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THE EARLY GROWTH AND TRAINING OF APPLE TREES

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THE AGRICULTURAL EXPERIMENT STATION

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A Study of the Growth of Apple Trees

Charles A. Keffer

THE SITE, AND CONDITIONS THE FIRST YEAR

There are three fundamentals in the making of his apple trees which the orchardist must provide—the fertility of the soil, protection from injury, and proper light requirement. The first of these depends upon an intelligent choice of orchard site and the proper use of fertilizers and tillage. The second is a development of recent years, not yet fully perfected—the use of insecticides and fungicides. The third is entirely a matter of training. The object of this investigation is to help to a better understanding of the training of apple trees.

The varieties studied are Jonathan, a tree of spreading habit, and York Imperial, of more compact, though not erect, growth. The trees were two years old when set in the spring (April) of 1900. Some of them had been formed in nursery, others were whips, and still others were pruned to a single stem when set, so that a decided range of form characters was already developed when the study began.

The trees were planted on a northern slope, partly in new land that had been cleared of dense forest growth of 35 years' standing, and partly in old land of good tilth. The new land was planted to potatoes between the tree rows, but the potato crop was a failure, so that practically nothing was taken from the soil. The old land was sown to cowpeas, a space three feet wide on either side of the tree rows being kept clean. All the orchard was given high tillage throughout the growing season. September 19-21 the peas were plowed under and the old land was sown to winter rye, which had made quite a sod by November 6, the first hard frost. The potatoes were plowed out late in October and rye was harrowed in.

There was a deficit of rain for the first 10 months of the year of a little over four inches, the most prolonged dry periods being in April and August. At no time, however, did the trees give any evidence of injury by drought. Scab effected both varieties somewhat, Jonathan more than York Imperial. The only insect injury was caused by a leaf skeletonizer and a caterpillar, and in no case were more than a few leaves destroyed on any one plant. The Jonathan trees stood in rather poorer soil than the York Imperials—the former being in a convex and somewhat steeper slope, the latter being in a concave slope. Throughout, the soil is a clay loam, with the strata of underlying yellowish shale rock much broken and lying vertical to the surface. On the whole the trees had a favorable season, and the conditions were practically identical for the two varieties in the new and the old land.

The winter of 1900-1901 was unusually dry, and the ground was frozen but little throughout the year. Even in wood poorly matured growth was common from terminal buds in the spring of 1901. The apple trees

started early into vigorous growth, which was well maintained until the middle of June, when a drought began which was almost unbroken by rains until August 5. During this drought, notwithstanding high tillage, growth was checked, especially in the Jonathans, which occupied poorer soil than the Imperials. Excessive rains followed the drought in August, so that the land was saturated with moisture until mid-September. The terminal buds, which had hardened up during the drought, started into new growth, but comparatively few of them made vigorous shoots, many forming only a whorl of new leaves at the end of the earlier summer's growth. Considering the saturated condition of the soil, this is not surprising.

Very little pruning was done after the trees were shaped when set. It was desired to see to what length the young limbs would grow the first year, the only cutting was to correct errors in shape of crown or to reduce the number when too many branches were formed.

The trees were unpruned at the end of the first season, to permit a study of bud development, so as to determine which buds on the branch made the strongest growth. One York Imperial tree was headed back quite severely, and a description in detail of the growth of this tree is given below. The result of leaving the branches unpruned at the end of the first year was that the second year's growth, starting mainly from terminal buds, made the limbs of the trees too long for their diameter, particularly in the Jonathans, and they bent very much by their own weight.

COMPARISON OF GROWTH IN 1900 AND 1901

The trees were planted in April, 1900; hence, any comparison during the first year they have been in orchard would be misleading. During the early part of 1900 the trees had to establish themselves in their new location, while in 1901 they were ready to push into vigorous growth at the beginning of the season. In each year there was a drought, but the deficiency in rainfall in 1900 (see table) occurred in April, and the soil was in good moisture condition from the winter rains. The drought of 1901, coming at midsummer when evaporation was at its height, was more serious in its results, though in neither year did the trees suffer materially. The more even rainfall of 1900 induced a steadier growth than that of 1901, during which there was a noticeable check at the time of the drought. One would have expected a very rapid growth during August and September of the past season, there being a heavy excess of rain. It may be questioned however whether the continuous rains of August were not as deleterious as the dry weather preceding them, resulting as they did in long continued saturation of the soil. The growing shoots hardened up their terminal buds in July, and in September, after the heavy August rains were over, the buds pushed, but most of them made little growth.

In the first year after planting the growth as a whole was more constant through the season, though the terminal shoots, making on the average 10.6 inches after June 26, grew slightly less than the average of the longest lateral shoots, which made 11 inches after June 26. The rainfall during the growing season for the two years, with the mean rainfall for the past 31 years, was as follows:

Record of Rainfall.

MEANS	1900			1901		
	No. Days	Greatest in One Day	Total Inches	No. Days	Greatest in One Day	Total Inches
Mar.... 5.37	13	(16) .92	4.02	11	(26)1.53	4.32
Apr.... 4.95	15	(4) .29	1.92	12	(2)1.70	5.35
May... 3.92	8	(26) .92	1.72	13	(21)1.45	4.03
June... 4.10	20	(28)1.86	6.42	13	(18)1.28	6.44
July ... 4.32	10	(30) .96	3.90	3	(7) .48	.69
Aug. .. 4.07	7	(24)1.24	3.46	22	(15)2.33	10.48
Sept. .. 2.70	10	(22)1.40	3.59	10	(15)1.03	4.14
Oct.... 2.79	6	(8) .93	2.21	5	(12)1.02	1.57
Nov. .. 3.81	12	(26)2.78	5.63	.....	.....	.....
Totals..36.03	101	(9)11.30	32.87	89	(8)10.82	37.02

Longest intervals without rain: 29 days*; 28 days†.

WHEN IS GROWTH MOST RAPID?

Spring and early summer is the period of most rapid growth, and the great majority of shoots make their principal growth in length before July 1. While this is true, the number of branches which make greater growth after July 1 than before is large enough to be of interest, and their position in the tree makes the fact of their continued growth a matter of practical importance in training.

From data taken during the past growing season the table on page 6 has been compiled. In it the season is divided into three periods of as nearly equal length as could be devised to conform to the date of measurement—the last week of each month. The first period—to June 30—may be regarded as including the time when conditions are most favorable for rapid growth; usually there is an abundance of moisture and suitable temperature during the early summer. The second period includes the hot months of July and August, and during the past season a severe drought was experienced in the earlier part of this period, checking growth, but presumably having the same effect on all parts of the trees. The third period includes September and October. This year's growth was not entirely stopped in the apple trees until December 15, though no lengthening of shoots took place after November 1. In order not to lengthen the table unduly, no shoot of less than four inches has been included, fractions of an inch are omitted, and for convenience each tree is recorded separately. One Jonathan tree was severely cut back in July, and one York Imperial was heavily pruned last winter, and these have not been included in the table, though they follow the same law of growth as those tabulated and are referred to in the discussion.

A comparison shows that about seventy-five per cent of all shoots on the 16 trees tabulated had made their principal growth in length before July

*Several small showers, only .49 inch fall on six days.

†Two small showers, on 16th and 29th.

TABLE I When is Growth Most Rapid?—Jonathan, Trees 1-1 to 2-4 inc.; York Imperial, Trees 9-1 to 11-1 inc.

Ju. 25	Aug. 28	Oct. 31
1-1		
T 16	16	16
11	17	17
5	11	13
5	11	13
4	11	13
6	11	13
6	13	15
5	12	19
2	12	20
11	17	17
T 21	25	25
3	11	14
6	14	15
...	14	14
10	20	20
T 19	24	25
13	19	19
12	21	21
7	15	15
9	20	20
6	15	20
11	19	19
1-2		
T 14	22	22
14	21	22
T 17	26	27
T 17	27	27
1	18	22
13	22	22
6	16	20
14	24	24
9	19	25
T 15	22	23
7	15	21
3	14	15
10	18	19
11	20	21
9	19	23
T 15	28	29

Ju. 25	Aug. 28	Oct. 31
1-2—Con.		
15	28	29
T 13	17	17
10	14	15
13	26	32
17	28	29
15	26	27
12	16	16
1-3		
T 11	11	11
7	8	9
9	13	20
T 10	15	15
2	11	17
9	16	21
3	12	20
T 19	23	28
T 19	23	28
T 10	14	15
6	10	11
7	13	17
7	16	21
15	16	17
10	17	17
8	18	18
2-1		
T 14	22	25
8	16	17
9	18	18
10	20	20
9	21	23
9	17	17
5	17	17
T 13	19	19
9	20	22
T 10	17	17
8	17	17
9	22	27

Ju. 25	Aug. 28	Oct. 31
2-2		
9	13	14
3	8	8
5	10	16
5	9	10
8	15	15
0	0	11
T 12	14	14
2	9	9
6	12	13
T 11	13	17
12	16	17
1	17	17
T 14	16	16
8	13	13
14	17	17
7	14	14
6	10	10
3	13	13
9	14	14
11	14	14
6	16	16
8	14	16
2-3		
T 18	20	20
12	16	16
7	15	20
12	18	19
14	19	20
T 15	21	22
T 16	16	16
11	16	16
12	14	14
12	15	15
12	16	16
8	12	12
T 10	16	16
5	17	17
8	15	16
0	14	16
9	20	24
T 22	32	33
T 18	24	24

Ju. 25	Aug. 28	Oct. 31
2-3—Con.		
T 18	19	19
8	16	20
11	13	25
7	16	18
2-4		
T 19	19	19
10	14	14
11	13	13
8	10	11
9	12	12
3	13	13
9	14	14
6	10	10
7	14	14
T 17	22	22
8	12	12
11	14	15
2	15	16
14	16	16
9	18	18
T 15	16	16
7	12	12
3	13	14
0	7	11
0	10	10
0	15	23
T 16	16	16
11	16	16
12	14	14
12	15	15
12	16	16
8	12	12
T 10	16	17
5	17	17
8	15	16
0	9	9
7	16	16
0	13	13

Ju. 25	Aug. 28	Oct. 31
2-4—Con.		
T 18	21	21
9	14	16
0	14	15
9	16	16
9	19	19
10	18	18
10	21	25
T 18	21	21
10	13	13
12	16	16
10	15	16
9	14	14
11	14	14
6	16	16
8	14	16

Ju. 25	Aug. 28	Oct. 31
9-1		
14	15	15
8	9	9
8	8	8
9	12	13
9	11	11
8	9	9
T 8	17	25
10	20	21
T 12	17	18
9	15	15
9	13	13
7	13	13
T —	18	22
T 10	17	20
T 12	19	20
11	18	18
9	12	12
12	17	17
14	20	20
8	13	15
0	3	9
9-2		
T 11	11	11
8	11	11
6	6	6
8	10	12
8	11	12
16	23	23
14	22	27
T 15	18	18
8	15	15
9	15	17
T 12	17	18
9	14	14
8	10	10
9	16	18

Ju. 25	Aug. 28	Oct. 31
9-3		
T 13	18	18
5	13	14
12	14	14
7	9	9
8	15	15
T 17	20	20
12	15	15
11	15	15
11	17	17
11	15	15
8	20	20
T 17	23	27
T 14	28	29
13	22	29
T 11	12	15
11	18	18
9	14	14
11	20	25
10	18	25
9-4		
T 23	28	29
15	27	33
12	14	25
T 21	34	37
11	23	29
T 22	32	40
18	28	34
12	23	28
T 23	34	43
16	23	28
17	26	28
11	21	31

Ju. 25	Aug. 28	Oct. 31
9-5		
T 15	18	18
12	21	24
0	8	16
8	17	25
T 18	25	30
13	24	25
13	26	29
13	23	23
12	23	27
13	27	30
T 12	17	26
12	22	26
9	17	21
7	19	26
7	15	18
9	21	28
6	24	33
15	29	35
T 16	23	26
17	23	25
8	20	26
16	19	21
10-1		
T 19	28	28
T 13	19	19
11	19	19
11	16	16
16	24	27
T 11	14	18
13	21	21
T 13	17	17
11	16	19
T 13	19	19
9	16	16
14	21	21
8	18	19

Ju. 25	Aug. 28	Oct. 31
10-2		
T 11	23	23
T 10	15	15
9	15	15
3	6	6
6	11	11
4	12	12
6	13	13
7	19	28
9	15	15
T 21	25	25
14	17	17
7	14	14
13	18	18
11	15	15
11	13	13
T 17	21	26
T 16	21	21
T 14	18	18
13	16	16
13	17	17
T 13	13	13
10	12	12
T 13	16	16
11	15	15
5	11	11
T 18	24	27
15	16	16
9	10	26
19	26	30
15	24	24
5	9	11
11	19	24

Ju. 25	Aug. 28	Oct. 31
10-3		
T 14	20	21
11	17	19
12	18	22
11	18	22
10	22	34
10	17	25
15	26	34
5	24	36
T 16	25	25
14	23	27
14	20	21
9	17	17
T 15	21	21
10	17	18
11	15	15
18	24	25
T 11	17	18
6	10	10
7	14	21
12	17	17
14	18	18
18	26	31
(*6 laterals 2 to 5, Ju. 2 to 28 ½ Oct.		
T 13	17	17
11	16	16
12	16	16
8	13	14

Ju. 25	Aug. 28	Oct. 31
10-4		
T 17	19	19
8	12	12
9	15	18
14	17	17
13	17	17
10	16	16
0	...	15
21	33	33
T 16	20	22
12	17	17
15	19	19
10	15	15
8	15	15
13	21	21
9	14	14
T 16	20	21
13	18	18
6	13	13
10	18	24
10	19	19
17	21	22
10	20	20
T 14	18	21
9	16	22
7	15	18
11	16	23
8	16	25
9	21	33
11-1		
T 6	13	13
T 8	18	24
13	26	26
T 6	11	11
T 5	11	11
T 10	16	29
T 11	15	15
T 14	20	20
T 11	21	21
T 8	10	10

1, and of the total aggregate growth of all shoots over 4 inches in length 56 per cent was made before this date. This does not mean that most of the shoots had ceased growing in length by that time—far from it. In point of fact, growth continued generally; the number of shoots on the 16 trees that grew less than three inches in length after July 1 is only 29 York Imperial out of a total of 211, and 24 Jonathan out of a total of 167, and of the 398 shoots noted in the tables only 15 made a growth of one inch or less after July 1.

There is a very evident lessening of growth after August 30, showing that much the greater part of the tree's work during the late summer and fall is in the line of maturing the wood already formed rather than in the making of new wood. One hundred and twenty-four shoots of York Imperial and 136 of Jonathan lengthened less than one inch after August 30. While this is over half the York Imperial and over 80 per cent of the Jonathan, there are many shoots of both varieties in active growth throughout September, and even the end of October finds some few still growing.

The outermost branches make their principal growth in length earlier in the season than do those nearest the trunk.

A comparison of all the terminal shoots (marked T in the table) with all the others will show in both varieties that the terminal shoots as a whole grow less in length after June 30 than the lateral shoots. The average growth per shoot of Jonathan after June 30 was in terminals 5.4 inches, in laterals 10 inches. York Imperial is evidently a variety of less determinate growth, for here the average of terminal shoots is 7.6 inches and of laterals 8.1 inches.

The difference in the periods of growth of terminal and lateral shoots is much better shown by a comparison of the topmost with the lowest shoots on the same branches. Such a comparison shows that the aggregate growth of terminal shoots of York Imperial after June 30 is 309 inches, of lowest shoots 416 inches. In Jonathan the aggregate growth of the outermost shoots is 156 inches, and of the lowest shoots on the same branches 383 inches. That is to say, the terminal shoots make their principal growth in length during the early part of the season; the lower shoots continue to grow relatively through a longer period. This law does not seem to apply with equal force to winter pruned trees, nor to those headed in during the growing season. Last winter a vigorous York Imperial was cut back from one-half to two-thirds throughout the new wood. The growth of its topmost and lowest shoots after June 30 is as follows, the topmost shoot being given first in each pair: 6-12, 16-18, 18-16, 20-20. On only one branch is there a decided increase of the lowest over the highest, two other cancel, and the fourth is a tie, the total being slightly in favor of the law.

During the entire season the terminal shoots in Jonathan made more growth than the longest lateral shoots on the same branches, the terminal shoots aggregating 721 inches and the laterals 701 inches. In 22 of the 35 branches having both terminal and lateral shoots the terminals equaled or surpassed the longest laterals in length. In York Imperial the aggregate of the longest laterals was 994 inches as against 939 inches for the terminals, but here again a majority of the terminal shoots, 24 out of 42, equaled or surpassed the longest laterals on the same branches.

The terminal bud, having relatively a greater store of food than the laterals, shoots into more vigorous growth when vegetation starts in the spring. When the outer part of the growth is removed, as in the winter pruning of young trees, the topmost bud remaining is no better supplied with stored food than its fellows, unless it be immediately below a check or pinch; but the sap that flows into the branch equals in amount what it would have been had no pruning been done. The buds remaining after pruning have thus the same supply as would have been distributed along the entire branch. The stored food influences growth only until leaves are fully formed, and there after the leading factor is the supply of sap. The pruned tree made more vigorous growth than any of its fellows, though the growth was prolonged over a greater period. While over 50 per cent of all the shoots on the York Imperial trees completed their growth in length by August 30, all of the branches on the winter pruned tree continued to grow freely, most of them making over ten inches in length after that date. The pruned tree is today the best under observation, showing clearly the good effects of the practice.

Summer pruning in the case of the single tree that was headed in seems to derange the usual habit of growth. A Jonathan tree left unpruned after its first year in orchard produced so many and such spreading branches that it was determined to head it in, and the work was done July 8. All the outermost parts of the previous year's growth, with the new shoots thereon, were pruned off, together with many of the inner branches. All the terminal shoots were thus removed, and as without exception these had made greater growth than the lower shoots on the same branches the pruning may be regarded as very severe. The growth since the pruning has followed usually the law noted above; the outermost shoots stop lengthening sooner than the lower shoots on the same branches, but in three cases this order is reversed in the summer pruned tree. The aggregate length of new wood produced in topmost shoots since June 30 is 87 inches, in the lowest shoots of the same branches 130 inches. It is important to note that when a branch is headed in its outermost remaining shoot bears the same relation to the pruned branch as did the terminal shoot to the unpruned branch; hence, other things being equal, it will get relatively a larger supply of sap than its fellows, and even though small when the pruning takes place it is soon stimulated into a growth so vigorous that it may be in the lead before the end of the season.

While this is true, many things can overcome the tendency of the sap to flow strongest to the outermost shoot: a wound, or any compression of the bark, such as is caused by tying up the limb, a heavy downward curve in the limb, a vigorous shoot near the base which has become well established before the pruning—any of these may be sufficient to overcome the law and will result in the development of the laterals at the expense of the outermost branch.

From the above discussion it is evident that if two varieties show such marked differences in their growth periods there must be a great range of difference in the many orchard varieties commonly grown. It is reasonably safe to assume, however, that the same general law of growth will hold in all, though in varying degrees, viz.: that the apple shoot makes

its principal growth in length before July 1, and that the outermost shoots finish their growth in length sooner than the lower shoots.

The practical application of these laws to orchard management would seem to rest chiefly in enabling the grower to shape up his trees by summer pruning. Persistent pinching of too vigorous lower shoots should force a lagging terminal into more active growth; thinning out lower shoots where too many have started should stimulate those remaining to increased growth. Heading in may be safely practiced where branches have become too long and sprawling, but it is best done in June, to give the outermost shoot remaining as long a period of growth as possible, especially if it be a backward shoot. The Jonathan tree that was headed in in July has almost completely healed the wounds made in pruning, the growing layer having almost covered the cut surfaces. This also is an advantage of relatively early summer pruning.

WHAT BUDS GROW? When the tree goes into winter quarters it bears many more buds than will push into growth the following spring. Many of these buds will remain dormant, some will start into growth, making only a small whorl of leaves, when they will stop, while yet others—and these are comparatively few—will grow into shoots. Most of the shoots formed will remain short spurs or will be cut out during the first pruning, so that, of the hundreds of buds which the young tree makes in the course of a growing season only a very few ever become branches.

The following table shows what percentage of buds formed in 1900 started into growth in 1901:

TABLE II What Buds Grow?

TREE	JUNE 30, 1901							OCT. 30, 1901				REMARKS
	Top Shoots	Lateral Shoots from New Wood	Lateral Shoots from Old Wood	Whorls: On New Wood	Whorls: On Old Wood	% of Buds that Start to Grow	% of Buds that Made Shoots	Ter. Shoots	Lat. Shoots from New Wood	Lat. Shoots from Old Wood	% Branches	
Jonathan:												
1—1	6 (all)	43	0	108	0	78	25	6	28	0	.....	Summer Pruned
1—2	8 " "	14	3	62	10	42	12	8	12	3	.....	.....
1—3	6 " "	11	0	84	0	53	9	6	11	0	9	.....
1—4	11 " "	52	4	177	11	56	14	0	30	1	.....	Summer Pruned
2—1	4 " "	13	2	39	3	58	18	4	9	1	.....	Summer Pruned
2—2	6 " "	16	0	107	0	59	9	6	16	.....	8	.....
2—3	5 " "	29	1	81	1	56	17	5	18	1	9	Summer Pruned
2—4	7 " "	58	0	151	0	64	19	7	65	0	18	Summer Pruned
York Imp.:												
9—1	4	35	10	62	2	70	29	4	18	.....	14	Summer Pruned
9—2	3 (all)	38	9	51	1	62	31	3	11	.....	10	Summer Pruned
9—3	4 " "	33	7	47	3	61	29	4	13	2	12	Summer Pruned
9—4	4 " "	35	5	21	2	59	39	4	14	0	16	Summer Pruned
9—5	6 " "	65	11	137	3	65	24	4	21	.....	7	Summer Pruned
10—1	6 " "	14	14	49	9	70	24	6	4	4	10	Summer Pruned
10—2	5 " "	26	12	38	11	63	30	4	18	12	23	Summer Pruned
10—3	5 " "	35	9	39	5	31	16	5	15	6	9	Summer Pruned
10—4	4 " "	84	3	67	1	71	41	4	24	1	13	Summer Pruned
11—1	4 " "	18	8	106	7	45	13	4	2	5	5	Summer Pruned

It will be observed that the two varieties under observation averaged about the same in the number of buds that started to grow, but the York Imperial made almost twice the number of shoots up to June 30 that were formed in Jonathan. This suggests the differences in growth existing among the many varieties of apples—a matter of great importance in their training. In Jonathan 59 per cent of all the buds above the lowest limb started into growth by June 30, and 15 per cent of all the buds had made shoots three-fourths inch or more in length. In York Imperial 60 per cent of the buds had started growth, and 28 per cent had made shoots.

Strong individuality is observable also in the several trees of each variety, the number of buds that started ranging from 42 per cent to 78 per cent in Jonathan and from 31 per cent to 71 per cent in York Imperial.

With one exception, the top bud on every branch made a shoot. Where no pruning was done in the winter of 1900-1 the terminal bud started into growth in the spring, and in almost every case made a strong shoot, though frequently it was overtaken during the season by shoots from lower buds. Where winter pruning was done, the top bud remaining in every case made a branch.

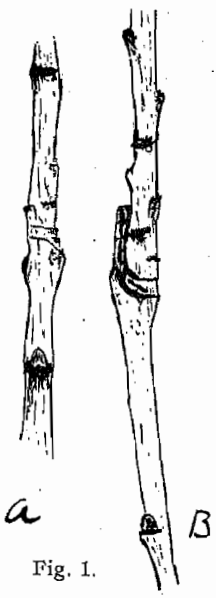


Fig. 1.

a—Check.
b—Pinch.

Aside from the development of the terminal buds into branches, pinching and checks in growth exert an influence in inducing the buds immediately below the check to make shoots. The buds immediately above such a check, and the lowest buds on the branches, generally remain dormant.

Careful observations, including all shoots in which a check to growth occurred during 1901, prove this. Where growth is checked by natural causes, as by dry weather, the spaces between the buds are very short, making a mark on the limb somewhat like that caused by the stopping of growth in autumn and its beginning the following spring (Fig. 1, *a*). Such a check does not result in as complete ripening of the wood just below it as follows pinching, in which the end of the shoot is removed, and the top bud must become quite mature before it can push, continuing the lengthening of the shoot (Fig. 1, *b*). Pinching also causes a more perfect ripening of the buds immediately below. The new growth that follows a check or a pinch is apt to be rapid, so that the first buds formed are very small and are not as perfectly developed as those toward the end of the branch, when the approach of winter causes the tree to mature its wood. The buds below a check are much larger and are better stored with food than those immediately above, so when spring comes and growth begins, they have an advantage over their fellows, and are apt to form shoots. Pinching is more sure to result in branches than checking, and the York Imperial responds more readily to both causes than the Jonathan.

There is a practical application of this law of growth. Pinching is an old practice, employed to maintain symmetrical development in young trees. When a shoot lengthens more rapidly than its fellows the tree is apt to grow one-sided. By pinching out the top of such a shoot its progress is stopped for a time and the other branches grow on, thus equalizing the parts of the crown. Oftentimes the same branch will require stopping several times before the others overtake it. Every time a shoot is pinched the first effect is to cause the buds immediately below to become more mature than would have happened had the branch been uninjured. Pinching, then, not only permits other shoots to overtake the pinched one, *but has an important influence upon the future growth of the shoot thus stopped*—the operation perfecting the buds below and making them more certain to form branches than they would otherwise. *It becomes important to remove or encourage these growths* according to their effect in the symmetry of the crown.

When two or more checks occurred in the same branch, it was seen that without exception, the outermost check had more influence in developing the buds below it than the lower checks. This doubtless results from the fact that in the earlier part of the season growth is more rapid, and the later checks are aided in their effect by the slower growth, with its tendency to more perfect development.

In studying these tables of the growth of buds, one is met with the question, what benefit to the tree results from the making of whorls of leaves? In table II it is seen that 40 per cent of the buds formed do not grow at all, and of those which do start much the greater part make only a whorl of leaves, and after the first year may remain as dormant as those which fail. The buds that form shoots seem to be the only important ones to the tree—the shoots formed are covered with leaves, and these are better placed for digesting food than those of the whorls, which are placed close against the old branch and are always shaded more or less by the new growth.

While it is true the leaves on the shoots are more exposed to sunshine and therefore do relatively more work, it must be remembered that much of the food they digest is used up in lengthening the shoot to which they are attached. A new layer of wood is being made each season, coating over every part of the wood already formed. These whorls of leaves are of the greatest importance in providing material for this new layer of wood, and they should be carefully protected by the grower.

In nursery practice the two-year-old trees are frequently stripped of the whorls of leaves along their trunks in September, to make them "ripen up" faster and be ready for fall delivery. The plan is utterly at variance with the principles of plant physiology and should be discouraged.

Another use which the whorls are to the young tree is in the ease with which they start into growth as compared with a bud that has remained dormant. Each whorl is in fact a short shoot, with a terminal bud at its tip and a lateral bud at the base of every leaf. The table shows that terminal buds are more apt to grow than lateral ones. In case of injury to a branch the most favorably placed whorl below will push, soon correcting the injury.

As the tree grows older the whorls become of first importance, especially in such fruits as the apple, in which the fruit is usually borne upon small spurs. The tiny branches showing upon young trees as whorls become the fruiting spurs in mature trees. Examine a bearing tree and you will find the fruit at the end of a short shoot, which produces just such a whorl of leaves as this which seems useless in the young tree. And it is reasonable to infer that the few leaves on the fruit spur have relatively more to do with digesting the food that is used in the growing fruit at its tip than any other leaves on the tree.

No tree can develop all the shoots that push, even in the second year after planting.

Inspecting table II. it is found that within two months or the time growth began several of the trees had started over 60 shoots into growth. If this many limbs start in the second year after planting one can conjecture what would be the condition of the unpruned tree in its sixth year, when it should begin bearing. Manifestly there would be an impenetrable mass of twigs, did not nature herself protect the trees against such exuberance of growth. The record of these trees shows that while many shoots started most of them made a growth of less than four inches during the season; but it became evident before midsummer that if left to themselves the longer shoots would soon be seriously interfering with one another. For a random example, upon one branch of a York Imperial tree the outermost 11 buds started into growth, and by June 25 they measured from 2¼ inches (the eleventh) to 13 inches (the terminal) in length. It is plain to see that the parent limb could not support 11 branches within a length of less than that number of inches. Space could not be found for them as they grew, and if it could, and all should develop, their attachment to the parent limb so close together must inevitably result in weakness in one or more members. Hence, on July 8, all but three were cut out, and these were chosen with reference to their direction of growth and their relation to the balance of the tree.

A FEW EXAMPLES IN TRAINING

The principal lesson to be learned from a study of the growth of young trees is that their first years in orchard should be a formative period, during which the utmost skill of the grower should be exerted in giving to each tree the best possible framework on which to build its future growth. One may not judge what will be the form of a tree at the end of its second year by its shape at the end of its first year in orchard. Here is York Imperial tree No. 3 in Row 9 (Figs. 2 to 6). The photographs tell the story of its development. At the end of its first year it had assumed the form seen in Figure 4, and was not at all an ideal tree. During the past season it produced many branches, as seen in Figure 5, and presented a rather difficult problem. In its pruning the one thing to be considered was, what will make the best skeleton for this tree? And in working out the problem it seemed best to cut away almost all of one of last year's limbs, because a new shoot, formed low upon the limb this year, took a better direction and gave promise of greater symmetry to the tree as a whole, with more light for its crown. The shaping that was done

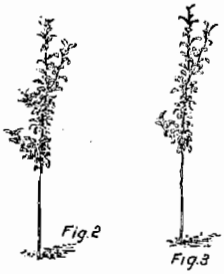


Fig. 2 Fig. 3

Before and after pruning
July 16, 1900

Fig. 4

Sept. 26, 1900

(Figure 6) had for its leading purpose the making of a good framework or skeleton. Good shoots were sacrificed to this end, and possibly more wood was removed than will meet the approval of many growers. The pictures are given not as examples of perfect pruning, but to emphasize a purpose and a condition of pruning; that purpose being that in the early years of a tree's life much may be sacrificed to secure a good framework; and the condition, that during these first years the grower may find it expedient to abandon his first form—the best possible that the tree permitted at the time—and cut away parts that he has done his best to favor.

York Imperial Tree 4 in Row 9, (Figs. 7 to 11), pruned also last winter, presents a very easy problem; following its first year's growth, the new wood of the present season is so well disposed as to require but slight thinning and an all round heading in. Unlike Figure 2, this tree was symmetrical from the first, and its pruning easy. In the Jonathan tree, No. 4 of Row 2, (Figs. 12 to 15), the series of photographs show a symmetrical form at the end of 1900, but the growth of

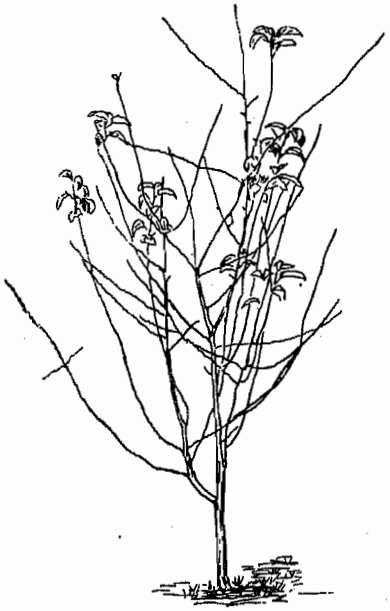


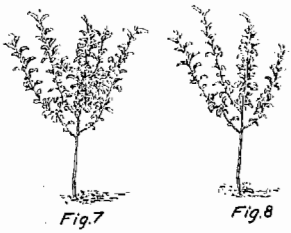
Fig. 5

Nov. 25, 1901

Fig. 6

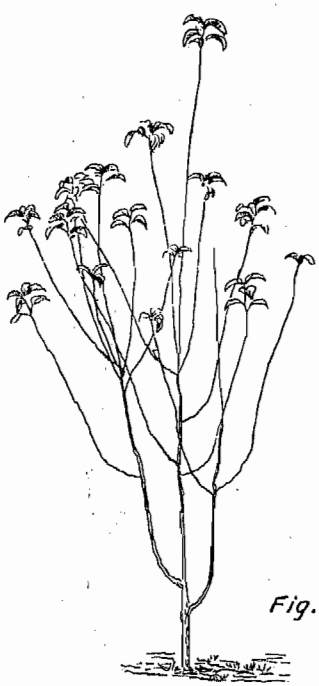
1901 has so thickened the crown that it became necessary to cut out two of last year's branches entirely, and to cut away much the greater part of the new growth on the limbs remaining.

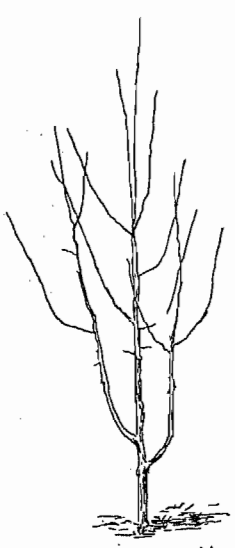
Could the protographs of all the trees under observation have been reproduced here, they would each have presented its own problem of pruning. In very few trees of the entire orchard has a symmetrical form been adopted by the tree itself. When first set the trees were headed in, so that the top should correspond somewhat to the root system, much of which had been cut away in digging. The first year many of them were very unsymmetrical in growth, and at the end of the second year they present a totally different



Before and after pruning
July 16, 1900

Sept. 26, 1900





Nov. 25, 1901

Fig. 12

July 16, 1900

Fig. 13

Sept. 26, 1900

crown from what was theirs at the end of the first season. In some cases branches have appeared just where they were most needed to balance the tree, but in most cases there is still a lack of symmetry, and in some few instances the new growth seems all to be where it is not wanted. Each tree is a separate problem in training. In all, these first years must determine not only present form, but, what is of much greater importance, their shape when mature, bearing trees. So it would seem that the grower can find no more practical problem than is presented in the training of his young orchard. Work intelligently done during the first years of the orchard, having for its object the making of each tree into the best possible fruit machine, will mean not only greater producing power, but it will mean longer life and higher quality of fruit.

SUMMARY.

1 Moisture conditions exert a marked influence over growth.

2 Growth is most rapid before midsummer, but many shoots continue to grow throughout the season.

3 The outermost shoots make their principal growth in length earlier in the season than do those nearest the trunk.

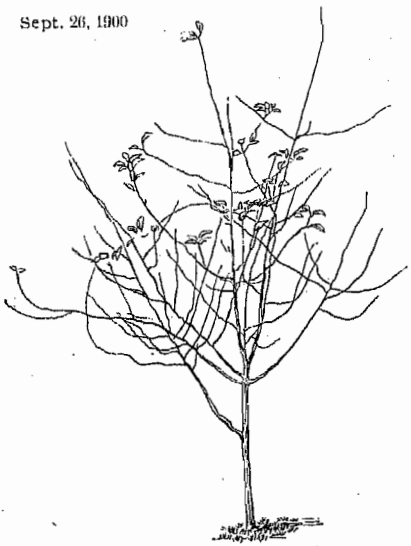


Fig. 14

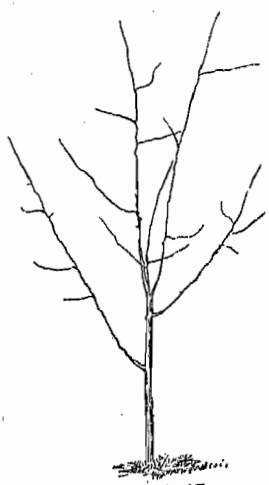


Fig. 15

Nov. 25, 1901

4 Symmetry can be increased by summer pruning or pinching.

5 Over half of all the buds formed in 1900 started into growth in 1901, but only 21 per cent made shoots ¾ inch or more in length.

6 A very marked difference was observed among the trees in the number of buds that started to grow, ranging from 31 per cent to 78 per cent.

7 With only one exception the terminal buds made shoots.

8 Pinching and natural checks to growth in 1900 resulted in the formation of shoots in 1901 from the buds immediately below, and pinching had a more pronounced effect than natural checks.

9 Where two or more checks occurred in the same shoot, the buds below the outermost check grew in more cases than those below the lower check.

10 The whorls of leaves which result from the starting of a bud which fails to make a shoot are of great importance to the tree in assimilating food for diameter and for root growth; they form shoots more readily than dormant buds, and as the trees grow older they form fruiting spurs.

11 The trees start more shoots than can become permanent branches; hence the importance of annual pruning or training.

12 The first years of the orchard should be a formative period, having for its principal object the making of the most perfect framework possible for each tree.

13 Each tree presents a separate problem to the pruner, who should endeavor to get the best disposition of branches, both in circumference of the crown and in attachment to the trunk.

14 Few trees are naturally symmetrical, and often several years will be required to get the tree trained to its best shape.

15 The object of training is to get ample light to every part of the crown when the tree shall come into bearing, while securing the greatest possible strength in the branches.