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PRELIMINARY RESULTS OF
BLUEBERRY SIZE AND YIELD IN
RELATION TO THE TIME OF PICKING

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PRELIMINARY RESULTS OF BLUEBERRY SIZE AND
YIELD IN RELATION TO THE TIME OF PICKING

By

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A Thesis

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Introduction

The blueberry of the highbush type, Vaccinium corymbosum, comprising most of the commercial plantings in Michigan is a bush which may reach twelve feet in height under favorable conditions. The inflorescence, a raceme, develops either terminally or from lateral buds in the axils of leaves on new shoots with all buds of the cluster in full bloom within three or four days of each other. The first fruit to ripen is that at the tip of the raceme. The later berries are harvested at the base. The first berries to ripen are larger than those which ripen later.

Commercial growers usually harvest the berries at approximately one- to two-week intervals, depending on the variety and the grower. The first picking is made as soon as the fruit has become blue or blue-black in color.

This paper reports the results of tests at South Haven Experiment Station, South Haven, Michigan, to determine the best time of picking blueberry fruits for maximum size and yield, and includes determinations of sugar and acid content and the growth and development of the fruit.

Methods and Materials

The two most important commercial varieties grown in Michigan, Rubel and Jersey, were selected for the

study. The plants were grown on Saugatuck sandy loam soil. The six-year-old Jersey plants were on a soil having a slightly higher content of organic matter than the soil on which the seventeen-year-old Rubel plants were growing.

The plants were carefully selected for uniformity on the basis of stem diameter. Johnston (4) has shown that growth and productivity are related. The work of Brightwell and Johnston (2) indicates that the diameter of the laterals has an influence on the size and yield of the fruit. Accordingly 30 plants, calipered six inches above the soil level, were arranged in three plots in which the total stem diameters were nearly equal. The diameters are listed in table 1.

Table 1. Total stem diameter of the plots.

Variety	Plot No.	Stem Diameter (Inches)
Jersey	1	90.8
	2	91.6
	3	90.8
Rubel	1	150.7
	2	150.9
	3	150.7

The plot pickings were determined as the season progressed. The first plot was picked at the time of the first commercial picking and a second and a third plot were picked at later dates. The time interval between the picking of plots 1 and 2 for both varieties was seven days. Plot 3 of the Jersey variety was picked 21 days after the picking of plot 1 and the interval between the picking of

plot 1 and plot 3 of the Rubel variety was 18 days. The pickings were continued at two-week intervals for all plots until all berries were removed from each plant in order that the second, third and fourth pickings of the plots would have the same time interval as the initial pickings. Only the blue or blue-black colored berries were picked as would be the case in the picking of the berries in commercial fields.

Thirty individual berries of Rubel, taken at random, were tagged and measured every second day beginning July 13 and ending at the time the berry fell from the plant. The transverse and axial diameters of each berry were measured. The volume calculated from the measurements of transverse diameter was found to closely approximate the actual displacement volume. This comparison is shown in table 2.

Table 2. Volume Comparison.

Stage of ripeness	Volume in ml. calculated $V=1/6\pi D^3$		
	Transverse diameter (in)	Axial diameter (in)	Displacement volume (ml)
Full ripe	1.436	0.695	1.37
	1.98	0.904	1.7
	1.438	0.695	1.5
Half ripe	0.696	0.382	0.6
	0.796	0.432	0.78
	0.591	0.382	0.6
Green	0.38	0.21	0.35
	0.464	0.23	0.43
	0.268	0.143	0.22

Size and yield records were kept on the individual plants throughout the season. The weighings and the cup counts were made immediately upon picking the fruit.

The size determinations were made by counting the number of berries required to fill a measuring cup. Chandler (3) has shown that blueberry size is accurately measured by the cup count method.

A noticeable difference was observed in the taste of berries depending on the time of picking. On August 5, a series of berries for the determination of total acid were picked in the following stages of growth (a) green, (b) one-quarter ripe, (c) one-half ripe, (d) three-quarters ripe and (e) full ripe.

One Rubel and four Jersey plants were allowed to remain unpicked to determine how long the berries would adhere to the plant. One Rubel and three Jersey plants were first picked 30 days after the initial picking of plot 1. One Jersey plant was not picked until 49 days after the initial picking of plot 1.

Results

The data on the yields of the Rubel and Jersey varieties are tabulated according to the plant and the picking date in tables 3 and 4. Table 7 is devoted to the yields of those plants which were not included in the three plot experiments but on which the initial picking was delayed until late in the season.

The berry sizes as determined by the cup count method are tabulated according to the plant and the picking date in tables 5 and 6 for the three plots. The fruit counts of

those plants which were not picked until 30 days and 49 days after the initial picking of plot 1 are recorded in table 8.

Since blueberries do not mature uniformly, the measurements of a given day are not an indication of maturity; therefore the change from green to blue or blue-black fruit color was considered an accurate indication of the time that berries had reached the same state of maturity. Volumes were computed for the berry measurements taken for the specified intervals before or after the appearance of the blue or blue-black fruit color regardless of the date on which the color appeared. The transverse volumes were averaged and are shown in figure 1.

The data for the sugar and acid content determinations for the four stages of fruit development, determined by special adaptations of the standard procedures, are shown in figure 2 *. The total sugar is expressed in percent of fresh weight and the acid content is expressed in milliliters of N/10 acid per gram of fruit.

At the time of each picking, berries were packaged and placed under simulated shipping conditions by having one pint of berries carried in an automobile for four or five

* The chemical analyses for sugar and acid content were done by Dr. E. J. Benne, chemist, Michigan Agricultural Experiment Station, East Lansing, Michigan.

Table 3. Yield of Rubel Fruit with the Dates at Top of
Column for Each Plot, South Haven, Mich., 1946.

Plot No.	Plant No.	Picking 1 (oz.)	Picking 2 (oz.)	Picking 3 (oz.)	Picking 4 (oz.)	Total (oz.)
1		7-22	8-5	8-19	9-2	
	1	26	90	49.5	3.5	169
	2	23	86.5	36	6.5	152
	3	54.5	58.5	21	8	142
	4	28.5	84.5	48	10.5	171.5
	5	24.5	81	31	8	144.5
	6	23	108.5	28	4	163.5
	7	44.5	90	19.5	6.5	160.5
	8	24	46	15	3	88
	9	42	58	15.5	3	118.5
	10	27.5	38.5	65	1.25	132.25
	Av.	31.75	74.15	32.85	5.42	144.17 (90)*
2		7-29	8-12	8-26		
	11	57.5	61.5	15		134
	12	77.5	57	14.5		149
	13	71.5	35	9.5		116
	14	61	90	26		177
	15	68	61.5	17		146.5
	16	71.5	42	18		131.5
	17	54.5	46	11.5		112
	18	51.5	27	3		81.5
	19	68	27	4		99
	20	62.5	39	9		110.5
	Av.	64.35	48.6	12.75		125.7 (79)
3		8-9	8-23			
	21	136	19			155
	22	77	6.5			83.5
	23	89.5	13			102.5
	24	108.5	15			123.5
	25	92.5	8.5			101
	26	118	26			144
	27	88.5	9.5			98
	28	103	12.5			115.5
	29	100	22.5			122.5
	30	106	16			122
	Av.	101.9	14.85			116.5 (73)
Sum Total		1978.5 (123)	1375.5 (86)	445 (28)	54 (3)	3893.7 (242)

* Reduced to the nearest pound.

Table 4. Yield of Jersey with Dates at Top of Column for
Each Plot, South Haven, Mich., 1946.

Plot No.	Plant No.	Picking 1 (oz.)	Picking 2 (oz.)	Picking 3 (oz.)	Picking 4 (oz.)	Total (oz.)
1		7-23	8-6	8-20	9-3	
	1	17.5	113.5	61.5	21	213.5
	2	15	93.5	73.5	23.5	205.5
	3	23	125.5	58.5	15	222
	4	11	89.5	75.5	25.5	201.5
	5	12	145.5	99.5	27	284
	6	19.5	93.5	66	26	205
	7	20	113	73	18	224
	8	17	112.5	85	23.5	238
	9	13.5	104.5	90	34	242
	10	12	127.5	65.5	15	220
	Av.	16.05	111.85	74.8	22.85	225.55 (141)
2		7-30	8-13	8-27	9-10	
	11	80	106.5	27	3.5	217
	12	63	93	36.5	4	196.5
	13	40.5	47	40.5	2	130
	14	45	65.5	46	1	157.5
	15	76.5	108	44.5	4	233
	16	38.5	85	54	7	184.5
	17	48.5	115	87.5	22	273
	18	51.5	118	73.5	18	261
	19	63.5	162	67.5	8	301
	20	94	100	20.5	1.5	216
	Av.	60.0	100.0	49.75	7.1	216.95 (136)
3		8-14	8-26	9-9		
	21	108	37	7		152
	22	150.5	39.5	4		194
	23	210	64.5	9		283.5
	24	166.5	62	15		243.5
	25	157.5	46.5	4		208
	26	245.5	78	9		332.5
	27	162	72	15.5		249.5
	28	168.5	67.5	8		244
	29	187.5	79	17		283.5
	30	139	54.5	6		199.5
	Av.	169.5	60.0	9.45		239.0 (149)
Sum Total		2455 (153)	2718.5 (170)	133.9 (84)	299.5 (19)	6814 (426)

* Reduced to the nearest pound.

Table 5. Cup Counts of Rubel Berries

Plot No.	Plant No.	Picking 1	Picking 2	Picking 3	Picking 4	Average
1		7-22	8-5	8-19	9-2	
	1	190	254	275	173	223
	2	191	270	220	288	242.2
	3	218	304	315	249	296.5
	4	224	259	295	268	261.5
	5	222	353	233	273	270.5
	6	198	296	287	372	288.3
	7	198	254	308	335	273
	8	206	307	308	369	297.5
	9	226	241	319	300	271.5
	10	249	303	282	...	278
	Av.	212.2	284.1	284.2	303	270
2		7-29	8-12	8-26	9-9	
	11	233	301	274		269.3
	12	177	253	275		235
	13	225	292	283		266.6
	14	216	257	296		256.3
	15	197	253	305		251.6
	16	226	293	390		303
	17	192	229	239		220
	18	213	260	232		235
	19	253	337	300		296.5
	20	217	268	284		256.3
	Av.	214.9	274.8	287.8		259
3		8-9	8-23	9-6		
	21	235	273			254
	22	220	242			231
	23	284	269			276.5
	24	211	290			250.5
	25	215	242			228.5
	26	218	245			231.5
	27	248	277			262.5
	28	253	334			293.5
	29	250	276			263
	30	231	278			254.5
	Av.	236.5	272.6			254.5
Grand Average		221.2	277.0	286.0	303.0	261.5

Table 6. Cup Counts of Jersey Berries

Plot No.	Plant No.	Picking 1	Picking 2	Picking 3	Picking 4	Average
1		7-23	8-6	8-20	9-3	
	1	115	206	278	256	213.7
	2	116	138	269	225	187
	3	130	194	297	263	221
	4	119	154	186	251	177.5
	5	127	158	160	223	167
	6	136	194	200	236	191.5
	7	125	167	168	227	171.5
	8	114	126	152	164	139
	9	129	144	149	169	147.7
	10	127	179	194	268	192
	Av.	123.8	166	205.3	228.2	180.8
2		7-30	8-13	8-27	9-10	
	11	129	150	161	246	171.5
	12	161	201	188	252	200.5
	13	195	293	230	...	239.3
	14	220	274	231	...	241.6
	15	130	154	161	194	159.7
	16	169	163	188	279	199.7
	17	148	144	183	256	182.7
	18	125	159	165	251	175
	19	133	133	138	207	152.7
	20	134	148	184	...	155.3
	Av.	154.4	181.9	182.9	240.7	185.9
3		8-14	8-26	9-9		
	21	154	179	259		197.3
	22	184	197	252		211
	23	167	208	252		209
	24	152	190	225		189
	25	166	196	248		203.3
	26	132	171	244		182.3
	27	161	225	287		224.3
	28	144	195	285		208
	29	134	196	272		200.6
	30	165	191	257		204.3
	Av.	155.9	194.8	258.1		202.9
Grand Average		144.7	180.9	215.4	233.3	189.9

Table 7. Yields of a Single Plant of Rubel Picked August 23, 1946; Three Plants of Jersey Picked August 23, 1946 and One Plant of Jersey Picked September 9, 1946.

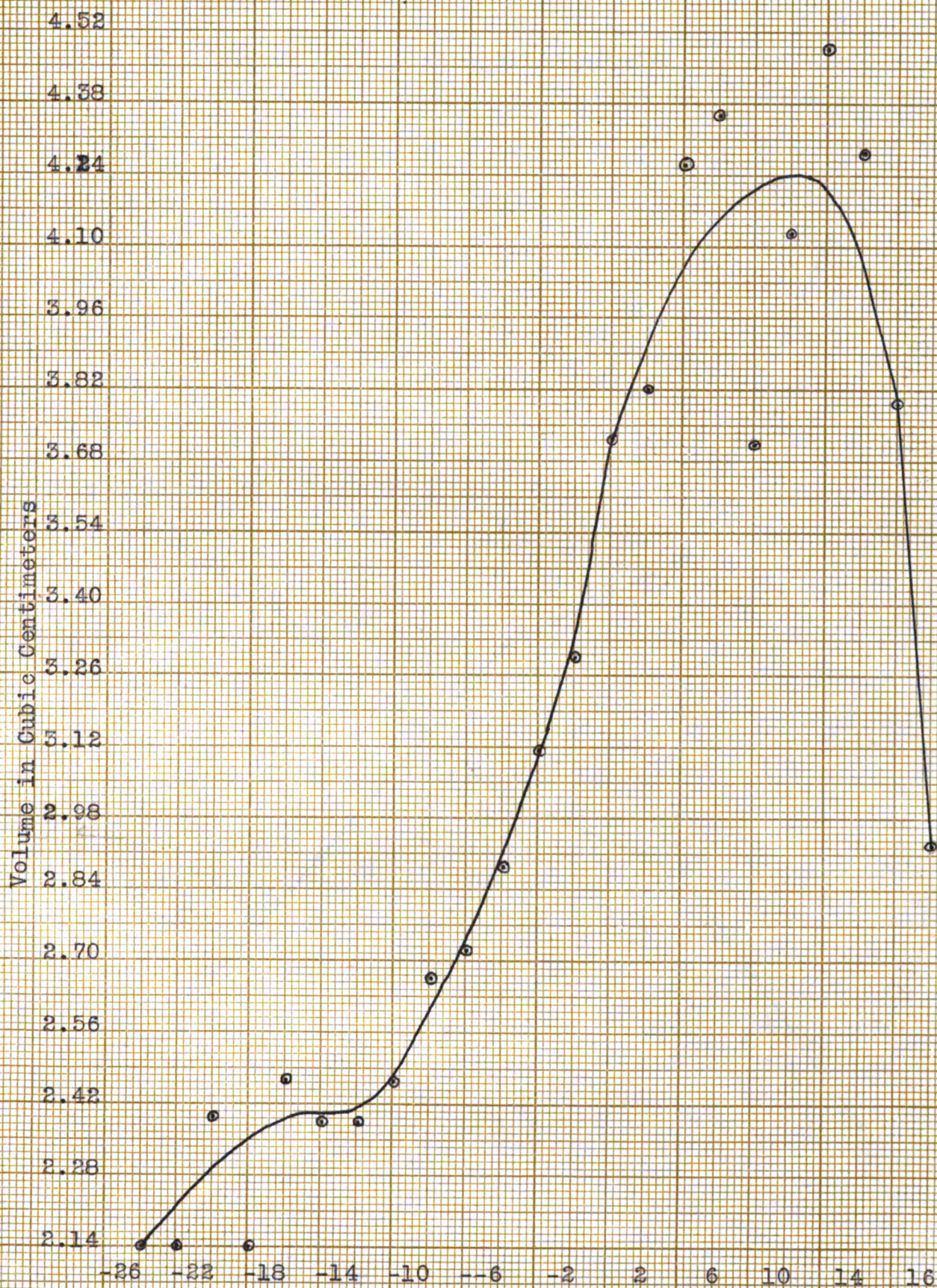
Variety	Picking 1 (oz.)	Picking 2 (oz.)	Total (oz.)
Rubel	8-23 198.5		198.5 (12.4)*
Jersey	8-23	9-9	
	103.5	7.5	111
	142.5	4	146.5
	138.5	8.5	147
Av.	128.2	6.6	134.1 (8.4)
Jersey	9-9 73.0		73.0 (4.5)

* Reduced to nearest pound

Table 8. Cup Counts of the Rubel and Jersey Plants Picked August 23, 1946 and September 9, 1946.

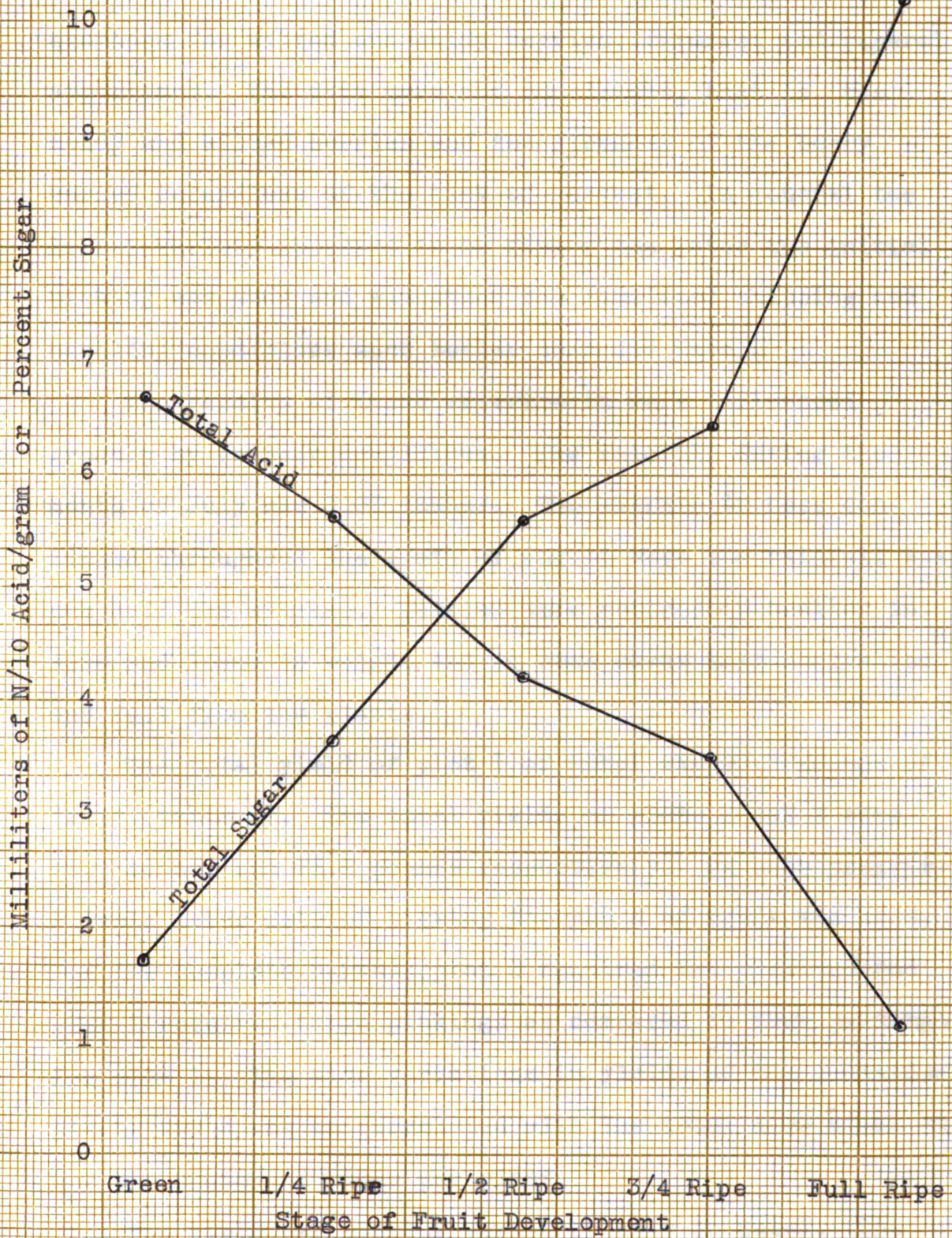
Variety	Picking 1	Picking 2	Average
Rubel	8-23 227		227
Jersey	8-23	9-9	
	176	260	218
	145	208	176.5
	139	179	159
Av.	153	215.6	184.5
Jersey	9-9 174		174

Figure 1. Fruit Development



Days Before and After Blue Fruit Color

Figure 2. Sugar-Acid Analysis



days, an average of 350 miles, and one pint being held in a building which was 3° to 5° F cooler than the outside temperature. At the end of the allotted time, the fruit was examined for wilted and moldy berries, firmness and general appearance. The data were not consistent, that is, the moldy and wilted berries and the firmness of the berry varied regardless of the time of harvest. In general the Jersey variety appeared to be firmer the later the initial picking was made and withstood the simulated shipping and handling conditions much better than did Rubel.

The results of these experiments were influenced greatly by weather conditions. The rainfall during the month of July was 0.03 inches. The extreme dryness continued throughout the month of August when the rainfall was one-half the average. Berries were noticeably smaller in size and lower in weight and in some cases they shrivelled and fell from the plants.

The total yield of plot 1 of Rubel was 90.1 pounds of fruit (table 3). The total yields of plots 2 and 3 were 78.7 pounds and 73.2 pounds respectively. On each progressively later date of picking the yield of fruit was less. For the complete harvest, plot 3 required two pickings and plot 2 required three pickings as compared to four pickings for plot 1. The wide variations in yields of the individual plants could not be correlated with the total stem diameter nor the number of stems per plant.

The yield per picking varied greatly in Rubel. The

total yield for the first picking of all three plots was 123.6 pounds as compared with 86.8 pounds for the second picking, 27.8 pounds for the third picking and 3.4 pounds for the fourth picking. Here again the yield per picking decreased as the season progressed, or as the number of pickings required to remove all the berries from the plant increased. It might be expected that as the season progressed the yield would reach a maximum before decreasing. Perhaps this would have been true in the case of Rubel had the first picking been made earlier in the season.

The yield records of Jersey (table 4) were different than those of Rubel. The total yield for plot 1 was lower than for plot 3, 140.9 pounds to 149.3 pounds. Plot 2 had the lowest yield, possibly because three plants were severely infected with a leaf spot disease. The infected plants, numbered 13, 14 and 16, yielded 8.2, 9.8, and 11.5 pounds as compared to the plant average of the plot, 13.5 pounds.

In Jersey the yield at the second picking was larger than the first followed by a decreasing yield in the third and fourth pickings. The first picking yielded 153.4 pounds as compared with 169.9 pounds for the second, 83.7 pounds for the third and 18.7 pounds for the fourth picking.

In order to determine how long a plant could go without a picking and still produce a good yield, one Rubel and three Jersey plants were left unpicked until 30 days after the initial picking of plot 1 and one Jersey plant was left

unpicked for 49 days after the initial picking of plot 1. The one Rubel plant yielded 12.4 pounds of fruit which was 1.3 pounds more than any single plant used in the three plots. The total stem diameter of this one plant was 16.85 inches as compared with 15.14 inches, the average for the plants of the three plots. Four plants of the three plots had larger total stem diameters than this one Rubel plant picked 30 days after the initial picking of plot 1, yet they did not produce so heavily.

The three plants of Jersey picked 30 days after the first picking of plot 1 yielded 8.3 pounds of fruit per plant as compared with the average of 14.2 pounds per plant of the thirty plants of the three plots. The one Jersey plant picked September 9, 49 days after the first picking of plot 1, yielded 4.5 pounds. The great reduction in the yield of this one plant can be accounted for by destruction or loss of fruit by birds. The berries which were picked were in good condition and held up well in the package. These observations suggest that the plants should not be picked as early as is the practice among growers.

There is a gradual increase in size of fruit from one month before ripe (blue or blue-black) fruit color appearance until approximately eight days before the ripe fruit color appears, at which time the rate of increase is accelerated (figure 1). This accelerated rate continues for twelve days after the ripe fruit color appears and then rapidly decreased. The data indicate that the berries

should not be picked as early as the color changes from the green to the blue-black color.

The cup counts indicate that the average berry size decreased as the number of berries left on the plant becomes fewer. The later maturing berries are fully developed but do not become as large as those that mature earlier. Cup counts for the Rubel variety (table 5) show an increase in the average size of berry as the initial picking of the plot is delayed. These results may be due to the fact that the plants of plot 3 were picked half the number of times of those of plot 1.

The size of the Jersey berries decreases as the number of pickings is increased and as the initial picking of the plot is delayed (table 6). The average berry size of the three plants with the initial picking delayed for 30 days was larger than the average berry size of the second plot. The one Jersey plant which was not picked until 49 days after the earliest picking of plot 1 produced the largest berries.

The relationship of the total sugars, expressed in percent sugar, and the total acid content, expressed in milliliters of N/10 acid per gram, as the berry develops from the green to the full ripe stage is shown in figure 2. The acid content decreases as the sugar concentration increases. These results are similar to those of Alwood (1) for grapes. Just how much the percent sugar increase and the acid decrease when the berry is left on the plant

to a later date was not determined.

Conclusions and Summary

The relationship between the time of harvest of blueberries and the yield and size of fruit is reported for the varieties Rubel and Jersey growing under Michigan conditions. This report is based on one season's work in which unusually dry weather played an important part in influencing the size and weight of berry. In spite of these limitations, the following conclusions may be drawn.

1. From 30 days until eight days before the change in fruit color, green to blue-black, the fruit growth is slow compared with the growth between the eighth day before and the twelfth day after the fruit color change.
2. The first picking of the plant yields the largest sized berries with a gradual decrease in all later pickings.
3. An increase in the average size of the berry occurs as the initial picking of the plot is delayed and as the number of pickings required to harvest all berries are reduced.
4. Total yield of Jersey increases while that of Rubel decreases as the initial picking is delayed and the pickings required for the removal of the berries from the plant are reduced in number.

Acknowledgments

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