EFFECT OF CERTAIN FALL TREATMENTS ON PEACH AND APPLE NURSERY TREES

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EFFECT OF CERTAIN FALL TREATMENTS

ON PEACH AND APPLE

NURSERY TREES.

THESIS

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by

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THESIS

INTRODUCTION

The production of a high percentage of vigorous A-grade trees is one of the nurseryman's most important problems. Such trees produced on desirable stocks not only are in greater demand at higher prices, but they are preferable from the orchardist's point of view. Many nurserymen are attempting to produce trees of this character through the liberal use of green manuring crops and of nitrogenous fertilizers applied in the spring, and by employing vigorous growing stocks. They have had partial success, but are constantly seeking further improvement. Hence, any other applicable cultural practices that could be successfully employed would be of considerable value to the nurseryman and the fruit grower. In this investigation various practices involving fall fertilization, partial defoliation, and partial root pruning were employed in an effort to produce apple and peach trees, which, when taken from the nursery and transplanted to the orchard would make a more rapid and total growth.

REVIEW OF LITERATURE

A review of the literature dealing with the carbohydrate-nitrogen ratio in plants shows rather conclusively that certain plant responses are definitely related to the relative amounts of carbohydrates and nitrogen found in their tissues. Fisher (3) observed that when N was abundant in respect to carbohydrates, vegetative responses were predominant, while if abundant carbohydrates were accompanied by an inadequate N supply for vegetative activity, reproduction took place. These findings agree closely with the more extensive work of Kraus and Kraybill (11) who recognized four classes into which a plant could be placed, based on the relative amounts of its available carbohydrates and N. Closely following these findings Gurjar (4) published similar results for the turnip, tomato, and radish.

Since the work on carbohydrate-nitrogen relations by Kraus and Kraybill, other investigators have sought the application of this theory to woody plants and have found that by changing the proportion of carbohydrates and N within the plant by various practices, they could obtain fairly definite responses. Harvey (5) found that defoliation of apple spurs in June seriously restricted

the differentiation of fruit buds presumably by lowering the ratio of carbohydrates to N. His chemical analyses showed that defoliation caused a relative increase of reducing sugars and soluble nitrogen, and a decrease of total carbohydrates in spurs, which changes are commonly associated with increased vegetative activity. Hooker (8) noticed that fruit-bearing spurs that developed leaf buds had a low starch and a high nitrogen content, while the barren spurs contained a low starch and a low nitrogen content. Harvey (6) in a later work, on the growth of apple shoots, showed that partial defoliation accelerated or retarded growth, according to the stage of development of the shoot, and that defoliation very early in the season retarded the growth.

Murneek (14) observed that the different degrees of defoliation of apple spurs in April, had a direct effect upon the setting of fruit, and upon changing the C/N ratio largely by decreasing the amount of nitrogen.

That this ratio may also be modified by early fall defoliation seems plausible. Thomas (20) found that the N content of the woody tissue remained constant during the growing season, but that the N begins to be translocated from the leaves to the branches in September, increasing their content during the fall months. This is also substantiated by the work of Richter (15) who observed a rapid translocation of N from the leaves to the branches during September and October in the case of apple and pear trees. However, Wehmer (22) Schulze and Schutz (18) are not convinced that the mineral substances are translocated from the leaves to the branches. Lincoln (13) who studied the loss of N from pear leaves, takes the point of view that the migration of N from the leaves actually fulfills a need or satisfies a deficiency in the tree and that the amount of N returning to the tree is determined by this deficiency. From his data he concludes that the persisting parts of the tree were able to hold only about half of the N that was absorbed from the soil.

It is quite generally accepted that the N content of trees can be increased with nitrogenous fertilizers under certain conditions. Hooker (10) found that the spurs of 16-year-old York trees fertilized in September, of their off year, showed a slightly higher N content in December than did the check trees. In another report (9) he presents data showing an increase in N in spurs of 7-year-old Jonathan and Ben Davis trees in May, following an application of a nitrogenous fertilizer in March. He was also able to increase the N in spurs of 20-year-old York trees in March by applying nitrate of soda the previous September.

Schrader and Auchter (17) who applied nitrogenous fertilizers to 20-year-old York trees growing in sod, either in the spring or fall, noted good growth responses the following spring and found a higher N content in spurs. They state "bearing apple trees which are growing poorly from a lack of a N supply will respond with increased foliage color, terminal growth, spur growth and trunk circumference from applications of either nitrate of soda or ammonium sulphate----."

Alderman (1) states, ---" trees respond differently to fertilizers under different cultural treatments. So great is the difference that under cultivation they may make no response whatever, while under sod treatment they may be remarkably stimulated by fertilization." Tukey (21), Hedrick and Anthony (7) and Anthony (2) hold the same views.

Roberts (16) writes, only----" a small amount of plant food is removed from the soil by the growth of nursery stock,---- any ordinary soil, cultivated as nursery lands are, should easily furnish in three years, ten times the plant food used by the tree." Lewis (12) says, "In general, under normal conditions, orchards from one to five years of age in Oregon do not need any fertilizer. If good stock has been chosen and proper methods of pruning, tillage and spraying are followed, trees should make a sufficient growth."

Stewart (19) concludes that, "The mineral requirements of wood are comparatively low. This largely accounts for the fact that young trees usually do not make a profitable response to fertilizer applications--."

Little is known, however, regarding the influence of such cultural practices as root pruning, defoliation and fertilization, when employed in late summer or fall in the nursery, on the later behavior of the tree. Conceivably some of them may be harmful or beneficial to such a degree as to be of considerable importance to the nurseryman or the fruit grower. It was with the object of obtaining information on certain aspects of these questions that this investigation was outlined.

MATERIALS AND METHODS

Uniform apple and peach trees one year from the bud (budded August, 1925) were chosen for this work in the fall of 1926. In addition to these, seedling trees just budded (August, 1926) were selected and given the same treatments as the one-year-old trees. However, in the course of the experiment, the peach seedling plots had to be discarded, due to carelessness of workmen, who, in cutting back the seedlings in the spring of 1927, removed most of the tags, making it impossible to secure any data of value.

A total of 13 plots were made of each of the one-year-old apple trees, apple seedlings, and one-year-old peach trees. The plots from one to six inclusive, in each of these series, were given individual treatments the first week in September, 1926. These treatments were duplicated on plots eight to thirteen inclusive, the first week in October, 1926. Plot 7 was retained as a check against all other plots.

Trees Under Investigation

One-year-old apple trees.- These were one year old from the bud at the time this work began in September, 1926. They were of the Winter Banana variety, budded on the French crab seedling stock, and were grown in the Greening Brothers' Nursery at Monroe, Michigan. Their uniformity in size throughout a large field appeared as quite good evidence of a rather homogeneous soil. The soil is a fertile silt loam and previous to the growing of these trees, had been in alfalfa sod for over ten years. These trees were planted in rows four feet apart and would average about 18 inches in the row. They received thorough cultivation during the course of the experiment. No fertilizers of any kind had been applied to the soil previous to this work. All large and small trees were eliminated, since only trees having a uniform height and diameter were desired.

<u>One-year-old peach trees</u>.- The peach trees used in this experiment were grown by S.E.Hawley at Fennville, Michigan. They were of the South Haven variety, budded in late August, 1925. The trees were uniform in size, growing in rows four feet apart, and about two feet in the row. The soil was a sandy loam of fair fertility, had received good cultivation, and an application of ammonium sulphate at the rate of 300 pounds per acre early in the spring of 1926.

<u>Transplanted apple and peach trees</u>.- The 10 trees from each of the one-year-old apple and peach plots, selected for transplanting were planted at South Haven, Michigan, on April 16, 1927, on a sandy type of soil of fair fertility, four feet apart each way. Growth measurements were made at intervals during the growing period. All trees received good cultivation during their period of observation.

<u>Apple trees not transplanted</u>.- These are the trees which remained in the plots in the nursery from which the transplanted trees were taken. Only one measurement of these trees was secured during the season of 1927, but it was thought these furnished useful information to the work at hand.

Apple seedlings.- These trees, which were French crab seedlings, had just been budded to the Winter Banana variety when this work started. They were also grown in the Greening Brothers' Nursery at Monroe, Michigan. They were planted adjacent to the one-year-old apple trees and had received the same cultural treatments.

Chemical analyses.- The results of the chemical analyses, given as variations from the check, will be included in the tables with the growth measurements. However, the chemical analyses, as made, are given complete in Tables 7 and 8.

Data showing the effects of the various treatments, given the peach and apple trees the previous fall, are given in Tables 1 to 6.

Treatments Given

Defoliation.-Alternate leaves were removed.

Fertilization.- Ammonium sulphate at the rate of 400 pounds per acre was applied in a narrow band four to six inches from the base of the trees, on both sides of the row.

Root Pruning.- All roots on one side of the tree were cut off with a spade. Roots were severed two inches from the stock.

The plots received the following treatments:

	Sept.(1926)		Oct.(1926)	
Plots	1	and	8	Defoliation only.
Plots	2	and	9	Defoliation and Fertilization.
Plots	3	and	10	Fertilization only.
Plots	4	and	11	Defoliation and Root Pruning.
Plots	5	and	12	Root Pruning.only.
Plots	6	and	13	Root Pruning and Fertilization.
Plot	7	Check		No treatment.

Each tree was measured for height and diameter at the time these treatments were given.

Ten trees from each plot, in the one-year-old apple and peach trees, were selected to be grown at South Haven, Michigan, the following season. The apple trees were pruned back to about 2.5 feet, in addition to the usual root pruning given before planting. All buds in excess of five were rubbed off, after growth had started, in order to establish a uniform number of branches on all trees. The peach trees were also given a light root pruning before planting, while the tops were pruned to six or eight branch stubs five inches in length. No attempt was made to limit the number of branches growing on these trees. All apple and peach trees were weighed after pruning and previous to planting. Weights were again secured at the time of lifting these trees November 26, 1927.

Collection and Preservation of Material

1. One-year-old apple trees - Two representative trees from each plot were dug December 22, 1926 for chemical analyses. These were pruned back to 2.5 feet in height and were root pruned to four to six inches. They were then brought to the laboratory and cut into small pieces, weighed, and placed in wide mouthed bottles, put into the oven at 90°C. for two hours, then dried at 65°C. until a constant weight was obtained. The samples were then weighed again, bottled and stoppered tightly. The tops (that portion above the point of union of bud and stock) and roots (that portion below this point) were analyzed separately. No analyses were made of the apple seedlings.

2. Peach trees - These trees were dug October 24, 1926. At that time two average sized sample trees from each plot were taken for analysis. They were handled the same as the apple trees, except that the tops were pruned back, leaving six to eight branch stubs five inches long on each tree. In both lots of trees, apple and peach, the trees were pruned the same as those that were to be grown for another year at South Haven.

Chemical Analyses

The dried sample tissue was ground to pass a 60-mesh sieve. A 5.gram portion of this ground material was placed in a casserole and repeatedly extracted in hot 80% alcohol. The extract when cool was decanted and filtered into a 500 cc. volumetric flask until 400 cc. of extract was obtained. The residue was placed on a filter and washed several times with 80% alcohol. The extract, after it had come to room temperature, was then made up to volume with 80% alcohol. The residue was dried in the oven at 65°C. and saved for the determination of total acid-hydrolyzable polysaccharides.

Total Soluble Sugars.- A 100 cc. portion of the alcohol extract was freed from alcohol, then taken up with distilled water and placed in a 250 cc. volumetric flask, neutralized with dilute NaOH, and clarified with lead acetate. This was made up to volume with distilled water and filtered. Two-hundred cc. of this filtrate was then placed in another 250 cc. volumetric flask and deleaded with finely powdered Na_2CO_3, after which it was neutralized with either ammonium hydroxide or acetic acid as was necessary. It was then made up to volume with distilled water, filtered and labeled "Combined Extract."

Fifty cc. of the combined extract was pipetted into a 100 cc. volumetric flask and brought to neutrality with dilute HCl, where necessary. Five cc. of concentrated HCl (spec. gravity 1.19) was added and the flask was then held at 70°C. for 10 minutes in a water bath. It was removed, cooled, neutralized with NaOH and brought up to volume with distilled water. A 25 cc. portion was used to determine total soluble sugars in terms of dextrose by the Munson and Walker method of determining reducing sugars.

Total Acid Hydrolyzable Polysaccharides.- A one-fifth aliquot of the dried residue from the alcohol extraction was placed on a filter paper and washed repeatedly with distilled water to remove any remaining soluble sugars. The filter was punctured and the residue washed into a 500 cc. Erlenmeyer flask. Then 8 cc. of concentrated HCl (spec. gravity 1.19) was mixed with 142 cc. of distilled water and this was added to the Erlenmeyer containing the residue. The flask was connected to a reflux condenser and refluxed for two and one half hours in boiling water. It was then removed, cooled, filtered into a 500 cc. volumetric flask, neutralized with NaOH, clarified with lead acetate, made up to volume and filtered.

Two-hundred cc. of this filtrate was then placed in a 250 cc. volumetric flask, deleaded with Na_2CO_3, neutralized with ammonium hydroxide or acetic acid, made up to volume and filtered.

A 50 cc. portion of this solution was used to determine the total acid hydrolyzable polysaccharides in terms of dextrose by the Munson and Walker method of determining reducing sugars.

All carbohydrate determinations were made in duplicate from and including the point where Na_2CO_3 was added in the deleading process.

Total Nitrogen.- Total nitrogen determinations were also made on both tops and roots separately. These determinations were made by the Experiment Station chemists.

Presentation of Results.

1. Defoliation

1. Growth - Data on the effect of defoliation on the trees under consideration are presented in Table 1. It is apparent that defoliation retarded, to a greater or less degree, increase in trunk diameter and in length of shoots in all of the apple trees. This general effect appears to be more pronounced in those trees receiving October defoliation than it does in those treated in September. This also holds true for the peach trees. However, the September defoliated peach

Table 1.- Growth measurements and chemical analyses of trees in plots receiving defoliation only, in comparison to the check plot

			Growth - Variations from check			Chemical analyses (percentage dry weight) - Variation from check					
						Percent Total Nitrogen.		Percent Total Soluble Sugars.		Total Acid Hydrolyzable Polysaccharides	
Trees	How handled	Plot	Diam. inches.	Growth inches per tree.	Weight grams.	Tops	Roots	Tops	Roots	Per cent Tops	Per cent Roots
	Transplanted	* 1	-.01	- 5.0	----	-.06	.14	3.4	8.5	5.0	19
		† 8	-.02	-18.0	-39.0	-.11	.09	-5.4	-2.0	6.0	1
	Not transplanted	* 1	-.04	- 4.7	----	----	---	---	----	---	---
Apple		† 8	-.08	-36.4	----	----	---	---	----	---	---
	Seedlings	* 1	----	-----	----	----	---	---	----	---	---
		† 8	----	- 2.0	----	----	---	---	----	---	---
	Transplanted	* 1	----	19.0	46.0	.1	-.22	-.8	1.3	3.0	13
Peach		† 8	----	-18.0	-15.0	----	-.03	-1.3	-6.0	3.0	3

* Received September-treatment
† Received October-treatment.

trees show an increase in top growth and weight over that of the check trees. Although not great, these differences may lead one to believe that defoliation in the fall is not a beneficial practice, and may actually prove harmful to the tree, by decreasing its vigor, and consequently the following season's growth.

2. Chemical analysis - It is evident from these analyses that the total carbohydrate content is considerably greater in the roots of the September-defoliated, transplanted apple and peach trees than in the check trees, with a fair increase in the tops of the September-treated, transplanted apple trees. The October-defoliated plots in both the transplanted apple and peach trees, show an appreciable decrease in soluble sugars, and a slight increase in polysaccharides. The N content of the roots in both September- and October-defoliated and transplanted apple trees show a distinct increase, with a decrease in the tops, while the opposite is true of both peach plots with the exception of the October-defoliated peach plot.

11. Fertilization

1. Growth - In Table 2 are the data showing the effect of fall fertilization on the apple and peach trees studied. The increase in shoot growth, as shown by the September and October fertilized apple trees, not transplanted, seems rather significant. It appears

Table 2.- Growth measurements and chemical analyses of trees in plots receiving fertilization only, in comparison to the Check plot

			Growth- Variations from check			Chemical analyses (percentage dry weight) Variations from check					
						Percent Total Nitrogen.		Percent Total Soluble Sugars.		Total Acid Hydrolyzable Polysaccharides.	
Trees	How handled	Plot	Diam. inches.	Growth inches per tree.	Weight grams.	Tops	Roots	Tops	Roots	Per cent tops	Per cent roots
	Transplanted	* 3	----	- 7.5	-13	-.05	.38	.5	2.4	-1.1	8.0
		† 10	.04	1.5	24	-.1	.08	-1.2	-.4	5.3	2.5
Apple	Not transplanted	* 3	-.04	16.0	---	----	---	---	---	---	---
		† 10	.07	18.0	---	----	---	---	---	---	---
	Seedlings	* 3	----	----	---	----	---	---	---	---	---
		† 10	----	-1.0	---	----	---	---	---	---	---
	Transplanted	* 3	.03	-11.0	3	.07	-.22	.8	-1.1	3.7	4.0
Peach		† 10	-.02	-34.0	-65	----	-.18	.7	-5.5	3.2	5.0

* Received September-treatment.
† Received October-treatment.

that in these two plots of trees, fertilization was beneficial, and suggests that, October fertilization especially, may profitably be employed on trees one year from the bud which are to remain in the nursery another season. This response is not evidenced by any of the other plots to any degree, which may presumably be taken as an indication that fall fertilization of these trees is of doubtful value, and may actually appear to retard shoot growth in the September-and October-fertilized peach plots.

2. Chemical analysis - The N content in the tops of the September and October-transplanted apple trees shows a decrease, while an increase is noted in the roots, especially in the September-fertilized plot. The opposite result is evident in the September- and October-treated peach trees. A small increase in soluble sugars is shown in the September-fertilized, tranplanted apple trees while a slight decrease is found in the transplanted apple trees receiving October-fertilization. The peach trees receiving the fertilizer in September and October show a small increase of soluble sugars in the tops and a decrease in the roots, with a rather evenly distributed amount of polysaccharides in the tops and roots.

111. Root Pruning

1. Growth - Data presented in Table 3 show the results of root pruning on apple and peach trees. The general negative response in growth of these trees which were root pruned is apparent. The increase in the September-treated apple trees, not transplanted, is small and may not be considered significant, while the September root pruned peach trees show an appreciable increase in shoot length that perhaps should be regarded as significant. This response may, presumably, be taken as indicating that root pruning of peach trees in September produced conditions within the tree favorable for a greater vegetative activity the following season. This condition, however, was apparently not produced in the October root pruned peach trees, as they show less shoot growth than the check trees. Therefore, from these data root pruning in October does not appear to be of value.

2. Chemical analysis - Although the transplanted apple trees, receiving September root pruning, show a decrease in shoot growth, they show an increase, in both tops and roots, of N, soluble sugars, and polysaccharides. The transplanted apple trees receiving treatment in October only show an increase of N in the roots, and polysaccharides in both tops and roots. The

Table 3.- Growth measurements and chemical analyses of trees in plots receiving Root pruning only, in comparison to the check plot

Trees	How handled	Plot	Growth - Variations from check: Diam. inches.	Growth inches per tree.	Weight grams.	Chemical analyses (percentage dry weight) Variations from check: Percent Total Nitrogen: Tops	Percent Total Nitrogen: Roots	Percent Total Soluble Sugars: Tops	Percent Total Soluble Sugars: Roots	Total Acid Hydrolyzable Polysaccharides.: Per cent tops	Total Acid Hydrolyzable Polysaccharides.: Per cent roots
Apple	Transplanted	* 5	.01	- 4.0	9	.09	.15	.6	3.7	4.1	15
		† 12	.01	---	10	---	.22	- .6	-2.0	7.2	2
	Not transplanted	* 5	.01	2.2	--	---	---	--	---	---	--
		† 12	---	-3.0	--	---	---	--	---	---	--
	Seedlings	* 5	---	-3.0	--	---	---	--	---	---	--
		† 12	---	-5.0	--	---	---	--	---	---	--
Peach	Transplanted	* 5	.03	21.0	53	.11	-.17	-3.2	-2.3	7.3	3.7
		† 12	---	-11.0	22	-.1	-.18	2.4	-6.0	3.4	4.0

* Received September-treatment
† Received October-treatment.

September and October root pruned peach trees also show an increase in polysaccharides in both tops and roots, with a decrease of N and soluble sugars in the roots.

IV. Defoliation and Fertilization

1. Growth - Data regarding the effect of defoliation and fertilization on the plots receiving this treatment are presented in Table 4. All plots, with the exception of the September treated apple trees, not transplanted, show a decrease in shoot growth. This general decrease is pronounced in all plots, and indicates that these treatments, in general, produced very unfavorable conditions within the trees, which had the effect of being inhibitory to vegetative growth.

2. Chemical analysis - From the chemical analyses it will be seen that the N content in the roots of the transplanted apple trees receiving October treatment show a considerable gain over that of the check, with a small decrease in the tops of both the September and October treated plots. An appreciable decrease of N in the roots of both the September and October treated peach trees is also of considerable value. There is also a decrease of soluble sugars in the tops of September treated peach trees, and in the tops of the October treated, transplanted, apple trees. No decrease

Table 4.- Growth measurements and chemical analyses of trees in plots receiving defoliation and fertilization, in comparison to the check plot

Trees	How handled	Plot	Growth - Variation from check: Diam. inches.	Growth inches per tree.	Weight grams.	Chemical analyses (percentage dry weight) Variation from check: Percent Total Nitrogen: Tops	Percent Total Nitrogen: Roots	Percent Total Soluble Sugars: Tops	Percent Total Soluble Sugars: Roots	Total Acid Hydrolyzable Polysaccharides: Per cent tops	Total Acid Hydrolyzable Polysaccharides: Per cents roots
Apple	Transplanted	* 2	.01	- 7.5	7.	-.05	.03	2	---	3.3	8.0
		† 9	---	-10.0	-3	-.09	2.20	-3	2.0	3.5	6.0
	Not transplanted	* 2	-.05	5.0	--	---	----	---	---	---	---
		† 9	-.05	-14.0	--	---	----	---	---	---	---
	Seedlings	* 2	---	- 2.0	--	---	----	---	---	---	---
		† 9	---	- 5.0	--	---	----	---	---	---	---
Peach	Transplanted	* 2	----	-10.0	24	.04	-.18	-5	---	7.0	8.6
		† 9	-.03	-12.0	-24.	---	-.37	---	1.1	7.0	5.2

* Received September-treatment
† Received October-treatment

of soluble sugars is evident in the roots of any of the plots. A general increase of polysaccharides is again shown in the tops and roots, of the transplanted apple trees receiving September and October treatment, and the peach trees which were also given September and October treatment.

V. Defoliation and Root Pruning

1. Growth - The data in Table 5 show the effect of fall defoliation and root pruning on the apple and peach trees so treated. The September treated peach trees show a distinct gain in trunk diameter, shoot length, and weight over that of the check plot. The October treated apple trees which were transplanted also show a slight gain but this is not significant. Aside from these two exceptions, all other plots show a very marked decrease in shoot growth and trunk diameter in relation to the check trees. This treatment has produced a greater inhibitory effect on the growth of the trees than any of the other treatments given. The seedling apple trees in both the September and October treated plots show the greatest decrease in growth compared to the number of growing points of the various lots of trees. These effects indicate that in general the cutting of roots with tree diggers, and the stripping of trees, in late September or early

Table 5.- Growth measurements and chemical analyses of trees in plots receiving defoliation and root pruning, in comparison to the check plot

			Growth - Variation from check			Chemical analyses -(Percentage dry weight) Variation from check					
						Percent Total Nitrogen		Percent Total Soluble Sugars		Total Acid Hydrolyzable Polysaccharides	
Trees	How handled	Plot	Diam. inches.	Growth inches per tree.	Weight grams.	Tops	Roots	Tops	Roots	Per cent tops	Per cent roots
	Transplanted	* 4	-.02	-12.5	9	-.1	-.03	2.8	4.5	3	11.5
		†11	.04	2.0	18	-.03	.16	-1.0	1.5	5	10.0
Apple	Not transplanted	* 4	-.08	-24.0	--	---	---	---	---	---	----
		†11	-.04	-26.0	--	---	---	---	---	---	----
	Seedlings	* 4	-.03	- 5.0	--	---	---	---	---	---	----
		†11	-.03	- 9.0	--	---	---	---	---	---	----
	Transplanted	* 4	.03	35.0	90	---	-.14	-5.0	1.0	8	8.0
Peach		†11	-.02	-35.0	-41	-.03	-.37	---	-.3	4.4	- .4

* Received September-treatment
† Received October-treatment

October as practiced by some nurserymen, tends to reduce the tree growth the following season.

2. Chemical analysis - There is also a general decrease of N shown in the tops and roots of the transplanted apple trees receiving September treatment, and the tops and roots of the peach trees treated in September and October. The transplanted apple trees which were given defoliation and root pruning in September show a good gain, in the tops and roots, of soluble sugars over that of the check, while the tops of the September treated, and the roots of the October treated peach trees show as large a decrease in soluble sugars. However, a considerable gain in polysaccharides is evident in the tops and roots of the transplanted apple trees and the tops and roots of the peach trees receiving September and October defoliation and root pruning.

VI. Root Pruning and Fertilization

1. Growth - From the data in Table 6 it is apparent that root pruning and fertilization in September, and especially October, had a general retarding effect upon the shoot growth in all plots, with the exception of the September treated apple trees, not transplanted, and the peach trees receiving treatment in September. This retarding of growth is

Table 6.- Growth measurements and chemical analyses of trees in plots receiving root pruning and fertilization, in comparison to the check plot

			Growth - Variation from check			Chemical analyses (percentage dry weight)- Variation from check					
						Percent Total Nitrogen		Percent Total Soluble Sugars		Total Acid Hydrolyzable Polysaccharides	
Trees	How handled.	Plot.	Diam. inches.	Growth inches per tree.	Weight grams.	Tops	Roots	Tops	Roots	Per cent tops	Per cent roots
	Transplanted	* 6	----	-5.0	----	.02	.18	-1.7	----	6.1	18.1
		† 13	.02	-2.0	30	-.06	.10	.9	3.5	8.6	15.8
Apple	Not transplanted	* 6	-.03	17.0	----	---	---	---	---	---	----
		† 13	----	-8.0	----	---	---	---	---	---	----
	Seedlings	* 6	----	-4.0	----	---	---	---	---	---	----
		† 13	----	-4.0	----	---	---	---	---	---	----
	Transplanted	* 6	.03	-31.0	52	.15	---	-5.0	1.4	4.3	3.0
Peach		† 13	----	-47.0	-56	.33	-.18	-1.1	-1.4	4.8	-4.9

* Received September-treatment
† Received October-treatment

most pronounced in the October treated peach trees which show the least shoot growth and weight gain of all plots given root pruning and fertilization. Here again, as previously noted in connection with Tables 3 and 5, the peach trees receiving September treatment, in which root pruning was a factor, show a considerable gain in shoot growth and weight over the check plot. This would indicate that peach trees, given partial root pruning in September, would presumably make a greater growth response the following season.

2. Chemical analysis - The transplanted apple trees given September treatment show a good increase in N in the roots, a decrease of soluble sugars in the tops, and an increase of polysaccharides, to quite a degree, in the roots. The apple trees which were transplanted and which received October treatment show slightly less N in the tops, with a fair increase in the roots. There also is a greater amount of soluble sugars and polysaccharides in both tops and roots of these same trees. The peach trees given September, and October treatments have a higher N content in the tops, with a decrease in the roots of the October treated trees. They also show a greater amount of polysaccharides in both tops and roots, with the exception of the roots of peach trees receiving October treatments.

Table 7.- Apple Trees.- Percentage soluble sugars, total acid hydrolyzable polysaccharides, and total N. (Percentage dry weight)

Plot	Treatment	Tops					Roots					Tops and Roots
		Percent Moisture	Percent Total Nitrogen	Percent Total Sugars	Percent Total Polysaccharides	Ratio of N to Sugars and Polysaccharides	Percent Moisture	Percent Total Nitrogen	Percent Total Sugars	Percent Total Polysaccharides	Ratio of N to Sugars and Polysaccharides	Ratio of N to Total Carbo-hydrates.
	Sept.											
1	Defoliation	48.4	.57	11.14	29.4	1-71	49.8	.82	10.81	53.7	1-79	1-75
2	Defoliation Fertilization	48.9	.58	9.71	28.1	1-65	47.4	.71	2.58	42.5	1-64	1-64
3	Fertilization	47.5	.58	8.26	23.7	1-55	49.6	1.06	4.74	42.4	1-44	1-50
4	Defoliation Root Pruning	48.5	.53	10.47	27.8	1-72	46.6	.65	6.87	45.8	1-81	1-76
5	Root Pruning	47.1	.72	8.29	28.9	1-52	46.7	.83	6.00	49.4	1-67	1-59
6	Root Pruning Fertilization	48.1	.65	6.00	30.9	1-57	48.0	.86	2.47	52.5	1-64	1-60
7	Check	46.7	.63	7.71	24.8	1-51	46.8	.68	2.33	34.4	1-54	1-52
	October											
8	Defoliation	46.7	.52	2.27	31.1	1-64	47.6	.77	Trace	35.1	1-45	1-55
9	Defoliation Fertilization	49.6	.54	4.86	28.3	1-61	52.4	.90	4.43	40.8	1-50	1-55
10	Fertilization	47.9	.53	6.51	30.1	1-70	51.7	.76	1.94	36.9	1-51	1-60
11	Defoliation Root Pruning	48.6	.60	6.69	29.7	1-61	49.8	.84	3.88	44.0	1-57	1-59
12	Root Pruning	46.7	.61	7.10	32.0	1-64	51.8	.90	Trace	36.0	1-40	1-52
13	Root Pruning Fertilization	48.0	.57	8.59	33.4	1-74	51.6	.78	5.82	50.2	1-72	1-73

Table 8.- Peach Trees - Percentage soluble Sugars, total acid hydrolyzable polysaccharides, and total N. (Percentage dry weight)

Plot	Treatment	Tops					Roots					Tops and Roots
		Percent Moisture	Percent Total Nitrogen	Percent Total Sugars	Percent Total Polysaccharides	Ratio of N to Sugars and Polysaccharides	Percent Moisture	Percent Total Nitrogen	Percent Total Sugars	Percent Total Polysaccharides	Ratio of N to Sugars and Polysaccharides	Ratio of N to Total Carbohydrates.
	September											
1	Defoliation	48.1	.93	4.55	37.1	1-45	54.5	1.42	7.92	50.4	1-41	1-43
2	Defoliation Fertilization	47.3	.87	Trace	41.0	1-47	54.7	1.46	6.45	45.7	1-36	1-42
3	Fertilization	48.9	.90	6.11	37.4	1-48	51.5	1.42	5.47	41.3	1-33	1-40
4	Defoliation Root Pruning	47.8	.84	Trace	41.5	1-49	57.4	1.50	7.59	45.2	1-35	1-42
5	Root Pruning	50.1	.94	2.14	41.4	1-46	54.4	1.47	4.24	40.9	1-31	1-38
6	Root Pruning Fertilization	56.8	.98	Trace	38.0	1-39	56.8	1.65	8.00	40.3	1-29	1-34
7	Check	57.6	.83	5.27	33.7	1-47	57.6	1.64	6.59	37.1	1-27	1-37
	October											
8	Defoliation	54.2	.82	3.96	36.9	1-50	54.2	1.61	Trace	40.8	1-25	1-37
9	Defoliation Fertilization	54.6	.81	5.58	40.6	1-57	54.6	1.27	7.71	42.3	1-39	1-48
10	Fertilization	55.5	.82	6.00	36.9	1-52	55.5	1.46	1.11	42.4	1-30	1-41
11	Defoliation Root Pruning	53.1	.80	5.58	38.1	1-54	53.1	1.27	6.27	36.8	1-34	1-44
12	Root Pruning	57.2	.74	7.65	37.1	1-60	57.1	1.46	Trace	41.2	1-28	1-44
13	Root Pruning Fertilization	49.3	1.16	4.15	38.5	1-37	49.3	1.46	5.17	32.7	1-26	1-32

It should be remembered that in work of this type the experimental error is large and should be given recognition if the data are to be interpreted correctly. Small variation from the check plot therefore, should not be considered of much significance, and the larger variations should be interpreted with discretion.

SUMMARY

1. Partial defoliation in the fall apparently hindered shoot growth and increase in trunk diameter the following season, with the exception of peach trees defoliated in September.

2. Fertilization increased the trunk diameter and shoot growth of the apple trees not transplanted, while it produced a greater or less retarding effect upon all the other trees.

3. Root pruning in general apparently had a retarding effect on the shoot growth of the trees. However, the peach trees receiving September root pruning responded favorably with an increased shoot length and gain in weight.

4. Defoliation and root pruning together hindered shoot growth and increase in trunk diameter

the following season. The September treated peach trees, however, again made a considerable gain over the check, both in shoot growth and increased size of trunk.

5. Root pruning and fertilization together was not conducive to greater shoot growth the following season, with the exception of the September treated peach trees and perhaps the apple trees not transplanted which received September treatment, as they made a greater growth than the check.

6. Defoliation and fertilization together in both September and October treatments retarded the shoot growth and increase in trunk diameter in practically all cases.

7. All treatments, taken collectively, had a retarding effect upon the growth response of the trees the following season. This, however, does not hold true with the September and October fertilized apple trees that were not transplanted, and the peach trees which had received treatment in September in which root pruning was envolved. Both of these lots of trees made a favorable response to the treatments, which would indicate that these may presumably be employed to produce a more vigorous growing tree in the nursery and in the orchard.

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