

FACTORS FAVORING OR OPPOSING INJURIES FROM
TRANSPLANTING.

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FACTORS FAVORING OR OPPOSING INJURIES FROM
TRANSPLANTING.

Introduction

Transplanting, no matter how carefully done, results in a greater or less shock to the plant moved. The change in environment is frequently a radical one, and root mutilation is bound to occur no matter how much care is exercised.

In the commercial culture of certain vegetables, transplanting is essential. Some, for instance, the slow growing vegetables, cannot be grown except in restricted localities, unless seeding under cover and transplanting are practiced. Others are so tender in their early stages that they must be started in a special seed-bed, and given special treatment for a preliminary period, in order to make their later field culture successful.

It is a matter of common knowledge that the various species differ in their response to the shock of transplanting. In some species, transplanting serves as a stimulus to earlier maturity or to heavier production or to both; in others it serves as a distinct setback and although the growth of the plants themselves may not be visibly affected in all cases, yet their yields are materially reduced. Between these two classes lie some vegetables that may be transplanted with good effect, provided the work is properly done.

In the commercial growing of seedlings which are to be transplanted, it is customary to force rapid growth, thus securing large succulent plants. To that end, seeds are started under optimum temperature in a well enriched seed-bed and lavishly watered. Water of proper temperature and in sufficient quantity is necessary in starting the embryo within the seed, but once the radicle takes hold, heavy watering is non-essential and may actually be harmful. Plant-food and moisture being at hand, the rootlets need not go in search of them; their ramification is inhibited, in consequence. The top, on the other hand, is encouraged to make rapid growth, by these very conditions, and disparity between top and root development results. A plant so constituted is poorly fitted to cope with conditions such as it is likely to find in the field, even though moving it to field conditions were all that happened when transplanting was done. When it is borne in mind that, in addition to having to adjust itself to changed conditions, the plant must repair root mutilation incident to transplanting, it will be realized that the handicap is not inconsiderable.

It is the custom to prepare all plants for the shock of transplanting, by some form of treatment to adapt those which are succulent as a result of having been grown in a favorable environment, to more severe conditions of the field. In fact, horticultural writers, and commercial growers agree, generally, that this treatment, known commonly as "hardening-off", is employed to act as a bridge between

the early treatment a seedling receives, and that which it is likely to encounter when set outside. Accordingly, those crops which are usually transplanted early in the season are fitted for withstanding low temperatures; those generally transplanted later, for surviving drought and sustained high temperatures. In the process of hardening-off, the plants are subjected to progressively lower temperatures, until outside temperature is reached. Simultaneously, water is withheld to a greater or lesser degree. The conventional "hardening-off" period lasts approximately two weeks. While this period gives the plant opportunity for some adjustment, yet the question arises as to whether a longer period during which moisture is withheld might not better fit the seedling both for the shock of transplanting, and for later unfavorable conditions, than does the comparatively short drying period included in the customary "hardening-off" interval.

Object of the Investigation

The purpose of this investigation was to determine the factors favoring or opposing the injuries following the transplanting of vegetables. The factors dealt with in this study were as follows:-

- (a) The relation of moisture supply to growth and successful transplanting of seedlings.
- (b) The character of the soil as determining its suitability for seeding and for transplanting, with reference to:-
 1. Fertility, and,
 2. Physical Condition.

Literature

Before attempting the discussion of the data collected during this investigation, it seems desirable to assemble a brief review of the literature bearing on the subject.

Discussions of plant handling agree on the necessity for such a process as "hardening-off", and they agree on the gradual lowering of the temperature as part of that process. Some mention is made of the advisability of withholding water during this period to induce slow growth and the resultant stockiness of plants.

Adams¹ says that plants, before transplanting, must be acclimated to outside conditions, and suggests that the "hardening-off" process is accomplished by gradually raising the sash (of the hotbed). Sprague²⁰ and Bouquet³, in a cursory way, merely suggest the raising of the sash on favorable days. Beattie² says that "if plants are young and very tender, it will be important to avoid too great a degree of moisture. Serious losses from 'damping-off' often result from excessive moisture, especially at night". He says, further, that keeping the temperature down, by ventilation, will go far in producing sturdy, thrifty plants that will bear shifting well. Dacy⁷ is more specific, in that he

1-Adams, C. S., Ky. Expt. Sta. Cir. 11 (1916)

20-Sprague, C. B., Wash. Expt. Sta. Pop. Bult. 98 (1916)

3-Bouquet, A. G. B., Ore. Extens. Club Cir. 4 (1915)

2-Beattie, W. R., Farmers' Bult. 460 (1911 & 1915)

7-Dacy, A. L., West Va. Expt. Sta. Cir. 13 (1915)

says:- "if the young plants are grown too fast by giving water too freely, or by keeping the temperature too high, they will be tender and succulent and easily injured, if not killed, by the trying conditions they are subjected to in early spring. It is the custom among gardeners, therefore, to keep plants growing at a moderate rate, and to harden them in preparation for the shift to outside conditions. This process begins about two weeks before it is safe to set plants in the field, and consists in reducing the amount of water given to just enough to keep them from wilting, increasing the amount of ventilation and subjecting them to low temperatures".

Textbooks in vegetable gardening discuss the matter in much the same way. Watts²² says of "hardening-off":- "This process is the firming of tissue to protect plants against hardships of transplanting freezing, hard drying winds or hot sunshine. Plants are hardened by watering sparingly, subjecting them to low temperatures and providing free ventilation. When hardening is begun, no more water should be used than is necessary to prevent serious wilting." Even here the hardening is to be done within a certain period, though the length of that period is not specified. Green¹⁰ says:- " 'Hardening-off' is a term used to denote the checking of the growth of plants in such a way as to cause their tissues to become firm and hard. It is accom-

22-Watts, R. L., "Vegetable Gardening" (1913)

10-Green, Samuel B., "Vegetable Gardening (1914)

plished by gradually subjecting them to a lower temperature than that in which they grew freely, or by drying them a little, thus finally nearly checking their growth." Lloyd¹⁵ in speaking of growing cabbage plants, says:- "They are simply hardened off in the bed, since the heat of the manure in the hotbed will have been spent, or the fire can be withheld." For tomatoes:-"as the time for transplanting approaches, the plants should be gradually hardened-off so that they will be making a slow, hard growth rather than a rampant, sappy one, at the time they are placed in the open." Boyle⁵ says, under "hardening-off", that it is accomplished by subjecting plants to cool temperatures and sometimes by withholding moisture. The hardening off process is begun about two weeks before the plants are to be set in the open, and is accomplished by reducing the temperature gradually, until the temperature of the hotbed or coldframe is the same as that outside."

The views on hardening-off plants held by successful growers of vegetables on a commercial scale are of interest in this connection. Pearce¹⁸ says:-"I harden the plants gradually. The first step is transplanting to the coldframe. At first I cover the frames with mats....then I leave off the mats. Towards the end of their time in the coldframe, I leave off the sash except at night. Also, I withhold water a short time before transplanting." Daggett⁸ says, of this matter:†

15-Lloyd, J. W., "Productive Vegetable Growing" (1914)

5 -Boyle, J. G., "Vegetable Growing" (1917)

18-Pearce, R. D., Market Growers' Journal, Jan.1, 1917.

8 -Daggett, F. E., Ibid.

"We sow our seed working for a slow, stocky growth." Continuing, he says, "The plants are set in the field "after being well hardened-off by being left out a few nights without protection." Orr¹⁷ apparently does nothing further than withhold water "for three days before transplanting."

In general, these authorities agree that a reduction of temperature should take place, although the period for such reduction varies. The practice of withholding water is mentioned only incidentally in these discussions. As bearing on the importance of this phase of the treatment, Chandler⁶ found that plants grown "dry" withstood lower temperatures than did succulent plants grown at the same temperatures but with a liberal supply of water. He found, further, that it required a lower temperature to kill cabbage plants grown "dry" in a warm greenhouse, than for cabbage plants wintered-over in the field, where they had an abundance of water. This would make it appear that the effective part of "hardening-off" is the "dry" culture.

Withholding water results in an increased sap density, which materially lowers the freezing-point of the sap and the death-point of plants. It should be possible to make plants more resistant to cold by withholding moisture. Chandler⁶ found, however, that this does not hold true beyond certain limits, and Harris¹² and Popenoe¹⁹ reached sim-

17-Orr, Emmett, Market Growers' Journal, Jan.1, 1917.

6 -Chandler, W. H., Mo. Res. Bult. 8 (1913)

12-Harris, J. A., Jour. Agr. Res., VII, 6 (1916)

19-Popenoe, Wilson, Ibid.

ilar conclusions. The latter investigated physical differences in an attempt to explain the various degrees in hardness of species of Avocado. They found differences in sap density corresponding, in a general way, with differences in hardness, but they concluded there are other factors making for hardness besides the low freezing point of cell sap.

A plant with dense sap should, because of its osmotic pressure, more readily imbibe soil moisture and nutrient solutions than a plant of lesser sap density. This feature might become an important one in case of drought, for such a plant might be able to subsist in a soil of much lower water content than a normal plant would. To secure this degree of density, however, Chandler⁶ found it necessary to grow the plants "dry" for a long period. Wilting for a short interval was not sufficient. The latter form of "drying" served, actually, as an additional shock to the plant, and plants so treated succumbed in greater proportion than those given any other treatment. Whether sap density so secured would persist and be effective for the plant later on is not certain.

The condition of plant sap, its abundance, and the rate of its flow, have long been believed to influence fruitfulness, but actual knowledge concerning the matter is comparatively recent. The ancients practiced mutilation of the trunks, shoots and roots of trees, which hastened or increased fruitfulness, but they probably knew nothing of the

6-Chandler, W. H., Mo. Res. Bult. 8 (1913)

philosophy of such treatment. It was not until 1710 that Van Oosten (quoted by Noehden¹⁶) advanced the opinion that fruitfulness is the result of the secretion of necessary substances, made possible by the retardation of the sap flow. This retardation, he points out, may be due to a variety of causes, but that it may be induced artificially, by transplanting.

Warder²¹ explains the reproductive activity of fruit trees towards the end of the growing season by the fact that there is a disturbance in balance between crude and elaborated sap, in favor of the latter. This condition he thinks is brought about by the scarcity of rainfall, resulting in a reduction in amount of inflow of crude sap. At the same time, the leaf area of the tree remains unchanged; carbon fixation goes on at a normal rate, and the result is the thickening of the sap, due to the accumulation of sugars. He adds that, in the autumn, the rootlets suffer from exhaustion, or at least they become lignified, and are probably made unable to take in soil moisture in a normal amount. The greater sap density results in reproductive, rather than in vegetative activity.

Fischer⁹ and Klebs¹⁴ bring out the fact that direct sunlight is contributory to fruitfulness, and Chandler⁶ has

16-Noehden, G. H., Hort. Trans. Vol. II (1817)

21-Warder, John, American Pomology, IX (1867)

9 -Fischer, H., Die Pflanze und das Licht.

14-Klebs, G., Willkuerliche Entwickelungsänderungen bei Pflanzen, II & III.

6 -Chandler, W. H., Mo. Res. Bult. 8, (1913)

shown that plants exposed to direct sunlight show increased sap density; dense sap is an accompaniment of increased yield apparently.

Winkler²³ explains the direct efficacy of increased density in sap by its restraining effect on a substance which he believes is an enzyme and which is responsible for vegetative activity in plants. With the activity of this enzyme inhibited the plant is enabled to fulfill its mission of reproduction.

23-Winkler, C. H., Doctor's Thesis, U. of Mo., (1916)

Method of the Investigation

The following species of vegetables were chosen for this investigation, since they are representative of the three classes as to their response to transplanting:-

1. Greenhouse lettuce, a leafy annual that bears transplanting well.
2. Greenhouse and field tomatoes, a fruit-vegetable which is grown to true maturity, and which is transplanted with more or less difficulty.
3. Field cabbage, a leafy biennial, hardy as to temperature, and easy to transplant.
4. Field peppers, a fruit-vegetable particularly tender and quite exacting in climatic and environmental requirements, and somewhat difficult to transplant.

Inasmuch as the commercial methods of raising plants vary between two rather wide extremes as to richness of seed-bed and method of watering, it was deemed wise to follow practices ranging between these two extremes, in the hope of finding the optimum. For this reason, the seed-beds used in this investigation ranged from one of pure sand to one of high plant-food content. The sand and the thinner mixtures were used to encourage development of extensive root systems, so as to determine whether a large initial root system is of value to the plant. The richer mixtures were used in order to determine whether plants with resulting scanty root systems were placed at a disadvantage by reason of this condition. Seed-beds of the various compositions were maintained in duplicate, one set kept "wet" enough to enable the

seedlings to grow vigorously; the other moistened sparingly and at intervals, preventing the plants from wilting. In this treatment, need for watering was indicated by a slightly flaccid condition of the plants in which state they felt velvety to the touch.

The transplanting media likewise ranged from a mixture low in plant food, to one highly fertile. Plants from every seed flat were set into each transplanting soil, in duplicate lots. Of these, one was kept "wet"; the other, "dry." As in the case of the seed-beds, the plants kept "wet" received the treatments gardeners generally accord the plants they grow for sale. The "wet" plants are accordingly the "checks" of the experiment.

When the plants for the crops to be matured in the greenhouse began crowding in the transplanting flats, they were set in the greenhouse benches. Those grown for field tests were shifted into coldframes from 4 to 6 weeks before transplanting. During the latter part of this interval, they underwent the customary treatment of "hardening-off", the coldframe sash being raised for progressively greater portions of the day until they were entirely removed, the plants having become gradually inured to outside temperature. At the same time, water was withheld except as the plants needed it. This latter phase of the "hardening-off" process, it will be observed, was not a change of treatment for the plants grown "dry"; they were simply continuing "dry".

Greenhouse Lettuce

The variety "Grand Rapids," a leaf lettuce, was chosen since it is adaptable to successful culture in soils such as the silt loam which abounds in the vicinity of Columbia, Missouri. The seed was sown October 4, 1916 in three kinds of seed-beds, of three very different mixtures, as follows:-

No. 1. Washed Missouri River sand,

No. 2. Sand and loam, equal parts,

No. 3. Sand, loam and manure, equal parts.

Two sets were maintained, one watered sufficiently to insure rapid growth, the other receiving simply enough moisture to keep the plants from wilting. The sand used, was washed river sand, practically devoid of plant food. The loam was silt loam, rather dense, but quite high in plant food content. The manure was well rotted horse manure. Throughout the work the endeavor was to follow established commercial methods.

On October 18, the seedlings were transplanted. At this time an appreciable difference between the root systems of the "dry" and "wet" plants was noted, those of the former being the more extensive. The tops of the "dry" plants, on the other hand, were very much smaller than were those of the "wet" ones. Of the "wet" set, those plants grown in the seeding mixtures in which manure was included, had the largest tops; those, in sand, the smallest. The intermediate seed-bed had plants of intermediate top-size. In the matter of size of root system, the plants in the sand

seed-bed led, the mixture without manure coming next. The mixture with manure contained the smallest root systems.

Of the "dry" flats, the mixture in which manure was included, contained plants whose top-size was very little, if at all, superior to those started in clean sand. This condition has been observed by farmers and by growers, in fields in which heavy manuring, particularly in dry seasons, has been done. The manure is moisture-absorbent, and, besides, renders the structure of the soil so open that it cannot retain moisture; plant-life is supported with difficulty, in consequence. The sand and loam seed-bed gave the largest-topped plants.

The transplanting media were as follows:-

No.1. Manure, one-half; loam, one-half.

No.2. Manure, one-third; loam, one-third; sand, one-third.

No.3. Manure, one-fourth; loam, one-half; sand, one-fourth.

Two sets of transplanting flats were used, one kept "wet", and the other, "dry". Complete lists of treatments employed are given on pages 16 and 17.

TABLE I

List of Treatments of Greenhouse Lettuce

Started in Seed-beds Kept "Dry".

Trtmt No.	Seed-bed	Transplanting Medium and Treatment.
1-	Sand	Manure (1/4), loam, sand; kept "dry".
2-	Sand, loam	" " " " " "
3-	Sand, loam, manure	" " " " " "
4-	Sand	Manure (1/3), loam, sand; kept "dry".
5-	Sand, loam	" " " " " "
6-	Sand, loam, manure	" " " " " "
7-	Sand	Manure (1/2), loam; kept "dry".
8-	Sand, loam	" " " " " "
9-	Sand, loam, manure	" " " " " "
10-	Sand	Manure (1/4), loam, sand; kept "wet".
11-	Sand, loam	" " " " " "
12-	Sand, loam, manure	" " " " " "
13-	Sand	Manure (1/3), loam, sand; kept "wet".
14-	Sand, loam	" " " " " "
15-	Sand, loam, manure	" " " " " "
16-	Sand	Manure (1/2), loam; kept "wet".
17-	Sand, loam	" " " " " "
18-	Sand, loam, manure	" " " " " "

The fractions in the brackets following the word "manure" indicate the proportion of manure the mixtures contained. (See page 15.) The relative amount of manure is taken to be a measure of the fertility of the transplanting medium.

TABLE II

List of Treatments of Greenhouse Lettuce
Started in Seed-beds Kept "Wet".

Trtmt No.	Seed-beds	Transplanting Medium and Treatment.
19-	Sand	Manure (1/4), loam, sand; kept "dry".
20-	Sand, loam	" " " " " "
21-	Sand, loam, manure	" " " " " "
22-	Sand	Manure (1/3), loam, sand; kept "dry".
23-	Sand, loam	" " " " " "
24-	Sand, loam, manure	" " " " " "
25-	Sand	Manure (1/2), loam; kept "dry".
26-	Sand, loam	" " " " " "
27-	Sand, loam, manure	" " " " " "
28-	Sand	Manure (1/4), loam, sand ; kept "wet".
29-	Sand, loam	" " " " " "
30-	Sand, loam, manure	" " " " " "
31-	Sand	Manure (1/3), loam, sand ; kept "wet".
32-	Sand, loam	" " " " " "
33-	Sand, loam, manure	" " " " " "
34-	Sand	Manure (1/2), loam; kept "wet".
35-	Sand, loam	" " " " " "
36-	Sand, loam, manure	" " " " " "

The fractions in the brackets following the word "manure" indicate the proportion of manure the mixtures contained. (See page 15.) The relative amount of manure is taken to be a measure of the fertility of the transplanting medium.

On October 29, five plants of each treatment were set in the greenhouse bench, which was filled with a mixture of equal parts of sand, screened loam and well-rotted manure. The soil in the bench was 7 inches deep. The greenhouse in which this investigation was conducted was held at a temperature somewhat above that required for lettuce, since the same house was used for wintering a miscellaneous collection of ornamental plants.

Observation of the plants at the time they were set in the bench disclosed that the plants which had been kept copiously watered invariably grew more rapidly than did those kept "dry".

Among the "wet" lots the rank in size of tops agreed with the amount of manure in the transplanting medium. Furthermore, among the several mixtures, the seedlings started in relatively thin mixtures grew better than did those whose seed-bed contained plant food in greater amount, regardless of the composition of the transplanting mixtures. The order of root-size remained unchanged.

Among the sparingly watered lots, the largest plants were found in the transplanting mixture containing the intermediate amount of manure. This observation agreed with that of a similar case in the seeding media. The rank of the plants as to size of top was somewhat changed, the seedlings started in rich and especially "wet" seed-beds falling behind; they suffered more from the check of "drying" in the transplanting stage than the plants from the "dry" seed-beds.

All the plants recovered from transplanting, but the large-leaved "wet" plants showed more wilting than the "dry" plants. There was also a greater loss of lower leaves in the "wet" class. Growth was resumed somewhat tardily among the plants from the "dry" lots. In less than four weeks, however, all differences in size of top were obliterated and the foliage completely covered the ground. At about this time evidence of mildew was observed. That portion of the bench which contained the plants from the "wet" flats was affected; the rest of the bench remained healthy. This disease is favored by high temperature and great humidity. The fact that the "dry" plants escaped might indicate that lettuce could be grown in a warm house by growing the seedlings "dry"; heating a lettuce house to conservatory temperature would not be an economical thing to do, however.

Soon after, the green aphid made its appearance and became established on the "wet" plants first. That this pest seemed to prefer the "wet" plants might be of economic significance, if this one instance may be considered representative. The house was fumigated with a tobacco preparation and the aphid checked.

On December 28, the entire crop was harvested. The harvesting record for the plants started in the "dry" seed-beds is given in Table III, on page 20; that for the "wet" seed-beds in Table IV, on page 21.

TABLE III

Harvesting Record for Greenhouse Lettuce started in Seed-beds
Kept "dry".

Trtmt No.	Marketable	Unmarktable	Total	%Mktable
1	511 gr	68 gr	579 gr	88
2	604	59	663	91
3	540	90	630	86
Totals	<u>1655</u>	<u>217</u>	<u>1872</u>	<u>88</u>
4	554 gr	74 gr	638 gr	87
5	641	111	752	85
6	660	130	790	84
Totals	<u>1855</u>	<u>315</u>	<u>2180</u>	<u>85</u>
7	640	52	692	92
8	602	64	666	90
9	622	66	688	90
Totals	<u>1864</u>	<u>182</u>	<u>2048</u>	<u>91</u>
10	459	99	558	82
11	475	114	589	81
12	486	158	644	76
Totals	<u>1420</u>	<u>371</u>	<u>1791</u>	<u>79</u>
13	567	110	667	84
14	616	140	756	82
15	531	118	649	82
Totals	<u>1714</u>	<u>368</u>	<u>2082</u>	<u>83</u>
16	532	105	637	84
17	755	105	860	88
18	612	110	722	85
Totals	<u>1899</u>	<u>320</u>	<u>2219</u>	<u>86</u>
Grand Totals)	10407	1773	12190	85

TABLE IV

Harvesting Record for Greenhouse Lettuce started in Seed-beds
Kept "wet".

Trtmt No.	Marketable	Unmarktable	Total	%Mktble
19	440 gr	112 gr	552 gr	80
20	545	99	644	85
21	518	62	580	89
Totals	<u>1503</u>	<u>273</u>	<u>1776</u>	<u>85</u>
22	675	108	783	86
23	584	115	699	83
24	590	47	637	93
Totals	<u>1849</u>	<u>270</u>	<u>2119</u>	<u>87</u>
25	542	62	604	90
26	815	106	921	89
27	840	75	915	92
Totals	<u>2197</u>	<u>243</u>	<u>2440</u>	<u>90</u>
28	406	110	516	79
29	296	90	386	77
30	348	109	457	77
Totals	<u>1050</u>	<u>309</u>	<u>1359</u>	<u>78</u>
31	470	118	588	80
32	460	122	582	79
33	400	115	515	78
Totals	<u>1330</u>	<u>355</u>	<u>1685</u>	<u>79</u>
34	555	95	650	85
35	530	125	655	81
36	550	118	668	87
Totals	<u>1635</u>	<u>338</u>	<u>1973</u>	<u>83</u>
Grand) Totals	9564	1788	11362	84

When grand totals are compared, it is seen that those treatments that included a seed-bed sparingly watered gave the highest yields, both gross and marketable.

Furthermore, treatments 7, 8 and 9; 25, 26 and 27; 16, 17 and 18; 34, 35 and 36, in which rich transplanting media were used, gave invariably better yields than did their parallel treatments in which the thinner transplanting media were employed.

In Table IV, record of the "wet" seed-beds, the highest-yielding group, by far, is that one comprising treatments 25, 26 and 27, which had as part the employment of a rich transplanting medium watered sparingly. The highest-yielding group of treatments among the "dry" seed-beds, is composed of treatments 16, 17 and 18, which included the employment of a rich transplanting medium watered copiously. The next best group is that one composed of treatments 7, 8 and 9, which is the group directly parallel with the one composed of treatments 25, 26 and 27 of the "wet" seed-beds. Closer scrutiny of the yields of treatments 16, 17 and 18, shows that this group owes its superiority to the abnormally high yield of treatment 17, as compared with the yields of both 16 and 18. The yields of the second group of the "dry" seed-beds (7, 8, 9) are consistently high throughout. This being the case, it would appear that the fact that the group composed of treatments 16, 17 and 18, led, may be discounted and that the conclusion that a rich transplanting medium kept "dry" is the best one to use, is not an illogical one.

As to what seed-bed to use, no very definite conclusion may be reached. In those treatments in which the seed-bed was sparingly watered, clean sand gave poor yields; where, however, water was applied in sufficient quantity, the yields were good. Summarizing Tables III and IV, studying the treatments in the groups into which they naturally fall (as to seed-beds), it is seen that:-

Sand, alone	gave best results in 5 cases.
Sand and loam	gave best results in 4 cases.
Sand, loam and manure	gave best results in 3 cases.

Summaries for Greenhouse Lettuce

The composition of the seed-bed does not appear to have much bearing on final results; it appears, though, that the seed-bed should be of low plant food content.

The amount of moisture to be applied to the seed-bed depends on its composition:- the richer, the less moisture.

The transplanting medium should be rich in plant food, and the amount of moisture applied should be the minimum on which a plant can make healthy growth.

Greenhouse Tomatoes

"Bonny Best Forcing", a standard variety for greenhouse culture, was used for the work. Eight treatments were used, as follows:-

Treatment No.	Seed beds	Transplanting Media	Moisture Treatments
1	Loam	Manure (1/2), loam;	"wet"
2	Loam	Manure (1/4), loam,	sand; "wet"
3	Loam	Manure (1/2), loam;	"dry"
4	Loam	Manure (1/4), loam,	sand; "dry"
5	Sand	Manure (1/2), loam;	"wet"
6	Sand	Manure (1/4), loam,	sand; "wet"
7	Sand	Manure (1/2), loam;	"dry"
8	Sand	Manure (1/4), loam,	sand; "dry"

The sand used in this experiment was clean Missouri River sand; the "loam" seedbed, a mixture of the following ingredients:-

Sand, one part
Manure, four parts,
Loam, three parts.

The transplanting media were made up as follows:-
Manure, one-half; loam, one-half, and,
Manure, one-fourth; Loam, one-half; sand, one-fourth.

The meaning of the words "wet" and "dry" have been explained in previous parts of the discussion and are herein used to convey the same sense.

The seed was sown January 16, 1916, in the greenhouse; all the seed-beds were kept moist. On January 31, the seedlings were transplanted, and, as anticipated, they were of two sizes. The seedlings standing in sand had smaller

tops than those grown in loam, yet the root systems of the former were much larger. All the seedlings endured the shift quite well. It was evident, however, that the plants which were started in sand resumed growth somewhat behind those grown in loam. Two weeks later, observation of the plants showed their rank as to height, largest to smallest, (the plants designated by their treatment numbers) to be:- 1, 2, 3, 5, 4, 6, 7, 8. That is, those plants that were set in the richer transplanting media, manure, one-half, grew more rapidly than those set in the thinner media, regardless of the difference in their root development at transplanting time. Furthermore, this growth was more rapid in those lots to which moisture was being applied in optimum amounts. On the contrary, those plants that were undergoing treatments 7 and 8, which included starting in a sterile seed-bed, and further checked by watering sparingly in the transplanting stage, made the slowest growth.

On February 22, observation of their rank in size of top was again made, and found to be:- 1, 5, 2, 6, 3, 4, 7, 8. The plants which were being copiously watered in the transplanting flats were continuing to make the most rapid growth, irrespective of the nature of their seed-beds. On this date, the "wet"-grown plants were potted; the soil mixtures and treatments remained unchanged. The "dry"-grown plants were potted on March 6.

On March 16, all plants were measured, the distance from their cotyledon scars to their tips being taken. The averages for each treatment are as follows:-

TABLE V

Plant-heights of the Various Treatments

Treat- ment No.	Height	Treat- ment No.	Height
1	38 mm	5	36 mm
2	34 "	6	31 "
3	29 "	7	28 "
4	21 "	8	22 "

This table shows that the plants from the richer transplanting media, copiously watered, had the largest tops regardless of the kind of seed-bed. (See Figs. T-1 and T-2, page 27.)

On March 20, the plants were set in the greenhouse. At this time, a representative of each treatment was selected, its sap expressed in the press described by Chandler in Missouri Research Bulletin No. 8, and frozen in the Beckmann apparatus, mentioned in the same work, in order to determine its density. The depressions of the freezing-points of the saps of the treatments follow, in their order.

TABLE VI

Sap-depressions of the Treatments, on Mar. 20, 1916

Treatment Number	Depressions	Treatment Number	Depressions
4	0.851	7	0.690
3	0.823	8	0.660
1	0.801	5	0.601
2	0.730	6	0.501



Figure T-1. The "wet" Plants at Setting



Figure T-2. The "dry" Plants at Setting

The greatest density occurred in the sap from plants started in loam and subjected to the "dry" treatment after transplanting. It is difficult to explain why plants in treatment 4 should have preceded 3, since the latter had the larger elaborating surface. It may be that, to induce increased sap density, more is gained by "drying" than by heavy feeding, to secure an increased carbon-fixing area.

On June 19, the leaf just above the second fruit-cluster was removed from one plant of each treatment, and the density of its sap determined. The data follow.

TABLE VII

Sap-depressions of the Leaf at Fruit-cluster #2

Treatment Number	Deprs'n	Treatment Number	Deprs'n
4	1.093	6	1.018
3	1.093	5	0.993
7	1.031	1	0.798
8	1.027	2	0.790

Comparing this table with the previous one, a few important changes are found to have taken place. The "dry" treatments (Nos. 4 and 3) maintained their greater density, but the "wet" treatments (Nos. 1 and 2) have decreased markedly. The "dry" treatments (Nos. 7 and 8) have increased quite distinctly, on the other hand. An explanation for the increased sap density of the "dry" treatments may lie in the fact of the lignification of their root systems, and to a consequent reduction in intake of crude sap. (Goffll makes

ll-Goff, E. S., "Principles of Plant Culture" III (1897&'16)

mention of lignification following desiccation.) It will be recalled (page 25) that resumption of growth among the "dry" plants was slower than that of those plants grown under the "wet" treatment. The same condition was observed when the sand-started seedlings were compared with those grown in the richer seed-bed. The table further shows that the first six treatments are so close that there is difficulty in placing them. It is quite likely that there is a tendency for differences at transplanting time to be lost, and that the sap density of the "wet"-grown plants is the point they all approach.

On July 7, the leaf above the fifth fruit-cluster of plants in each treatment was removed and the depression of the sap determined. The leaves just above fruit-clusters were selected in order to describe their location definitely and to secure comparable data by testing leaves equally near to clusters of fruit in similar stages of maturity. The data follow.

TABLE VIII

Sap-depressions and Green Weights of the Leaf at Fruit-

Treatment Number	Cluster #5	
	Depression	Green Weight
3	1.030	32.2 Grams
4	0.990	36.6 "
7	0.975	33.0 "
5	0.970	27.9 "
2	0.965	26.6 "
6	0.950	25.9 "
8	0.925	30.2 "
1	0.900	26.1 "

The weight of green leaves was recorded in order to determine correlation, if any existed, between the weight of leaves and the density of sap. While treatment 3 showed the greatest concentration of sap, yet the difference between it and the rest of the treatments is not particularly pronounced. The tendency for sap density to approach a common point appeared to persist. No correlation between sap density and green weight was found, because of the fact that the leaves of the "dry"-grown plants were, as a rule, smaller thicker and of a coarser texture than those of the "wet"-grown plants.

On August 1, the leaves just above fruit-cluster number 9 were taken in duplicate, and, in addition to the data secured in previous tests, moisture-free weights of leaves were secured. The records follow:-

TABLE IX

Sap-depressions, Green Weights, and Moisture-free Weights
of Leaves at Fruit-cluster #9

Treat- ment No.	Depressions		W e i g h t s		Percent of Dry Matter
	First Sample	Second Sample	Green	Dry	
3	0.785	0.767	28.0 Gr	5.96 Gr	21.2%
7	0.775	0.780	25.7 "	4.33 "	16.2
2	0.775	0.770	25.7 "	4.85 "	19.0
8	0.775	0.761	20.1 "	4.01 "	20.0
1	0.760	0.772	37.9 "	5.36 "	14.2
6	0.757	0.772	22.8 "	4.45 "	19.5
4	0.745	0.760	28.0 "	4.78 "	17.1
5	0.725	0.760	30.7 "	5.65 "	18.4

Again the order is seen to have changed to such an

extent that it is difficult to explain the change. It will be noticed, however, that if the method of bearing is considered, as will be done in succeeding pages, an explanation may be suggested.

For the time being, it may be said that the plants which appear to have the greatest sap density in table IX, are the ones that matured their fruits late. This apparently substantiates the point made by Winkler²³, that the greatest sap density is found in the region adjoining a fruit cluster just prior to its blooming, and that this condition disappears gradually as the ripening of the fruit proceeds. (See Footnote.)

Further study of Table IX shows that, for the leaves taken, at least, there is no correlation in any particular, between dry and green weights, sap density and percentage of dry matter.

Records of growth, taken week by week, were kept; these data are given in Table X, page 33, and graphically, in Chart "A", page 32.

²³-Winkler, C. H., Doctor's Thesis, U. of Mo. (1916)
NOTE:- It was hoped in the present experiment that the effect of bearing fruit could be avoided by waiting until the fruit in any-numbered cluster was at the same stage of ripening. This was almost wholly impossible, because of the difference in ripening behavior of the various treatments. By using leaves, similarly placed on the plants in question (the leaves thus representative of the plants, which could not be sacrificed) it was hoped to get data relative to the plants as a whole. Owing to the marked difference in bearing habit of the plants in this experiment, the data secured may hardly be considered comparable.

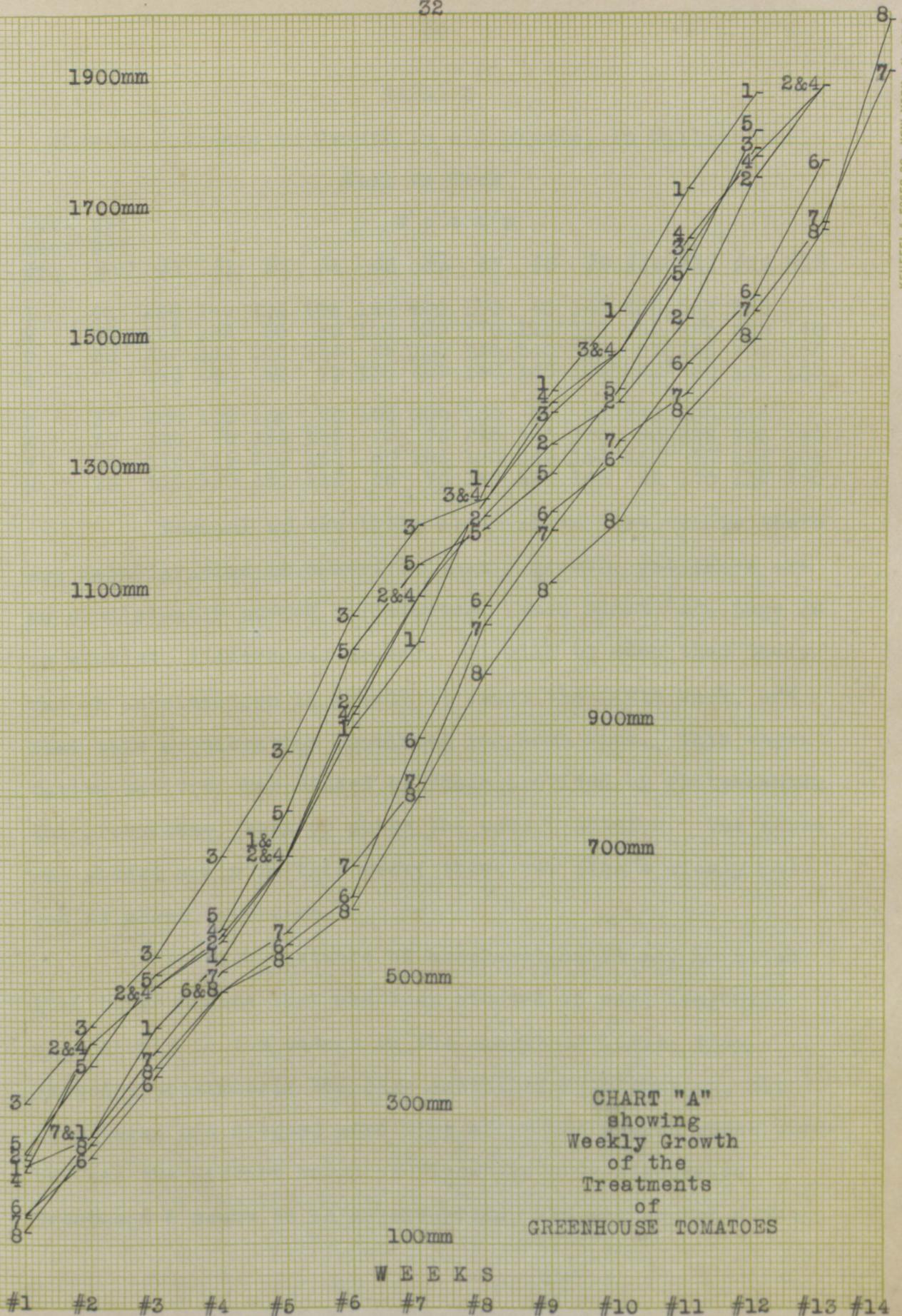


CHART "A"
 showing
 Weekly Growth
 of the
 Treatments
 of
 GREENHOUSE TOMATOES

TABLE X

Showing Increase in Growth in all Plants, in Millimeters,
Week by Week

Trt- ment Set No.	Hgt (mm)	W e e k s												
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
1	40	230	140	125	105	160	200	130	40	145	230	185	145	
2	34	195	185	85	80	120	230	170	125	110	65	125	215	140
3	30	290	120	105	155	65	105	140	240	135	95	155	155	100
4	22	195	200	85	70	130	220	180	125	105	70	80	165	135
5	37	200	140	130	70	185	250	130	55	85	130	180	215	
6	32	100	95	135	115	75	75	245	205	155	85	145	105	190
7	29	115	115	140	120	60	100	130	245	150	135	75	125	135
8	23	115	130	130	110	55	70	175	190	145	95	170	115	180

Perusal of the table above shows that, while there are peculiarities in amount of weekly growth, yet there are no consistently marked differences. When Chart "A", page 32 is studied, differences appear. It will be seen that there was an acceleration in growth at about the fifth week, and that this acceleration continued for some time. This vegetative activity was caused by shade provided by whitewashing the greenhouse. Week #8 shows the same condition. The house was shaded again in this week; there was also a cloudy period at about this time.

In each instance of acceleration it may be noted that those plants that had been started in sand responded more slowly to the change in the amount of light; they showed approximately the same amount of acceleration, but they began and stopped some time after the plants whose seedbed was the mixture known as "loam" in this discussion. Treatment 5 seems to be an exception, the reason for such

a condition being obscure.

All plants were pruned to a single stem, and the branch shoots cut out weekly. The prunings were weighed and records were kept to discover if there exists correlation between the growth rate of branch shoots and that of the main stalk. No such correlation was found. Shading at various times, mentioned on page 33, had quite as much to do with rapid growth of axillary shoots as it had with that of the tips of the plants. So far as could be determined, all treatments of plants were similarly affected.

A record was kept of the number of basal leaves it was found necessary to remove. Leaves that were 50% shriveled, and whose yellowed petioles parted readily from the stalk with a clean break, were considered as useless to the plant. Those removed from the bases of the plants for ventilation, were not included.

This record, compiled week by week, gave no tangible data, since the leaves were not "shed" with any regularity, yet when totals are examined, it appears as if the treatment has much to do with the persistence of foliage of tomato plants. The records of leaves removed follows:-

TABLE XI

Treat- ment.	Leaves shed per Plant.	Treat- ment	Leaves shed per Plant.
1	9	5	7
2	6	6	6
3	7	7	4
4	4	8	4

The order does not occur as might be expected. However, the "dry" plants appear to have the greatest persistence, particularly those grown in sterile, or relatively poor media.

While pruning, it was evident that some plants were prone to leafiness of clusters. At first, this phenomenon was considered evidence of carelessness in "roguing" the seed plants by the seed grower. When this condition was found to persist only in certain lots of plants, a record of the leaves removed was taken. On the most checked treatment, #8, the clusters were leafy without exception, whereas in treatment #1, the one receiving optimum treatment throughout, but two clusters of a total of 36 were leafy. The intermediate treatments bore an intermediate number of leafy clusters, but the percentage of their occurrence did not follow any very specific order.

The significance of the leafy clusters is not altogether plain, except that leafiness at this point may be a sign of fruitfulness, something of a paradox. Comparing the yields of the various treatments it is found that those treatments that bore most heavily, had the greatest number of leafy clusters. The rank in leafiness does not agree strictly with that in yield, however.

Records of blooming were kept, the date of the opening of the first blossom being recorded. The data are given in graphical form in Chart "B", page 36. A significant fact is the tending of the lines to converge at the 9th

June 25

June 20

June 10

May 31

May 21

May 11

May 1

April 21

April 11

April 1

March 20

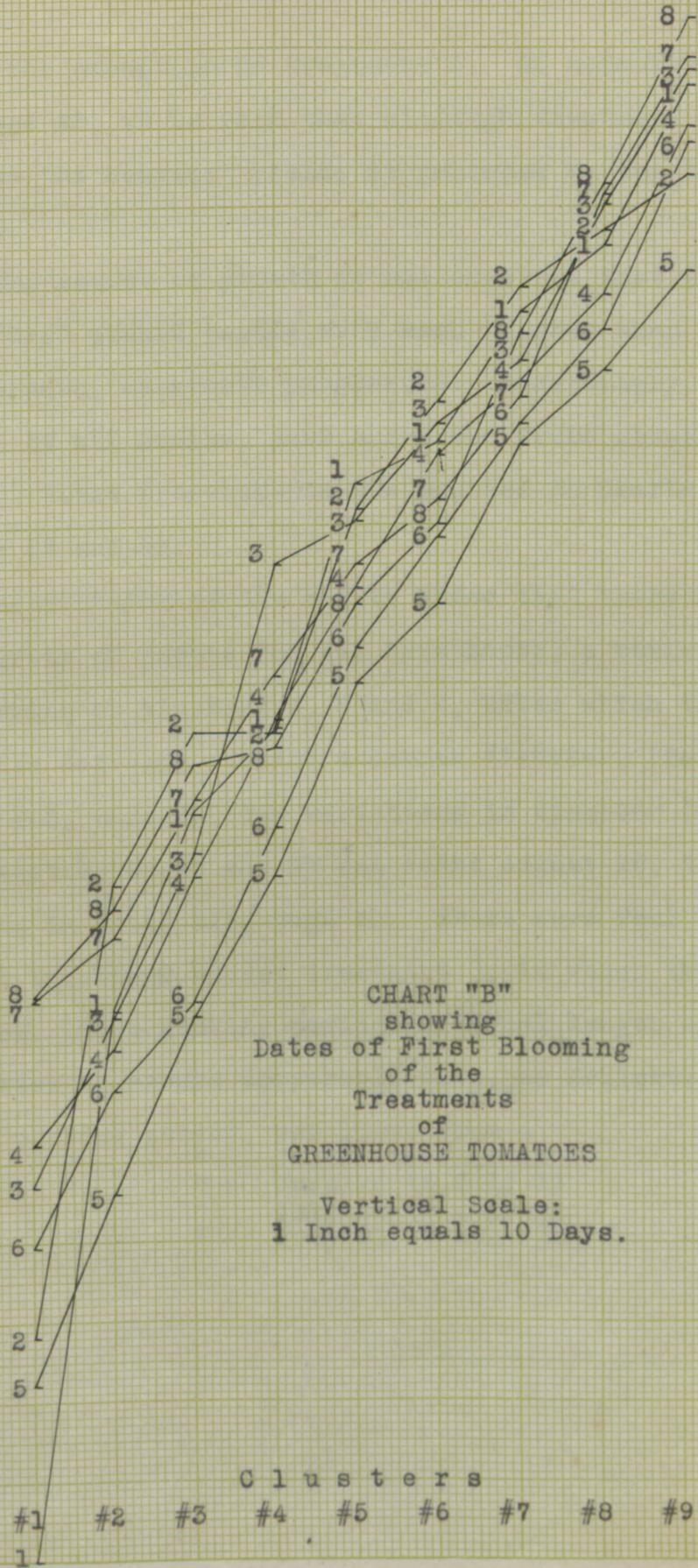


CHART "B"
 showing
 Dates of First Blooming
 of the
 Treatments
 of
 GREENHOUSE TOMATOES

Vertical Scale:
 1 Inch equals 10 Days.

Clusters

#1 #2 #3 #4 #5 #6 #7 #8 #9

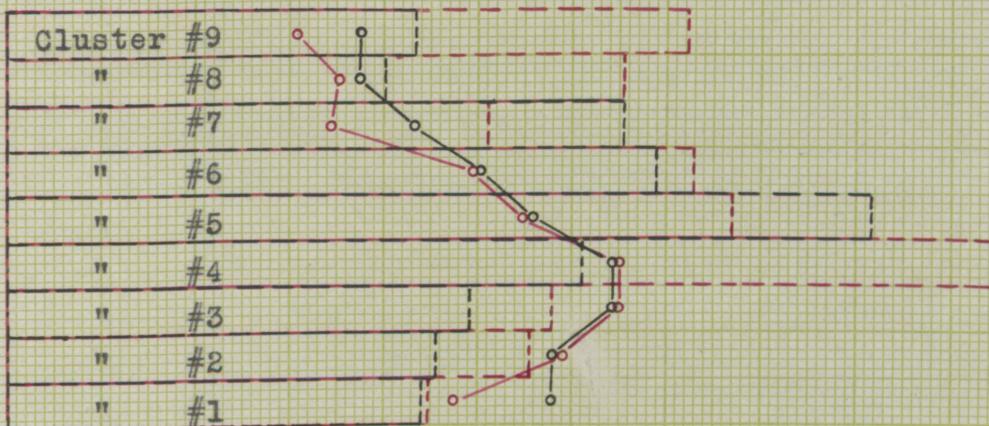
cluster, with the exception of treatment 5. On consulting Table XIII, page 42, it is seen that although treatment 5 did not produce the heaviest yield, it produced by far the earliest fruit.

In the course of growth it was observed that the stems on the "dry" plants became very much thicker than those of the "wet" plants, as growth progressed. Accordingly, the mean diameters of all stalks, just above the fruit clusters, were recorded. These measurements are plotted in Charts "C" and "D", pages 38 and 39.

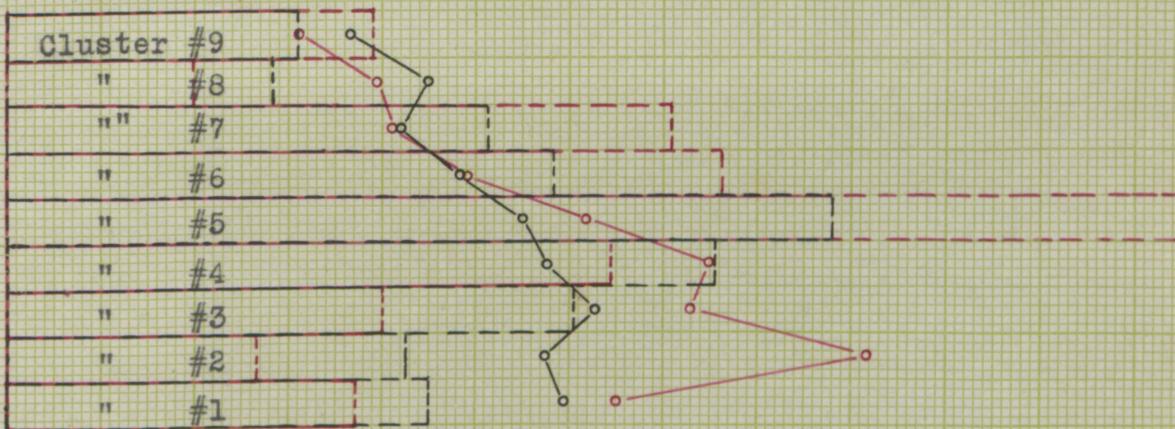
An examination of the charts shows that there is a general similarity of curves for all treatments, a maximum diameter occurring at clusters 2, 3 and 4, after which there is a progressive decrease, toward a common diameter. (See Figs. T-4 and T-5, page 40, for variations in diameter.)

Harvesting began May 17 and ended August 18; the record is given in Table XII, page 41. There were four plants in each treatment except treatment 8, in which there were only three. Five picking periods of equal length are assumed, in order to secure comparable data, as follows:-

1st picking period,	May 17 to June 4
2nd	" " June 5 to June 23
3rd	" " June 24 to July 12
4th	" " July 13 to July 31
5th	" " July 31 to Aug. 18.



Treatment #1 ("Wet"):- Black Data.
 " #3 ("Dry"):- Red "



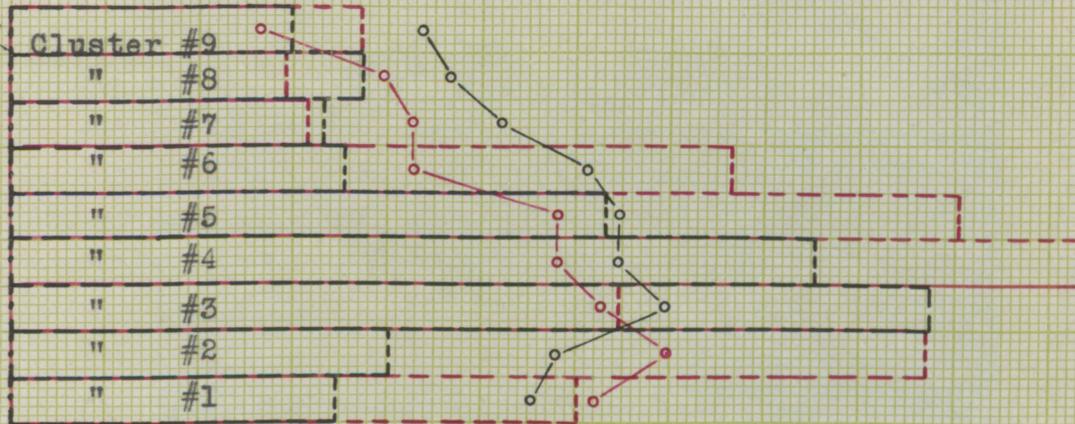
Treatment #2 ("Wet"):- Black Data.
 " #4 ("Dry"):- Red "

LEGEND:-

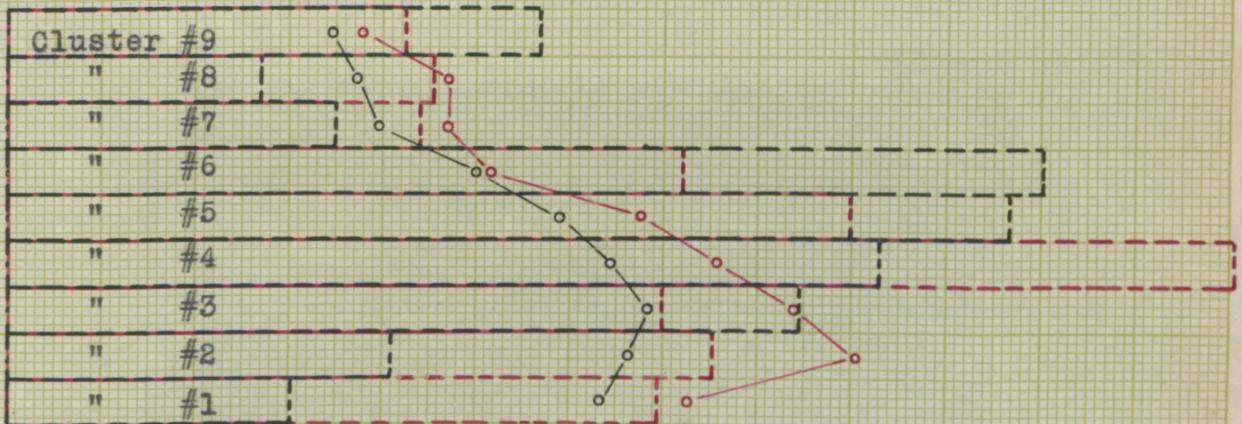
The Enclosed Areas show Weight of Fruit, in Grams; One Square Inch to 400 Grams.

The Circle-dash Lines show Stalk Diameters at Clusters; One Inch to 5 Millimeters.

CHART "C"
 showing, compared the "Wet" and "Dry" Treatments of GREENHOUSE TOMATOES as to Weight of Fruit and Stalk Diameters



Treatment #5 ("Wet"):- Black Data.
 " #7 ("Dry"):- Red "



Treatment #6 ("Wet"):- Black Data.
 " #8 ("Dry"):- Red "

LEGEND:-

The Enclosed Areas show
 Weight of Fruit, in
 Grams; One Square Inch
 to 400 Grams.

The Circle-dash Lines
 show Stalk Diameters
 at Clusters; One Inch
 to 5 Millimeters.

CHART "D"
 showing, compared
 the
 "Wet" and "Dry" Treatments
 of
 GREENHOUSE TOMATOES
 as to
 Weight of Fruit
 and
 Stalk Diameters



Fig. T-3. A Plant of Treatment 8. Note Stalk Diameter



Fig. T-4. A Plant of Treatment 1. Note Stalk Diameter

TABLE XII

Harvesting Record for Greenhouse Tomatoes, in Picking Periods

Tr't- ment No.	Seed Beds	Trans- planting Media	Moist- ure Trtmt	May 17 to June 4		June 5 to June 23		June 24 to July 12		July 13 to July 31		Aug. 1 to Aug. 18		TOTAL	
				No.	Wt	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
1	Loam	Manure($\frac{1}{2}$), "wet"	(Mktble) (Unmkt)	6-648 1- 56	20-1579 6- 242	46-4261 15- 456	24-1909 13- 600	18-1747 4- 260	114-10144 39- 1614						
2	Loam	Manure($\frac{1}{4}$), "wet"	(Mktble) (Unmkt)	5-334 4-192	12- 902 9- 453	29-2827 5- 188	39-4730 9- 435	8- 777 7- 248	93- 9570 34- 1516						
3	Loam	Manure($\frac{1}{2}$), "dry"	(Mktble) (Unmkt)	4-298 1- 70	11-1003 8- 332	54-4593 2- 110	43-4400 11- 295	30-2524 2- 60	143-12818 24- 867						
4	Loam	Manure($\frac{1}{4}$), "dry"	(Mktble) (Unmkt)	4-458 - --	8- 580 9- 362	28-2087 3- 140	44-4966 4- 110	15-1225 2- 60	99- 9316 18- 672						
5	Sand	Manure($\frac{1}{2}$), "wet"	(Mktble) (Unmkt)	8-774 2-164	12- 944 6- 360	34-3840 - --	46-3062 12- 370	4- 292 6- 370	104- 8912 26- 1064						
6	Sand	Manure($\frac{1}{4}$), "wet"	(Mktble) (Unmkt)	1- 90 - --	16-1620 1- 50	64-4927 7- 210	34-4279 10- 325	16-1301 8- 278	131-12217 26- 863						
7	Sand	Manure($\frac{1}{2}$), "dry"	(Mktble) (Unmkt)	- -- - --	7- 747 1- 32	40-3725 5- 163	50-5761 2- 70	23-1992 4- 156	120-12225 12- 421						
8	Sand	Manure($\frac{1}{4}$), "dry"	(Mktble) (Unmkt)	- -- - --	6- 481 2- 61	26-2640 5- 213	45-5191 5- 189	24-2170 9- 383	101-10302 21- 846						

TABLE XIII

Showing Earliness and Total Yields in Grams, of Treatments

Treat- ment No.	Seed Bed	Trans- planting Media	Moist- ure Trtmt	Percentages picked and Pick'g Periods					Total Yield per Plt.
				#1	#2	#3	#4	#5	
1	Loam	Manure(1/2)"wet"		6%	16%	42%	19%	17%	2532
2	Loam	Manure(1/4)"wet"		3	10	30	49	8	2388
3	Loam	Manure(1/2)"dry"		2	8	36	34	20	3195
4	Loam	Manure(1/4)"dry"		5	6	22	53	14	2338
5	Sand	Manure(1/2)"wet"		9	10	43	34	4	2223
6	Sand	Manure(1/4)"wet"		1	13	40	35	11	3055
7	Sand	Manure(1/2)"dry"		-	6	30	47	17	3057
8	Sand	Manure(1/4)"dry"		-	5	24	50	21	3241

In Table XIII, which is a summary of Table XII, it is seen that those plants that came from the rich transplanting media, manure (1/2), copiously watered, gave the earliest yields. The next earliest plants were those that were transplanted into the thinner mixture, manure (1/4), and kept "wet". It is seen, furthermore, that, in each case the earliest plants have been started in a seed-bed of sand.

Those plants that were kept "dry" in transplanting constitute a group tardy in maturing their fruit; their yields are high, however.

When earliness is combined with high yield, either of two treatments may be used:- (1) Treatment 3, in which both the seed-bed and the transplanting medium are rich, and the transplanting medium kept "dry", and (2), treatment 6, in which both the seed-bed and the transplanting medium are low in plant food, but the treatment should be "wet". The yield of treatment 3 is much the better of the two.

Since there developed distinct differences in the bearing habits of the various lots of plants, it was deemed advisable to investigate these differences in detail. The weights of fruit, in grams, for each cluster were taken and the totals assembled in Table XIV.

TABLE XIV

Weight of Fruit, by Clusters, and Total Weight per Plant,
in Grams

Treat- ment No.	C l u s t e r s									Plant Total
	#1	#2	#3	#4	#5	#6	#7	#8	#9	
1	221	227	241	306	455	341	328	198	215	2532
2	220	218	303	374	432	288	260	139	154	2388
3	224	278	490	520	368	360	263	329	363	3195
4	153	110	188	324	620	354	347	51	191	2388
5	165	199	478	428	316	172	165	183	145	2223
6	149	209	405	467	615	622	174	133	283	3055
7	299	483	326	565	510	384	163	145	182	3057
8	348	477	348	707	447	459	222	226	207	3241

This table, as well as Table XV, immediately following, shows that there is a progressive increase in weight up to clusters #5 and #6, after which a decline takes place. This decline is not so pronounced, however, in treatments numbers 3, 4, 7 and 8, in which water is sparingly applied during the transplanting stage. This feature has commercial significance, and may be a point in favor of using the "dry" treatment for improving greenhouse tomato yields.

Table XV, following, giving average weights of fruits, shows even more strikingly the variation in cluster-yields.

TABLE XV

Average Weights, in Grams, of Marketable Fruits, by Clusters

Treat- ment No.	#1	#2	#3	#4	#5	#6	#7	#8	#9
1	71.0	65.7	76.3	80.7	93.6	108.0	71.7	57.0	72.0
2	56.3	70.0	96.6	101.0	115.6	124.1	102.0	79.0	101.0
3	79.0	65.2	68.5	95.4	98.6	125.0	112.0	110.0	96.7
4	97.8	46.9	76.4	85.6	106.0	104.0	96.2	83.5	80.6
5	86.0	80.3	98.5	74.0	111.4	76.0	73.0	79.0	64.8
6	73.6	91.2	78.0	92.8	109.2	104.0	95.1	100.0	77.3
7	80.0	92.0	87.3	102.0	120.0	118.0	108.0	97.0	81.0
8	62.8	85.3	67.7	111.5	112.0	120.0	108.8	91.6	102.0

The data given in Table XV are shown graphically in Charts "C" and "D", pages 38 and 39. These charts also show the stalk diameters as discussed on page 37. A striking similarity between the yield diagram and that for stalk diameters is seen. The heavy-yielding clusters occur just above the maximum stalk diameters, which fact makes it appear that thickened stems are reservoirs for plant food which becomes effective for the fruit clusters in the next node.

In this connection, it will not be out of place to indicate a correlation between yields and sap concentration. On page 30 in Table IX, is shown the rank of the plants as to their sap concentration at cluster 9, from an observation made August 1. In Table XVI, page 45, the rank of the treatments as to their sap density is given, beginning with the greatest. Besides these data are given the rankings of the treatments as they follow, in total marketable yield, in

marketable yield during the last picking period, and in yield of cluster 9, beginning with the largest:-

TABLE XVI

Rank of the Treatments in the Following Particulars:-

Sap Dens. Clust.#9	Total Yield	Yield Period#5	Yield Clust.#9
Trtmt 3	Trtmt 3	Trtmt 3	Trtmt 3
" 7	" 7	" 8	" 7
" 2	" 6	" 7	" 2
" 8	" 8	" 1	" 1
" 1	" 1	" 6	" 6
" 6	" 2	" 4	" 8
" 4	" 4	" 2	" 4
" 5	" 5	" 5	" 5

The agreement is by no means perfect, but it is close enough to be interesting.

The main conclusion to be drawn from the tables discussed is that the effect of treatment before setting the plants under identical conditions, is lost progressively as growth continues. The limit is evidently the untreated, unchecked plant.

A detailed study relative to the marketable percent of fruit indicates that the plants grown "wet" gave uniformly smooth, symmetrical fruit, as shown in Fig. T-7, page 46. The plants grown "dry", on the other hand, produced a large proportion of fruit cracked about the calyx end, as shown in Fig. T-6, page 46. The cracking was due, probably, to the lignification of the fruit walls, making them unable to accommodate themselves to the growth of the pulp and of the seed-masses.



Fig. T-6. Characteristic Fruit on "dry" Treatment #8



Fig. T-7. Characteristic Fruit on "wet" Treatment #1

The fruit was rendered unsightly, and would have been unmarketable, except that forced tomatoes are so frequently affected in this way. Their quality was not impaired by reason of any toughness or woodiness. The Blossom End Rot was somewhat troublesome during the first few weeks of harvesting. Its occurrence was found to be greater among the plants that had undergone the "wet" treatment. This is of doubtful significance, since, when watering was more carefully done, the disease was almost entirely eliminated. The unmarketable fruit constituted that portion that was too small to sell. The percentages of marketable fruit (by weight) are shown in the following table:-

TABLE XVII

Percentages of Weights of Marketable Fruit, by Clusters

Treat- ment No.	C l u s t e r s									Average
	#1	#2	#3	#4	#5	#6	#7	#8	#9	
1	88%	90%	87%	90%	92%	89%	94%	80%	76%	86%
2	90	87	86	89	86	90	90	82	72	86
3	90	89	91	91	96	96	100	100	100	94
4	93	88	90	92	100	96	94	97	100	93
5	96	86	98	98	97	96	97	100	100	89
6	90	95	100	96	97	100	97	100	95	94
7	88	100	100	100	100	100	100	100	100	97
8	85	90	96	98	100	100	92	100	100	93

In the above table it will be seen that the plants grown in the richer transplanting media and sparingly watered, gave the largest percent of marketable fruit, and, also of these, those started in sand seed-beds were the best.

Effect of Early Treatment on Blossoming Behavior.

Early in the course of the work, it was observed that blossoming was more profuse among the "dry" plants than it was among those receiving the "wet" treatment. The table following shows the difference in flowering.

TABLE XVIII

Showing Numbers of Blossoms and Fruits, by Clusters.

Treatment No.	C l u s t e r s : -									
	#1	#2	#3	#4	#5	#6	#7	#8	#9	Ave.
1-No. of Blossoms	19	25	27	28	30	25	25	21	22	23
" " Fruits	15	15	13	16	20	25	18	15	14	15
Percentage Set	79	60	48	57	67	100	72	60	67	68
2-No. of Blossoms	23	23	33	26	24	27	27	26	21	25
" " Fruits	18	16	17	19	17	10	11	8	8	14
Percentage Set	78	70	52	73	71	37	42	38	40	56
3-No. of Blossoms	22	27	34	36	34	24	24	24	23	24
" " Fruits	14	23	33	24	16	12	9	12	15	17
Percentage Set	64	85	97	67	47	50	37	50	65	71
4-No. of Blossoms	23	27	21	40	48	31	29	25	25	30
" " Fruits	14	15	17	20	27	17	18	6	13	16
Percentage Set	61	56	81	50	56	55	62	24	52	54
5-No. of Blossoms	19	22	26	28	27	31	27	20	23	25
" " Fruits	12	14	22	26	14	11	11	10	10	14
Percentage Set	63	64	85	93	52	35	41	50	43	56
6-No. of Blossoms	24	81	40	29	32	27	23	24	25	34
" " Fruits	19	14	24	25	27	27	11	8	20	19
Percentage Set	79	45	60	86	84	100	48	33	80	56
7-No. of Blossoms	28	24	41	37	31	30	27	29	29	31
" " Fruits	21	21	15	22	17	13	6	6	9	15
Percentage Set	75	88	37	60	55	43	22	21	31	49
8-No. of Blossoms	26	27	24	31	36	43	40	23	17	29
" " Fruits	20	15	18	19	12	9	9	12	9	14
	77	56	75	61	33	21	22	52	53	48

In this table it is seen that there is an appreciable discrepancy between the number of fruits set, and the number of blossoms. In order to arrive at a reason for this condition, germination of pollen from the various plants was attempted, with no very great success. Mixtures of cane sugar and glycerine, ranging from 5% to 30% of each, singly and in combination, were used. The results of the attempts bore very little resemblance to the fruit-setting behavior of the treatments, except that the pollen from treatments 3, 4, 7 and 8, which were the "dry" treatments, failed to germinate in a greater number of cases than did pollen taken from the plants grown "wet". The "wet" plants gave the higher percent of fruit set, they also gave fruit of smooth, symmetrical outline. The "dry" plants, it will be remembered, gave angular fruit, a condition known by greenhouse men to follow poor pollination, or, as it may be in this case, pollen of low viability.

It has been observed at the Oregon Station, that a large number of blossoms may follow a poor setting of fruit. Bouquet⁴ found that, in case blossoms were removed from tomato plants of the Earliana variety, the plants made an attempt to replace them. This occurred repeatedly. The behavior of the prolifically blooming plants employed in this investigation which set an abnormally small percentage of fruit may be explained in this way. It is doubtful, though,

⁴-Bouquet, A. G. B., Second Bienn. Oregon Hort. Rept., '13-14

whether such an explanation will serve in the case of the heavily-blooming plants that comprised the "dry" treatments which set a sufficient percentage of their fruit to make their yields greater than that of normal plants.

It may be that the energy of a plant may be dissipated simply in blooming, and that pollen of low viability may result. Whether the pistils and ovaries share the weakness of the stamens can only be determined by fertilizing these blossoms with pollen from "normal" ones. As the matter rests, it is impossible to tell whether the poor setting of fruit on these plants is the cause for, or an effect of, profuse blooming.

Summary for the Greenhouse Tomatoes

As in the case of lettuce, the seeding soil should have in it some plant food, since sand, alone, evidently puts the plant too much on its own resources. Too great disparity of top and root is not desirable.

The transplanting medium should be quite fertile. In this experiment, a mixture that contained 50% of well-rotted manure, gave better results than one that had half that amount.

The amount of moisture applied during the transplanting stage should be small; the "dry" plants were, in every case, superior to those given "wet" treatments.

Field Tomatoes

The Earliana variety was chosen for the work since it matures fruit in considerable quantity before frost intervenes. As in the case of the greenhouse tomatoes, eight treatments were used, as follows:-

Treat- ment No.	Seedbeds	Transplanting Media and Treatments
1	Loam	Manure(1/2), loam; kept "wet"
2	Loam	Manure(1/4), loam,sand; kept "wet"
3	Loam	Manure(1/2), loam; kept "dry"
4	Loam	Manure(1/4), loam,sand; kept "dry"
5	Sand	Manure(1/2), loam; kept "wet"
6	Sand	Manure(1/4), loam,sand; kept "wet"
7	Sand	Manure(1/2), loam; kept "dry"
8	Sand	Manure(1/4), loam,sand; kept "dry"

The sand seedbed was clean Missouri River sand; the loam seedbed, a mixture of the following:-

Sand, one part,
Manure, four parts,
Loam, three parts.

The transplanting media were made up as follows:-
Manure, one half, loam, one half,
Manure, one fourth, loam, one half, sand, one fourth.

The use of the words "wet" and "dry" has been explained in previous parts of this discussion.

The seed was sown on February 23, 1916, in the greenhouse; all seedbeds were kept moist. On March 7, the seedlings were transplanted as given in the list at the head of this page. When the plants began crowding, they were shifted to 3-inch pots, in mixtures of the same composition

as used before. On April 12, they were transferred to the coldframe.

On May 8, eight plants of each treatment were set in the field. The plants were staked with the intention of pruning to single stem.

All plants recovered from moving early, though it appeared that those that had been sparingly watered up to this time, suffered least. The difference was small, though.

When growth was resumed, differences began to appear. Those plants, which had received moisture in abundance, previous to their field-setting, grew rapidly in height, with a pronounced tendency toward slenderness. The "dry" plants, on the other hand, grew stocky, increasing very slowly in height; their blooming was delayed, as well. When they began to bloom, however, there was in some instances as much as a 25% increase in the number of blossoms over that of the "wet" plants.

Records of weights of the prunings were kept, but there was no characteristic difference in the weights of prunings taken from the "wet" and the "dry" plants. The same tendency toward leafy clusters was evident as in the greenhouse tomatoes. Those plants that had been started in the sand seedbed, and then transplanted into the "thin" mixture "wet" or "dry" (6 and 8) gave rise to the greatest numbers of leafy clusters. (A detailed discussion of this phenomenon in connection with the greenhouse crop appears on page 35.)

Harvesting began on July 1; the record follows:-

TABLE XIX

Harvesting Record for Field Tomatoes, in Picking Periods

Treatment No.	July 1 to July 15		July 15 to July 31		Aug. 1 to Aug. 12		Sep. 1 to Sep. 20		Sep. 21 to Oct. 7		TOTAL	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
1 (Mktble)	4-	428	43-	6621	22-	2863	17-	1711	38-	3041	124-	14664
(Unmkt)	2-	140	13-	1170	13-	843	13-	780	80-	2400		
2 (Mktble)	9-	1127	29-	3861	23-	2979	12-	1450	46-	4811	119-	14228
(Unmkt)	6-	530	16-	1388	15-	971	14-	910	61-	2440		
3 (Mktble)	8-	1114	20-	3303	39-	5743	27-	3804	39-	4146	133-	18110
(Unmkt)	5-	404	8-	683	2-	133	12-	840	74-	2312		
4 (Mktble)	12-	1684	15-	2123	21-	2380	21-	2500	44-	4121	113-	12808
(Unmkt)	3-	249	14-	1001	27-	2004	16-	892	71-	4252		
5 (Mktble)	2-	260	23-	3835	33-	4494	21-	2111	41-	3522	120-	14222
(Unmkt)	2-	126	10-	839	26-	888	11-	562	52-	3514		
6 (Mktble)	2-	140	21-	3217	37-	5370	24-	2998	34-	2922	133-	14647
(Unmkt)	7-	189	10-	765	15-	1236	18-	1251	64-	3864		
7 (Mktble)	14-	2398	25-	3610	28-	4095	19-	3512	44-	4441	130-	18056
(Unmkt)	3-	397	16-	1414	28-	2039	21-	1414	90-	2824		
8 (Mktble)	8-	905	20-	2979	10-	1207	18-	2122	41-	3811	97-	11204
(Unmkt)	10-	778	24-	1912	19-	1379	16-	1111	67-	3321		

The record of the picking period from August 13 to August 31 has not been given in the above table for the reason that some unauthorized picking was done from clusters 5 and 6, causing distortions to appear in the records. It was deemed advisable, therefore, to discard the data dealing with these clusters throughout in order not to vitiate the accuracy of the balance.

All plants were "topped" when cluster 10 had ap-

peared, since it was extremely unlikely that the fruit in clusters beyond this one could mature before frost came.

The last picking, following a killing frost, was made October 7. It included all the fruit set, size rather than color determining its marketability. There were very few blossoms on the plants at this time.

In Table XIX, it is seen that treatments 3 and 7 gave by far the best total yield. Of these two, the treatment started in sand (7) is the earlier.

Earliness appears to follow two kinds of treatment namely, the use of a sand seed-bed, and the use of a thin transplanting medium. Of treatments 3 and 7, the latter, having a sand seed-bed, gave individual fruits of a slightly larger size; the fruit in the upper clusters of plants undergoing this treatment was the less variable, as well.

The following table contains summaries as to the ranks of the various treatments, in several particulars, beginning with the best:-

TABLE XX

Summaries as to Ranks in:-

Yield to Sept.1	Ave. Size of Fruit, to Sept.1	Ave. Size of Fruit, after Sept.1.	Total Yield
3, 7	3,7,5,1	3,7	3,7
6	6,8,2,4	2	1,6,2,5
1		4	4,8
5		8	
2		5	
4		6	
8		1	

As shown in Table XX, the treatments, as regards their total yields, fall into three distinct groups, as follows:- (1) 3 and 7; (2) 1, 5, 2 and 6; (3) 4 and 8. Further, treatments 3, 4, 7 and 8 appeared to show the least variation and decrease in the size of fruit under the drouthy condition that prevailed the latter part of July, during which period their first clusters were setting fruit.

Conclusions for Field Tomatoes

Those plants which were started in a seedbed of sand, and set in a transplanting medium low in plant food, and given a minimum amount of moisture, gave the earliest fruit.

If a high yield, though not a particularly early crop is sought, the seedbed should contain more available plant food than a seedbed of sand would provide. The transplanting medium should be high in plant food, and moisture should be scant. For fair yield, and earliness of maturity of the crop, the treatment should be the same, except that a seedbed of sand should be employed.

The use of sand as a seedbed for inducing earliness is not so clearly indicated as in the case of the greenhouse crop, though it does appear to have this effect to a certain extent. Probably the proper seeding medium to use is one in which enough sand occurs to encourage the formation of a moderately large root system.

Field Cabbage

The varieties, Early Jersey Wakefield and Copenhagen Market, were used for the work. The seed was sown on February 6, 1916, in the greenhouse. The treatments to which the various lots of both varieties were subjected were the same as for the field tomatoes, as given on page 51.

On February 22, transplanting was done, and on March 10 the plants were put into the coldframe, where they were put through the "hardening-off" treatment commonly employed in the culture of cabbage.

On March 28, nine plants of each treatment, and of each variety, were set in the field. Figure C-1, page 57, shows the field, with the plants under test in the foreground. There is a distinct difference in size between the "dry" plants on the right and the "wet" ones on the left.

On the following night, a minimum temperature of 28° Fahr. occurred, together with a light fall of snow. The "dry" plants remained green, whereas the "wet" ones became tinged with color. All the plants withstood the freezing well. On April 3 and 4, snow fell, and, until April 11, a minimum temperature of approximately freezing occurred nightly. The head-leaves of the "wet" plants turned deep purple and blue, and some of the outside leaves were entirely destroyed. The "dry" plants remained green. No appreciable growth of either class of plants took place.

With the advent of warmer weather, both sets of plants began to grow at apparently equal rates. The "wet"



Fig. C-1. The Cabbage Field at Setting, March 28.



Fig. C-2. The Cabbage Field at First Cutting, June 12

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plants, whose chlorophyll had been most disturbed by the freezing weather, seemed to suffer none on account of this injury. Some of their colored leaves resumed their normal green shade, and some of them were shed.

No disease was present, and the few worms that appeared were easily kept in check. There was, however, an infestation of Cabbage Curculio, which fact was not discovered before the pest had made considerable inroads in the plants of treatment 8 of the Wakefield variety, stunting all of the heads and destroying one. No other plants were attacked.

Cutting began on June 12; the records follow:-

TABLE XXI

Harvesting Record for Early Jersey Wakefield Cabbage,
under Cutting Dates

Treat- ment No.	June 12		June 14		June 16		June 20		June 25		Total	
	Hds	Gr	Hds	Gr	Hds	Gr	Hds	Gr	Hds	Gr	Hds	Gr
1	2-	1617	-	----	3-	2470	4-	3760	-	----	9-	7847
2	5-	5157	2-	1850	1-	910	-	----	1-	228	9-	8145
3	4-	4056	3-	2585	-	---	2-	1166	-	----	9-	7807
4	3-	2672	1-	910	2-	2045	2-	1594	-	----	8-	7221
5	3-	3037	1-	882	2-	1730	-	----	2-	910	8-	6559
6	3-	2663	1-	855	2-	1194	3-	2420	-	----	9-	7132
7	3-	2492	3-	2220	2-	1760	1-	795	-	----	9-	7267
8	-	----	-	----	1-	750	1-	672	6-	4150	8-	5572
	23-	21694	11-	9302	13-	10849	13-	10417	9-	5288	69-	57550

TABLE XXII

Harvesting Record for Copenhagen Market Cabbage,
under Cutting Dates

Treat- ment No.	June 12		June 14		June 16		June 20		June 25		Total	
	Hds	Gr	Hds	Gr	Hds	Gr	Hds	Gr	Hds	Gr	Hds	Gr
1	1-	1260	2-	2475	2-	2730	4-	4770	-	----	9-	11235
2	2-	2760	4-	4685	1-	1424	2-	3280	-	----	9-	12149
3	1-	1015	2-	2135	3-	4000	2-	1815	-	----	8-	8965
4	-	---	1-	1424	4-	5230	4-	5460	-	----	9-	12204
5	1-	850	2-	2360	2-	1960	2-	2390	2-	2560	9-	10120
6	3-	3155	1-	1650	3-	3070	2-	2785	-	----	9-	10660
7	2-	1990	1-	1024	2-	1875	4-	4220	-	----	9-	9109
8	<u>2-</u>	<u>2610</u>	<u>3-</u>	<u>4150</u>	<u>4-</u>	<u>4840</u>	<u>-</u>	<u>----</u>	<u>-</u>	<u>----</u>	<u>9-</u>	<u>11600</u>
	12-	13640	16-	19903	21-	25219	20-	24720	2-	2560	71-	86042

In Tables XXIII and XXIV, following, are found the data contained in the Harvesting Records, presented in such a form that conclusions may be drawn.

TABLE XXIII

Summary for Copenhagen Market Cabbage

Treat- ment No.	Percentage cut on Cutting Dates:-					Ave. Wt. of Head
	#1	#2	#3	#4	#5	
1	11%	22%	24%	43%	--	1248 Gr
2	23	39	12	26	--	1350 "
3	11	24	45	20	--	1120 "
4	--	12	44	44	--	1356 "
5	9	23	20	23	25	1124 "
6	30	15	29	26	--	1184 "
7	22	36	42	--	--	1298 "
8	22	11	20	47	--	1300 "

TABLE XXIV

Summary for Jersey Wakefield Cabbage

Treat- ment No.	Percentage cut on Cutting Dates:-					Ave. Wt. of Head
	#1	#2	#3	#4	#5	
1	20%	--	32%	48%	--	872 Gr
2	63	23	11	--	3	905 "
3	52	33	--	15	--	867 "
4	37	13	28	22	--	903 "
5	46	13	26	--	15	820 "
6	37	12	17	34	--	793 "
7	34	30	24	12	--	808 "
8	--	--	13	12	75	697 "

From the summaries it is seen that, although the two varieties do not respond alike throughout, yet, in both, treatments 2 and 4 gave the highest yields. These treatments include the use of a somewhat enriched seedbed (loam), and of the richer transplanting media (manure, 1/2). As for earliness, treatment 2 is the best for both varieties. This treatment is the one in which the transplanting medium is kept "dry". Altogether, there seems to be no advantage in using a sand seedbed, except in one case of the Copenhagen Market variety, which one instance may reasonably be ignored.

The efficacy of a denser sap in carrying plants through unfavorable temperatures, in the spring, could not be tested. It is reasonable to suppose, however, that, in view of the difference in the sap depressions of the treatments, that the plants with the denser sap should be able to withstand lower temperatures than the "wet" plants, whose sap was thinner.

Field Peppers

"Ruby King" was the variety chosen for the work, since it matures its fruit in a normal season and with an easily recognizable change in color; it is also a popular market variety. As in the case of the field tomatoes, eight treatments were used, as follows:-

Treat- ment No.	Seedbed	Transplanting Media and Treatments.
1	Loam	Manure(1/2), loam; kept "wet"
2	Loam	Manure(1/4), loam, sand; kept "wet"
3	Loam	Manure(1/2), loam; kept "dry"
4	Loam	Manure(1/4), loam, sand; kept "dry"
5	Sand	Manure(1/2), loam; kept "wet"
6	Sand	Manure(1/4), loam, sand; kept "wet"
7	Sand	Manure(1/2), loam; kept "dry"
8	Sand	Manure(1/4), loam, sand; kept "dry"

The sand seedbed was clean Missouri River Sand;

the one of loam, a mixture of the following:-

Sand, one part,
Manure, four parts,
Loam, three parts.

The transplanting media were made up as follows:-

Manure, one half; loam, one half, and

Manure, one fourth; loam, one half; sand, one fourth.

The relative meaning of the terms "wet" and "dry" have been explained in previous parts of the discussion.

The seed was sown April 1, in the greenhouse; all the seedbeds were kept moist. On May 10, the seedlings were transplanted as per treatments listed above. On June 19, eight plants of each treatment were set in the field.



Fig. P-1. The "dry" Plants at Setting

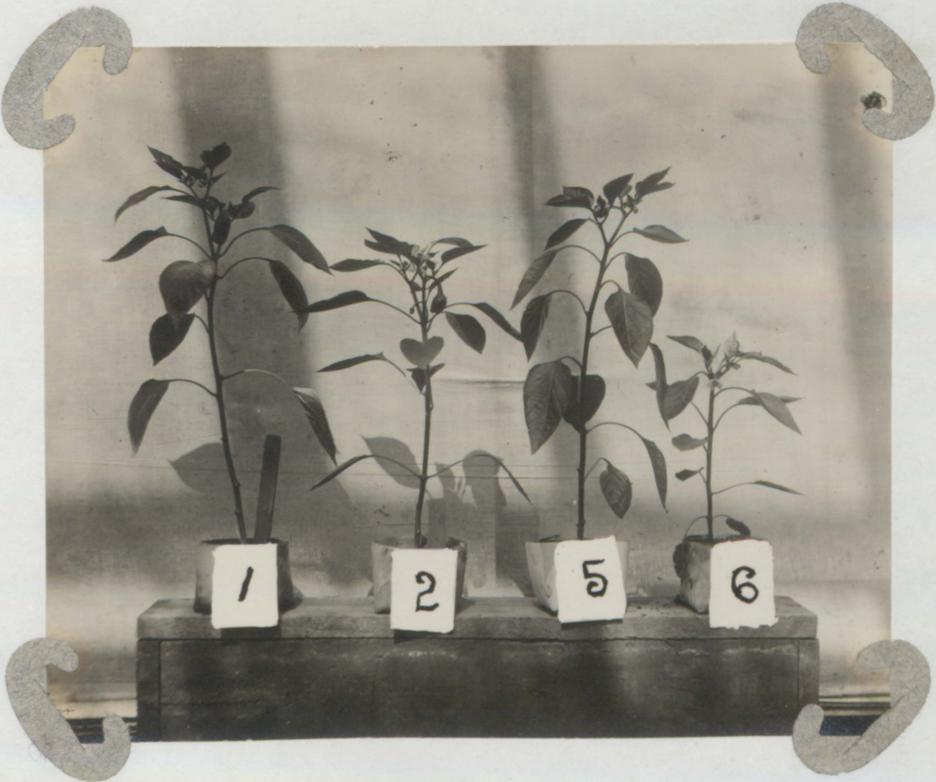


Fig. P-2. The "wet" Plants at Setting

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Figures P-1 and P-2, page 62, show the plants at this stage. All treatments recovered from transplanting well; the "wet" plants appeared to resume growth first.

The entire plat was free from insects and all the treatments thrived except treatment 2, which suffered from mosaic. Five of the plants of this treatment were affected.

At setting time, one plant of each treatment was reserved, its sap expressed and frozen. The list of treatments in the order of the depressions of the freezing-points of their sap, beginning with the largest, follows:-

TABLE XXV

Sap Depressions of Pepper Plants at Setting

Treat- ment No.	Depressions
8	0.905
4	0.885
3	0.785
2	0.780
6	0.725
7	0.720
5	0.665
1	0.655

Although the series from the "driest" to the "wettest" plant did not exactly correspond with that of the amount of depression, yet, in this series the "driest" plant (treatment 8) had the greatest depression, and the "wettest" one (treatment 1), the smallest.

Picking began on August 8, and ended September 30, after frost had killed the plants. The record follows:-

TABLE XXVI

Harvesting Record for Field Peppers, under Picking Dates
(Eight Plants per Treatment)

Treat- ment No.	Seed Beds	Trans- planting Media	Moist- ure Trtmt	Aug. 8		Aug. 17		Aug. 26		Sept. 4		Sept. 13		Sept. 26		Sept. 30		Total	
				No	Wt	No	Wt	No	Wt	No	Wt	No	Wt	No	Wt	No	Wt	No	Wt
1	Loam	Manure($\frac{1}{2}$), "wet"	{Mktble) (Unmkt)	4-212 2- 58	2-121 4- 47	5-356 5-118	4-280 5-130	7-512 3-112	5-400 3- 91	32-1810 30- 490	59-3871								
2	Loam	Manure($\frac{1}{4}$), "wet"	{Mktble) (Unmkt)	4-102 3- 58	3- 91 4- 50	8-143 3- 42	9-179 4- 52	7-152 5- 61	5-102 7- 68	24- 436 47- 418	60-1205								
3	Loam	Manure($\frac{1}{2}$), "dry"	{Mktble) (Unmkt)	2- 77 4- 63	2- 82 4- 57	- -- 3- 63	- -- 6-118	- -- 8- 90	- -- - --	41- 128	4- 159								
4	Loam	Manure($\frac{1}{4}$), "dry"	{Mktble) (Unmkt)	- -- 5- 90	2- 53 11-154	7-156 5- 54	8-171 7- 70	6-119 9- 84	4- 86 11- 90	16- 308 36- 291	43- 893								
5	Sand	Manure($\frac{1}{2}$), "wet"	{Mktble) (Unmkt)	2- 82 4- 81	4-158 5- 39	- -- 4- 52	4-170 6- 47	5-193 5- 41	6-218 7- 52	31- 930 19- 79	52-1751								
6	Sand	Manure($\frac{1}{4}$), "wet"	{Mktble) (Unmkt)	5-162 2- 35	- -- 4- 55	3- 56 3- 38	4-120 5- 41	4- 85 - --	4- 90 11- 89	24- 610 19- 92	44-1123								
7	Sand	Manure($\frac{1}{2}$), "dry"	{Mktble) (Unmkt)	- -- 5- 67	2-109 1- 15	4-153 1- 37	3-120 2- 41	3-104 5- 72	- -- 6- 81	19- 410 24- 188	31- 896								
8	Sand	Manure($\frac{1}{4}$), "dry"	{Mktble) (Unmkt)	1- 49 3- 48	3- 76 5- 50	2- 85 5- 86	1- 32 7-101	2- 81 8-102	- -- 37-290	-- -- -- --	9- 323								

By "marketable" fruit is meant that that became scarlet because of maturity, and which was free from disease even though its size was below normal for the variety. The "unmarketable" fruit was that rendered so by reason of an attack of anthracnose, which disease was the only one that attacked the plot as a whole. (See previous note regarding mosaic, page 63.)

The occurrence of the anthracnose does not admit of ready explanation, except that it may have been the result of malnutrition, which is one of the causes for the disease in peppers. Those plants most checked, through shortage either of plant food or of moisture, suffered most from the disease. On the other hand, treatment 1, in which there was administered no check throughout, resulted in the heaviest and most disease-free yield.

In Table XXVI it is seen that, as a group, the plants which had as part of their treatment a limited amount of moisture in their transplanting stage, gave lower yields than did those which received moisture in abundance. (Compare treatments 1, 2, 5 & 6 with 3, 4, 7 & 8.)

Keeping the plants "wet" after transplanting does not appear to suffice, however. A check administered by starting the seed in a relatively sterile seed-bed shows plainly when, for instance, treatments 1 and 5 are compared. These two treatments are identical, except for the difference in the composition of their seed-beds.

Lack of plant food in the transplanting medium,

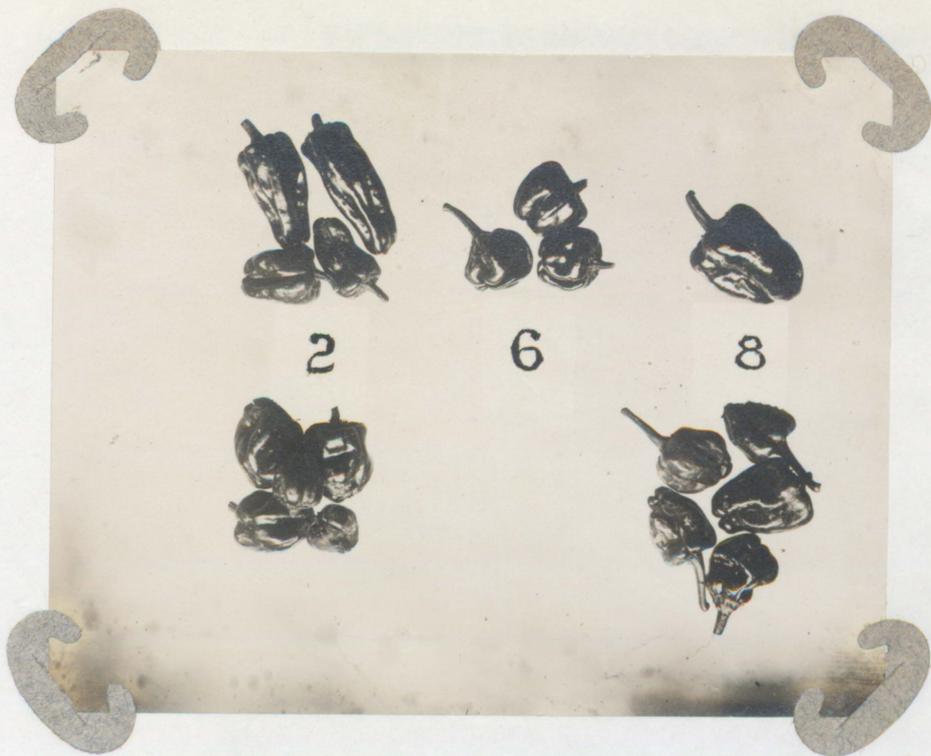


Fig. P-3. Characteristic Fruits



Fig. P-4. Characteristic Fruits

even though moisture may be present in sufficient quantity, has a deleterious effect, evident when treatment 2 is compared with treatment 1. It will be recalled (See page 63.) that treatment 2 suffered from an attack of mosaic, which may explain to some extent, at least, the low yield of this treatment. The generalization holds, however.

A complete summary of the treatments, in the order of their excellence, in various particulars, follows:-

TABLE XXVII

Summaries, as to Ranks in:-

Sap Density	Average Wt. of Fruit		Mktble Percent	
Treat- ment No.	Treat- ment No.	Ave. Wt.	Treat- ment No.	Percent
8	1	66 Gr	1	81%
4	3	40 "	5	79
3	8	36 "	6	76
2	5	34 "	7	64
6	7	29 "	2	62
7	6	25 "	4	55
5	4	21 "	8	32
1	2	20 "	3	18

Figures P-3 and P-4, page 67, show fruits characteristic of the various treatments; the marketable fruits are placed above the label bearing the treatment number, and the unmarketable ones, below. The striking characteristics are the generally pointed, smooth and symmetrical form of the fruit borne on the plants seeded in loam, and the distorted, bull-nosed fruits from the sand-started plants. When the check was administered later, as, for instance, by trans-

planting to a thin mixture or to one kept sparingly watered, the same effect, that of foreshortening, and stunting, is observed. The difference in size is also striking.

Altogether, the only treatment to use seems to be one in which there is not administered any check of any nature, at any stage of growth. Gardeners contend that peppers resent any other treatment; this paper can suggest no reason.

Summary

(1) All of the crops grown during this investigation, with the exception of peppers, gave earlier yields when the seed-bed was low in plant food. Clean sand appeared to be the best medium for this purpose.

(2) Earliness was accentuated by the employment of a transplanting medium somewhat low in plant food, and watered only when the plants stood in need of moisture.

(3) For tomatoes, the use of a somewhat richer seed-bed was shown to result in more productive plants. A transplanting mixture high in plant food should follow, with moisture sparingly applied. In the case of the leaf crops, lettuce and cabbage, a rather "thin" transplanting mixture may be used, and the treatment may be "wet" or "dry".

(4) Growing plants succulently did not prove to be of advantage in any case.

As for the peppers, difficulties outside the province of this present investigation were encountered. It is interesting to note, however, that those plants that had undergone the most severe treatment with respect to shortage of plant food or of moisture at any stage, gave the highest percentage of diseased fruits, though the plants themselves appeared healthy.

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