weeks. Avocado behaved similarly in the compost medium. The failure of Oneco tangerine and Valencia orange to root points out the inadequacy of the material; young, angular wood only was available. As the technique of choosing the proper wood, and, perhaps, of making the proper cut, improves, doubtless the ratio of rooted to unrooted cuttings will continue to increase.

Summary

Research into the rooting problem has lead to the adaption of the constant spray method to full sunshine. This method appears to be a satisfactory method of rooting sub-tropical fruit plants if free drainage is provided in the medium. Cuttings give best results if only the bottom third of an eight inch cutting is stripped of its leaves. Promising results were obtained from citrus cuttings, while results with other fruits merit further experimentation.

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WEED CONTROL STUDIES AROUND YOUNG AVOCADO TREES

Roy W. Harkness
Florida Agricultural Experiment Stations
Sub-Tropical Experiment Station
Homestead

Introduction

On the oolitic limstone soils of Dade County, newly planted avocado trees seldom grow as fast on old citrus land as on freshly scarified pineland. In some groves, the majority of the young trees have failed to grow at all and have eventually died. However, after the trees are well established, they grow very well on the old citrus land.

This difficulty sometimes occurs after compensating for the minor element deficiencies of the soil. Raw pineland apparently contains enough magnesium to supply young avocado trees for at least a year or two, while land that has had orange or grapefruit groves is generally deficient in magnesium and possibly in some other elements. Severe cases of magnesium deficiency have been found on avocados on old citrus land and in some cases, the correction of this deficiency has been all that was needed to start a vigorous growth.

In other groves, the trees have failed to grow in spite of ample supplies of magnesium fertilizer and copper, zinc and manganese sprays. Various theories are held for the cause of the poor growth but a superficial inspection of the groves show a striking difference in the weed growth on old and new land. On newly scarified pineland, weed competition is seldom serious until the trees are three or four feet high, while on the old land, continuous weed control is required. Some weed control is practiced in practically all groves but it seemed likely that the control was frequently inadequate.

One purpose of the present investigation was to find out if the poor growth found in some commercial groves could be accounted for by inadequate weed control. As finally designed, the experiments should give some general information on the establishment of young avocado groves.

Trees of the Booth 8 variety were planted on May 3, 1949, in seven rows of 19 trees each. The trees were 10 feet apart in the row and the rows were 12 feet apart. The ground had been scarified about twelve years previously and had lain idle for several years. It was grown up to Natal grass and Bidens with numerous plants of perhaps a dozen other species. The ground was disced and the trees planted in the usual way. A water basin was made around each tree and about 1½ large shovels of pine shavings were placed in this basin. All trees were fertilized according to standard practice and they also received the normal nutritional sprays (see Fla. Agr. Bull. 141).

Plan of Experiment

The 133 trees were divided into 19 treatments of 7 trees each. Each treatment was divided into three plots. One plot had three trees, the other two each had two. The plots were randomized.

The treatments were, as follows:

1. Kept free of weeds by hoeing about once a month during wet weather and somewhat less frequently during dry weather.

2. Mulched heavily with pine shavings for about a three-foot radius. A few weeds were pulled by hand.

3. Mulched with dead grass. A few weeds were pulled by hand.

4. Native weeds allowed to grow.

5. Mowed whenever Plot 1 was hoed.

6. Alternately hoed or mowed whenever Plot 1 was hoed.

7-10. Originally started as herbicide control plots. Later they were mowed like Plot 5. However, Plot 8 is now being used for test of a commercial weed-killing oil. On July 8, 1949, Treatment 10 received 2 lbs. of 50% sodium trichloroacetate in 2 gals. of water, distributed in a three-foot radius around each of the seven trees. The damage to weeds and grass was slight so on July 21, 4 lbs. of the material was distributed in the same manner.

11. Bermuda grass planted and allowed to grow. Other grass and weeds pulled out by hand.

12. Same as Plot 11 except that the top of the Bermuda grass was mowed twice.

13. Bidens seeded and allowed to grow. Most other weeds were pulled out by hand.

14. Same as Plot 13, except that the Bidens have been mowed five times.

15, 16. Wild Tradescantia planted and allowed to grow. However, the dry weather of January to May 1950 killed most of the Tradescantia, so 15 is now being mowed like 5 and 16 is being hoed like 1.

17, 18. Bryophyllum planted and allowed to grow. Other weeds were pulled out by hand. On May 5, 1950, the Bryophyllum in 17 was cut off at about one foot height and on July 14, when three feet high, it was mowed.

19. Extra plot about like 6.

Results

On July 22 and October 13, 1949, and on May 9 and September 13, 1950, measurements were made of the height of the trees and the spread of the branches. The height is probably accurate within one or two inches but the spread of the branches is more uncertain and has little value except to show that the trees surrounded by tall plants such as Bryophyllum or Bidens did not spread as much as the others. The height of the individual trees are given in Table 1 and the average heights and spreads on the final date are given in Table 2.

Various statistical comparisons of the data in the two tables have been made and most of the calculations involving the earlier measurements are consistent with those for the heights on the last date. There is no significant difference between the five best treatments, 1, 2, 3, 17 and 18; that is, between hoeing, mulching or Bryophyllum, There is also no difference between the three worst treatments, 4, 10 or 13 (weeds, T. C. A., or Bidens). The best treatments are significantly better than the poorest at the 1% level. All the remaining ten treatments fall in an intermediate group and none of the ten show a significant variation from any other treatment of these ten. Taking this group as a unit, which admittedly is not a very sound statistical procedure, this group is significantly better than the poorest and significantly poorer than the best at the 1% level. When comparing individual treatments, these ten are in most cases neither significantly better than the poorest nor poorer than the best. All these calculations were made on the basis of living trees. Inclusion of trees apparently killed by the treatments would have placed Treatment 11, 12 and 14 among the poorest.

The fact that the trees in the hoed plots (1) grew about the same as those in the mulched plots (2 and 3) indicates that weed control is one of the most important factors in the environment of the tree. It does not indicate that there is no difference between muching and clean cultivation because these experiments only show large differences and also the hoeing used was only one of the many possible systems of clean cultivation.

Mowing (Treatments 5, 7 to 9) evidently does not give adequate control of weeds around small trees. Treatment 6 which was hoed about every two months and mowed in between times was not much better than the mowed plots, so that suggests that Treatment 1 might have been better if it had been hoed more often. The weeds were frequently several inches high when the No. 1 plots were hoed. However, that would have made the hoeing better than the mulched plots, which would be rather surprising, and, in fact, as will be discussed later, there is reason to suspect that very frequently hoed plots would be worse. Regardless of the interpretation, these results indicate that poor weed control causes much of the poor growth in commercial groves.

The 2, 4-D plots were abandoned because the treatment merely killed the broad leafed plants and it soon became evident that grasses harmed the trees at least as much as the other weeds. The second T. C. A. treatment on No. 10 plots burned one tree a little but caused no visible effect on the other trees. Nevertheless, it evidently damaged the roots because these trees never caught up with the other mowed plots. The killing of the grass was also very temporary.

Chemical mowing of the grass with a contact weed killer, such as aromatic petroleum oil, might be satisfactory if the trees were shielded and large and frequent applications were made. It has not yet been done satisfactorily in this experiment.

On the basis of present observations, the Bermuda grass was the most harmful of the treatments. Until the dry weather of the spring of this year, the trees in these plots grew well but on some of the hot dry days, about half of the trees showed wilting and three of them died completely. The only trees in the 11 and 12 plots that continued to grow well were those that were not surrounded by a good stand of Bermuda grass.

In the Bidens and the natural cover (large Bidens and Natal grass), there did not appear to be so much wilting during the dry weather, although two trees died in 14 and one in 4. Most of the trees continued to grow slowly and showed a good green color, although they were shaded by the Bidens.

Tradenscantia formed a thick mat around the trees and at first it suppressed the other weeds. However, the dry weather killed most of it so the trees passed through the dry period with a mulch of dead Tradescantia vines.

The Bryrophyllum was rather slow to start growing but after a few months it was very vigorous and three or four feet high in the area that received fertilizer. During the dry weather when the trees were wilting in some of the other plots, the trees surrounded by Bryophyllum continued to put out a new flush of growth without any signs of wilting. The surface of the soil under these plants was cool and moist when it was hot and dry in practically all the other plots. In the mulched plots, the soil under the mulch was also moist but it was not cool. Judging by general appearance, the trees in the Bryophyllum plots seem to be at least as vigorous as any of the other trees in the test.

Discussion

Bryophyllum is not now being recommended as a practical cover crop. One difficulty is that it is slow to get started, so it would probably not crowd out the objectionable weeds for a long time. The cost of hand weeding as was done in these plots would probably be prohibitive. Either with or without hand weeding, the Bryophyllum might eventually shade out all the other weeds but without weeding it might not be soon enough to protect the young trees. In the sun, it grows slowly when not fertilized but it apparently responds to fertilizer more than most weeds. Any time the Bryophyllum is mowed, the competition will start again.

The forcing of the avocado trees to an upright growth might be an advantage, since large branches within two or three feet of the ground are rather undesirable. Bryophyllum is a shade tolerant plant so it might continue to grow long after all other weeds were shaded out by the avocado trees. That might be considered a serious objection, since there are obvious cultural advantages of a bare leaf mulch under large avocado trees. However, there is no reason to believe that the Bryophyllum would be an undesirable environment for the trees.

Out of the 133 trees in this experiment, only two have shown yellow leaves and they were in Plots 3 and 19. In both cases, the yellow color was apparent on July 22, 1949. The one in Plot 3 died about a year later while the one in Plot 19 is still alive and still yellow, although 33 inches high. Since the trees that were killed by being choked by weeds did not show chlorosis, it appears that they all died from lack of water rather than from any nutrient deficiency.

In one commercial grove that was observed before this investigation was started, a large proportion of the trees were yellow. These experiments indicate that the yellow color could not have been caused by weed competition. The theory has been proposed that the citrus trees have left some substance in the soil that is toxic to the avocado trees. However, there is no direct evidence for such a theory. Experiments in California ("Effects of Various Leaching Treatments on Growth of Orange Seedlings in Old Citrus Soils," by James P. Martin in SOIL SCIENCE 69: 43 (1950), and private correspondence) have indicated that while old citrus soil is harmful to citrus seedlings, it is not harmful to avocados. The question cannot be definitely answered at present but it is quite possible that the yellow color in the commercial grove and also on the two trees in this experiment may have been caused by some factors that originated in the nursery or at the time of planting. When the roots of some of the yellow trees were examined, no disease was found but the root system was smaller than normal. In some other groves which had been flooded, numerous cases of root rot were found.

When diseases, insect pests, structural injury and micro-nutrient deficiencies are eliminated, it is probable that the growth of the young trees is solely a function of the general supply of water and nutrients. These experiments are consistent with the theory that the only effects of weeds, cultivation and mulching are to influence the supply of water and nutrients. With the amounts of fertilizer normally used, water seems to be the most important factor on the shallow limestone soils of Dade County.

Weeds affect the supply of water to the trees by the absorptive capacity of their roots and by the transpiration of their leaves. Bermuda grass has a very great mass of fine roots, as well as a comparatively large leaf surface. On the other hand, Bryophyllum is almost an air plant so it does not have an extensive root system and its leaves are waxy with an exceptionally small number of stomata. A plant of that type makes an ideal cover crop for conserving moisture.

Numerous investigations have shown the value of mulches for conserving moisture, so it is a little surprising that these treatments were not better than clean cultivation by hoeing. It is possible that changing the technique of handling the hoed plots would have given a greater loss of water and reduced growth. For one thing, the plots were seldom hoed oftener than once a month. Therefore, the ground was covered with one to four inches of grass and weeds, a considerable part of the time. Such plants with small root systems and small leaf surface may act as a mulch to conserve moisture. Also, after the hoeing, there was some dust and trash left on the surface. Possibly there may be some direct benefit from stirring the soil or pruning the roots slightly but it seems unlikely that such effects would compensate for a large decrease in water supply.

Conclusions

To get rapid growth in young avocado trees, it is essential to control the weeds. Mowing does not give satisfac-

Fig. 1. Tree 1 E in the hoed plots on May 26, 1950. The tree to the left is 2 E in the shavings mulch plot. The indistinct tree to the right is 7 E.

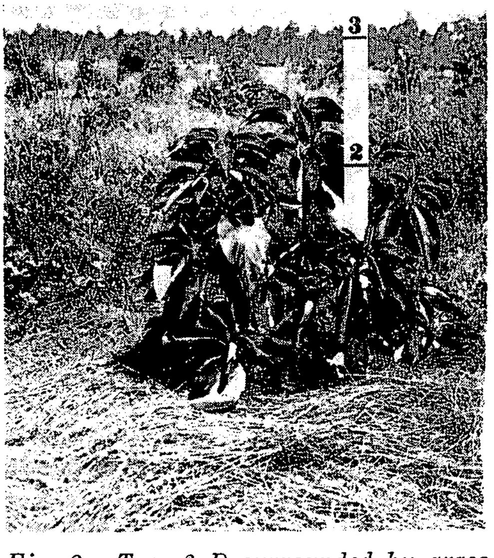

Fig. 2. Tree 3 D surrounded by grass mulch on May 26, 1950.

tory control around the young trees. Bermuda grass is much worse than Bidens which is generally the dominant broad leaf plant in fertilized groves. Presumably any other grass that makes a thick mat would also be quite harmful.

Differences between mulching and clean cultivation by hoeing are less important than differences between good and poor weed control.

A plant such as Bryophyllum which crowds out other weeds and has a small root system and a low rate of transpiration furnishes as good an environment for the trees as complete weed control.

On this shallow limestone soil, when normal amounts of fertilizer are used, weed competition appears to be mainly a competition for water.

Fig. 3. Tree 4 C surrounded by native weeds on May 26, 1950. It was necessary to pull the weeds away to show the tree.

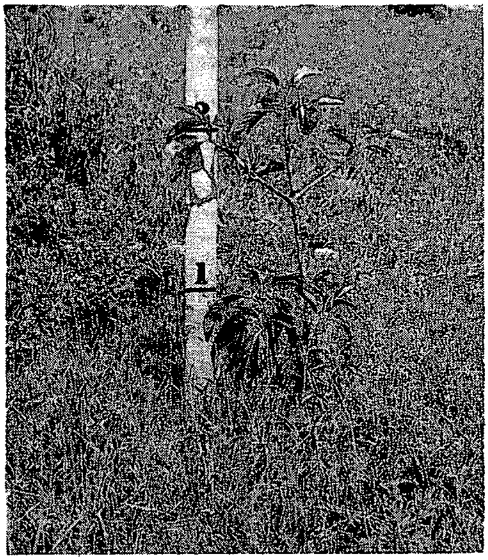

Fig. 4. Tree 12 E surrounded by Bermuda grass on May 26, 1950. Note the small leaves and spindling nature of the tree. The top of this tree died within a month after taking the picture.

Fig. 5. Tree 17 E surrounded by Bryophyllum on May 26, 1950. Note the large avocado leaves by the stake and above the Bryophyllum. To the left is the clump of Bryophyllum surrounding tree 18 E.

TABLE 1.
HEIGHTS OF INDIVIDUAL TREES IN INCHES ON DATES INDICATED.

Treatment[1]	Tree	7/22/49	10/13/49	5/9/50	9/13/50
1	A	17	31	38	51
	B	18	29	32	40
	C	16	22	26	40
	D	24	33	45	54
	E	19	32	40	54
	F	18	25	39	57
	G	19	25	39	52
Average		19	28	37	50
2	A	21	28	42	56
	B	17	26	33	39
	C	24	29	32	46
	D	21	26	36	50
	E	21	26	32	46
	F	18	25	29	39
	G	23	36	48	67
Average		21	28	36	49

[1] See "Plan of Experiment" in text of paper.
[2] "Lost" trees were cut off or otherwise lost by causes not the result of the treatment.
[3] "Dead" trees were presumably or at least possibly killed by the treatment.

TABLE 1—Continued
HEIGHTS OF INDIVIDUAL TREES IN INCHES ON DATES INDICATED.

Treatment[1]	Tree	7/22/49	10/13/49	5/9/50	9/13/50
3	A	14	31	42	58
	B	17	27	36	46
	C	19	25	32	43
	D	19	25	32	44
	E	19	00[2]	—	—
	F	17	28	41	55
	G	20	27	37	50
Average		17	27	37	48
4	A	17	18	23	30
	B	23	23	26	00[3]
	C	16	17	19	32
	D	18	18	22	22
	E	14	14	18	28
	F	19	21	23	31
	G	19	21	26	33
Average		18	19	22	29
5	A	15	18	23	35
	B	17	18	00[2]	—
	C	16	20	20	00[2]
	D	18	23	28	38
	E	18	18	28	38
	F	15	17	21	30
	G	17	23	32	51
Average		17	20	25	38
6	A	23	32	48	65
	B	16	21	22	28
	C	17	28	36	47
	D	18	24	31	41
	E	17	21	23	30
	F	17	21	24	30
	G	18	24	33	45
Average		18	24	31	41
7	A	16	19	23	32
	B	23	26	29	38
	C	16	20	29	30
	D	16	19	24	33
	E	21	27	35	47
	F	23	27	31	33
	G	22	26	33	39
Average		20	22	29	36

[1] See "Plan of Experiment" in text of paper.
[2] "Lost" trees were cut off or otherwise lost by causes not the result of the treatment.
[3] "Dead" trees were presumably or at least possibly killed by the treatment.

TABLE 1–Continued
HEIGHTS OF INDIVIDUAL TREES IN INCHES ON DATES INDICATED.

Treatment[1]	Tree	7/22/49	10/13/49	5/9/50	9/13/50
8	A	20	28	43	60
	B	23	28	38	45
	C	17	00[2]	—	—
	D	19	23	28	33
	E	18	23	24	34
	F	15	18	20	24
	G	12	15	15	21
Average		18	23	28	36
9	A	16	18	00[2]	—
	B	16	20	26	39
	C	23	29	37	38
	D	22	28	30	39
	E	14	18	22	29
	F	19	23	28	33
	G	23	31	42	58
Average		19	24	31	39
10	A	22	24	22	20
	B	24	21	21	29
	C	17	23	24	35
	D	17	23	27	37
	E	15	16	19	16
	F	18	24	26	31
	G	18	00[2]	—	—
Average		20	24	23	28
11	A	20	26	28	32
	B	20	25	28	38
	C	22	30	38	44
	D	17	25	37	41
	E	23	34	38	49
	F	17	20	23	00[3]
	G	18	22	26	30
Average		20	26	31	39
12	A	17	30	50	65
	B	18	25	30	00[3]
	C	14	20	29	31
	D	17	22	32	38
	E	20	27	27	16
	F	19	25	28	00[3]
	G	23	27	30	34
Average		18	25	32	37

[1] See "Plan of Experiment" in text of paper.
[2] "Lost" trees were cut off or otherwise lost by causes not the result of the treatment.
[3] "Dead" trees were presumably or at least possibly killed by the treatment.

TABLE 1—Continued
HEIGHTS OF INDIVIDUAL TREES IN INCHES ON DATES INDICATED.

Treatment[1]	Tree	7/22/49	10/13/49	5/9/50	9/13/50
13	A	16	21	21	35
	B	19	21	24	31
	C	18	20	29	31
	D	17	17	24	27
	E	16	18	20	30
	F	18	20	25	33
	G	19	22	24	33
Average		18	20	24	31
14	A	21	30	36	54
	B	19	23	27	33
	C	14	15	20	26
	D	15	15	20	00[3]
	E	19	21	25	30
	F	15	20	26	00[3]
	G	17	23	20	38
Average		17	21	23	36
15	A	17	24	24	35
	B	26	29	39	48
	C	21	25	34	43
	D	21	26	34	44
	E	18	25	34	45
	F	21	25	33	44
	G	18	21	28	31
Average		20	25	32	41
16	A	17	23	38	52
	B	14	25	29	38
	C	21	28	33	44
	D	21	27	35	41
	E	18	22	30	39
	F	18	26	33	40
	G	15	19	27	31
Average		18	25	32	41
17	A	16	25	39	56
	B	20	26	36	45
	C	22	26	35	48
	D	16	20	28	38
	E	17	29	38	52
	F	16	21	32	42
	G	22	35	50	64
Average		18	26	37	49

[1] See "Plan of Experiment" in text of paper.
[2] "Lost" trees were cut off or otherwise lost by causes not the result of the treatment.
[3] "Dead" trees were presumably or at least possibly killed by the treatment.

TABLE 1—Continued
HEIGHTS OF INDIVIDUAL TREES IN INCHES ON DATES INDICATED.

Treatment[1]	Tree	7/22/49	10/13/49	5/9/50	9/13/50
18	A	21	27	52	72
	B	17	22	35	56
	C	20	25	31	44
	D	22	26	31	49
	E	20	24	37	53
	F	22	29	39	57
	G	21	30	40	65
Average		20	26	38	57

[1] See "Plan of Experiment" in text of paper.
[2] "Lost" trees were cut off or otherwise lost by causes not the result of the treatment.
[3] "Dead" trees were presumably or at least possibly killed by the treatment.

TABLE 2.
AVERAGE DIMENSIONS OF TREES IN INCHES ON SEPTEMBER 13, 1950.

	Treatment	Height	Spread	Ratio: Height to spread	No. of trees killed
18	Bryophyllum	57	37	1.64	
1	Hoed	50	51	0.99	
2	Shavings	49	47	1.04	
17	Bryophyllum	49	39	1.26	
3	Grass mulch	48	54	0.89	
6	Mowed-Hoed	41	39	1.05	
16	Tradescantia	41	37	1.11	
15	Tradescantia	41	35	1.17	
9	Mowed	39	36	1.08	
11	Bermuda grass	39	30	1.30	1
5	Mowed	38	31	1.22	
12	Bermuda grass	37	32	1.16	2
8	Mowed	36	43	0.82	
7	Mowed	36	31	1.16	
14	Bidens	36	26	1.38	2
13	Bidens	31	21	1.47	
4	Natural cover	29	21	1.38	1
10	T. C. A.	28	24	1.16	