T H E S I S

G R O W T H OF A P P L E S
IN RELATION TO
C O D L I N G M O T H C O N T R O L

Submitted by
William P. Yetter Jr.
for the Degree of Master of Science
Colorado Agricultural College
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THIS THESIS HAS BEEN APPROVED AND RECOMMENDED FOR

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Professor of Horticulture

Professor of Veterinary Pathology

Committee on Advanced Degrees
Colorado Agricultural College
Fort Collins, Colorado

THIS THESIS HAS BEEN READ

APPROVED AND RECOMMENDED

FOR CREDIT

Head of the Department of Zoology and Entomology

Colorado Agricultural College

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February 28, 1926.

GROWTH OF APPLES IN RELATION TO CODLING MOTH CONTROL

BY WILLIAM P. YETTER JR.

OBJECT OF INVESTIGATIONS.

Experiments in measuring apples were undertaken in 1920 at Canon City, Colorado and in 1921, 1922, and 1923 at Grand Junction, Colorado to determine three things: (1) Does the rate of growth of apples at different intervals during the summer effect the efficiency of cover sprays for the codling moth ? (2) Do apples growing under Colorado conditions have more or less definite periods when they make their main rate of increase in area ? (3) Is the rate of increase in area uniform during the growing season ?

METHODS.

The method used to determine the size of the apples was to record the largest tranverse and longitudinal diameters of each individual apple every three days during the season beginning in May and ending in September.

In most cases just the transverse diameter was recorded. The area of the skin surface was then computed by using the geometrical formula $A = 4\Pi R^2$.

The measurements at Canon City in 1920 were made with the outside calipers. The distance across the jaws of the calipers was then measured to the nearest sixty-fourth of an inch.

The measurements at Grand Junction were made with vernier calipers reading to one thousandth of an inch.

MATERIALS.

In all, 30 Winesap, 15 Florabell and 50 Ben Davis were measured at Canon City.

The experiment was repeated in 1921 at Grand Junction, Colorado on 25 Ganos, 35 Jonathans, and 38 Winesaps; in 1922, on 20 Yellow Transparents, 30 Winesaps, and 50 Ben Davis; in 1923, on 35 Jonathans, 24 Switzers, and 41 Winesaps.

The investigation was carried on in three different orchards. The trees were approximately 25 years old, except the Jonathan and Switzer trees used in 1922 and 1923 which were about 20 years old. The trees were all in good condition.

The orchard at Canon City had considerable lawn grass growing in it. The orchard was not cultivated but did receive the normal irrigation treatment.

The two orchards at Grand Junction had a great deal of the so-called water or bull grass and

weeds growing in them. The orchards had recently been fertilized with barnyard manure. They received the normal irrigation treatment. The soils in all three orchards were somewhat sandy and loamy.

Originally 393 apples were selected and tagged. The selection included apples that were well distributed throughout the trees, some being partially shaded, others being well exposed to the sun and light.

Accidents occured to a number of the apples under observation and of the 393 selected at the start only 391 reached maturity.

It was practically impossible to measure every apple at the same place and with the same degree of accuracy each time. However, efforts were made to see that all of the measurements were carefully made each time the work was done.

Weather conditions during the season of 1920 at Canon City, and 1921, 1922, and 1923 at Grand Junction were about normal.

The spray dates used were those determined by the development of the codling moth at the State Entomological Field Laboratory, Grand Junction, Colorado. The Canon City spray dates were determined by the growers themselves. Therefore no effort was made to use the apple measuring data collected there and apply it to codling moth control in this paper other than simply presenting the results of the measurements made there.

PRESENTATION OF DATA.

The measurements of the Winesap, Gano, and Jonathan apples in 1921 given in Table No.1 are used to explain the results throughout the paper except where otherwise mentioned.

To secure the area of the apples, the geometrical formula $A = 4\pi R^2$ was used. A discussion of this point will follow later in the paper. The average area of the Jonathans when the first cover spray was applied on May 22, was 1.078 square inches. When the second cover spray was applied on June 3, the area had increased to 2.556 square inches, a growth of 1.478 square inches or 137.10 percent. In the same period, the Ganos increased from 1.246 square inches to 2.907 square inches in area, a growth of 1.661 square inches or 133.31 percent while the Winesaps increased from 0.895 square inches to 2.410 square inches in area, a growth of 1.515 square inches or 169.27 percent. By June 13, the date of the third cover spray, the area of the Jonathans had increased to 3.801 square inches, an increase of 1.245 square inches or 48.71 percent; the Ganos to 4.300 square inches, an increase of 1.393 square inches or 47.91 percent and the Winesaps to 3.664 square inches, an increase of 1.254 square inches or 52.03 percent. On July 3, the date of the fourth cover spray, the area of the Jonathans had increased to 6.834 square inches, an increase of 3.033 square inches or 79.79 percent; the Ganos

to 7.822 square inches, an increase of 3.522 square inches or 81.91 percent and the Winesaps to 5.507 square inches, an increase of 1.843 square inches or 50.30 percent. By this time all three varieties had reached an area approximately one-third of their areas acquired by September 19.

From May 22 to July 3, a period of 42 days, 4 cover sprays were applied. The first brood larvae were hatching during this period and the increase in area between sprays for the Jonathans was 137.10, 48.71, and 79.79 percent respectively; for the Ganos, 133.31, 47.91, and 81.91 percent and the Winesaps, 169.27, 52.03, and 50.30 percent respectively. The increase during this entire period for the Jonathans was 533.95 percent, for the Ganos, 527.77 percent and for the Winesaps, 515.31 percent.

From July 3 to August 23, during which time the apples were subject to the greatest attack from the second brood larvae, the rate of growth was very much decreased. During this period, 4 cover sprays were applied. The increase in area during these periods for the Jonathans was 54.37, 24.36, and 29.75 percent; for the Ganos, 48.97, 20.47, and 26.11 percent, and for the Winesaps, 47.50, 24.19, and 32.39 percent respectively. During this time of 51 days, the second brood larvae were hatching in the greatest numbers and the increase in area for the whole period for the Jonathans was 148.91 percent; for the Ganos, 126.35 percent, and for the Winesaps, 142.53 percent.

From May 22 to July 3, the first brood larvae were the most active. By July 3, the areas of all three varieties were more than 6 times as great as they were on May 22. The second brood larvae were the most active during the period from July 3 to August 23. By August 23, the areas of all three varieties were more than twice as great as they were on July 3.

During the period of the first brood attack, the areas of the apples increased approximately 400 percent more than they did during the period of the second brood attack.

Figure No.1 shows the number of square feet of skin surface or area to be sprayed each cover spray on Gano, Jonathan, and Winesap trees averaging 1500 apples per tree during the growing season of 1921.

FIG. 1. SHOWING NUMBER OF SQUARE FEET OF SKIN SURFACE TO BE SPRAYED EACH COVER SPRAY ON EVERY TREE AVERAGING 1500 APPLES DURING THE GROWING SEASON OF 1921

GRAND JUNCTION, COLORADO, 1921.

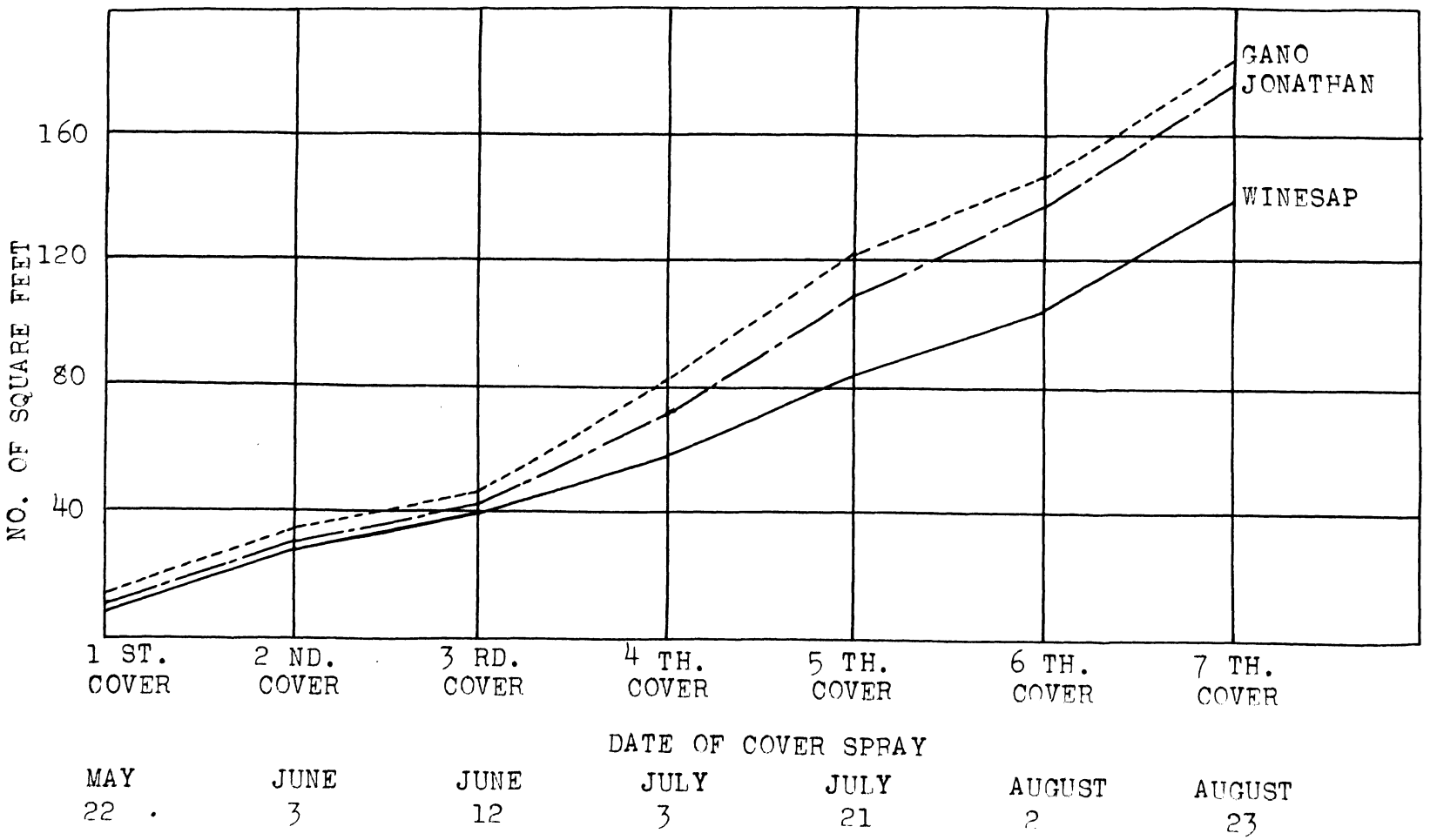


Figure No.2 shows the number of square feet of skin surface or area to be sprayed each cover spray and the percent of increase in area between sprays on a Gano tree averaging 1500 apples on it during the growing season in relation to the time of spraying.

While one purpose of the data is to show that the rate of increase in area is the greatest during the forepart of the season, one should not get the impression that the greatest increases in area are made then.

Figure 2 shows that a Gano tree with 1500 apples would on May 22, the date of the first cover spray, have 12.98 sq.ft. of skin surface to be sprayed. By June 3, a period of 12 days and the date of the second cover spray, 30.28 sq.ft. would have to be sprayed. This is an increase of 17.30 sq.ft. or 133.31 percent. On July 21, the date of the fifth cover spray, 121.39 sq.ft. would have to be sprayed. By August 2, a period of 12 days and the date of the sixth cover spray, 146.24 would have to be sprayed. This is an increase of 24.85 sq.ft. or 20.47 percent. This shows that while the rate of increase in area is the greatest during the forepart of the season, yet the greatest increases in area are made during the latter part of the season.

FIG. 2. SHOWING PERCENT OF INCREASE IN AREA BETWEEN SPRAYS ON A GANO TREE AVERAGING 1500 APPLES DURING SEASON AND THE NUMBER OF SQUARE FEET OF SKIN SURFACE TO BE SPRAYED IN RELATION TO THE TIME OF SPRAYING

GRAND JUNCTION, COLORADO, 1921.

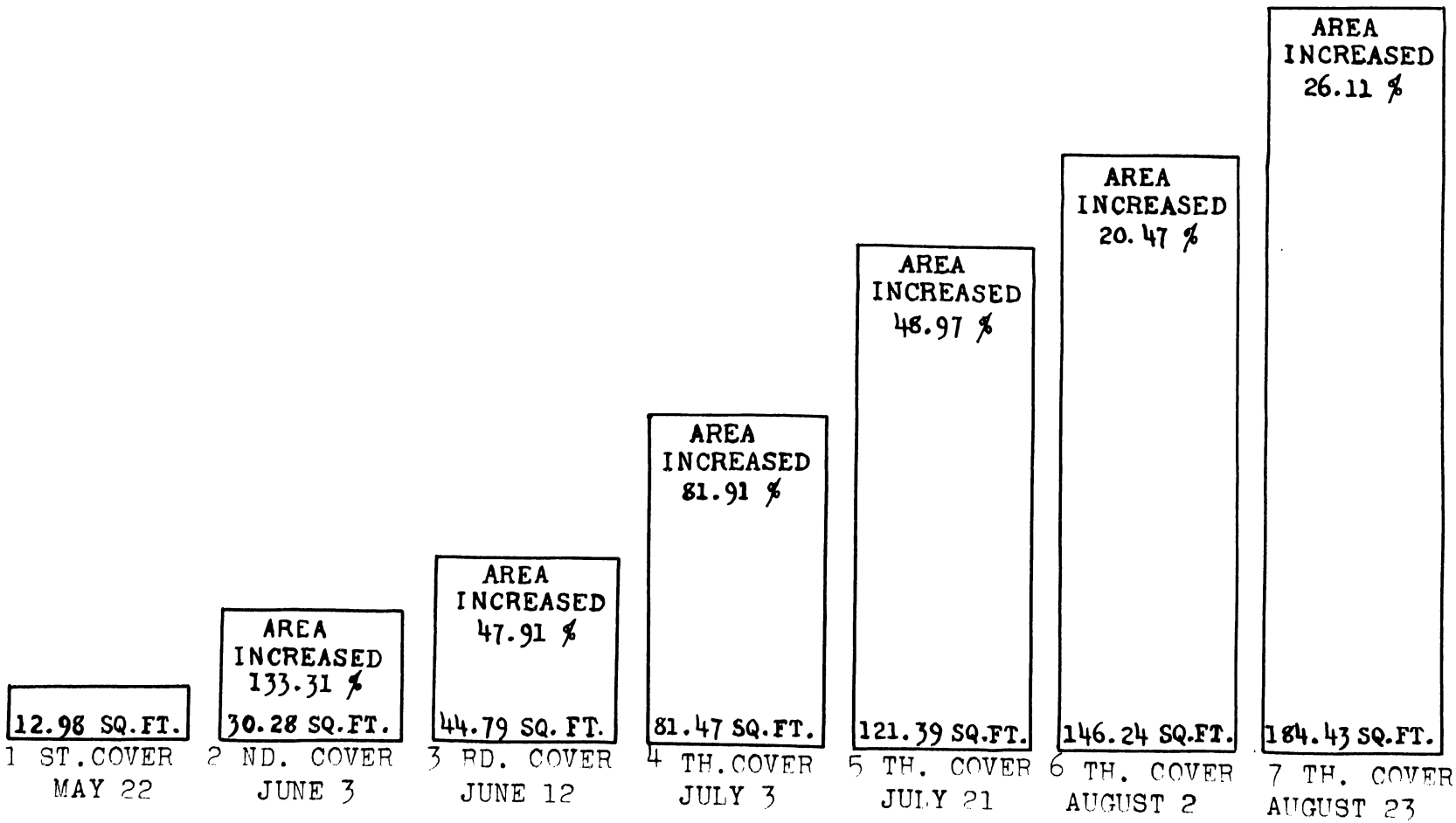


TABLE 1, GIVING RATE OF GROWTH OF WINESAP, GANO, AND JONATHAN APPLES, GRAND JUNCTION, COLORADO. 1921.

NO. OF SPRAYS.	DATE OF SPRAY	NO. OF DAYS BETWEEN SPRAYS.	ACTUAL AVERAGE TRANSVERSE DIAMETER IN INCHES.			AVERAGE GROWTH IN AREA IN SQUARE INCHES PER DAY BETWEEN SPRAYS.			COMPUTED AVERAGE AREA IN SQUARE INCHES.			PERCENT OF INCREASE IN AREA BETWEEN SPRAYS.		
			WINESAP	GANO	JONATHAN	WINESAP	GANO	JONATHAN	WINESAP	GANO	JONATHAN	WINESAP	GANO	JONATHAN
1 ST. COVER	MAY 22	----	.535	.630	.586	----	----	----	.895	1.246	1.078	----	----	----
2 ND. COVER	JUN 3	12	.877	.963	.902	.126	.138	.123	2.410	2.907	2.556	169.27	133.31	137.10
3 RD. COVER	JUN 12	9	1.080	1.171	1.100	.139	.155	.138	3.664	4.300	3.801	52.03	47.91	48.71
4 TH. COVER	JUL 3	21	1.325	1.579	1.266	.088	.168	.144	5.507	7.822	6.834	50.30	81.91	79.79
5 TH. COVER	JUL 21	18	1.609	1.926	1.832	.145	.213	.206	8.123	11.643	10.543	47.50	48.97	54.27
6 TH. COVER	AUG 2	12	1.793	2.114	2.043	.164	.199	.214	10.088	14.039	13.111	24.19	20.47	24.36
7 TH. COVER	AUG 23	21	2.062	2.374	2.327	.156	.175	.185	13.356	17.705	17.011	32.39	26.11	29.75
CEASED MEASURING GANO & WINESAP	SEP 22	30	2.286	2.616	----	.102	.126	----	16.416	21.499	----	22.91	21.43	----
CEASED MEASURING JONATHAN	SEP 19	27	----	----	2.558	----	----	.131	----	----	20.556	----	----	20.84

Under Grand Valley conditions, extraordinary care must be exercised in spraying for the codling moth. Many operators fail to realize that if the attack of the larvae is to be stopped, a great amount of surface area scattered throughout the trees, protected by leaves and limbs, must be thoroughly covered with spray at proper times.

For example, if a Gano tree averaged 1500 apples on it during the spraying season of 1931 and using the data on measuring, the operator would have had to cover with spray about 12.98 sq.ft. of skin surface when the first cover spray was called for on May 22; the second cover spray on June 3, 30.28 sq.ft.; the third cover spray on June 12, 44.79 sq.ft.; the fourth cover spray on July 3, 81.47 sq.ft.; the fifth cover spray on July 21, 121.39 sq.ft.; the sixth cover spray on August 2, 146.24 sq.ft.; the seventh cover spray on August 23, 184.43 sq.ft.

Now it is an extremely difficult matter to cover that surface thoroughly, because in the forepart of the season the apples are small and are covered with a fuzz which makes it hard for the spray to stick. The apples being small, the operator does not always see them and then the leaves will often protect the apple in such a way that it does not receive very much spray. If an apple is to receive the maximum protection from the attack of the larvae, the operator must be decidely careful, patient, and skillful in his methods because during the first part of the season,

the skin surface or area is rapidly increasing and the efficiency of the poison covering is consequently decreased. Such natural obstacles as wind, foliage, limbs, etc., which are always in the path of the operator, also deter from efficient work.

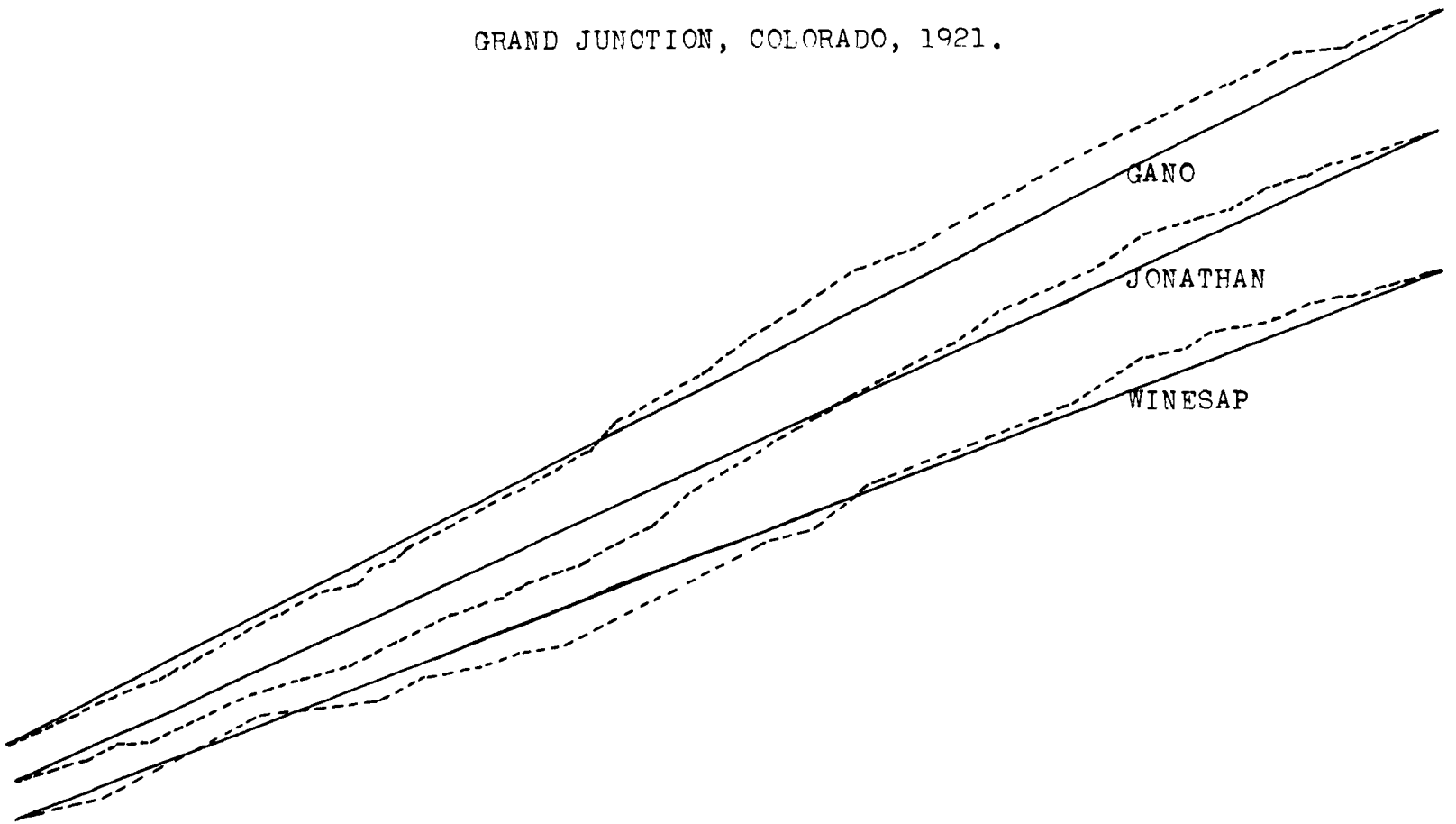
Theoretically if the apples had made the same increase in area each time the measurements were made, the growth would be as indicated by the heavy, solid line in Figure No.3. The actual increase in area each time the measurements were made is indicated by the broken line.

The figure shows that all three varieties of apples do not make the same increase in area at regular intervals throughout the growing season. Instead, the increases fluctuate considerable during certain times of the season and less during other times.

In spite of this fluctuation, the curves representing the actual increases do approach, to a certain extent, the theoretical curve.

FIG. 3. CURVES SHOWING THE ACTUAL INCREASE IN AREA EACH TIME MEASUREMENTS WERE MADE IN RELATION TO THE SAME THEORETICAL INCREASE IN AREA EACH TIME

GRAND JUNCTION, COLORADO, 1921.



MEASUREMENTS MADE FROM MAY 19 TO SEPTEMBER 22

SOLID LINE REPRESENTS THEORETICAL INCREASE IN AREA AND
BROKEN LINE REPRESENTS ACTUAL INCREASE IN AREA

To illustrate that the use of data on the measurement of apples has some practical value as an aid in determining spray dates, Figure No. 4 was made to show the hatching periods of codling moth eggs in relation to the time of spraying and the percent of increase in area of Winesaps between sprays in 1923.

Figure No. 4 shows that the first brood eggs were hatching from May 28 to July 3, the greatest hatch taking place from May 28 to June 15. From May 25, the date of the first cover spray, to June 6, the date of the second cover spray, the area increased 190.57 percent. From June 6 to June 15, the third cover spray, the area increased 40.63 percent. From June 15 to June 30, the fourth cover spray, the area increased 30.09 percent.

Due to the fact that the greatest increase in area and the greatest hatch of the first brood eggs occured between May 25 and June 15, a period of 21 days, three cover sprays were applied to the apples in order to secure the maximum protection from the worms.

From June 15 to June 30, the area was not increasing as fast and being a time when the egg hatch was rapidly falling off, the fourth cover spray was called for on June 30. This cover spray was timed to take care of the stragglers of the first brood and the beginners of the second brood and was therefore not as valuable as some of the other sprays.

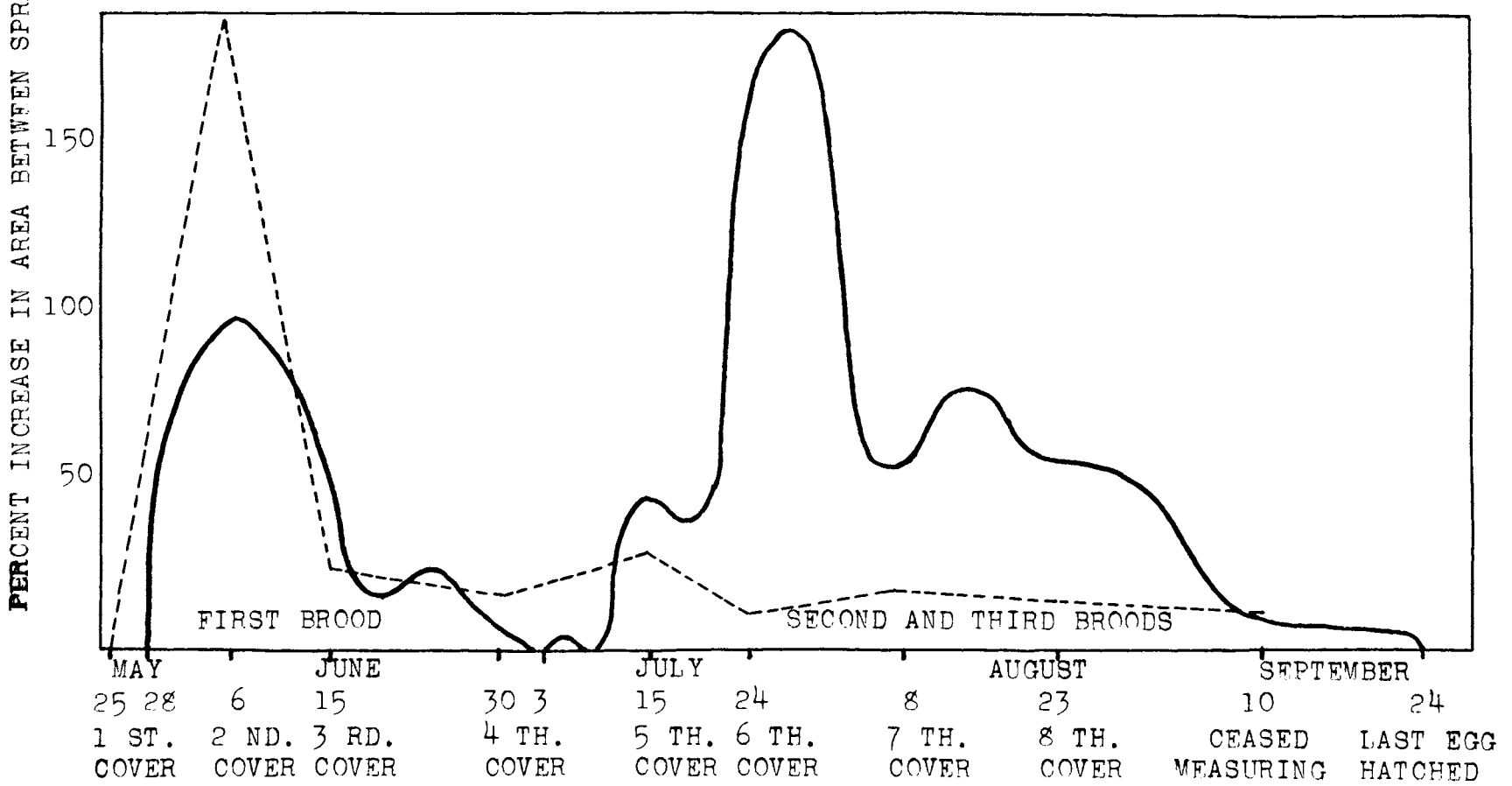
On July 11 with the second brood eggs hatching rapidly and the rate of increase in area beginning to

increase,it was thought advisable to call a cover spray for July 15. From June 30 to July 15, the area increased 51.84 percent.

From July 15 on for several days, the egg hatch dropped a little. The rate of increase in area also dropped. Then the egg hatch began increasing very rapidly and with the rate of increase in area decreasing, a cover spray was called for on July 24. From July 15 to July 24, the area increased 17.97 percent. By August 5, the egg hatch had dropped considerably but with the rate of increase in area increasing, a spray was called for on August 8. From July 24 to August 8, the area increased 27.27 percent. After August 8, the egg hatch increased considerably for a few days and then gradually decreased until about August 30, when a sudden drop occured. From August 8, the rate of increase in area was slowly decreasing and up to August 23, the date of the eighth cover spray, the area increased 24.16 percent. From August 23 to September 10 when the measuring was stopped, the area increased 15.00 percent. The eggs continued to hatch in small numbers until September 24.

FIG. 4. SHOWING THE HATCHING PERIODS OF CODLING MOTH EGGS IN 1923 IN RELATION TO THE TIME OF SPRAYING AND THE PERCENT OF INCREASE IN AREA OF WINESAPS BETWEEN SPRAYS

GRAND JUNCTION, COLORADO, 1923.



BROKEN LINE REPRESENTS PERCENT OF INCREASE IN AREA OF WINESAPS BETWEEN SPRAYS
SOLID LINE REPRESENTS THE HATCHING PERIODS OF CODLING MOTH EGGS

To show that the apple so nearly approaches a sphere that the geometrical formula $A = 4\pi R^2$ can be used, the data in Table No. 2 were compiled.

The first thing to do was to get the approximate area of an apple by some reliable method.

A planimeter was used to measure the area of a number of apples because, aside from the inaccuracy of the human hand in operating the instrument, it gives the area quite accurately.

The skin of each apple was carefully removed in sections and the area of each section was measured by means of the planimeter. The total areas of the sections measured gave the area for the individual apple.

The next thing to do was to find out which of the diameters incorporated in $A = 4\pi R^2$ would give results closest to those of the planimeter.

The means of the areas found by using the transverse and longitudinal diameters were computed and compared with the areas measured by the planimeter. The closest results to those found by use of the planimeter were secured by incorporating the transverse diameter in $A = 4\pi R^2$.

TABLE 2, SHOWING DIFFERENCES BETWEEN AREA MEASURED BY A PLANIMETER AND AREA COMPUTED USING GEOMETRICAL FORMULA $4\pi R^2$ WITH TRANSVERSE AND LONGITUDINAL DIAMETERS

VARIETY.	-1- AREA IN SQ. IN. MEASURED BY A PLANIMETER.	-2- AREA IN SQ. IN. COMPUTED USING TRANSVERSE DIAMETER.	-3- AREA IN SQ. IN. COMPUTED USING LONGITUDINAL DIAMETER.	MEAN OF 2 AND 3.	TRANSVERSE DIAMETER IN INCHES.	LONGITUDINAL DIAMETER IN INCHES.
WINESAP	25.002	27.099	19.073	23.086	2.937	2.464
WINESAP	25.557	27.136	18.292	22.714	2.939	2.413
JONATHAN	23.793	25.160	16.734	20.947	2.830	2.308
JONATHAN	25.305	25.949	19.902	22.9255	2.874	2.517
JONATHAN	21.858	22.732	15.890	19.311	2.690	2.249
DELICIOUS	29.092	28.501	26.366	27.4335	3.012	2.897
DELICIOUS	29.903	29.841	30.171	30.006	3.082	3.099

At Canon City, the measurements were all made to the nearest 64 th. of an inch. In Table No. 3, the results have been figured to read in terms of thousandths of inches. In all cases the transverse diameter was used.

TABLE 3, SHOWING APPLE MEASUREMENTS MADE AT CANON CITY, COLORADO, 1920.

BEN DAVIS			WINESAP			FLORABELL		
DATE	DIAMETER	AREA IN SQ. IN.	DATE	DIAMETER	AREA IN SQ. IN.	DATE	DIAMETER	AREA IN SQ. IN.
						JUNE 28	1.392 in.	6.087
JULY 1	1.476 in.	6.844	JULY 1	1.362 in.	5.827	JULY 1	1.475 "	6.834
" 4	1.585 "	7.892	" 4	1.441 "	6.523	" 4	1.585 "	7.892
" 7	1.626 "	8.303	" 7	1.478 "	6.862	" 7	1.625 "	8.295
" 10	1.706 "	9.143	" 10	1.540 "	7.470	" 10	1.700 "	9.079
" 13	1.777 "	9.920	" 13	1.5899 "	7.941	" 13	1.756 "	9.687
" 16	1.835 "	10.578	" 16	1.646 "	8.511	" 16	1.810 "	10.292
" 19	1.901 "	11.353	" 19	1.702 "	9.100	" 19	1.863 "	11.020
" 22	1.960 "	12.068	" 22	1.750 "	9.621	" 22	1.913 "	11.496
" 25	2.012 "	12.717	" 25	1.800 "	10.178	" 25	1.947 "	11.909
" 28	2.056 "	13.279	" 28	1.871 "	10.997	" 28	2.011 "	12.705
" 31	2.151 "	14.535	" 31	1.941 "	11.835	" 31	2.075 "	13.526
AUG 3	2.212 "	15.371	AUG 3	2.003 "	12.604	AUG 3	2.123 "	14.159
" 6	2.271 "	16.202	" 6	2.063 "	13.370	" 6	2.178 "	14.902
" 9	2.320 "	16.909	" 9	2.103 "	13.894	" 9	2.212 "	15.371
" 12	2.372 "	17.675	" 12	2.159 "	14.643	" 12	2.251 "	15.918
" 15	2.409 "	18.231	" 15	2.187 "	15.026	" 15	2.279 "	16.316
" 18	2.453 "	18.93	" 18	2.225 "	15.552	" 18	2.317 "	16.865
" 21	2.491 "	19.493	" 21	2.260 "	16.046	" 21	2.345 "	17.275
" 24	2.526 "	20.045	" 24	2.291 "	16.489	" 24	2.373 "	17.690
" 27	2.564 "	20.653	" 27	2.327 "	17.011	" 27	2.402 "	18.125
" 30	2.593 "	21.123	" 30	2.354 "	17.408	" 30	2.433 "	18.596
SEPT 2	2.628 "	21.697	SEPT 2	2.385 "	17.870	SEPT 2	2.458 "	19.128
" 5	2.634 "	21.796	" 5	2.421 "	18.413	" 5	2.485 "	19.400

TABLE 4, GIVING RATE OF GROWTH OF GANO AND JONATHAN APPLES, GRAND JUNCTION, COLORADO. 1921.

NO. OF SPRAYS.	DATE OF SPRAY.	NO. OF DAYS BETWEEN SPRAYS.	ACTUAL AVERAGE LONGITUDINAL DIAMETER IN INCHES.		AVERAGE GROWTH IN AREA IN SQUARE INCHES PER DAY BETWEEN SPRAYS.		COMPUTED AVERAGE AREA IN SQUARE INCHES.		PERCENT INCREASE IN AREA BETWEEN SPRAYS.	
			GANO	JONATHAN	GANO	JONATHAN	GANO	JONATHAN	GANO	JONATHAN
1 ST. COVER	MAY 22	----	----	----	----	----	----	----	----	----
2 ND. COVER	JUN 3	----	----	----	----	----	----	----	----	----
3 RD. COVER	JUN 12	STARTED MEASURING--JUNE 15. ----	1.182	1.097	----	----	STARTED MEASURING--JUNE 15. 4.387	3.773	----	----
4 TH. COVER	JUL 3	18	1.440	1.328	.118	.098	6.512	5.540	48.43	46.83
5 TH. COVER	JUL 21	18	1.707	1.588	.147	.132	9.149	7.922	40.49	42.99
6 TH. COVER	AUG 2	12	1.853	1.751	.136	.142	10.779	9.621	17.82	21.44
7 TH. COVER	AUG 23	21	2.067	1.973	.125	.124	13.408	12.216	24.39	26.97
CEASED MEASURING GANOS	SEP 22	30	2.267	----	.091	----	16.130	----	20.30	----
CEASED MEASURING JONATHANS	SEP 19	27	----	2.155	----	.087	----	14.575	----	19.31

TABLE 5, GIVING RATE OF GROWTH OF BEN DAVIS AND WINESAP APPLES, GRAND JUNCTION, COLORADO. 1922

NO. OF SPRAYS.	DATE OF SPRAY.	NO. OF DAYS BETWEEN SPRAYS.	ACTUAL TRANSVERSE DIAMETER IN INCHES.		AVERAGE GROWTH IN AREA IN SQUARE INCHES PER DAY BETWEEN SPRAYS.		COMPUTED AVERAGE AREA IN SQUARE INCHES.		PERCENT OF INCREASE IN AREA BETWEEN SPRAYS.	
			BEN DAVIS	WINESAP	BEN DAVIS	WINESAP	BEN DAVIS	WINESAP	BEN DAVIS	WINESAP
1 ST. COVER	JUN 3	----	.905	.902	----	----	2.573	2.556	----	----
2 ND. COVER	JUN 12	9	1.155	1.165	.180	.189	4.190	4.263	62.84	65.21
3 RD. COVER	JUN 21	9	1.343	1.320	.165	.134	5.675	5.473	35.41	28.38
4 TH. COVER	JUL 9	18	1.748	1.601	.218	.143	9.599	8.052	68.91	47.12
5 TH. COVER	JUL 21	12	1.981	1.873	.227	.247	12.328	11.021	28.43	36.87
6 TH. COVER	AUG 5	15	2.252	2.147	.240	.231	15.932	14.481	29.23	31.39
7 TH. COVER	AUG 20	20	2.463	2.361	.156	.152	19.058	17.512	19.62	20.93
CEASED MEASUR-ING	SEP 16	27	2.720	2.656	.155	.172	23.242	22.161	21.95	26.55

TABLE 6, GIVING RATE OF GROWTH OF YELLOW TRANSPARENT APPLES, GRAND JUNCTION, COLORADO. 1922.

NO. OF SPRAYS.	DATE OF SPRAY.	NO. OF DAYS BETWEEN SPRAYS.	ACTUAL AVERAGE TRANSVERSE DIAMETER IN INCHES.	AVERAGE GROWTH IN AREA IN SQUARE INCHES PER DAY BETWEEN SPRAYS.	COMPUTED AVERAGE AREA IN SQUARE INCHES.	PERCENT OF INCREASE IN AREA BETWEEN SPRAYS.
1 ST. COVER	JUN 3	----	1.079	----	3.657	----
2 ND. COVER	JUN 12	9	1.370	.249	5.894	61.17
3 RD. COVER	JUN 21	9	1.623	.264	8.271	40.32
4 TH. COVER	JUL 9	18	2.098	.309	13.828	67.18
HARVEST	JUL 12	3	2.159	.267	14.630	5.79

TABLE 7, GIVING RATE OF GROWTH OF WINESAP AND JONATHAN APPLES, GRAND JUNCTION, COLORADO. 1923.

NO. OF SPRAYS.	DATE OF SPRAY.	NO. OF DAYS BETWEEN SPRAYS.	ACTUAL AVERAGE TRANSVERSE DIAMETER IN INCHES.		AVERAGE GROWTH IN AREA IN SQUARE INCHES PER DAY BETWEEN SPRAYS.		COMPUTED AVERAGE AREA IN SQUARE INCHES.		PERCENT OF INCREASE IN AREA BETWEEN SPRAYS.	
			WINESAP	JONATHAN	WINESAP	JONATHAN	WINESAP	JONATHAN	WINESAP	JONATHAN
1 ST. COVER	MAY 23	----	.613	.709	----	----	1.178	1.579	----	----
2 ND. COVER	JUN 6	12	1.044	1.048	.187	.156	3.423	3.447	190.57	118.30
3 RD. COVER	JUN 15	9	1.238	1.276	.155	.141	4.814	4.718	40.63	36.87
4 TH. COVER	JUN 30	15	1.412	1.491	.097	.151	6.263	6.985	30.09	48.05
5 TH. COVER	JUL 15	15	1.740	1.802	.361	.215	9.510	10.203	51.84	46.07
6 TH. COVER	JUL 24	9	1.890	1.998	.113	.259	11.219	12.538	17.97	22.88
7 TH. COVER	AUG 8	15	2.132	2.238	.204	.213	14.279	15.726	27.27	25.43
8 TH. COVER	AUG 23	15	2.376	2.468	.230	.227	17.729	19.132	24.16	21.66
CEASED MEASUR-ING	SEP 10	18	2.548	2.649	.148	.161	20.389	22.038	15.00	15.19

TABLE 8, GIVING RATE OF GROWTH OF SWITZER APPLES, GRAND JUNCTION, COLORADO. 1923.

NO. OF SPRAYS.	DATE OF SPRAY.	NO. OF DAYS BETWEEN SPRAYS	ACTUAL AVERAGE TRANSVERSE DIAMETER IN INCHES.	AVERAGE GROWTH IN AREA IN SQUARE INCHES PER DAY BETWEEN SPRAYS.	COMPUTED AVERAGE AREA IN SQUARE INCHES.	PERCENT OF INCREASE IN AREA BETWEEN SPRAYS
1 ST. COVER	MAY 25	----	1.095	----	3.766	----
2 ND. COVER	JUN 6	12	1.565	.327	7.694	104.30
3 RD. COVER	JUN 15	9	1.886	.386	11.174	45.23
4 TH. COVER HARVEST	JUN 30	15	2.270	.334	16.188	44.87

CONCLUSIONS.

As a result of these studies, the following conclusions seem justified:

(1) That during the time when the attack of the first brood larvae is going on, the cover sprays then are the most important ones and are of the greatest value.

(2) That during the early part of the season, the apples are increasing their surface areas faster than any other time and consequently the efficiency of the poison covering is rapidly reduced.

(3) That the apples growing under Colorado conditions have more or less of a definite time when they make their main rate of increase in area.

(4) That the rate of increase in area is not uniform during the growing season.

(5) That the rate of increase is high during the forepart of the season and low during the latter part.

(6) That during the period of the first brood codling moth larval attack, the areas of the apples may be expected to increase from 350 to 400 percent more than they will during the period of the second brood attack, depending of course upon the variety, season, age of tree, cultural methods, irrigation, etc.

(7) That the use of apple measuring data is of value as a means in aiding the determination of spray dates.

(8) That the geometrical formula $A = 4\pi R^2$, using the transverse diameter, will give the area for most apples close enough for all practical purposes.

(9) That the greatest diameter should be incorporated in the formula $A = 4\pi R^2$ to get the area of the apples.

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