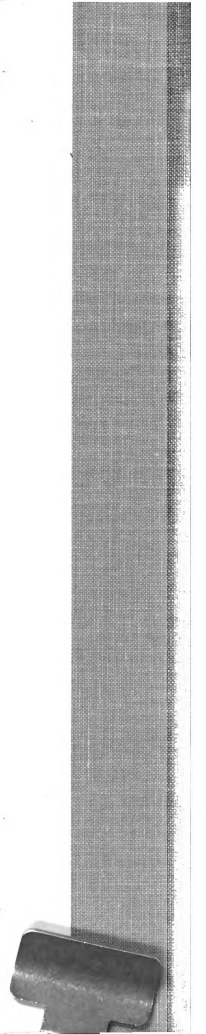
TRANSPLANTING AS A FACTOR IN GROWING PLANTS

THESIS FOR DEGREE OF M. HORT.

JESSE GEORGE BOYLE

1914

THESIS



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Jesse George Boyle

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TRANSPLANTING AS A FACTOR IN GROWING PLANTS.

Introduction.

Transplanting is a term used to designate the removal of living plants and establishing them in new quarters. The operation may be performed when plants are in a dormant state or when they are growing. Some plants transplant readily without serious injury, while with others the operation is a difficult one and attended with considerable danger to the life of the plant.[1] The ability of certain species to undergo the changing of their position in the soil, with the necessary loss of roots and the arresting for a time of their vital activities, is remarkable and may be attributed largely to the manner of root growth and the inherent power of the plant to recuperate after a severe shock of this nature.

As a class, annual or perennial plants producing long tap roots are difficult to transplant. This is largely due to the great loss of roots that occurs when the plant is reset. Trees like the oak, hickory and walnut, all of which have long tap roots, are very difficult to transplant and when grown in the nursery, they are transplanted once or twice when young

to so change the development of the root system that they will be able to withstand the shock of resetting when they have become older. This same principle applies likewise to annuals. In order to secure earliness and a longer bearing season, many vegetable plants are started in hotbeds or cold frames in early spring and set in the field when outside weather conditions have become favorable. The grower of plants has come to recognize transplanting to be a desirable practice even with those sorts that may be reset successfully without difficulty. Experience has shown that transplanting hotbed-grown flower and vegetable plants once or twice before setting them in the open ground, will cause them to develop in such a manner that when they are set, they will grow more successfully than if the plants are allowed to grow where the seed was sown until transplanted to the field. Although transplanting is generally considered a paying practice and is quite common with the greenhouse operator and the gardener, its effect upon plant growth and actual value in a comparative way have been given little consideration.

In the following discussion and tables, the term transplanting applies to the re-setting of seedling plants between the time of sowing the seed in the hotbed and the placing of the plants in the ground. It does not have reference to the actual operation of setting in the field.

OBJECT

It was the object of this investigation to determine the effect of transplanting seedling tomato plants upon the following phases of plant growth:

1. Root and stem development;
2. Earliness of bearing and total yield.

SOURCE OF DATA

The data, upon which this thesis is based, were secured by the author during the season of 1911 from carefully conducted experiments which were under his direct supervision at the Purdue Experiment Station, LaFayette, Indiana. The same experiments were also carried out in 1910 and 1912. From the standpoint of season and other considerations, the work of 1911 was the most uniform, and for this reason its results have been used in this thesis. The results of 1910 and 1912 were very similar to those of 1911 here-in reported.

LOCATION AND SOIL

The experimental plots were located on the trial grounds of the Horticultural department at Purdue University. The soil on this location is known as the Sioux loam, consisting of a dark brown loam to a depth of eighteen inches, containing a large percentage of silt, some coarse sand and fine gravel. The sub-soil

is a brown or reddish-brown loam, having about the same texture as the soil, and is underlaid at an average depth of two feet by a bed of gravel many feet in depth. The sub-soil is very porous,making artificial drainage unnecessary in this locality.

The soil possessed but an average amount of fertility. It was fertilized in the early spring of 1911 by a light top dressing of barnyard manure, at the rate of four tons to the acre. A rye cover crop was turned under a few days before the plants were set.

VARIETY

The Stone variety of tomato was used in this experimental work. The plants were strong and vigorous and produced a good yield of large,solid,bright red fruit. This variety is grown largely as a field crop for canning and is one of the best standard sorts for main crop purposes.

SIZE OF PLOTS

Each plot consisted of twenty plants, set at a distance of five by five feet, which would make a total of 1742 plants to the acre. The tests were conducted in duplicate in order to have a direct check on the experimental error.

METHOD OF STARTING PLANTS

All of the tomato plants used in this test

were started in a hotbed, which was of the pit type, having twenty inches of stable manure to provide the artificial heat. Six inches of composted soil was placed upon the manure and the seed sown in it on March 25th. The bed was handled carefully, as regards proper temperature and moisture conditions, in order to keep the plants growing vigorously. Double light sash were used to provide the necessary protection. Several days before setting in the plots, the sash were removed whenever the weather permitted, to harden off the plants.

The plants grown in the hotbed were handled in five distinct ways from the time the seed was sown until the plants were removed to the open ground. Following is given the method used in producing the plants for each of the five experimental plots.

Plot 1.- The tomato seed were sown in rows six inches apart across the bed. When the first true leaves began to form, the plants were thinned to a distance of two inches apart in the row. They were then allowed to grow in the hotbed soil until set in the experimental field on May 18th. The root system was disturbed only when the plants were field set.

Plot 2.- The seed were sown in rows six inches apart across the bed. The young seedlings were transplanted into flats April 20th. Composted soil was used in the flats and the plants were set two inches apart. As the plants were removed from the hotbed, each

was lifted with a small ball of earth attached to the roots, so that a majority of the fine root hairs were not destroyed. After transplanting, the flats were placed in the hotbed and the plants left there until they were set. The roots were disturbed twice. (See Fig. 3).

Plot 3.- The seed were sown and the plants handled similar to those in plot 2 except that when the seedlings were transplanted into flats, they were pulled loose from the hotbed soil and not lifted. These plants lost a large portion of their roots at this transplanting. The root systems were disturbed twice. (See Fig.3).

Plot 4.- The plants grown in this plot were handled in the hotbed the same as in plot 2 except that they were transplanted twice into flats instead of once. The plants were lifted with soil attached each time, and the transplantings were done April 15th and 29th. At the second transplanting, the plants were taken from one flat and set into another. The roots were disturbed three times, twice when transplanted, and once when set in the field. (See Figs. 3 and 5).

Plot 5.- The plants for this plot were started by sowing the seed in four-inch dirt bands placed in the hotbed. Two seed were sown in each to insure a stand, and when three weeks old the plants were thinned to one in each band. The plants grew in the same soil

where the seed were sown until set in the field, when the dirt band, soil and plant were removed intact and set in the desired location. The roots were disturbed in no way whatever.

Table I.- Giving dates of sowing seed in the hotbed, transplanting into flats and setting in the field for the tomato plants grown in each of the five experimental plots.

Plot	Seed sown in hotbed	Transplanted into flats	Set in field
1	March 25	Not transplanted	May 18
2	March 25	April 20 (with soil)	May 18
3	March 25	April 20 (pulled)	May 18
4	March 25	April 15 and 19 (with soil)	May 18
5	March 25	Grown in dirt bands, not transplanted.	May 18

SETTING PLANTS

The land was thoroughly fitted and marked off in check rows five by five feet apart. A trench four inches deep was then made along the rows in one direction, and the plants immediately set (See Fig. 2). All plants set in each of the five plots, grown as previously mentioned, were removed from the hotbed with a ball of earth attached to the roots. The plants with the soil were placed in carriers and dropped where they were

to be grown. A worker followed and set each by hand, using only moist soil around the roots.

CULTIVATION

Immediately after the plants had been set, the land was cultivated to loosen the packed soil. The plots were kept free from grass and weeds throughout the season. As long as the distance between the vines permitted, a horse cultivator was used in cultivating. During the remainder of the season the soil was kept in condition by hand hoeing. Considerable care was taken to prevent the formation of a crust after rains, and to maintain a dust mulch at all times.

PICKING AND GRADING

The fruit was picked every other day during the heavy bearing season. At each picking the vines were examined carefully and all red ripe fruits were gathered.

In grading, the sound, smooth tomatoes, free from cracks, and not under size, constituted the first grade. Those that were inferior to the above in size, or smoothness, or with slight cracks about the stems or apex of the fruit, were classed as seconds. Immediately after picking, the fruits were graded and weighed. All decayed fruits were discarded.

TEMPERATURE AND RAINFALL

As shown in Table II, the temperature during 1911 was ideal in April and May for the growth of the plants. During the latter part of June and early July, the temperature ranged from 90° to 104° F., accompanied by a very light rainfall, which reduced the yields materially. The temperature and rainfall in August and September were more favorable and the vines bore heavily until frost. The total rainfall from April 1 to October 1, was 18.81 inches, which would have proven an ample supply, if it had been more evenly distributed.

Table II.- Average temperature and amount of rainfall from April to October 1911.

Month	Temperature, F.			Rainfall
	Av.Mean	Maximum	Minimum	
April	49.36°	72°	26°	3.86 inches
May	67.30°	96°	31°	2.35 inches
June	74.30°	101°	49°	2.10 inches
July	75.50°	104°	46°	2.96 inches
August	72.40°	99°	48°	2.71 inches
September	67.90°	92°	45°	4.83 inches

PART I.

EFFECT OF TRANSPLANTING ON ROOT AND STEM GROWTH.

The development of the roots and stems of several tomato plants grown similar to those planted in each of the five plots were carefully examined on May 18th, at which time the plants were transferred from the hotbed and set in the open ground. Especial attention was given to the length, stockiness and strength of stem, size of the root system, and the development of the flowers and fruits. The condition of the plants set in each plot, and the effect of the change to the open ground upon their immediate development, was as follows:

Plot 1.- The stems of the plants set in this plot were ten and twelve inches long, of a pale color beneath the leaves, rather slender and soft. A few flowers had formed and were beginning to open. The roots had spread to a considerable distance in the hotbed soil and when taken up for setting at least one-half of the roots were broken off. When set in the field, the plants wilted considerably, and it took them six to eight days to attach themselves to the soil and begin growing. Some of the plants were so slender and top-heavy that they were broken over by the wind and had to be re-set.

Plot 2.- The stems of the plants grown in

this plot were 6 to 8 inches high, a dark green color, stocky, and somewhat woody at the base. A few flower clusters had just begun to form. The roots were bunched more than in plot 1, only about one-fourth of them being torn away when removed from the flats and set. There was but little wilting when the plants were placed in the open ground and they commenced growing on the third or fourth day from setting. There was no wilting of plants or breaking of the stems by the wind. (See Fig.8)

Plot 3.- The plants in this plot were similar to those in plot 2 at the time the plants were set in the experimental plots. (See Fig. 9).

Plot 4.- The stems were slightly shorter than those set in plot 2 and somewhat stockier and stronger. A few flower buds had formed. Approximately one-fifth of the root system was lost when the plants were removed from the flats and set. The plants withstood the shock of transplanting better than those in any of the preceding plots. (See Fig. 4).

Plot 5.- The stems averaged 8 to 10 inches in length, were stocky, strong and woody at the base. The plants were well formed and had a few fruits on them from one-fourth to one-half inch in diameter. The root systems were the largest of any of those set in the five plots. The roots had grown to the sides of the dirt bands and turned backward into the soil

within. When set outside, no roots were injured and the plants began growing immediately. (See Fig. 7).

PART II.

EFFECT OF TRANSPLANTING ON EARLINESS OF BEARING AND TOTAL YIELD.

The tomato is a warmth loving plant, its native habitat being in the warmer parts of South America. Under these natural conditions, the plant is a perennial and lives from eighteen months to two years. The bearing season of the tomato in its wild state extends over a period of one year, and the plant produces until it is entirely exhausted. In our own climate, the tomato is an annual, since it is killed by frost, which very greatly curtails its bearing season. The limits of the growing season in the open air for the tomato in this climate is the last frost in spring and the first in the autumn. This varies from five and one-half to six months, which is too short a time in which to grow a paying crop. In order to lengthen the season, tomato plants are started in a hotbed in March and carried along under artificial conditions by the gardener until the weather is settled and warm, when they are set outside. The handling of the seedling plants in the hotbed is a very important factor in the production of maximum yields. Just how important, the following tables and discussions will tell.

TABLE III.- Daily yield record for plot 1.

Date Picked	Weight	
	Firsts	Seconds
July 19	.37 lbs.	
July 25	.5 lbs.	
August 4		.5 lbs.
August 7		.25 lbs.
August 10	6.5 lbs.	
August 14	5. lbs.	
August 16	4.5 lbs.	
August 21	11. lbs.	.5 lbs.
August 26	8.5 lbs.	
August 30	14.25 lbs.	1.25 lbs.
Sept. 2	3.75 lbs.	.5 lbs.
Sept. 6	32. lbs.	3. lbs.
Sept. 9	32.5 lbs.	1.5 lbs.
Sept. 13	10.75 lbs.	.25 lbs.
Sept. 19	8.5 lbs.	.5 lbs.
Sept. 27	5. lbs.	1.25 lbs.
Oct. 3	9.75 lbs.	1. lbs.
Oct. 11	13.5 lbs.	1. lbs.
Oct. 19	42. lbs.	4. lbs.
Total	208.37 lbs.	15.5 lbs.

EARLINESS OF BEARING

In Tables III to VII inclusive are given the daily yields of tomatoes harvested from each of the five plots. From these tables it will be noted that the first ripe fruit was picked from plot 5 on July 14, fifty-seven days from the time the plants were set in the field, and one hundred ten days from the date of sowing the seed in the hotbed. The plants grown in plot 5 were started by sowing the seed in dirt bands, and the roots were not disturbed at any time in their growth, and consequently were not checked when set. The early bearing in this plot was largely due to the fact that they did not have to overcome the shock of transplanting, as did those in the other plots. The plants grew without interruption from seeding until harvesting time.

Plot 4, set with plants that had been transplanted twice in flats in the hotbed, was the second earliest bearer, the first ripe fruits being picked on July the 17th, three days later than plot 5.

Plot 1 was third producing its first ripe fruit July 19th; plot 3 fourth, and plot 2 fifth, its first ripe fruits being gathered on July 29th. This made a difference of fifteen days between the earliest and latest plots to come into bearing, due entirely to the treatment the plants received in the hotbed.

TABLE IV.- Daily yield record for plot 2.

Date Picked	Weight	
	Firsts	Seconds
July 29	.5 lbs.	
August 1	1.5 lbs.	.5 lbs.
August 4	.75 lbs.	.25 lbs.
August 7	1.5 lbs.	.5 lbs.
August 10	7. lbs.	.5 lbs.
August 14	5. lbs.	
August 16	2. lbs.	.5 lbs.
August 21	6.5 lbs.	1.5 lbs.
August 26	18. lbs.	1. lbs.
August 30	13.5 lbs.	.25 lbs.
Sept. 2	8.5 lbs.	1.5 lbs.
Sept. 6	44. lbs.	3.75 lbs.
Sept. 9	29.25 lbs.	2.75 lbs.
Sept. 13	20.75 lbs.	.75 lbs.
Sept. 19	3.5 lbs.	.25 lbs.
Sept. 27	3.75 lbs.	.25 lbs.
Oct. 3	8.5 lbs.	.75 lbs.
Oct. 11	8.75 lbs.	.75 lbs.
Oct. 19	21.5 lbs.	2.5 lbs.
Total	204.75 lbs.	18.25 lbs.

In Table VIII is given the yield that was taken from each plot by July 31 and August 31, which are more valuable data from the standpoint of earliness of bearing than the date of the first picking of ripe fruits. It is seen in this table that up to and including July 31, plot 5 had borne fruit at the rate of .5 tons per acre and plot 2 .021 tons per acre, being the highest and lowest yielders respectively. Plot 4 was second with a yield of .36 tons, plot 3 third with .043 tons, and plot 1 fourth with .037 tons per acre.

The yield data given under August 31 in Table VIII shows distinctly the effect of transplanting upon earliness of bearing. On this date plot 5 ranks first with a yield of 6.16 tons and plot 4 second with a yield of 4.29 tons per acre. Plot 3 is third with 3.29 tons, plot 2 fourth with 2.76 tons and plot 1 fifth with a yield of 2.31 tons per acre. From the standpoint of earliness, the preceding ranking is the most valuable of the three and represents the placing of each of the five methods of starting tomato plants from the standpoint of early fruiting. The order is as follows:

First- Plants started in dirt bands.

Second- Plants transplanted twice into flats.

Third- Plants transplanted once into flats, pulled.

Fourth- Plants transplanted once into flats, with soil attached to the roots.

Fifth- Plants grown in hotbed soil, not transplanted.

TABLE V.- Daily yield record for plot 3.

Date Picked	Weight Firsts	Seconds
July 25		.5 lbs.
July 27	.5 lbs.	
August 1	1.5 lbs.	.37 lbs.
August 4	1.12 lbs.	.75 lbs.
August 7	.5 lbs.	.62 lbs.
August 10	4. lbs.	.75 lbs.
August 14	10. lbs.	1.75 lbs.
August 16	3. lbs.	.5 lbs.
August 21	8. lbs.	.75 lbs.
August 26	18.75 lbs.	1.25 lbs.
August 30	19.5 lbs.	1.5 lbs.
Sept. 2	6. lbs.	1. lbs.
Sept. 6	39.5 lbs.	3.5 lbs.
Sept. 9	39. lbs.	2.25 lbs.
Sept 13	12. lbs.	
Sept. 19	4.75 lbs.	.25 lbs.
Sept. 29	3. lbs.	.25 lbs.
Oct. 3	5.5 lbs.	.5 lbs.
Oct. 11	10.5 lbs.	1.5 lbs.
Oct. 19	23. lbs.	2.5 lbs.
Total	210.12 lbs.	20.5 lbs.

TOTAL YIELD

The yields of ripe and green fruits harvested from each of the five plots are given in Table IX. The weight of green fruits given for each plot was secured by picking all the green fruits on the vines after the first killing frost.

Plot 5 leads with a yield of 9.07 tons per acre of green fruits, and 14.93 tons of ripe fruits, making a total yield of 24 tons per acre. It exceeded the highest yield of any of the other plots by 3.51 tons of ripe fruits and 2.09 tons of green fruits per acre. This record places this method of starting tomato plants, where the roots are never disturbed, in a class by itself, and proves it to be the most desirable practice.

Plot 4 ranks second, which indicates that two transplantings are more desirable than one. Of those that were transplanted once into flats with soil attached to the roots and those that were pulled when transplanted, it is seen that the latter method used in plot 3 produced .33 tons more tomatoes than did plot 2. Plot 1 bore a slightly larger crop than plot 2 but when it is considered that unfavorable weather conditions at setting time will cause many plants to perish, when grown as were those in plot 1, it can be seen that the manner of growing as used for plot 2 is the more desirable.

TABLE VI.- Daily yield record for plot 4.

Date Picked	Weight	
	Firsts	Seconds
July 17	.62 lbs.	
July 19	3.75 lbs.	
July 22	1. lbs.	1.5 lbs.
July 25	1.25 lbs.	
July 29	.25 lbs.	
August 1	2. lbs.	.87 lbs.
August 4	.5 lbs.	1. lbs.
August 7	2.25 lbs.	
August 10	8.75 lbs.	
August 14	14.25 lbs.	2.25 lbs.
August 16	7. lbs.	.75 lbs.
August 21	11. lbs.	1.5 lbs.
August 26	20.5 lbs.	2.5 lbs.
August 30	14. lbs.	1.75 lbs.
Sept. 2	9. lbs.	.5 lbs.
Sept. 6	40.5 lbs.	7. lbs.
Sepb. 9	36.75 lbs.	2.25 lbs.
Sept. 13	16. lbs.	1.5 lbs.
Sept. 19	5.25 lbs.	1.25 lbs.
Sept. 27	4. lbs.	1. lbs.
Oct. 3	5.25 lbs.	.5 lbs.
Oct. 11	7.75 lbs.	1. lbs.
Oct. 19	21.5 lbs.	2.5 lbs.
Total	232.62 lbs.	29.62 lbs.

TABLE VII.- Daily yield record for plot 5.

Date Picked	Weight	
	Firsts	Seconds
July 14	1.5 lbs.	
July 17	1.75 lbs.	.62 lbs.
July 20	1.93 lbs.	1.13 lbs.
July 22	1.49 lbs.	1.25 lbs.
July 29	1.44 lbs.	.66 lbs.
August 1	3.5 lbs.	1.36 lbs.
August 4	5.36 lbs.	1.13 lbs.
August 7	4.25 lbs.	.25 lbs.
August 10	15.75 lbs.	2. lbs.
August 14	23.5 lbs.	1.5 lbs.
August 16	7.75 lbs.	
August 21	12. lbs.	.25 lbs.
August 26	21.75 lbs.	.5 lbs.
August 30	28.5 lbs.	.5 lbs.
Sept. 2	7. lbs.	.75 lbs.
Sept. 6	50.75 lbs.	4.25 lbs.
Sept. 9	54.5 lbs.	4.25 lbs.
Sept. 13	20.5 lbs.	1.5 lbs.
Sept. 19	9.75 lbs.	.25 lbs.
Sept. 27	4.5 lbs.	.75 lbs.
Oct. 3	3.75 lbs.	.25 lbs.
Oct. 11	11. lbs.	1. lbs.
Oct. 19	24. lbs.	2.5 lbs.
Total	316.22 lbs.	26.64 lbs.

The total yield of ripe and green fruits secured from plots 1, 2, 3, and 4, as given in Table IX, are approximately the same while the yield of ripe fruits varies.

Table VIII.- Giving the date of picking the first ripe fruit and the calculated yield per acre of fruit harvested from plots 1 to 5 at the end of July and August.

Plot	First Ripe Fruit	Yield, Ripe Fruits to July 31	August 31
1	July 19	.037 Tons	2.31 Tons
2	July 29	.021 Tons	2.76 Tons
3	July 25	.043 Tons	3.29 Tons
4	July 17	.36 Tons	4.29 Tons
5	July 14	.5 Tons	6.16 Tons

These four methods of starting the plants had little effect upon the total crop borne by each plot, but did affect the amount of ripe fruits harvested. That is, the larger the yield of ripe fruits, the smaller the amount of green fruits left after frost. With these four plots the manner of starting the young tomato plants in the hotbed had little effect upon the total yield, but did cause more fruits to ripen on some plots than did on others previous to frost.

The dates upon which the highest yields were harvested are about the same being Sept. 9 for plots 1

and 5, and Sept. 6 for plots 2, 3 and 4. The amounts picked on a one-acre basis from each of the five plots upon these dates varied from 2.55 tons, taken from plot 5 to 1.52 tons taken from plot 1. Plot 2 produced 2.07 tons; plot 4, 2.06 tons; and plot 3, 1.87 tons per acre upon their heaviest yielding dates.

TABLE IX.- Calculated yield per acre of ripe fruit, green fruit picked after frost and the total yield harvested from the five plots of tomatoes set with plants started in various ways.

Plot	Yield Per Acre		
	Green	Ripe	Total
1	6.72 Tons	9.75 Tons	16.47 Tons
2	6.98 Tons	9.71 Tons	16.69 Tons
3	6.42 Tons	10.04 Tons	16.46 Tons
4	6.09 Tons	11.42 Tons	17.51 Tons
5	9.07 Tons	14.93 Tons	24.00 Tons

The ranking of the five plots from the standpoint of ripe fruits produced is as follows:

First - Plot 5. Plants started in dirt bands and not transplanted.

Second-- Plot 4. Plants transplanted twice into flats, with soil attached to the roots.

Third - Plot 3. Plants transplanted once into flats, pulled.

Fourth - Plot 1. Plants grown in the hotbed soil, not transplanted.

Fifth - Plot 2. Plants transplanted once into flats with soil attached to the roots.

SUMMARY

Part I.

1. Tomato plants started in hotbed soil and not transplanted previous to setting in the field were tall, spindling and tender. Fifty per cent of the roots were broken off and the plants wilted considerably when set.
2. Plants transplanted once with soil attached to the roots were rather stocky, strong and wilted but little at setting time.
3. Plants transplanted once into flats and pulled loose from the soil in the hotbed were apparently in the same condition when set in the field as those that had soil attached to the roots when transplanted.
4. Plants transplanted twice into flats were stockier, the stems somewhat larger and of a more woody growth than those transplanted but once. They were also checked less at setting time.
5. Plants that were started in dirt bands and had their roots disturbed at no time in their growth were stocky, well formed and did not stop growing when set.
6. Transplanting tomato plants into flats had a tendency to bunch the roots and accustom the plants to the change when field set, so that the growth was checked much less than was the case with the plants that were not transplanted.

Part II.

7. Tomato plants grown in dirt bands and not transplanted, produced earlier and larger yields than any of the five methods tested.
8. Plants that were transplanted twice into flats, bore larger and earlier crops than those that were transplanted once.
9. Tomato plants pulled loose from the hotbed soil when transplanted, and a large portion of the root system destroyed, produced earlier and larger yields than those that were lifted with soil attached and a considerable portion of the root system retained.
10. Transplanting caused a greater amount of fruits to ripen before frost, but did not materially increase the total production of ripe and green fruits.
11. If the root system of the tomato plant is not disturbed throughout its growth, it will bear the largest and earliest crop.
12. If tomato plants are started in such a way that the root system must be disturbed when the plants are set in the field, transplanting once or twice will cause the production of a larger yield.

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Fig. 1,- Tomato Experimental Plots,
Purdue University, 1911.

Fig. 2,- Experimental Plots with rows furrowed out for setting tomato plants.

Fig. 3,- Size and condition of tomato plants at the time of first transplanting into flats. Those at the left were pulled. Those at the right were lifted with soil attached to the roots.

Fig. 4,- Size and condition of tomato plants at time of setting in the field, which had been previously transplanted twice into flats. (Plot 4).

Fig. 5,- Size and condition of tomato plants at time of second transplanting into flats.

Fig. 6,- Showing method of removing tomato plants from flats with soil attached to the roots at time of setting in the field.

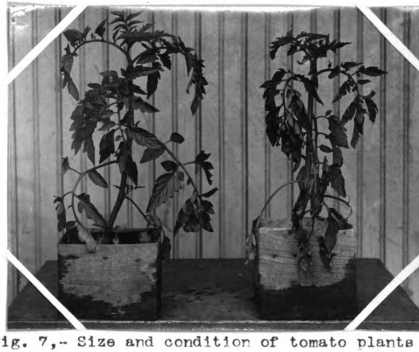

Fig. 7,- Size and condition of tomato plants at time of setting in the field which had been previously grown in dirt bands. (Plot 5).

Fig. 8,- Size and condition of tomato plants at time of setting in the field, which were previously transplanted once into flats, with soil attached to the roots. (Plot 2).

Fig. 9,- Size and condition of tomato plants at time of setting in the field, which were previously transplanted once into flats, pulled. (Plot 3).

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