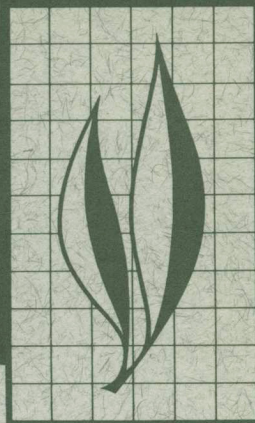


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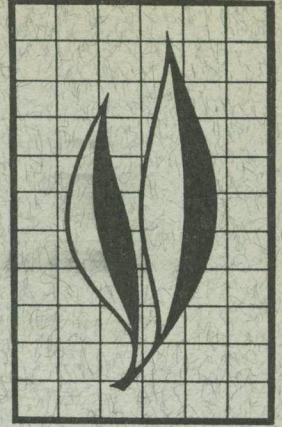
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Pot Experiments Related to the Peach Replant Problem

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Composting of peach-root substances with two different soils in pot cultures did not prove to be a reliable method of simulating the peach replant problem though peach-root wood sometimes hindered nitrogen availability and in one experiment other root substances depressed the growth of peach seedlings. Successive plantings in pots of these soils did produce the depression. Soil fumigation was an ineffective treatment but steaming effected a partial recovery.

A third soil, less fertile than the other two, did not exhibit the replant depression but was injured by steaming.

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Pot Experiments Related to the Peach Replant Problem¹

IN A PREVIOUS STUDY of the specific peach replant problem it was demonstrated that the addition of peach-root bark, or its dried alcoholic extract, to small peach seedlings in sand culture, could cause severe injury to the seedlings (Proebsting and Gilmore, 1940). Hilderbrand (1945) also showed stunting of peach trees in sand cultures containing peach roots. Havis and Gilken-son (1947), using 3-gallon sand cultures and a circulating nutrient solution of 18 liters, found no injury to the growth of 1-year-old budded nursery stock, or to very young peach seedlings when peach roots or peach-root substances were included in the cultures.

Hirai *et al.* (1957) found inhibition of peach seedlings due to addition of peach-root bark to the culture medium. Seedlings grown in bark and soil com- posts which had been heated after mix- ing did not show growth depression, but the depressive effect of the bark was not lessened by fumigation of the com- post with formalin or carbon bisulfide.

Hirano (1957), in experiments using 1-year-old peach trees in pot culture,

produced no inhibiting effect by the addition of peach "rootlets." However, when the experiment was repeated the following year, apparently using larger quantities of rootlets, marked retarda- tion of growth was observed.

Puzzling differences of this sort among the results of various workers or among the results of various experi- ments of the same worker, are char- acteristic of the study of the specific peach replant problem. Similarly, a great variability results when peach trees are replanted in commercial fields.

The pot experiments reported here had the initial objective of confirming in soil culture the harmful effects of peach-root bark previously noted in sand cultures and of identifying the fraction responsible for the injury. Comparisons were also to be made with composts of other materials.

As the experiments continued, obser- vations were made on the effects of re- peated cropping of pots with peach seedlings, and attempts were made to alleviate the replant problem thus pro- duced.

MATERIALS

Pots: These were cans of about 14 liters capacity, 24 cm in diameter and 32 cm high.

Soils: No. 20—Yolo loam collected

from non-peach locations on the Uni- versity fields at Davis.

No. 26—Hanford sandy loam from the bottoms on the north side of the

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American River east of Sacramento. All collections of this soil were taken from a single surface location in a field where a peach replanting had shown poor performance.

No. 27—Hanford loamy fine sand from the bottoms on the south side of the American River east of Sacramento. All samples were collected from a single location under natural cover.

Judged by growth of first plantings of peach seedlings in pots, soil 20 was the most fertile, soil 27 the least, and soil 26 intermediate.

This lesser fertility of soil 26 compared with soil 20 probably cannot be attributed to its collection from a replant situation as previous work has demonstrated that such soils do not necessarily show the replant depression when first planted to peaches in pot culture (Proebsting and Gilmore, 1940).

Water: Water used for the cultures was a class-one agricultural water from shallow wells at the Experiment Station.

Nitrogen Source: Ammonium nitrate, with the exception of calcium nitrate in experiment 8, was used as a nitrogen supply.

Spray Materials: Various sprays and dusts were used as appropriate for the control of mites and mildew.

Soil Fumigants: Dichloropropene, carbon bisulfide, white gasoline, chlorobromopropene, and ethylene dibromide, were at times used as soil fumigants in attempts to restore productivity to soils which had become unproductive in pot culture.

Composting Materials: Roots and root fractions of peach, root barks of various other *Prunus* species including almond, myrobalan, apricot, cherry, as well as trunk bark of peach and hemlock, and filter paper were used in preparing composts. Roots were obtained from near the crowns of pulled trees and either stored as pieces of whole root or after separating into wood and bark. Usually the roots or their parts were air-dried and stored at room tem-

perature, but one collection of peach root material was frozen and stored at -10°C . Variety of the rootstocks from which peach-root collections were made was not usually known but can be assumed to be Lovell seedlings, except for one collection which, as indicated in the tables, was Muir seedlings.

After drying, the peach-root bark was additionally fractionated by solvent and chemical means. The following eight fractions were used to prepare seven composting materials based on peach roots or their parts:

1. Whole peach root.
2. Peach-root wood.
3. Peach-root bark.

4. RAx—the residue of peach-root bark after grinding and extracting with cold 95 per cent ethyl alcohol.

5. Ax—the dried alcohol extract of peach-root bark. This was dried by reduction in vacuum, below 45°C , to a thick syrup which was then thinly spread on a glass plate until brittle. The scales obtained by scraping the material from the plate were ground in a mortar and exposed to air for some weeks to insure removal of the solvent.

6. BA1—a fraction precipitated from Ax as follows: A quantity of Ax was mixed with an equal weight of water and brought into solution by stirring and mixing. A clear, deep-red syrupy solution resulted which from its clarity in thin layers appeared to be a true solution. This was then poured, with stirring, into a weight of water equal to about nine times the weight of solute, so that the final weight of water was about ten times that of the solute. A quantity of reddish-brown material was precipitated as a flocculent mass by this dilution. The precipitate was filtered on a Büchner funnel and washed with two to three portions of distilled water.

7. BA2—a saturated solution of neutral lead acetate, $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$, was added to the filtrate from the BA1 preparation to precipitate an additional fraction which was recovered on a Büchner funnel and transferred to

TABLE 1
COMPOSITION OF PEACH ROOTS
(Dry-weight basis)*

Weight	Fraction	Percentage of		
		Whole root	Bark	Ax
<i>gm</i>				
500	Root.....	100		
305	Wood.....	61		
195	Bark.....	39	100	
118.9	RAx.....	23.8	61	
76.1	Ax.....	15.2	39	100
27.9	BA1.....	5.6	14.3	36.6
35.9	BA2.....	7.2	18.4	47.2
12.3	BA3 (Incompletely dried).....	2.4	6.3	16.2

* Values obtained by proportionate distribution of losses in a procedure to the components.

95 per cent ethyl alcohol. The precipitated organic materials were freed of lead with hydrogen sulfide in 95 per cent alcohol, concentrated in a vacuum still at below 45°C, and dried on a glass plate.

8. BA3—the filtrate from the BA2 precipitation was cleared of lead by saturating with hydrogen sulfide, and the filtrate from the lead sulfide reduced in a vacuum still below 45°C. After the solution was reduced to a high concentration, absolute ethyl alcohol was introduced and distilled off three or four times to reduce the amount of water and acetic acid present in the concentrate as the result of the lead acetate clarification. The concentrate so produced was a thick syrupy mass which was hygroscopic and difficult to dry, although thin layers could be dried in a dessicator. Thick layers crusted and could be dried only after very long periods of time.

A representative composition of peach roots, gathered in the fall, according to the described fractions, is shown in table 1. The BA1 and BA2 fractions are tannins of the phlobotanin type and apparently vary only in their state of aggregation, the BA1 fraction being the heavier polymer. Progressive polymerization of these tannins occurs in aqueous solution, BA1 being slowly precipitated from aqueous solutions of extracts containing BA2. Dried preparations of BA2 can rarely be completely redissolved in water and the amount redissolved is dependent on using a small rather than a large amount of water, the optimum being in the range of 20 gm of BA2 to 80–100 cc of water.

The BA3 fraction, from its method of preparation, would be expected to be mostly carbohydrates and glucosides, or their degradation products.

METHODS

Growth measurements, as dry weight of tops, or height measurements in experiment 2, were made on peach seedlings grown for a season in pots of soil prepared by composting, or by having had peach seedlings grown in them in previous seasons. At times, various fumigants or steam treatments were used in attempts to restore fertility where

this had been reduced by previous cropping.

With the exception of experiment 1, which was done in a greenhouse, all experiments were carried out in a lath-house shaded from the afternoon sun by a row of trees, and were subject to year-to-year climatic variations.

Seedlings for the tests were grown

in the greenhouse or lathhouse, in small pots of steamed soil, till transplanted to the test pots. The seeds used were of the Lovell variety and were after-ripened under aseptic conditions as previously described (Gilmore, 1950). In some years it was possible to select uniform seedlings and in others it was necessary to use seedlings of varying heights, in which case, after grading, a uniform distribution of the various sizes was made to the different sets of pots in the experiment.

Growing periods of seedlings prior to and after transplanting to the test pots varied somewhat from year to year. Transplanting dates fell between May 1 and June 16 and seedling heights varied from 10 to 40 cm. These differences are indicated in the tables which also show the number of days between transplanting and harvest of the tops. The latter values are not accurate indications of growing periods in the pots. Harvest was made at irregular times late in October or early November after the cessation of growth, but before leaf fall. These differences in growing times and conditions are of little importance when comparisons are made between sets of trees grown in the same year. It will be apparent that where comparisons are made between trees grown in successive years, that these differences are likewise minor in comparison to other factors affecting growth.

There was no sanitary control between pots or groups of pots containing soils of different series. Ample opportunity for transfer of soil organisms among the pots was afforded on the preparation bench, by transplanting and weeding tools, by watering procedures, and by birds which worked on the surface of the pots.

In experiments 1-4 the substances used in the tests were mixed with sufficient soil to fill the pots to within 2.5-5.0 cm of the top. In some tests the trees were planted soon after preparing the composts and in others a delay of

weeks occurred, as indicated in the tables. Root and bark material was applied in various physical conditions. Unless specified as fresh or frozen, the material was taken from dry storage. Material designated as fresh was composted soon after collection and that designated as frozen was taken from material stored in fresh condition at approximately -10°C .

In experiments 1 and 2 application of the fractions of peach root were made at rates approximating the amounts present in 500 gm of whole, dry roots; exceptions being root wood, experiment 2, where insufficient material was available, and BA3, experiment 2, where application was made in greater amount to insure that the weight of solids in the incompletely dried mass was at least equivalent to that occurring in 500 gm dry roots. In experiments 3 and 4, additions of the composting substances were made at uniform rates, 190-200 gm per pot, dry weight basis, with the exception of Ax which was used at its rate of occurrence in 500 gm of dry roots.

In experiment 4 and subsequent experiments, plantings were made in pots of soil previously used to grow peach seedlings. In these pots the old root systems were usually killed prior to replanting by cutting off the stump below the crown, or by other means; but in some cases the short stumps (1-2 cm high) remaining from the previous harvest were allowed to produce one to three sprouts which were pruned back occasionally to maintain the old root systems in a living but not vigorous condition. These pots are designated as "old roots alive." Later in experiment 8, new shoots were allowed to grow for a season on the old root systems without the inclusion of a new tree in the pot; reference to these one-season shoots on the previous year's root system is made by "2nd year shoot."

In attempts to restore fertility of pots, which had become unproductive as the result of growing peach seedlings

in them, the following treatments were tried: Five cc of dichloropropene or carbon bisulfide, or 15 cc of non-leaded gasoline injected 12 cm below the soil surface 48 days before planting, experiment 5. Thirty cc of ethylene dibromide or chlorobromopropene applied 12 cm below the soil surface after which a polyethylene cover was tied over the pot for 48 hours and then the soil was exposed to air in shallow trays for 15 days with frequent stirring, experiment 7. Steaming the pots three hours at 12 lb and nine hours at 15 lb. Submerging the pots in a tank of water for 90 days in an attempt to produce anaerobic decay of the roots and residues of previous plantings. Screening to remove old root systems. Submersion did not

accomplish its purpose as numbers of the stumps sprouted after removal from the tank.

Checks were sometimes employed in multiple sets to get some idea of the variation to be expected among sets of such small numbers. Each numbered experiment refers to seedlings grown in a particular year and the experiments are numbered in the order in which they were done. As additional pots of soil were introduced into the experiments, previously used pots were discarded to keep their number within reasonable bounds. It is for this reason that so few replanted pots of the first soil used (No. 20) were available in the latter experiments.

RESULTS AND DISCUSSION

Composts

The details of experiments 1-4 are given in tables 2-5 summarized in table 6, where the results for selected compost treatments are expressed as percentage of their checks in order to facilitate comparison.

Experiment 1: The first experiment indicated that peach-root substances were harmful composting agents for pot soils used to grow peach seedlings, but puzzling features of these results appeared to raise more questions than they answered.

From previous work with sand cultures (Proebsting and Gilmore, 1940) it was expected that the bark or some fraction of the alcohol-soluble extract would prove most injurious. Yet it was the root wood which showed the greatest injury. Likewise, a question was raised by the much greater injury which occurred through the use of powdered bark when compared with bark applied in chunks. Poor performance of Ax and the mixture of BA1 and BA2 was expected but poor performance of RAx was not.

If poor performance of peach seedlings in composts of root substances was

dependent on some poisonous root fraction, it would be expected, provided a good separation could be made, that the poisonous fraction would produce an inhibition somewhat of the order of the whole peach root, and that other fractions would show little effect. Some modification of this supposition would have to be made to account for the effect of one component on another if solution rates were involved, or if through the action of the soil flora a material were altered with regard to its toxicity. It is thought from laboratory observations that rate of breakdown or decomposition of various components of peach root may be influenced by the presence of other components. Peach-root wood or alcohol-extracted bark, if stored in a moist condition at room temperature, is rapidly attacked by molds. Moist peach root bark or an alcoholic extract of bark, when converted to water solution may be stored without precaution. The BA3 fraction is so susceptible to organism attack that it cannot be handled in water solution without strict asepsis. Despite these laboratory observations peach roots do decompose in the soil, but nothing is

TABLE 2
COMPOSTING EFFECT ON AVERAGE DRY WEIGHT OF PEACH SEEDLING TOPS
(Pot experiment 1)*

Rank of set	Treatment		Arithm. means	No. of pots	Standard deviation	Coefficient of variation
	Composting material	Amount				
		<i>gm</i>	<i>gm</i>		<i>gm</i>	<i>per cent</i>
1	Check.....	...	61.6	5	4.0	6.5
2	BA3.....	20	59.2	5	2.4	4.0
3	Check.....	...	53.8	5	6.9	12.8
4	Peach-root bark (chunks).....	194	50.6	5	12.8	25.3
5	Whole peach root (chunks).....	500	40.0	5	13.2	33.0
6	RAX Muir.....	112	28.0	5	13.2	47.1
7	AX.....	81	27.3	5	18.9	69.2
8	Peach-root bark (powder).....	194	27.0	5	7.0	25.9
9	Proportional mixture of BA1 + BA2	58	18.7	5	7.3	39.1
10	Peach-root wood (chunks).....	306	12.2	5	6.4	52.4

* Soil 20 from greenhouse bins. Composting done just prior to transplanting with 7.5 cm seedlings February 2 which were then grown 163 days in the greenhouse. No nitrogen added.

TABLE 3
COMPOSTING EFFECT ON AVERAGE HEIGHT OF PEACH SEEDLINGS
(Pot experiment 2)*

Rank of set	Treatment		No. per set	Height
	Composting material	Amount		
		<i>gm</i>		<i>cm</i>
1	AX Muir.....	81	5	69
1	Peach-root bark (powder).....	194	5	69
1	Almond-root bark (chunks).....	190	5	69
1	Myrobalan-root bark (chunks).....	190	5	69
1	Apricot-root bark (chunks).....	190	5	69
1	Hemlock bark (powder).....	190	5	69
1	Filter paper (shredded).....	190	5	69
2	Cherry-root bark (chunks).....	190	5	66
2	Whole peach roots (chunks).....	500	5	66
2	Peach-root bark (chunks).....	194	5	66
2	Proportional mixture BA1 + BA2 Muir.....	58	5	66
2	Peach-trunk bark (chunks).....	190	5	66
3	RAX.....	112	5	63
3	Peach-root wood (chunks).....	100	5	63
4	Check.....	...	5	60

* Soil 20 from field collection. Composting done 36 days prior to transplanting with 40 cm seedlings June 3, which were then grown 81 days in the lathhouse. Four gm of ammonium nitrate per pot 13 days prior to transplanting.

known of the rate of decomposition or whether some components may be more slowly attacked than others. In the case of the whole root it is not known whether the bark may exert a retarding influence as compared to the wood with bark removed.

Experiment 2: Consideration was given to the possibility that the poor performance of peach-root wood was a nitrogen suppression effect. Therefore,

in setting up the second experiment, 4 gm of ammonium nitrate were added to all pots, prior to transplanting, in the hope of separating toxic effects from nitrogen suppression effects if such existed. The experiment was expanded to include root barks of other *Prunus* species, a bark with high tannin content (hemlock) and a pure source of cellulose (filter paper).

In this experiment (table 3) all com-

posted sets grew vigorously and outperformed the single check set. Though the RAx treatment and peach-root wood at the lesser rate of application comprised the poorest group of the composts, this would seem to be of little significance since they did outperform the check, and because differences for the entire planting were small.

A decision was made not to harvest this experiment but to allow the trees to grow a second year in the pots to see if a delayed reaction to the treatments would occur. It did not. Growth the following year continued excellent.

Experiment 3: In experiment 3 a change was made to soil 26, and composting materials were employed at a constant dry-weight basis equivalent of 190 gm per pot with the exception of Ax applied at 81 gm per pot. As a result of the previous two experiments the question of nitrogen suppression was now uppermost. Nitrogen application was delayed till sometime after transplanting so some idea of performance could be had, and the effect of the delayed nitrogen application appraised. Three sets of checks were used to get some idea of the spread among sets comprised of such small numbers.

Fifty days after transplanting it appeared that all treatments except peach-root wood were performing as well as or better than the checks. Trees in the peach-root wood composts showed severe injury. This set had made little growth; terminal buds had formed, the leaf color was quite yellow, and it was apparent that without intervention the seedlings would not survive. At this time 4 gm of ammonium nitrate were added to the root-wood set as well as other sets showing any yellowish cast of leaves. Some days later, after opportunity to observe response was had, the remaining sets were treated.

The response of the root-wood compost was remarkable. Within a week the terminal buds had broken and growth resumed, but after such severe injury did not regain normal vigor. The only other set to show response to the heavy nitrogen application was the hemlock-bark set which developed a better leaf color. No influence on shoot growth was noted.

Leaf analyses made on the harvested material at the end of the experiment showed the peach-root wood set to have the highest values for both nitrogen and phosphorus at 3.1 per cent and .24

TABLE 4
COMPOSTING EFFECT ON AVERAGE DRY WEIGHT OF PEACH SEEDLING TOPS
(Pot experiment 3)*

Rank of set	Treatment		Arithm. means	No. of pots	Standard deviation	Coefficient of variation
	Composting materials	Amount				
		<i>gm</i>	<i>gm</i>		<i>gm</i>	<i>per cent</i>
1	Apricot-root bark (chunks).....	190	73.1	5	8.7	11.9
2	Peach-root bark (frozen chunks)....	350	63.8	5	7.8	12.3
3	Almond-root bark (chunks).....	190	59.1	5	9.7	16.4
4	Myrobalan-root bark (chunks).....	190	54.0	5	8.2	15.2
5	Hemlock-trunk bark (powder).....	190	52.5	5	8.2	15.7
6	Cherry-root bark (chunks).....	190	49.1	5	5.4	10.9
7	Peach-root bark (chunks).....	190	46.5	5	7.3	15.7
8	Check.....	...	46.4	5	7.9	17.0
9	Ax.....	81	45.3	5	12.4	27.3
10	Check.....	...	44.8	5	7.1	15.8
11	Whole peach root (chunks).....	190	43.7	5	7.2	16.4
12	Check.....	...	42.4	5	5.9	13.8
13	Peach-trunk bark (chunks).....	190	40.9	5	7.6	18.4
14	Peach-root wood (frozen chunks)....	350	17.8	5	5.9	33.3

* Soil 26. Composting done 36 days prior to transplanting with 27-35 cm seedlings May 1, which were then grown 170 days in the lathhouse. Four gm of ammonium nitrate per pot 50 days after transplanting.

TABLE 5A
COMPOSTING EFFECT ON AVERAGE DRY WEIGHT OF PEACH SEEDLING TOPS
(Pot experiment 4)*

Rank of set	Treatment			Arithm. means	No. of pots	Standard deviation	Coefficient of variation
	Composting material	Amount	Compostg. time				
		<i>gm</i>	<i>days</i>	<i>gm</i>		<i>gm</i>	<i>per cent</i>
1	Check steamed 8 hrs @ 12 lb.....	...	...	53.7	5	3.7	6.7
2	RAX Muir	190	67	50.4	5	11.1	22.0
3	Check steamed 3 hrs @ 12 lb.....	...	...	49.5	5	4.2	8.4
4	Peach-root bark (frozen chunks).....	350	67	49.4	5	9.6	19.4
5	Peach-root wood (chunks) steamed 3 hrs	190	67	48.1	5	5.8	12.0
6	Peach-root bark (fresh chunks).....	350	150	47.0	5	3.2	6.8
7	Check .....	...	...	46.1	5	5.1	11.0
8	Check .....	...	...	44.6	5	4.2	9.3
9	Whole peach roots (fresh).....	350	150	42.7	4	6.3	14.8
10	Peach-root bark (powder).....	190	67	41.6	5	6.2	15.0
11	Check .....	...	...	41.4	5	4.5	10.9
12	Peach-root wood (fresh).....	350	150	40.6	5	2.5	6.0
13	Check .....	...	...	40.1	5	5.6	14.0
14	Peach-root bark (chunks).....	200	150	39.3	5	6.4	16.4
15	Peach-root wood (chunks).....	190	67	38.7	5	2.6	6.7
16	Peach-root wood (chunks) + 100 gm AX.....	200	67	38.7	5	5.5	14.3
17	Peach-root wood (chunks).....	200	150	34.2	5	5.8	17.1

* Soil 26. Composting done about 150 days or 67 days before transplanting with 20 cm seedlings on June 7, and then grown 157 days in the lathhouse. Four gm of ammonium nitrate per pot 27 days and again 73 days after transplanting.

TABLE 5B
REPLANTING AND TREATING EFFECTS ON AVERAGE
DRY WEIGHT OF SEEDLING TOPS
(Pot experiment 4)

Rank of set*	Replanting			Arithm. means	No. of pots	Standard deviation	Coefficient of variation
	Age of root system	Condition of root system	Soil type				
	<i>years</i>			<i>gm</i>		<i>gm</i>	<i>per cent</i>
18.....	2	Dead†	20	25.4	5	5.8	22.9
19.....	2	Dead†	20	25.3	5	4.2	16.8
20.....	2	Living	20	10.8	4	5.4	50.3
21.....	2	Living	20	6.8	5	2.7	39.5
22.....	1	Dead	26	19.0	5	2.2	11.3
23.....	1	Living	26	8.3	5	1.6	19.3

* Continuation from table 5A.

† Steamed 3 hrs @ 12 lb.

per cent respectively. Potassium at 3.0 per cent was 0.1 per cent below the highest value shown.

Two of three experiments now indicated that, of the composting materials used, all except peach-root wood were either ineffective or beneficial, and that the harmful effects of peach-root wood were at least in part due to the reduction of available nitrogen.

Experiment 4: In experiment 4

the composting experiments were continued (table 5A) and in addition some previously cropped pots, to be discussed later, were replanted (table 5B). Composting was done as previously, but the time between composting and transplanting was increased to test if a longer time allowed for decay of the composts had an effect. Some of the sets were prepared in a 2-week period approximately 150 days before trans-

planting. Another series was prepared with materials available 67 days before transplanting. The steamed sets were autoclaved 28 days before transplanting. The first application of nitrogen was made 27 days after transplanting when poor leaf color was first noticeable. Nitrogen was again applied 73 days after transplanting to insure continuance of a high nitrogen level.

In this experiment there was even less evidence that the composting substances were responsible for any great harm to the seedlings. The 150-day compost of peach-root wood showed the least growth but the performance of this set was much better than the root-wood set of the previous year and only little worse than the poorest check. Peach-root wood compost which had been steamed was superior to any of the non-steamed checks. It would appear that for root wood, at least any harmful effects were due to nitrogen suppression through biological activity.

For all except the root-wood composts, three of the four experiments indicate that they were harmless or beneficial. Experiment 1, however, remains to raise the question of whether these materials are always innocuous. Here all composting materials showed some suppression of growth with the exception of the BA3 fraction. It might be argued that these pots, tested in the greenhouse, were subject to environmental conditions conducive to higher biological activity and that BA3, the exception, was added in a relatively small amount and so easily decomposed that its effects were dissipated in a relatively short time. Yet in experiment 3, where peach-root wood showed unmistakable evidence of nitrogen suppression, only the hemlock bark, of all the other sets, showed any suggestion of such an effect.

The question of modes and rates of decomposition of peach-root residues and their effects on subsequent plantings remain unanswered, but it seems, from these experiments, that the re-

plant problem cannot be reliably simulated by means of peach-root composts.

Replanting and Treating Effects

As a part of experiment 4, some pots of soils 20 and 26 were replanted. Composting history of soil 20 is variable and unknown. Pots of experiment 2 in which vigorous growth had continued for two years were taken at random. Two sets of soil 20 were steamed to insure death of the roots and reduce biological activity, and in two sets the old root systems were maintained in a living condition. The pots of soil 26 had not been composted but were checks from experiment 3. Old roots of one set in this soil were kept living.

Replanting was done in the presence of living roots versus dead roots of the previous planting with the thought that if toxic materials were released into the soil by the dead roots this would be prevented, or at least slowed in the case of the roots kept living. For both soils the growth of the replantings was roughly half the expectation for these soils where the old root systems were killed, but was reduced to a fifth or less when the replant was grown in the presence of a living root system of the previous planting. This additional retardation due to the presence of a living root system from a previous planting proved to be typical in subsequent replantings. The effect, as explained in Gilmore (1962), does not appear to be due to any interaction dependent on contact of the two root systems but simply to an insufficient volume of soil for the two plants.

Experiment 5: The following year, in experiment 5 (table 7), it was decided simply to replant the pots in the lathhouse using a different treatment (fumigant) or condition (old roots living or dead) for each pot of the sets as then constituted. The resulting reconstituted sets each contained 20 pots of soil 26 and 4 pots of soil 20 with the exception of the set treated with gasoline which had only three pots of soil 20.

TABLE 6
WEIGHTS OF COMPOSTING MATERIALS AND GROWTH OF PLANTINGS
(Selected data from experiments 1 to 4)

Peach-root composting material and condition	Soil 20				Soil 26				
	Experiment 1		Experiment 2		Experiment 3		Experiment 4		
	Com- posting materials per pot	Average weight of tops	Com- posting materials per pot	Average weight of tops	Com- posting materials per pot	Average weight of tops	Com- posting materials per pot	Composting time	
								150 days	67 days
								Ave. weight of trees	
	<i>gm</i>	<i>per cent</i> *	<i>gm</i>	<i>per cent</i> *	<i>gm</i>	<i>per cent</i> *	<i>gm</i>	<i>per cent</i> *	
Peach-root composting materials									
Whole root									
Dry.....	500	70	500	110	190	98	...	...	...
Fresh.....	...	...	...	...	...	...	350	99	...
Wood									
Dry.....	306	21	100	105	...	...	190	80	...
							200	...	90
Fresh.....	...	...	...	...	...	...	350	93	...
Steamed.....	...	...	...	...	...	...	190	110	...
Frozen.....	...	...	...	...	350	40	...	...	...
Bark									
Dry.....	194	89	194	110	190	104	200	91	...
Powder.....	194	48	194	115	190	96	190	...	97
Fresh.....	...	...	...	...	...	...	350	109	...
Frozen.....	...	...	...	...	...	...	350	...	115
Ax.....	81	48	81	115	81	102	...	...	...
RAx.....	112	49	112	105	...	...	190	...	117
BA1 + BA2...	58	33	58	110	...	...	...	...	...
BA3.....	20	103	...	...	...	...	...	...	...
Mean dry wt									
Checks in gm	57		60 cm†		44.5				43.0‡
Other composting materials									
Almond-root bark.....			190	115	190	132			
Myro-root bark.....			190	115	190	121			
Apricot-root bark.....			190	115	190	164			
Cherry-root bark.....			190	110	190	110			
Hemlock-trunk bark.....			190	115	190	118			
Filter paper.....			190	115	...	...	
Peach-trunk bark.....			190	110	190	92			

* Percentage of check.

† Height basis.

‡ Exclusive of steamed checks.

Only 12 checks (soil 26) were used as this soil had become unavailable and only this amount of unused soil remained from the previous year's collection.

Table 7 shows the extremely poor growth of these seedlings regardless of treatment or condition. Though the two soils used were of different series no differences were noted in their behavior to replanting. The poor performance of the checks throws doubt on the validity of the results, but there is reason to believe that the poor performance of the checks—much worse than any of the others on a survival basis—was due to some condition peculiar to them; and that the poor growth of the remainder of the plants was the result of the previous cropping to peach. What this influence on the checks might have been is not known, but the possibility exists that since these pots of soil were stored outside the lathhouse from the time of collection the previous spring they may have been subjected to some herbicide used in weed control on the Experiment Station. In any event these pots showed a considerable degree of recovery the following season while the remainder did not.

Experiment 6: Experiment 6 (table 8) shows the results of replanting the pots of experiment 5, and in addition the performance of seedlings the first

planting in soil 27, newly introduced into the experiment. Again replants in soils 20 and 26 showed almost total inhibition. Growth in the 12 pots used as checks in experiment 5 was much better than in the previous year but by no means up to the potential of this soil. It is interesting to note that the growth in these pots the second year was inversely related to that occurring in the first. The six in which the first year trees had died immediately after transplanting produced an average weight of 31.1 gm in the second year. Five pots which had produced seedlings weighing up to 5.5 gm from the first planting produced an average of 25.8 gm their second and the single pot that first produced a 10.2 gm seedling had only a 12.4 gm seedling its second year.

Previously uncropped pots of soil 27 showed poor growth of the seedlings, as compared with first planting in soils 20 and 26; but, as will be seen, this was a normal performance for this soil.

Experiment 7: In experiment 7 (table 9), pots of soil 26 were treated in various ways in an attempt to correct their poor performance resulting from repeated cropping. The pots of soil 27 which were first cropped the previous year were similarly treated. With soil 26, steaming was apparently of some benefit which, though great in relation to the untreated pots, still did not ap-

TABLE 7
REPLANTING AND TREATING EFFECTS ON AVERAGE DRY
WEIGHT OF SEEDLING TOPS (SURVIVORS)
(Pot experiment 5)*

Rank of set	Treatment	Survivors (Arithmetic means)	No. of original pots	Surviving
		<i>gm</i>		<i>per cent</i>
1	Check.....	7.0	12†	50
2	DD 5 cc.....	5.7	24‡	75
3	CS ₂ 5 cc.....	5.0	24‡	91.7
4	Not treated.....	3.8	24‡	83.3
5	White gasoline 15 cc.....	2.2	23§	95.8
6	Previous year's roots alive.....	1.3	24‡	91.7

* Treatments applied to pots in which seedlings had previously been grown, 48 days before transplanting with 10-20 cm seedlings June 16, which were then grown 112 days in the lathhouse. No nitrogen applied.

† Soil 26 not previously cropped.

‡ 20 pots of soil 26 and 4 pots of soil 20.

§ 20 pots of soil 26 and 3 pots of soil 20.

TABLE 8
REPLANTING EFFECTS IN SOILS 20 AND 26, AND FIRST PLANTING IN
SOIL 27 ON AVERAGE DRY WEIGHT OF SEEDLING TOPS (SURVIVORS)
(Pot experiment 6)*

Rank of set	Treatment		Survivors (Arithmetic means)	Original pots	Survival
	Cropping state	Soil			
			<i>gm</i>	<i>number</i>	<i>per cent</i>
1	Checks of experiment 5.....	26	28.5	12	100
2	Not previously cropped.....	27	20.7	90	91
3	Cropped 2-3 years.....	26	3.6	100	75
4	Cropped 4 years.....	20	3.5	19	89.4

* Transplanted with 15-25 cm seedlings May 11 and then grown 159 days in the lathhouse. Four gm ammonium nitrate per pot 17 days after transplanting.

TABLE 9
REPLANTING AND TREATING EFFECTS ON AVERAGE DRY
WEIGHT OF PEACH SEEDLINGS
(Pot experiment 7)*

Rank of set	Treatment	Arithm. means	No. of pots
Soil 26			
		<i>gm</i>	
1	Steamed 3 hrs @ 12 lb.....	13.1	11
2	Not treated.....	7.1	11
3	Submerged 90 days.....	6.7	11
4	Not treated.....	6.1	11
5	Not treated.....	5.4	11
6	Not treated.....	4.7	11
7	Screened.....	3.3	11
8	Ethylene dibromide 30 cc of 85% solution.....	3.2	11
9	Chlorobromopropene 30 cc.....	1.8	11
Soil 27			
1	Submerged 90 days.....	20.1	10
2	Not treated.....	18.1	10
3	Not treated.....	17.6	10
4	Not treated.....	16.8	10
5	Not treated.....	16.2	10
6	Check not previously cropped.....	16.3	10
7	Check not previously cropped.....	16.2	10
8	Ethylene dibromide 30 cc of 85% solution.....	10.4	10
9	Screened.....	10.1	10
10	Steamed 3 hrs @ 12 lb.....	4.5	10
11	Chlorobromopropene 30 cc.....	1.7	10

* Previously cropped pots (12-20 cm seedlings) transplanted after treatments, June 6 and then grown 129 days in the lathhouse. No nitrogen applied.

proach restoration of normal fertility. For soil 27 the same treatment apparently caused great harm. Chlorobromopropene was harmful to both soils probably because of incomplete removal even after the 15-day exposure period in trays. Ethylene dibromide may have been harmful and for the same reason. There is a suggestion that, for both soils, screening to remove the old root systems was harmful.

Experiment 8: In experiment 8, which is tabulated only as a part of table 10 arranged to show the successive yearly performance of selected replanted and treated pots, only two treatments were done. A set of each soil 26 and 27 were steamed at 15 lb for 9 hours to check the results of the previous year's milder steamings at 12 lb for 3 hours. The remainder of the sets were allowed to sprout and grow from the stumps. Three gm of calcium nitrate were added to each pot in July.

For soil 26 the more vigorous steaming gave added benefit. The production of this set was restored to approximately half that of the first planting. Steaming of soil 27 confirmed the harmful results of the previous year.

The growth of second-year shoots on the previous year's stumps is interesting. For soil 26 the sets 3 and 4 with which there had been no effective interference showed the weight of the second-year shoots to exceed that of the first by 3.4 times. For soil 27, which

showed no apparent replant effect the second-year shoots from replanted sets 12, 14 and 17 were only twice the weight of the first. The difference in ratios of first- to second-year shoots for the two soils being obviously due to the extremely poor first-year replant growth in soil 26. This difference in the relative performance of second-year shoots in the two soils is indicative of partial recovery, with time, of the depressed replantings in soil 26. This effect has been noted in the field (Gilmore, 1959). The beneficial effect of steaming and the apparent harmful effect of screening in experiment 7 is shown in the growth of second-year shoots in soil 26.

For soil 27, which did not show the replant effect, the harmful effect of steaming was confirmed. Also in the growth of second-year shoots the harmful effects of the previous year's steaming was still apparent. Some effect of the previous year's screening apparently carried over but there was recovery from the ethylene dibromide treatment.

Harmful effects of screening out the old root systems, if such effects actually exist, are difficult to understand. It might be thought that a harmful organism could have been introduced by the screening process but since in the entire work no sanitary precautions were observed, and ample opportunity was present for cross transfer from pot to pot, this is unlikely.

TABLE

COMPARISONS OF AVERAGE DRY WEIGHTS PRODUCED IN SUCCESSIVE YEARS

Set no.	Pots in set	Experiment 2		Experiment 3		Experiment 4		Experiment 5	
		Preplantg. treatment	Dry wt. of tops	Preplantg. treatment	Dry wt. of tops	Preplantg. treatment	Dry wt. of tops	Preplantg. treatment	Dry wt. of tops
1	10		<i>gm</i>		<i>gm</i>		<i>gm</i>		<i>gm</i>
		Soil 20							
		Unknown	Est. 50	Continue growth		Steam 3 hrs @ 12 lb	25.3	Various fumigants	6.2
2	10	Unknown	Est. 50	Continue growth		Old roots alive	6.9	Various fumigants	4.2
3	11	Soil 26							
						Various composts	44.5	Various fumigants	3.8
						Various composts	39.3	Various fumigants	3.4
						Various composts	41.4	Various fumigants	1.4
						Various composts	47.5	Various fumigants	2.3
						Check	42.2	Various fumigants	2.3
						Check steam 3 hrs @ 12 lb	53.7	Various fumigants	6.8
				Check	44.8	Old roots alive	8.3	Various fumigants	2.0
				Check	46.4	Old roots dead	19.0	Various fumigants	1.6
								Check	7.0
		12	10	Soil 27					

* 6 pots.

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IN SELECTED REPLANTED POTS, AND IN RESPONSE TO VARIOUS TREATMENTS

Experiment 6		Experiment 7		Experiment 8	
Preplantg. treatment	Dry wt. of tops	Preplantg. treatment	Dry wt. of tops	Preplantg. treatment	Dry wt. of tops
	gm		gm		gm
Soil 20					
No treatments	4.6	No treatment	3.2		
No treatments	2.5	No treatment	5.1		
Soil 26					
No treatments	3.1	No treatment	7.1	No treatment 2nd year shoot	22.4
No treatments	3.0	Submerged	6.7	No treatment 2nd year shoot	24.8
No treatments	3.1	No treatment	4.7	Steam 9 hr @ 15 lb	23.5
No treatments	2.7	Steam 3 hrs @ 12 lb	13.1	No treatment 2nd year shoot	39.5
No treatments	4.7	Chlorobromopropene 30 cc	1.8		
No treatments	6.8	Screened	3.3	No treatment 2nd year shoot	9.8
No treatments	1.5	Ethylene dibromide 30 cc of 85% solution	4.3		
No treatments	3.8	No treatment	3.5		
No treatments	28.5	No treatment	10.9	No treatment 2nd year shoot	32.6
Soil 27					
Previously uncropped	20.2	No treatment	16.8	No treatment 2nd year shoot	40.1
Previously uncropped	23.2	Steam 3 hrs @ 12 lb	4.5	No treatment 2nd year shoot	10.2
Previously uncropped	16.2	No treatment	17.6	No treatment 2nd year shoot	33.3
Previously uncropped	21.5	Ethylene dibromide 30 cc of 85% solution	10.4	No treatment 2nd year shoot	36.3
Previously uncropped	18.4	No treatment	18.1	Steam 9 hr @ 15 lb	5.7
Previously uncropped	22.1	Submerged	20.1	No treatment 2nd year shoot	35.6
Previously uncropped	18.7	Chlorobromopropene 30 cc	1.7	No treatment 2nd year shoot	6.7
Previously uncropped	24.0	Screened	10.1	No treatment 2nd year shoot	25.3*

SUMMARY AND CONCLUSIONS

Three of four experiments designed to simulate the peach replant effect in soil pot cultures by composting the soils with peach root substances failed. Peach-root wood sometimes gave depression in these experiments but nitrogen suppression due to stimulation of biological activity by the wood seemed to be the causative factor. In one experiment all peach-root substances except one (the sugar-glucoside fraction) gave some depression but nitrogen availability as a cause was suspected only in the peach-root wood fraction.

In two fertile soils used, the replant problem could be simulated by growing a seedling for a season, harvesting the top in such a way that the roots were killed and replanting with a new seedling the following season. Response of these soils to fumigants was poor. Fertility was only partly restored by steaming. Replanted seedlings in one of these soils gave evidence of partial recovery if they were allowed to continue growth a second year.

A third soil, less fertile than the others, did not show the replant effect but was severely injured by steaming.

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