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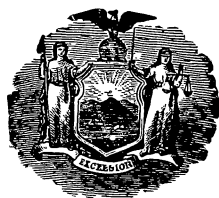
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## STARTER SOLUTIONS FOR TOMATO PLANTS FOR 1943

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## ABSTRACT

A GREENHOUSE test was made to determine the relative effectiveness of fertilizer mixtures permitted for sale in New York in 1943 when used in starter solutions for transplanting tomato plants. Each of the 23 treatments was tested on an acid (pH 4.8) and on a neutral soil (pH 7.2). Tomato plants for this test were grown in composted soil in flats for 6 weeks and for 8 weeks in the usual commercial method for cannery tomatoes, and were then transplanted to the two soil types when the starter solutions were applied. Four of the solutions were also applied to the foliage instead of the roots. The effectiveness of the different treatments was judged 23 days later when the plants were rated for quality, measured, photographed, and their dry weights determined.

Comparisons were made of 4-16-4, 4-10-5, 4-10-10, and 3-12-6 grades of commercially mixed fertilizers prepared from ammoniated superphosphate with the same grades prepared from sulfate of ammonia and ordinary superphosphate. It was found that the former mixtures were less acid and more satisfactory for starter solutions. All of these mixtures were used at the rate of 10 pounds to 50 gallons of water, and all solutions were used at the rate of  $\frac{1}{4}$  pint per plant (91 gallons per acre), poured around the roots as the tomatoes were transplanted.

The 13-26-13 and the 11-32-14 mixtures formerly recommended were used at the rate of 4 pounds per 50 gallons of water, and a completely soluble alkaline 16-48-18 mixture used at the rate of 3 pounds per 50 gallons of water was included. The higher analysis mixtures have the advantage of less insoluble residue, but the ordinary fertilizers made satisfactory starter solutions.

Nitrate of soda alone and superphosphate alone made poor starter solutions, but the two combined made a well-balanced solution that was very effective.

Applying nutrient solutions to the foliage was not nearly as effective as pouring the same solutions around the roots. Apparently nitrogen was and phosphorus was not absorbed thru the leaves.

Field experiments in 1942 of starter solutions similarly tested the previous winter in the greenhouse are cited and show a very close correlation between the greenhouse rating of the starter solutions and the effect of these solutions in increasing field yields of marketable tomatoes, indicating the accuracy of the quick greenhouse tests in forecasting the relative effectiveness of each fertilizer when used for starter solutions in the field. Good starter solutions increased the early yields about  $1\frac{1}{2}$  tons per acre.

## STARTER SOLUTIONS FOR TOMATO PLANTS FOR 1943

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### INTRODUCTION

FIELD experiments for five years with starter solutions used in transplanting tomatoes (2, 3, 4)<sup>1</sup> have shown that certain solutions have given profitable increases in yields of cannery tomatoes. In the course of these experiments over 100 different solutions have been tried, a few of which have consistently proved superior and their commercial use is steadily increasing. Fertilizer manufacturers, always alert to new uses of fertilizer, have manufactured some of these "special transplanting mixtures" for the convenience of growers.

Two outstanding mixtures have been the 11-32-14 made up of Ammo Phos and nitrate of potash and the 13-26-13 composed of Ammo Phos, Uramon, nitrate of soda, and muriate of potash (5). Both of these mixtures proved very satisfactory on a wide variety of soils and with all kinds of transplanted vegetables and were extensively used. Neither of them can be prepared this year, except in a few cases where manufacturers have a limited supply left over from previous years.

To meet the war emergency and to find suitable substitutes for these excellent starter solutions, an experiment was conducted in the greenhouse in the winter of 1941-42, using fertilizer materials then obtainable. These results were published in April 1942 in FARM RESEARCH (6) to aid growers in their efforts to increase food production that year. The starter solution mixtures that appeared most promising in those greenhouse tests were later tested in the field and the results are shown in Table 2. These showed that some commercial grades of fertilizer then obtainable could be used satisfactorily for starter solutions.

In 1943 the acute shortage of chemical nitrogen and government restrictions (Food Production Order No. 5, January 18, 1943) eliminated all the fertilizer grades that had proved most satisfactory for starter solutions in the previous tests. Accordingly, a new series of

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<sup>1</sup>Refers to Literature Cited, p. 18.

experiments was undertaken in the greenhouse in early 1943 to test the fertilizer mixtures obtainable under these restrictions.

Most commercially mixed fertilizers are of two general types. In one type sulfate of ammonia is mixed with superphosphate and other ingredients. In the other type superphosphate is treated with a nitrogen solution containing ammonia, thus producing a mixture containing ammoniated superphosphate. Such a mixture is less acid and does not harden so readily as a mixture containing sulfate of ammonia and regular superphosphate. Accordingly, it seemed important to try out in starter solutions several fertilizer grades, comparing grades made up with ammoniated superphosphate versus the same grades containing sulfate of ammonia and ordinary superphosphate.

Food Production Order No. 5 of the United States Department of Agriculture permitted the sale of only nine grades of mixed fertilizer containing chemical nitrogen in New York State. Of these grades, the 2-8-10 and 3-12-15 were eliminated as possible starter solutions because of their very low ratio of nitrogen. For this experiment it was decided to use the following four grades, *viz.*, 4-16-4, 4-10-5, 4-10-10, and 3-12-6 (treatments Nos. 1 to 4 and 9 to 12 in Table 1).

To broaden the scope of the experiment and make it of more direct interest to a larger number of growers, two soils were used, namely, an extremely acid heavy soil, Fulton silty clay (pH 4.8) from Fredonia, and a neutral, moderately heavy soil, Ontario loam (pH 7.2) from Geneva.<sup>2</sup>

## PLAN OF 1943 EXPERIMENTS

The tomato plants were grown in the usual commercial manner for cannery tomatoes. When the seedlings were 2 weeks old, they were transplanted to 16 × 22 inch flats in composted soil, setting 108 seedlings to the flat. Two lots of plants were used, one being planted 2 weeks earlier than the other. The older lot was therefore held for eight weeks in the transplanted flat. This lot of plants was checked in growth by having used up most of the available nutrient supply in the flat. They were typical of plants grown commercially for the cannery crop.

Each lot of plants was taken from the flats on the same day,

<sup>2</sup>The author wishes to acknowledge the assistance of Mr. L. M. Oliver of the Cooperative G. L. F. Soil Building Service for furnishing the Fulton soil and the mixed fertilizers for this test and for suggesting the need for this experiment.

graded for uniformity, and divided into 23 lots of uniform size. They were then transplanted to each soil type. At the time of transplanting a starter solution was poured around the roots in a manner similar to the ejection of water in a transplanting machine. Each solution was used at the rate of  $\frac{1}{4}$  pint per plant. This is at the rate of about 91 gallons per acre. In four of the lots (Nos. 20 to 23, inclusive) only water was poured around the roots when they were transplanted, but the tops were dipped in four of the starter solutions. It had been suggested that fertilizers could be applied satisfactorily as a spray on the foliage, and these four lots were included to test this theory.

Six plants of each age in each soil type were treated with each starter solution as previously described. At the end of 1, 2, and 3 weeks after transplanting detailed notes were made of the size, color, and condition of the plants in each treatment. As in the 1942 greenhouse test (6), the height of the plants and the percentage showing blossom clusters were determined and they were rated for quality. For this quality rating an expert plant grower critically examined all the lots on each soil type and graded them into four classes as follows: Plants that were sturdy and growing vigorously and were a healthy green color, with strong side shoots and large blossom clusters, were rated excellent (E in Table 1). Plants that had not made quite such vigorous growth, were slightly spindling but not stunted, or whose foliage showed a faint tinge of off-color suggesting nutrient deficiencies were rated good (G). Plants that were somewhat stunted and spindling in growth and showed evidence of nutrient deficiencies (purple veins or yellow leaves) were rated fair (F). They would probably make a satisfactory crop. Plants classed as poor (P) were stunted, spindling, lacking in healthy green color and vigor, and were markedly inferior to the other three classes. The results of these comparisons of the growth of the plants from each of the 23 starter solutions and of the two ages of plants on the two soil types are compiled in Table 1.

After being rated for quality, the plants were soaked thoroly, the soil carefully washed away from the roots, and any differences noted in root development of the various lots. Typical plants showing root and top growth of several lots grown on Fulton silty clay soil are shown in Fig. 1.

After the plants were thoroly washed they were dried at a temperature of 120° F for a week after which the dry weights were determined (Table 1). These dry weights should be an accurate index of the relative substance of the plants resulting from the different starter

TABLE 1.—EFFECT OF VARIOUS STARTER SOLUTIONS ON EARLY GROWTH OF TOMATO PLANTS, 1943, AS MEASURED BY DIFFERENCES 23 DAYS AFTER TRANSPLANTING.

TREAT- MENT No.	INGREDIENTS PER 50 GALS. WATER*	ACIDITY OF SOLU- TION, pH	ON HEAVY ACID SOIL (pH 4.8)				ON NEUTRAL LOAM SOIL (pH 7.2)			
			Plants 6 weeks old when transplanted		Plants 8 weeks old when transplanted		Plants 6 weeks old when transplanted		Plants 8 weeks old when transplanted	
			Av. height, inches	Av. dry weight, grams	Quality†	Av. height, inches	Av. dry weight, grams	Quality†	Av. height, inches	Av. dry weight, grams
1	10 lbs. 4-16-4 (ammoniated superphosphate)	5.23	13	8.3	E	13	5.7	E	12½	9.2
2	10 lbs. 4-10-5 (ammoniated superphosphate)	5.73	12	5.0	E	11	3.2	E	13	9.8
3	10 lbs. 4-10-10 (ammoniated superphosphate)	5.54	12	5.0	E	11	3.5	E	12	6.3
4	10 lbs. 3-12-6 (ammoniated superphosphate)	5.50	13	7.0	E	9½	3.7	E	11	6.7
5	10 lbs. 3-12-6 (magnesia)	5.18	12	6.2	G	10	3.7	G	11½	6.5
6	4 lbs. 11-32-14	5.53	12	7.1	E	11	5.8	E	13	9.3
7	Water only (check)	—	8	2.5	P	6	1.3	F	11	4.7
8	4 lbs. 13-26-13	5.41	11	8.3	E	10	7.7	E	12½	9.8
9	10 lbs. 4-16-4 (ordinary superphosphate)	4.66	13	5.7	G	10	6.5	E	12½	7.0
10	10 lbs. 4-10-5 (ordinary superphosphate)	5.18	10½	5.3	G	9	4.7	E	13	9.0
11	10 lbs. 4-10-10 (ordinary superphosphate)	5.12	11	4.2	G	10	3.3	E	13½	8.3
12	10 lbs. 3-12-6 (ordinary superphosphate)	5.10	10	5.7	G	10	3.8	E	12	6.2
13	10 lbs. 4-10-5 special	5.45	10	6.7	G	9½	6.2	E	13	8.3
14	Home mixture of nitrate of soda, superphosphate, and potash	4.1	10½	5.0	G	10½	4.5	E	13	8.3

15	1 lb. di-potassium phosphate, 2 lbs.	7.78†	E	11½	6.8	E	10½	7.3	E	12½	8.9	E	12	8.1
16	1 lb. di-ammonium phosphate nitrate of soda	8.28† 7.04†	F F	9½ 9	2.8 3.4	G P	9 11	4.8 1.8	E G	12 10	8.7 5.2	G G	11½ 10	6.0 5.6
17	3 lbs. nitrate of soda	3.53	F	10	3.0	F	10	2.7	G	9½	4.8	F	10	3.7
18	6 lbs. 20% superphosphate													
19	3 lbs. nitrate of soda, 6 lbs. 20% superphosphate	3.50	E	12	6.0	G	10½	4.2	E	13	7.8	E	10	5.3
20	Tops dipped in No. 8 soln.	5.41	P	9	2.7	P	9	1.7	F	10½	3.3	P	10½	2.5
21	Tops dipped in No. 15 soln.	7.78†	P	9½	2.5	P	9	2.2	F	11	4.7	P	10	3.3
22	Tops dipped in No. 16 soln.	8.28†	P	9	2.7	F	10	2.8	F	11	4.2	P	9½	3.3
23	Tops dipped in No. 5 soln.	5.18	P	9	2.5	P	9½	1.5	F	11	4.3	P	9½	2.8

\*All solutions were used at the rate of  $\frac{1}{4}$  pint per plant. The plants were 6 inches tall when transplanted.

†E = Excellent; G = Good; F = Fair; P = Poor.

‡Alkaline solution.

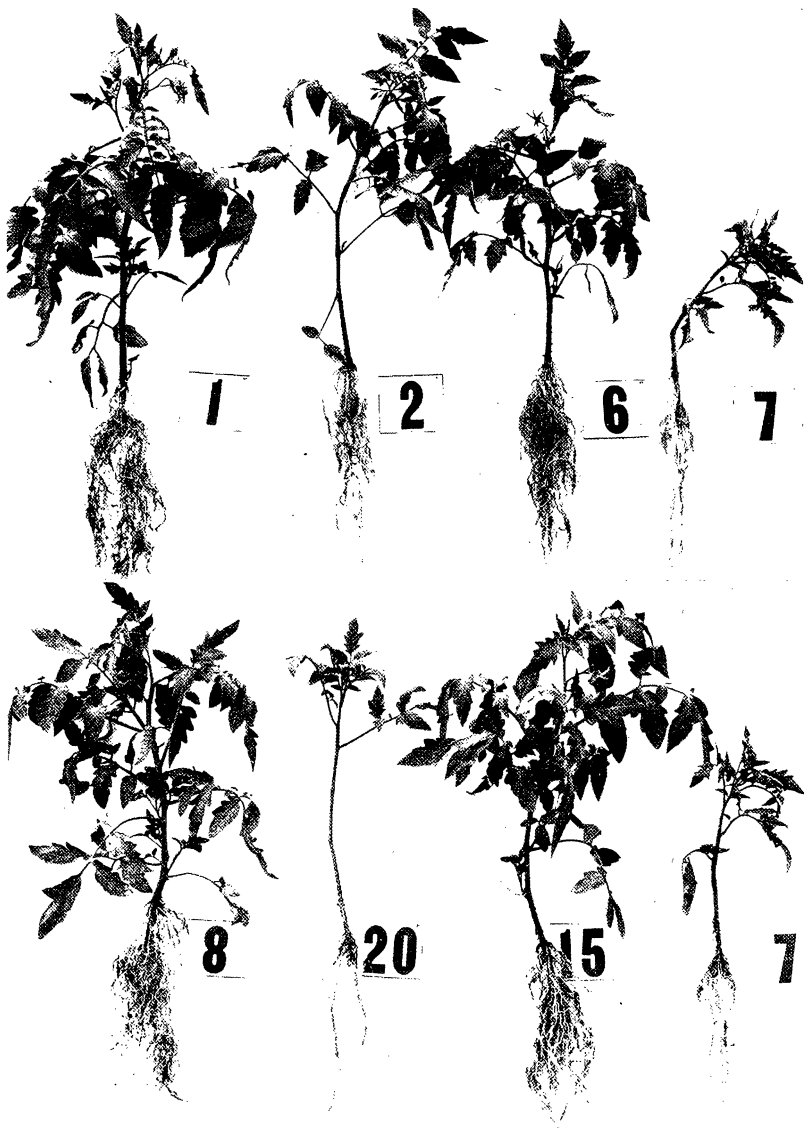


FIG. 1.—EFFECT OF DIFFERENT STARTER SOLUTIONS ON EARLY GROWTH OF TOMATOES ON FULTON CLAY SOIL.

Typical plants showing differences in growth 23 days after transplanting. No. 1 solution was 10 pounds of 4-16-4 fertilizer to 50 gallons of water; No. 2 was 10 pounds of 4-10-5; No. 6 was 4 pounds of 11-32-14; No. 8 was 4 pounds of 13-26-13; No. 20 was No. 8 solution applied to foliage only; No. 15 was 3 pounds of 16-48-18 mixture; No. 7 was check (tap water). All solutions were used at rate of  $\frac{1}{4}$  pint per plant, or 91 gallons per acre.



solution treatments and also should indicate the effect of the soil type and age of plants at transplanting time on their rapidity of growth.

## COMPARISON OF STARTER SOLUTIONS

As a basis of comparison to determine the effectiveness of the various starter solutions, a check lot of plants of each age was transplanted on each soil type. These check lots (No. 7, Table 1 and Fig. 1) were transplanted the same as the other lots except that  $\frac{1}{4}$  pint of tap water only was poured around the roots at the time the plants were transplanted.

### THE 13-26-13 AND 11-32-14 MIXTURES ESPECIALLY EFFECTIVE

Careful observation of the appearance of the plants in each lot thruout the period of this test showed that the 13-26-13 mixture (No. 8, Table 1 and Fig. 1) used at the rate of 4 pounds to 50 gallons of water proved especially effective on each soil type and with each age of plants. With this starter solution the plants became established quickly and made a sturdy vigorous growth. The foliage was a healthy color and strong side shoots and a good root system developed in each soil. There was no sign of injury from this solution on either soil. The 11-32-14 mixture (No. 6, Table 1 and Fig. 1) also gave excellent results on each soil, but the dry weights indicate it was not quite equal to the 13-26-13 mixture.

### REGULAR MIXED FERTILIZERS PROVE VERY SATISFACTORY

Nine ordinary commercially mixed field fertilizers approved for sale in New York in 1943 were included in this experiment. Each of these fertilizers (Nos. 1 to 5 and 9 to 12, inclusive, Table 1) was used at the rate of 10 pounds to 50 gallons of water. This would roughly approximate the amounts of soluble nitrogen, phosphoric acid, and potash that would be obtained from 4 pounds of the more concentrated transplanting mixtures. Tests in 1942 (Table 2) showed that 10 pounds of the regular mixed fertilizers proved satisfactory for starter solutions. The four grades of mixed fertilizers used in the 1943 experiment were 4-16-4, 4-10-5, 4-10-10, and 3-12-6. The first three grades proved very satisfactory, but the 3-12-6 grade was not quite as good, apparently because of the low content of nitrogen.

#### AMMONIATED SUPERPHOSPHATE VS. SUPERPHOSPHATE AND SULFATE OF AMMONIA

Four grades of commercial mixed fertilizers made with ammoniated superphosphate (Nos. 1 to 4, Table 1) were compared with corresponding grades made with regular superphosphate mixed with sulfate of ammonia (Nos. 9 to 12, Table 1). In each grade the ammoniated superphosphate mixture was less acid, which seemed to be an advantage on the acid soil.

Of the four grades under comparison the 4-16-4 was more acid than the others and the 4-10-5 was the least acid. Probably the higher ratio of phosphoric acid in the 4-16-4 grade caused the greater acidity. It is noteworthy that in spite of its greater acidity the 4-16-4 proved slightly superior to the other grades as a starter mixture, especially in the acid soil which had a very high capacity for "fixing" phosphorus in an unavailable form.

#### MAGNESIUM NOT NEEDED IN STARTER SOLUTIONS

The commercial fertilizer used in treatment No. 5, Table 1, contained magnesium in the form of sulfate of potash-magnesia. Comparing this 3-12-6 fertilizer with the same grade without magnesia (treatment Nos. 4 and 12, Table 1), it is evident that as used in this test there was no advantage in adding magnesium to the starter solution. Apparently these soils supplied adequate amounts of magnesium for the tomato plants, or extra magnesium was not needed at this stage of growth.

#### NITRATE AND AMMONIA NITROGEN MIXTURE GOOD

Treatment No. 13, Table 1, was a special 4-10-5 grade in which half of the nitrogen was supplied by nitrate of soda and half by ammoniated superphosphate. This mixture was slightly less acid and gave slightly better results on the acid soil than the same grade in which the nitrogen was derived entirely from sulfate of ammonia (No. 10, Table 1), or the same grade in which the nitrogen was derived entirely from nitrate of soda (No. 14, Table 1).

#### DISADVANTAGES OF NITRATE OF SODA, SUPERPHOSPHATE, AND POTASH MIXTURE

A mixture of nitrate of soda, superphosphate, and muriate of potash was included for comparison (treatment No. 14, Table 1). Fertilizer dealers do not make up such a mixture because it "sets" or

"cakes" in a very short time. Consequently, such a mixture would have to be mixed by the individual grower. Furthermore, under present government restrictions, growers would have to buy each ingredient in 100-pound lots and would have to file special certificates to buy the nitrate of soda, therefore this home mixture would be especially difficult to obtain this year. In the experiment this mixture did not prove superior to commercially mixed fertilizer of similar grade (4-10-5) made with either ammoniated superphosphate (No. 2, Table 1) or with sulfate of ammonia and regular superphosphate (No. 10, Table 1). The mixture containing nitrate of soda (No. 14, Table 1) was extremely acid, due probably to the unbuffered superphosphate, and on the acid soil this extreme acidity caused severe root injury when first applied. After about 10 days, probably because of the alkaline residue from the nitrate of soda, the plants recovered from this root damage and made a good growth.

#### NITRATE OF SODA ALONE NOT SATISFACTORY

Many growers have used nitrate of soda alone in the transplanting water when transplanting cabbage or tomato plants. In treatment No. 17 (Table 1) nitrate of soda was used at the rate of 3 pounds to 50 gallons of water. It made a neutral solution and would leave an alkaline residue in the soil when the nitrate was taken up by the plant. This did not make a satisfactory starter solution. As in many previous experiments, plants receiving the nitrate of soda solution made a poor growth. The foliage was very dark green and the veins of the leaves were purple indicating acute phosphorus deficiency. A typical plant is shown in No. 17, Fig. 2.

#### SUPERPHOSPHATE ALONE NOT SATISFACTORY

Altho previous tests have indicated that starter solutions should be higher in phosphorus than other nutrients to stimulate the most rapid plant growth, superphosphate alone (No. 18, Table 1 and Fig. 2) did not make a satisfactory starter solution. In previous tests (2) liquid phosphoric acid was also very unsatisfactory. Apparently the extreme acidity of the superphosphate solution (pH 3.5) seriously injured the roots. Prince and Tiedjens (1) report that, "Strongly acid solutions, with pH values less than 5, are not as suitable for use at transplanting time as those having higher pH values." The foliage of the plants receiving the superphosphate solution was yellowish green; many of the lower leaves fell off, and the plants received a

severe check, apparently due to root injury, but finally recovered and made a fair growth.

#### BALANCED MIXTURE IMPORTANT

Altho nitrate of soda alone (No. 17, Table 1) and superphosphate alone (No. 18) made very poor starter solutions, when the two ingredients were added together (No. 19) the balanced solution produced excellent plants, notwithstanding the extreme acidity of this solution due to the superphosphate. On the acid soil this solution caused some root injury at first, but the plants quickly recovered and made a strong growth as shown in No. 19, Fig. 2.



FIG. 2.—SHOWING IMPORTANCE OF BALANCED NUTRIENTS IN STARTER SOLUTIONS FOR TOMATOES.

Typical plants 23 days after transplanting with the following solutions: No. 17, 3 pounds of nitrate of soda to 50 gallons of water; No. 18, 6 pounds of 20 per cent superphosphate; No. 19, 3 pounds of nitrate of soda plus 6 pounds of 20 per cent superphosphate; No. 7, check (water only).

#### A NEW COMPLETELY SOLUBLE ALKALINE SOLUTION

One objection to the use of ordinary mixed fertilizers for starter solutions is the large amount of insoluble residue that must be strained out to prevent clogging the tubes in the transplanting machine. A completely soluble mixture that can be poured directly

into the tank on the transplanter is much more convenient and easier to use. Also, in acid soils, it might be an advantage to use an alkaline starter solution. Three years ago the writer devised such a mixture (No. 15, Table 1) and has used it with excellent results in greenhouse tests on a poorly buffered acid soil, sassafras sandy loam (pH 5.2) from Grenloch, N. J.; a moderately buffered sassafras silt loam (pH 6.4) from New Brunswick, N. J.; a poorly buffered Dunkirk sand (pH 6.25) from Oaks Corners, N. Y.; a well-buffered neutral Ontario loam (pH 7.2) from Geneva; and an extremely acid, very heavy Fulton silty clay (pH 4.8) from Fredonia, N. Y. This mixture has also been used for 3 years in field tests on Ontario loam at Geneva and has given excellent results as shown in Table 2, No. 7.

TABLE 2.—EFFECT OF STARTER SOLUTIONS ON EARLY AND TOTAL YIELDS OF TOMATOES, 1942 FIELD TESTS.\*

SOLUTION NO.	INGREDIENTS PER 50 GALS. WATER	ACIDITY OF SOLUTION, pH	GREENHOUSE RATING†	YIELDS, TONS PER ACRE			
				To Aug. 31	Gain over check	Total yield	Gain over check
1	4 lbs. 11-32-14 mixture	5.80	E	3.18	1.66	16.45	1.54
2	10 lbs. 5-10-5	5.50	E	2.90	1.38	16.64	1.73
3	5 lbs. 5-10-5	5.95	G	2.04	0.52	15.15	0.24
4	10 lbs. 5-10-5 (magnesia)	5.43	N	3.08	1.56	15.87	0.96
5	5 lbs. 5-10-5 (magnesia)	Lost	N	2.10	0.58	15.22	0.31
6	10 lbs. 4-16-4	5.55	E	2.47	0.95	15.71	0.80
7	2 lbs. di-ammonium phosphate, 1 lb. di-potassium phosphate	7.70	E	2.85	1.33	16.35	1.44
8	Water only (check)	—	P	1.52	—	14.91	—
9	5 lbs. 4-16-4	6.20	G	1.87	0.35	14.80	0.11
10	10 lbs. 3-12-6	5.70	G	2.15	0.63	15.56	0.65
Difference necessary for significance (19 to 1)				—	0.61		2.07

\*Entire field uniformly fertilized with 600 pounds 5-20-5 drilled deeply. All solutions used at rate of  $\frac{1}{4}$  pint to the plant or 91 gallons to the acre.

†Greenhouse rating refers to greenhouse test of starter solutions. Index based on growth and appearance of plants 23 days after transplanting. E = Excellent; G = Good; P = Poor; N = Not tested.

Plant physiologists have long used di-potassium phosphate in nutrient solutions and have noted particularly that it stimulates root development. The author has tried mixing the di-potassium phosphate with various nitrogen compounds, such as Urea, sulfate of ammonia, and nitrate of soda, as in No. 16, Table 1, but none of these mixtures has given satisfactory results. However, the mixture of 2 pounds of

di-ammonium phosphate with 1 pound of di-potassium phosphate, No. 15, Table 1, and No. 7, Table 2, has not caused any injury in the tests thus far conducted and has always greatly stimulated sturdy growth of the tomato plants. It appears to be a most promising mixture for a starter solution when used as described below.

This mixture, which has an analysis of  $16\frac{2}{3}$  per cent nitrogen, 48 per cent phosphoric acid, and 18 per cent potash, has to be handled differently from any of the other mixtures described. The two ingredients resemble granulated sugar in appearance and dissolve in water about as readily as sugar. However, the two materials must be kept separate until needed for transplanting. If the dry materials are mixed in advance, free ammonia will be given off, but when mixed in solution this will be taken up by the water.

#### STARTER SOLUTIONS NOT EFFECTIVE ON FOLIAGE

It has been suggested that nutrient solutions could be applied to the foliage to stimulate plant growth. To try this out, four of the solutions were applied to the tops instead of the roots by dipping the tops in the solution at transplanting time. This thoroly covered both the top and bottom surfaces of the leaves which should permit maximum absorption of the nutrients if this method were effective. The results are shown in Nos. 20 to 23, Table 1, and clearly indicate that as used in this test the nutrient solutions were *not* effective when applied to the foliage. The foliage of the plants in each of these lots turned a very dark green, indicating they had absorbed the nitrogen from the solutions, but the veins of the leaves showed the purple discoloration characteristic of phosphorus starvation. Apparently they did not absorb sufficient phosphorus when it was applied only to the foliage.

#### BEST AGE OF CANNERY TOMATO PLANTS FOR TRANSPLANTING

In 6 years' experiments in the field the author has compared tomato plants grown from seed sown March 10, March 25, and April 10. These were all transplanted to the field under uniform conditions about May 25. In 4 of these 6 years the youngest plants (6 weeks old at transplanting time) produced the largest early yields and total yields of tomatoes. In the other 2 years the plants from seed sown March 25 produced the largest yield. In all 6 years the oldest plants (10 weeks old at transplanting) produced the lowest yields. These tomatoes were grown in the usual commercial method for the cannery

crop, that is with 108 seedlings to the flat. Under such crowded conditions the plants become hardened and partially starved and they do not pick up quite so quickly as younger plants that have not been so severely checked in growth. A similar result is well illustrated in Fig. 3 which shows typical plants of the two ages used in the greenhouse experiment reported here. In 23 days after transplanting, the plants



FIG. 3.—EFFECT OF SOIL TYPE AND AGE OF TOMATO PLANTS AT TRANSPLANTING TIME ON RAPIDITY OF GROWTH.

The younger plants had outgrown plants that were 2 weeks older on each soil 23 days after transplanting. All plants grown in composted soil and transplanted same day. A was 8 weeks old and B was 6 weeks old when transplanted to Fulton silty clay (pH 4.8). C was 8 weeks old and D was 6 weeks old when transplanted to Ontario loam (pH 7.2).

that were 6 weeks old when transplanted had outgrown the plants which were older and more severely hardened when they were transplanted. It should be emphasized that these are plants grown under crowded conditions in the flat. Market gardeners who can afford (because of higher unit returns) to space their plants farther and keep the plants well supplied with nutrients and growing vigorously can obtain earlier yields by starting tomato plants earlier and they are not so likely to obtain marked response from starter solutions when transplanting. This is partly due to their more liberal fertilizer practices in the field as well as to better nourished plants at transplanting time.

## CORRELATION BETWEEN GREENHOUSE AND FIELD RESULTS

The conclusive test of the value of any starter solution is its effect on yield of marketable tomatoes. The greenhouse experiment (6) conducted in the winter of 1941-42 was designed as a quick test to obtain results in time for field planting to meet the war emergency which had reduced the supply of fertilizers obtainable for starter solutions. It was believed that the results of this greenhouse experiment could be considered as a reliable index of the relative value of various materials tested as starter solutions. The final proof of the value of any of these starter solutions had to be determined by field tests in which yields of marketable tomatoes formed the basis for judging the value of the starter solution.

Accordingly, 10 starter solutions were compared in a field experiment in 1942. The results of this experiment are given in Table 2, in which the field yields can be correlated with the preliminary greenhouse tests. As in all previous field experiments, the principal effect of starter solutions was in the increased yield of early tomatoes. In Table 2 the early yields (to August 31) are tabulated separately from the total yields. Comparing the greenhouse rating with the early yields, it is evident that there is a very definite correlation indicating the accuracy of the greenhouse rating. The four treatments given an E rating (excellent) in the greenhouse all produced significant increases in early yields. Of the three treatments in the test which rated G (good) in the greenhouse, only one produced a significant increase in field yields and none of them equalled the yields of any treatment rated E in the greenhouse. The check treatment rated P (poor) in the greenhouse also produced the poorest early yield in the field. Based on the close correlation between the greenhouse rating and the field results in 1942, it seems reasonable to expect that the greenhouse experiments herein reported (Table 1) should be a reliable guide as to which fertilizers are likely to give satisfactory results when used as starter solutions in the field in 1943.

The field experiments again proved that the correct use of a good starter solution is a very profitable practice in growing cannery tomatoes. An increased yield of about  $1\frac{1}{2}$  tons of tomatoes by August 31 from the use of a starter solution in the transplanting machine is very much worth while. Furthermore, tomatoes harvested early in the season are always of higher quality than those harvested late, and there is less congestion and less waiting at the factory to unload.



Consequently, an increase in early yields is of particular value to growers of cannery tomatoes and to canners.

At the rate used in this experiment ( $\frac{1}{4}$  pint of solution to the plant) 10 pounds of fertilizer to 50 gallons of water would require only 18 pounds of fertilizer per acre for the starter solution. That this small quantity will give excellent results is shown in Table 2, Nos. 2, 4, and 6. It also shows that 5 pounds of ordinary mixed fertilizer to 50 gallons of water are not sufficient (Nos. 3, 5, and 9, Table 2), but that 4 pounds of high analysis transplanting mixture (No. 1, Table 2) and 3 pounds of higher analysis (No. 7, Table 2) are satisfactory.

Altho these small quantities per acre seem trifling, previous experiments (3) have shown that larger quantities are likely to be harmful due to an excessive concentration of soluble salts. It has also been shown (3, and unpublished data) that these quantities adequately meet the needs of the tomato plants for the first 3 or 4 weeks after transplanting. During the transplanting operation much of the plant's root system is torn off and disturbed. Consequently, a good starter solution poured around the roots when transplanting will help sustain the plant at a critical time and will enable it to recover quickly and grow more rapidly. The result is less loss of plants in the field and an earlier crop.

## CONCLUSIONS

Very satisfactory starter solutions can be made with some grades of mixed fertilizers that are permitted for sale and use in New York in 1943. Of these grades the 4-16-4, 4-10-5, and 4-10-10 proved most satisfactory and the 3-12-6 grade was fairly satisfactory. The 4-16-4 grade appeared best of these four. All of these grades should be used at the rate of 10 pounds to 50 gallons of water and  $\frac{1}{4}$  pint of solution per plant. There will be considerable insoluble residue in these mixtures, which should be kept out of the tank of the transplanter machine. This can be done by mixing the fertilizer with water in a separate container and pouring off the solution carefully or straining it as it is poured into the tank. Stock solutions can be made in advance using 1 pound of mixed fertilizer to the gallon of water and then adding water to 10 gallons of this stock solution to make 50 gallons of starter solution.

Mixed fertilizers containing ammoniated superphosphate were less acid and more satisfactory for starter solutions than mixtures of regular superphosphate and sulfate of ammonia.

The high analysis special transplanting mixtures, such as the 13-26-13 or the 11-32-14, are especially effective when used at the rate of 4 pounds to 50 gallons of water as starter solutions in transplanting cannery tomatoes. A new completely soluble alkaline 16-48-18 mixture used at the rate of 3 pounds to 50 gallons of water is also especially effective if the separate ingredients are not mixed until ready to use. Unfortunately, under the war time restrictions, these three mixtures are not readily obtainable.

Tomato plants that had been held in crowded flats for 6 weeks recovered quickly and grew more rapidly after transplanting than plants held 8 weeks in the flat.

Applying nutrient solutions to the foliage was not effective in stimulating growth.

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