has progressed so rapidly and proved so remunerative that the owners have become practically independent within a very short time.

Today there are thousands of acres under glass thruout the United States, and every year the acreage is being increased rapidly. Especially is this true near the large market centers such as New York, Chicago, Philadelphia, Boston, St. Louis, and others perhaps just as prominent. There is perhaps more area under glass devoted to tomato growing than to any other single crop. The price of fifteen to thirty-five cents per pound for the fruit brings handsome returns to the grower, and herein lies the secret of success in the work, for without a good market where the highest prices can be had, the effort is sure to result in failure.

So far as the writer has been able to learn, there has been very little work done along the forcing of vegetables in this particular region of Idaho, and if the population continues to increase as rapidly ufor the next twenty five years as it has the past

twenty five years, thefe is bound to be a great opportunity for some one to make a fortune in this line of work.

The state is yet in its infancy, and as large cities spring up and the population increases, there is bound to be a demand for fresh vegetables.

The question that confronts us is: Are we going to grow thesevegetables at home, or are we going to pay California exorbitant prices for what she grows? Every year the state of Idaho is sending hundreds of dollars to other states which might as well be kept at home provided the forcing industry proves a success here as it has elsewhefe .

The object of this experiment then shall be to determine whether or notthe forcing of tomatoes will prove profitable. In order to be profitable it must, of course, give sufficient returns to pay all expenses involved and at the same time give a reasonable profit to warrant the grower for his labor.

History of Tomato

The tomato is believed to be a native of Peru, but is indigenous thruout Mexico and as far north as Texas and California in a form very much resembling the Cherry tomato of the garden. It was probably first cultivated in south Europe as early as 1561, more for ornamental purposes than for its use as a vegetable.

It was first thought to be poisonous and the first record we have of its being used as food was in 1582.

The fruit was introduced into Philadelphia by a French refugee from San Domingo in 1798. It was first offered for sale in the markets of New Orleans in 1812, and was first grown for market purposes about 1829, but it was not mentioned in the premium lists of the leading horticultural varieties until 1839.

The type of fruit grown at that tme was very much like the present Cherry type. The fruit, however, is very variable in habit and is readily susceptible to the influence of selection.

The history of the well known garden varieties is of quite recent date. The first large tomato to appear was known as the "Large Red", and this was followed a few years later by the "Fiji Island" and Cook's Favorite". Among comparatively recent varieties may be mentioned such as the Perfection, Lorillard, Ignotum, Dwarf Champion, Beuty, Stone Aristocrat, Ruby, and Earlianna. All of these are large, smooth, and highly colored varieties and are the result of a lot of painstaking and care in the breeding and selection of the fruits.

Attempts have been made from time to time to produce yellow fruits with a blushed cheek, but so far the attempts have failed.

The blush cheek has been obtained, but it fails to remain constant when planted to field conditions Within the last fewyears little progress has been made in the improvement of varieties.

Growing the Plants

The plants were grown from seed secured from the Spokane Seed Company, of Spokane, Washington. The soil in which the seed were sown consisted of a mixture of equal parts of garden loam, sand, and well rotted and finely pulverized stable manure The soil was placed in four inch flats and the seed sown in rows four inches apart and covered with about half an inch of sand, and then the soil was watered until it was saturated.

The seeds were sown on November 14th and the young plants began to appear on November 21st, or just one week after they were sown. The plants were allowed to remain in the flats until the third leaf began to appear and the plants have developed enough roots to enable them to be transplanted without serious injury. This required about three weeks from the time the plants were up.

Potting Off

On December 13th the plants were taken from the flats and transferred to three inch pots. At this time they were about three and a half inches high (Figure 1).

The soil used in the pots consisted of the following mixture: one part well rotted manure, two parts garden loam, and one part clean sand. These were thoroly mixed and the young plants were taken from the flats with a small particle of soil attached to the roots (Figure II) and as soon as transferred to the pots they were given a thoro watering. Of the one hundred forty plants potted off, not one of them died or even showed signs of wilting from the operation. The growth did not appear to be even checked by the process.

Type of House

The house in which this experiment was conducted is of the even spann type with ridge pole extending north and south which makes it a desirable type for the forcing of vegetables. The house is ventilated by both side and ridge pole ventilators which are raised and lowered by means of shafting. The portion of the house in which

Fig. 1. Showing proper size plants for potting off first time.

Fig. 2. Showing proper and improper way of taking up plants for potting.

the experiment was conducted is twenty feet by fifty feet, or has an area of one thousand square feet. The house is heated by hot water pipes, the water being heated by a boiler which is located at the north end of the house.

The bed in which theplants were grown was of the raised type; is located in the center of the house; is eight by fifteen feet and six inches deep.

Soil

The soil used in the permanent bed consisted of the following: three parts garden loam, one part sand, and one part rotten manure. The manure was run thru a quarter inch meshed sieve, then it w was mixed with the sand and loam. The bench was filled until the soil was about seven inches deep or one inch deeper than the bennh itself. As soon as the soil was placed in the bench it was saturated with water, and as soon as dry enough it was gone o- ver with a rake and hoe and all lumps broken up. The soil was pulverized in this way about three times before the plants were set in.

The mixture as given above makes a soil that is both rich and of excellent physical condition. It takes up and conserves a good supply of moisture and does not become crusted after watering.

Getting Plants in Permanent Bed

The plants were taken from the small pots and planted to the permanent bed on January 24th. At this time the plants were about one foot high, growthy, stocky, and nearly ready to bloom, many of the plants having quite conspicuous Bloom clusters (Figure III)

They were set in rows eighteen inches apart and the plants set twelve inches apart in the row, therefore only eighty plants were required to fill the beds. Of the eighty plants set, forty were of the Stone variety and forty of the Beauty variety. The plants were set about one inch deeper in the bed than they stood in the pots and as soon as thetransplanting was done the soil was firmed about the roots and then water was applied. The soil from the pots was left attached to the roots of the plants when they were set in the permanent bed.

The distance, sixteen by twelve inches proved too close for the plants since they made a very vigorous growth. The writer believes that eighteen inches or even two feet each way would be better, especially where there is so much cloudy weather as occurs in this locality during the winter months

So dense was the growth that it became necessary to take out every other row in order to give more room and sunlight. The plants now stand two feet by sixteen inches and are plenty thick.

Temperature of House

The temperature of the house during the experiment varied from thirty-two degrees to ninety-five degrees, the two temperatures given being extremes. Only once, February 4th, did the temperature reach the freezing point. This was caused by a rapid fall in temperature from thirty degrees to minus ten degrees F on the outside. Some few of the plants were slightly injured by the freeze, but these soon overcame the injury.

The average temperature of the house during the winter would be about sixty degrees F, being about fifty degrees at night and seventy degrees during the day.

The weather during the winter months was mostly cloudy so that little sunshine could be had to assist in the growth of the plants and in the warming of the house.

Watering

Watering was done at irregular intervals, but generally about once every two weeks. The frequency depended upon the weather a whole lot;

Fig. 3. Showing size of plants for transplanting into the permanent bed.

Fig. 4. View of bench showing plants after they had been transplanted and staked

the clear periods requiring the most water.

The water was applied directly to the soil until itbecame saturated, and the foliage of the plants was never wet more than could be avoided. Owing to the fact that the soil around the edges of the bench became dry more quickly than the interior it required watering about twice as often as did the interior of the shed.

As the days grew long and hot it became necessary to water the plants at least once a week or they would suffer from drouth.

Cultivation:

The plants required very little cultivation other than the establishing of a soil mulch shortly after each watering. There were very few weedseeds in the soil, so little cultivation was required for this purpose. What cultivation they received was given by means of a small hand rake which loosened the soil scarcely deeper than one and a half inches.

Pruning and Training:

In this experiment the plants were pruned to a single stem, the side suckers being kept cut off as soon as they formed. As the plants grew taller, they were tied to stakes which were made of building laths. These laths were set about four inches deep in the soil and fastened at the top to a wire which had been stretched over each row and fastened to the rafters of the house. These wires were about four and a half feet above the soil in the bench. (Figure IX) The plants were tied to the stake at intervals of about one foot. They were not bound tightly to the stakes, but simply fastened so that they could not fall down.

As the plants grew larger and the foliage became dense, it was necessary to cut off a portion of each leaf in order to allow the sunlight to enter more readily.

Pollenizing:

The tomatoes being grown under glass and during the winter season when there are no active insects to carry pollen from one flower to another made it necessary to do this work by hand. The method of pollenizing was as follows:

About midday when the sun was hottest andhence the pollen thoroly dry, the writer went into the house and carefully shook the pollen from each individual flower on to

his forefinger. When a sufficient amount had been collected in this way, the pistil of each flower was touched to the pollen. The pistil is generally covered with a waxy substance which causes the pollen to adhere quite closely to it. The pollenizing was done at regular intervals of two days, it generally requiring about one half hour to pollenize all the blossoms. It seems that just a few grainsof pollen is just as good for fertilizing a flower as is a large quantity or at least no difference was noticed in the size or shape of fruit where large or small quantities were used.

Supporting Fruit Clusters:

As the tomatoes grew to good size, it was necessary for them to have some kind of support in order to prevent the cluster stem from being broken. The support consisted of a small cotton twine which was tied to the stem of the fruit and then to the main stem at some point above, drawing the string just tight enough to hold the fruits in their natural position.

Diseases

Damping off:

This disease was present to a limited extent in the seed bed. It is caused by one or more fungi which inhabit the soil. The young plants when attacked take on a dark brown or even black appearance at the base of the stem. The area attacked soon contracts until the stem is less than one third natural size. It also loses its rigidity at this time and the young plants fall over and after a short time die seemingly from lack of moisture. This disease is quite common especially were plants are grown in moist hot beds or greenhouses.

The remedy for the trouble is to carefully remove all infested plants from the seed bed and withhold the water as long as possible. Plants that are kept in a rather dry soil and atmosphere seldom suffer from this trouble. It would be a good idea to sterilize all soil before putting it in the seed bed, thus greatly lessening the chances of attack by the fungus. The disease has never been known to attack plants after they are three or four inches high.

Leaf Curl or Oedema:

The Leaf Curl, or Oedema, is not necessarily a disease, but seems to be a physiological trouble brought about by one or several causes. The trouble in this case was first noted by the writer shortly after the plants had reached the blossoming stage. The Curl seemed to be most severe during the hottest portion of the day. Often the whole of the foliage except a few of the bottom leaves would be curled up at mid-day, while early the next morning the trouble could hardly be detected.

The trouble is said to be due, First: to excessive moisture, and this is very likely the principal reason in this case since the soil when saturated would remain wet for at least two weeks. This was due to the fact that very little sunshine was to be had during that particular season of the year. The trouble was also more pronounced shortly after a watering than it was just before watering.

Too severe pruning is also offered by some writers as a cause.of the trouble in this case because the plants were attacked even before the pruning began. Excessive fertilizing is also offered as a cause of the trouble and this, the writer believes, is partly accountable for the trouble in this case.

If the above are thecauses of the disease or trouble then the remedy must be less water and less fertilizer or

less severe pruning. The writer believes that a cultivating in which a good portion of the roots were injured greatly aided in checking the trouble in this experiment. If the ground is kept only reasonably moist while the seeds are germinating and kept fairly dry after the young plants appear there is little danger of the loss of many plants from this cause.

Blossom End Rot:

The blossom end rot is a fungous or a bacterial disease which attacks the fruit of the tomato generally after it is half grown or perhaps nearly ripe.

In the case of this experiment the disease was first noted on the fruit about two weeks before the ripening period. Itfirst appeared as a small light brown spot which appeared to be just beneath the skin of the fruit. The spot gradually enlarges until the fruit is ripe and often it destroys the whole fruit. Generally, however, it does not cover more than one eighth of the fruit. As the disease progresses the spots become darker in color and soon the area attacked begins to shrink or dry up thus causing a sunken area at the point of attack.

There has been no satisfactory remedy for this disease, but it is reported that Bordeaux Mixture will check the ravages of the disease. In this experiment only the largest fruits were attacked by the disease and these were generally on the plants that were shaded most.

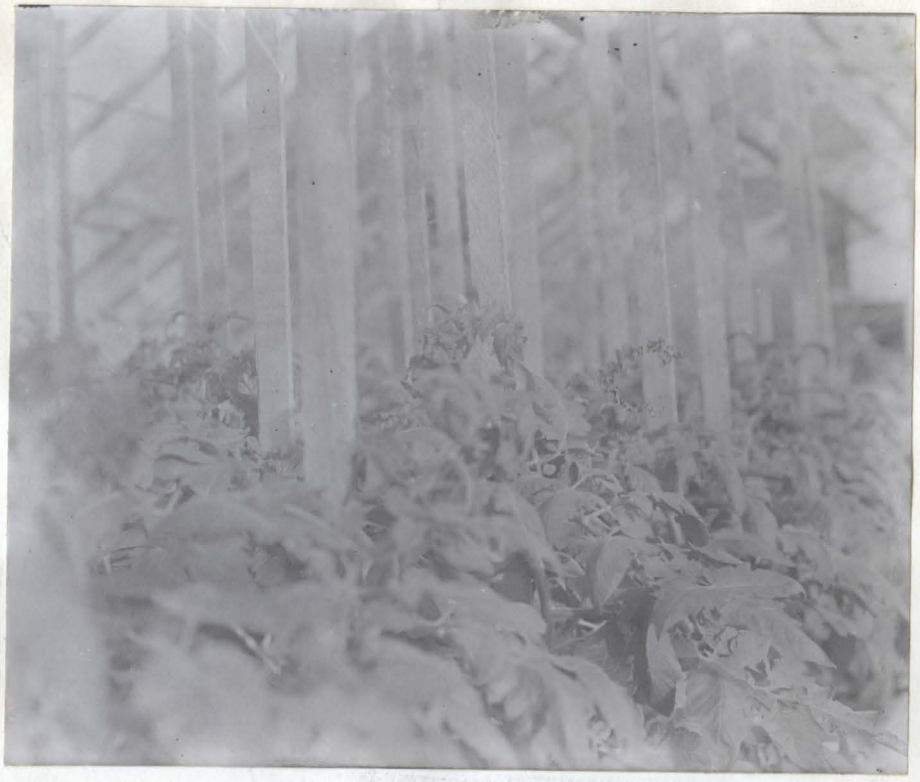

Fig. 5. Showing Oedema or leaf curl of the tomato.

Fig 6. Blossom end rot of the tomato.

Insects

Green Aphis:

Thegreen aphis is a small greenish louse-like insect that attacks the tomato plant at any and all seasons of growth. They have been present on the plants in this experiment, but never became numerous enough to cause any serious damage. It belongs to that class of insects which suck their food from the juices of the plant and hence they cannot be controlled by poisons. Fortunately however we can easily control the pest by spraying with tobacco preparations or by fumigating with nicotine paper. There are several broods of this insect each summer the first broods giv ng birth to liv ng young and the last brood laying eggs in w ich stage the winter is passed.

White Fly:

The white fly is one of the most serious pests to the forcing industry of the tomato. The adult insect is a small white fly or moth, about one twentieth inch in length and is equipped with sucking mouth parts. There have bee quite a few noticed on the plants in this experiment, but their numbers were not thought great enough to cause any damage. The number, however, has gradually increased, and it is only a question of time until

some method of control mustbe taken up. Fumi-
gation with hydrocyanic acid gas has given quite
satisfactory results where used. The gas is,
however, very poisonous and the work must be
done with the greatest ofcare.

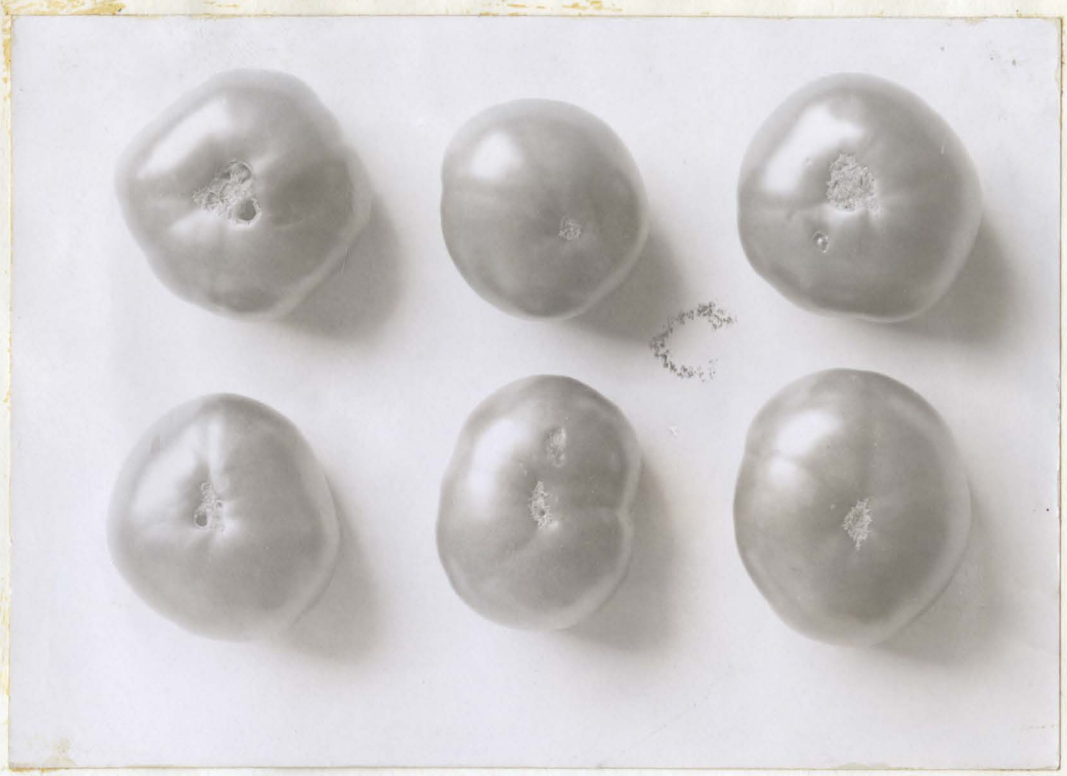

Fig. 7. Normal tomatoes free from disease.

The following table shows the height at which first cluster of fruit was borne above ground, and also the length of the three first internodes of ten plants. It will be noticed that the first internode in this case was the shortest while the second one was the longest. Other things being equal, the shorter the internodes the more clusters of fruit that would be borne on a stem.

TABLE I

Plant No.	Height of first cluster in inches	Length of first internode	Length of second internode	Length of third internode
1	10	8	6	7
2	17	7	7½	7½
3	13	6	6	5½
4	16	6	6½	8
5	14	6½	7	7
6	12	7½	9	9
7	14	6½	7	8
8	18	6½	7	
9	12	6	11	7
10	16	5½	7	7
Averages	14.2	6.5	7.4	7.33

The following table shows the number of blooms and the number of fruits set on first three clusters of ten plants. It is noticed here that the second cluster had more blooms and also set more fruit than did either the first or third clusters. On this variety more fruits set on the second cluster, while on the Beauty variety (Table #4), the greater number set on the third cluster. It may therefore be a variety characteristic:

TABLE #2

Plant No.	No. blooms on first cluster	No. fruits set on 1st cluster	No. blooms on 2nd cluster	No. fruits set on 2nd cluster	No. Blooms on 3rd cluster	No. fruits set on 3rd cluster
1	5	3	7	5	7	5
2	6	6	7	5	4	3
3	9	3	9	3	6	5
4	7	3	7	4	6	3
5	7	5	7	3	6	3
6	6	4	7	5	5	4
7	7	2	7	3	7	2
8	7	4	6	6	6	2
9	6	5	7	4	6	4
10	5	6	8	6	7	5
Averages	6.5	4.1	7.2	4.4	6.0	3.6

Same as Table #1 except for Beauty variety:

TABLE #3

Plant Number	Height above ground of 1st cluster in inches	Length of 1st internode in inches	Length of 2nd internode in inches	Length of 3rd internode in inches
1	13	6	6	6
2	11	6	5½	5½
3	10	6	5½	6
4	12	5½	6	6
5	11½	6	6	5
6	12	5½	6	6
7	11½	5	5½	5½
8	11	6	6	6½
9	14	4	6	7
10	12	5½	6	6½
Average	11.8	5.85	5/95	6.0

Same as Table #2 except for Beauty variety.

TABLE #4

Plant No.	No. blossoms 1st cluster	No. fruits set 1st cluster	No. blossoms 2nd cluster	No. fruits set 2nd cluster	No. blossoms 3rd cluster	No. fruit set 3rd cluster
1	6	5	5	3	6	3
2	9	3	9	0	7	2
3	7	0	8	4	6	3
4	7	4	7	2	7	3
5	8	1	13	3	6	4
6	7	2	8	4	6	4
7	6	3	8	3	7	4
8	5	4	6	5	7	3
9	8	4	8	3	6	3
10	7	3	2	2	5	3
Averages	7.0	2.9	7.4	2.9	6.3	3.2

COST

In calculating cost all labor is counted at twenty fivecents per hour;

Coal, 21¾ tons @ $6.35 - $138.25 divided by 11				$12.57
Depreciation in value of house reckoned at 2%, or $1000 x .02, or $20.00 - $20.00 divided by 11				1.82
Preparing soil, 6 hours @ 25¢				1.50
Potting off plants,	2 hrs.	@	25¢	.50
Transplanting,	2½	"	"	.63
Watering	4¼	"	"	1.06
Pruning	4½	"	"	1.12
Tying up plants	3½	"	"	.87
Tying up clusters	1¾	"	"	.44
Picking fruit	2	"	"	.50
Cost of stakes				.50
Firing boiler	23	"	"	5.75
Cost of wire				.20
Cost of seed				.10
Total cost				27.07

YIELD

The total yield of the crop was 179½ pounds, of which 98½ pounds were of the Beauty variety and 81 pounds of the Stone. There were 22 plants of the Stone variety. 81 divided by 22 equals 3.7 pounds per plant.

There were 31 plants of the Beauty variety 98½ divided by 31 equals 3.1 pounds per plant.

The yield of 179½ pounds on 1/388 of an acre would be 179½ x 388, or 68,646 pounds per acre.

68646 x 0.15 equals $10,296 per acre

179½ lbs. @ 15¢ equals $26.92, returns from crop

$26.92 - $27.07 equals -0.15 loss

Then if 1/388 acre gives a loss of $0.15 one acre would give a loss of 388 x .0.15 or $48.20.

CONCLUSIONS.

If the above can be depended upon as being reliable it would notpay to grow tomatoes under greenhouse conditions. If, however, the area be sufficient to require a man's constant attention the cost of growing would decrease to such an extent that the writer believes it would prove a profitable business. After the country becomes thickly settled the price off tomatoes will very likely be several cents per pound higher.

SUMMARY

1. The time for maturing a crop of tomatoes requires longer during the winter than it does in summer, therefore it is necessary to start them about October 1st in order to have them ripen at the proper time.

2. The damping-off fungus can be kept in check by keeping the soil as dry as possible and by watering at mid-day rather than at night.

3. Oedema seems to be caused by excessive watering, fertilizer, and pruning. Therefore, the remedy would be to do lessof these or break some of the root system.

4. The Beauty tomato ripens a little earlier than the Stone and its fruits are more smooth, but the yield per plant was slightly less.

5. The distance 12" x 16" for setting plants proved too close. The writer would recommend at least 18" x 2' as a proper distance apart. When grown too close the leaves cast too much shade and the chances of disease are greater.

6. The Stone variety gave a yield of 3.7 pounds of fruit per plant while the Beauty gave 3.1 pounds per plant.

7. The temperature of the house should be kept above the (50 degrees F) mark which was about the average temperature during the winter.

8. Taking the experiment as a guide the growing of tomatoes would not prove profitable on a small scale. The writer believes, however, that if considerable area was devoted to the crop it would be profitable. The price of fifteen cents

per pound for greenhouse tomatoes is rather low and this also accounts for the negative results here obtained. The cost of caring for a house many times larger than this one would require proportionately less labor in keeping as well as lessen the cost of fuel

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