AN ABSTRACT OF THE THESIS OF

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(Name) (Degree) (Major)

Date thesis is presented April 27, 1967

Title FACTORS INFLUENCING FRUIT BUD FORMATION AND YIELD OF THE MARION BLACKBERRY

Abstract approved
Major Professor

In 1960 tests were initiated on the Marion blackberry (*Rubus* hybrid) to study the effect of (1) plant spacing, (2) time of training canes to the trellis and (3) amount of cane to train to the trellis with regard to fruit bud formation and total yield.

Plant spacing varied with 2.5, 5 and 10 feet between plants in the row. Time of training the canes to the trellis was approximately the middle of the months of August, September, October and February. The amount of cane trained on the trellis was either the entire length of all sound canes or only enough of each cane to reach the adjacent plant.

Total yield of fruit, fruit spur determinations, time of fruit bud formation, leaf size and number and carbohydrate:nitrogen ratio of leaves were studied and/or measured.

Although yield differences were greatest in the early years of the planting, 4-year averages indicate that closer spacing of plants resulted in highly significant increases.

August-trained canes produced the highest yields, followed in order by February, September and October.

Differences in yield between the length of canes trained were very small and generally non-significant. When more cane growth was trained, a corresponding increase in training time was required, particularly at the closer plant spacings.

August and September training of canes stimulated the axillary buds to elongate and produce lateral growth. These laterals on August-trained canes matured enough to allow the formation of fruit buds, while laterals on September-trained canes were generally too succulent to form fruit buds.

August-trained canes produced more fruit spurs per foot of row than February-trained canes. No difference in number of flower buds per fruit spur occurred between August and February training.

Leaf counts on November 1 indicated that trellis training done in August produced more trifoliate leaves per foot of row than when the canes remained on the ground. Trifoliate leaves from ground-level training were larger.

Axillary buds were collected at 2-week intervals starting on August 1 and continuing until November 15 for the purpose of determining the time of fruit bud formation. The canes were divided into three sections, (1) basal, (2) mid- and (3) terminal, and each sampled separately. Buds from trellis-level training changed little during August and September; however, on October 2, buds from the terminal area only of canes and laterals were showing elongation. By mid-October, buds from all areas of the cane were showing an elongation of the apex. The first and only floral structure, expressed as a broadening and flattening of the apex, was observed in terminal section buds sampled on November 15. In contrast, basal and mid-section buds from canes trained along the ground during the summer showed an elongation of the apex by October 2, and by November 15 well defined floral structures were observed. Buds from the terminal section of cane were beginning to show some elongation by mid-November.

Carbohydrate and nitrogen determinations were made on trifoliate leaves sampled from various loci on the canes on November 1. Older leaves, regardless of plant spacing or time of training, had the lowest nitrogen content. Carbohydrate content of leaves was quite variable. The C:N ratio was lowest for the 5-foot spacing in both trellis-level and ground-level training. Leaves from the terminal area of the canes had the lowest C:N ratio.

FACTORS INFLUENCING FRUIT BUD FORMATION AND YIELD OF THE MARION BLACKBERRY

by

Willis Arden Sheets

A THESIS

Submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1967

APPROVED:

Professor of Horticulture

In Charge of Major

Head of Horticulture Department

Dean of Graduate School

Date thesis is presented April 27, 1967

Typed by Nancy Broome

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to Dr. Ralph Garren, Jr., and Dr. R. M. Bullock for their guidance in this investigation and to Dr. H. J. Jensen for his constructive criticism of the manuscript. Appreciation is also extended to the personnel of the North Willamette Experiment Station.

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INTRODUCTION

Blackberries have been grown commercially in Oregon for about 50 years. The average yield of fruit per acre ranges from 2 to 4 tons, depending upon the variety. With current economic conditions of increasing competition from other fruit products and spiraling costs of production, there is a need for increasing the yield per acre to remain competitive and obtain profits.

Presently there are about 6,330 acres of trailing-type caneberries growing in Oregon. The 1965 crop was valued at $6,462,000. This represents a gross income of approximately $1,000 per acre and is a substantial portion of the farm income, particularly in Clackamas, Marion, Multnomah, Polk, Washington and Yamhill Counties.

Investigations to determine how production per unit of cost could be increased were initiated in 1960 at the North Willamette Experiment Station near Aurora, Oregon. Tests were designed to determine three factors in relation to optimum yields: (1) plant spacing, (2) time of training canes to the trellis and (3) the amount of cane to train to the trellis. Because of the favorable effects of close spacing on yield indicated by early results of this research, many of the new acres planted from 1961 through 1965 were planted at a higher plant density per acre. See Fig. 1 (p. 2).

The term "caneberry" includes many kinds of plants; however, in this text it will refer to the trailing types of the species Rubus. Included in this group are the summer varieties such as Aurora,

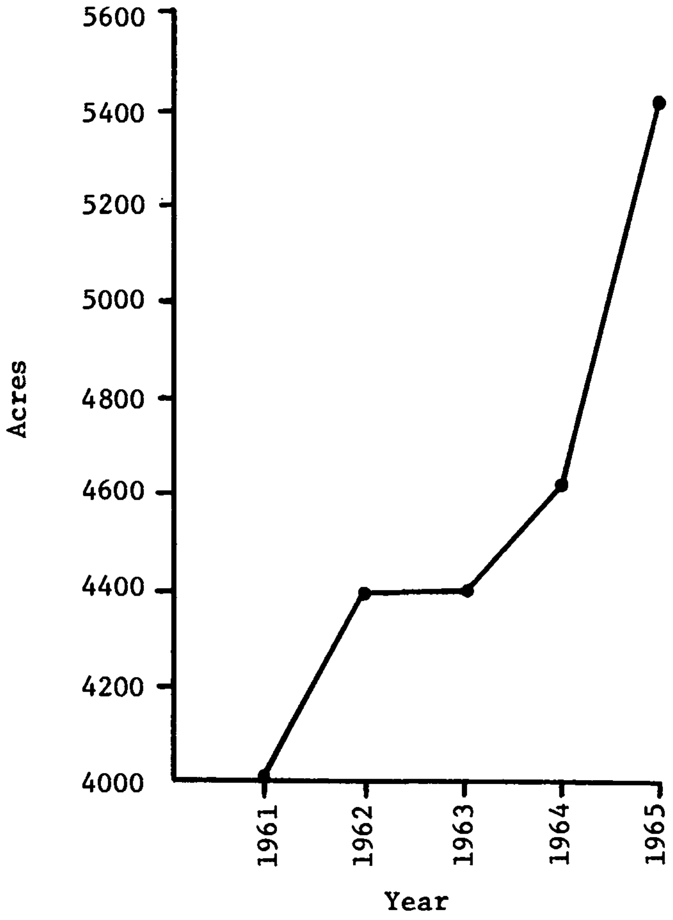


Fig. 1. Acreage of trailing berries (not including Loganberries) in Oregon for 1961-1965.

Boysenberry, Cascade, Loganberry and Marion, as well as the fall variety, Thornless Evergreen.

Blackberries are perennial plants even though the canes are handled in a biennial manner. They can be further divided into upright and trailing forms, the former being where the canes are stiff and remain in an upright position, usually requiring no trellis for support. In contrast are the trailing types where the canes are somewhat flexible and, as elongation proceeds, trail along the ground. This type requires a trellis which supports the fruiting canes. The trellis usually consists of one or more wires supported by posts.

During the growing season two kinds of canes are present, fruiting canes trained to the trellis and new canes or current season's growth, usually trained along the ground parallel to the row. After harvest the canes that have borne fruit become weak or die. These are removed from the trellis and the new canes may then be wrapped on the wire. The wrapping and/or weaving of canes on a trellis is called training. With the exception of removing old canes, pruning as used in this text refers to altering the length of canes or laterals.

The summer varieties ripen fruit from late June through mid-August, while the Thornless Evergreen harvest season starts about August 10 and extends through mid-September.

LITERATURE REVIEW

There appears to be little experimental information pertaining to the factors influencing fruit bud formation in caneberries. In the period around 1930, there were some studies concerning flower bud differentiation of certain brambles (17, 21, 29). Robertson (21) has worked more recently with flower bud development in the genus Rubus.

The conditions of environment that favor fruitfulness can be stated briefly. Gardner (7) has suggested that a plant must have favorable temperature, adequate room, soil, water, nutrients, and light of sufficient day length and intensity. These factors should be such that a moderately rapid growth may be made. Extremes of drought, shade and starvation may delay or inhibit reproduction while extremes of high fertility, water and sunlight favor an over-vegetative condition. Somewhere between these extremes is the mean or average that promotes the reproductive processes.

According to Gardner (7), fruitfulness is associated with moderate growth and the internal condition in which there is an accumulation of carbohydrates. This indicates that the building of a supply of carbohydrates that is beyond the amount required for respiration and new vegetative growth is a necessary antecedent, though not the only one, to the plants becoming fruitful--that is, forming flower buds, flowers, fruits and seeds.

Beach (2) states that fruitfulness is associated with an accumulation of carbohydrates in the buds and stems or adjacent tissues. Working with black raspberries in Colorado, he found that larger-sized fruit is borne on the lower part of the canes and branches, but the fruit of the highest quality and in the largest numbers is borne nearer the base of the branches and immediately below the branches on the main canes. This corresponds to the area of the greatest accumulation of carbohydrate.

The plant builds tissue from nitrogen, phosphorus, potassium, carbon and other elements. It has been shown, as reported by Gardner (7), that nitrogen is a limiting factor more frequently than any other nutrient. Under most conditions, the carbohydrate-nitrogen relationship is more important than any of the other nutrient relationships in determining whether the plant is to deplete its supply of carbohydrates in making new growth or is to accumulate them in the form of a stored surplus.

According to the author previously cited, influence over the manufacture, utilization and total content of carbohydrates in the plant is indirect and imperfect. Control over the plant nitrogen supply and resultant nitrogen content is more direct and certain. Consequently, the carbohydrate-nitrogen relationship is under some degree of control. It is possible, to a considerable extent, to direct the plant activities into either vegetative or reproductive growth. Often the optimum condition for fruitfulness may be obtained by the temporary use of larger amounts of nitrate nitrogen to promote for a short period in the spring a very rapid vegetative growth, then withhold further nitrogen supplies.

Most caneberries form flower buds several months before they fruit. Waldo (30) found that the Evergreen blackberry in Oregon showed fruit bud differentiation in November. The Youngberry and the wild trailing blackberry formed fruit buds in October. Loganberry showed fruit bud formation during September and October. Robertson (21), working in Scotland, found that the development of primary inflorescences reached a fairly advanced stage in autumn in the red raspberry and in blackberries. However, flower bud initiation in Himalayan Giant blackberry was first observed in October.

MacDaniels (17) in New York states that the time of fruit bud differentiation for the Cumberland black raspberry is October, while the Herbert red raspberry differentiated in February and March. He also noted that it is quite clear that the flowers of the Snyder blackberry differentiate about the last of August with little change between September and March.

In Iowa, Snyder (24) found that the first visible evidence of flower initiation is a broadening and flattening of the floral axis. This condition was first observed in buds of Latham red raspberry that were collected April 25. He states, ". . . apparently discernible flower initiation occurs sometime after bud expansion in the spring."

In trailing blackberries, Waldo (30) found there are secondary buds, the largest of which is outside and slightly below the main central bud. These buds differentiate flower parts later than the main bud. In years when hard freezes occur early in the dormant period and if the canes are not killed, the fruit produced the following summer comes from these secondary buds.

Light is another important factor connected with fruit bud formation. Kraybill (11) found that shading of apple and peach trees resulted in decreased fruit bud formation. This was associated with an increase in moisture and total nitrogen and a decrease in free reducing substances (monosaccharides), sucrose (disaccharides) and starches (polysaccharides).

Hardiness to cold temperatures is very important. According to Brierley (4), bramble canes that are allowed to "harden off" prior to the onset of the winter dormancy period will, in general, be more hardy. This same author, in studies of transpiration rates in Latham red raspberry, concluded that when there is excess soil moisture, maturity can be hastened by leaving the old canes in place until the end of the growing season.

Brierley (5) also found that canes of Latham red raspberry that become dehardened by mild temperatures in early winter can be rehardened to some extent if canes are exposed to freezing temperatures later. However, fully dehardened canes cannot be rehardened sufficiently to escape injury at temperatures below 0° F.

Growth of plants is affected by many factors. One of these is the effect of hormones which have become known generically as the auxins, i. e., growth regulators which induce cell enlargement at low concentrations. Recently a more rigid definition has been stated by Bentley (3), "Auxins are a group of hormones which as substances affect extension of the cell wall, and are accompanied by water uptake in the cell." Extension of the cell wall and water uptake are probably the aspects of growth most nearly related to the primary effect of auxins on the cells. They resemble indole-3-acetic acid in physiological action. Tukey (27) states that auxins are generally acids or their derivatives with an unsaturated cyclic nucleus.

It is not generally knownjust what function auxins have in the actual development of flower buds; however, it is believed that they are necessary to the actual growth of the fruit. Wright (34), working with the black currant, Ribes nigrum, found two acid auxins and one neutral auxin plus other compounds in ether extracts of the fruit. One of the acid auxins was identical with IAA (indole acetic acid) and he called this A_1. The other acid auxin which he called A_2 was chemically related to A_1. A_3, the neutral auxin, appeared to be identical with IAN (3-indoleacetonitrile). Histological studies showed two periods of rapid fruit growth. The first of these was due primarily to cell enlargement in the pericarp and the second to cell enlargement in the placenta. It was shown that A_1 and A_3 had two peak periods of concentration and these corresponded to the same periods of most rapid growth.

In Oregon, Zielinski and Garren (35) found that fruit size of Chehalem and Thornless Evergreen blackberries was increased from about 19 to 31 per cent from applications of two sprays of a mixture of parachlorophenoxyacetic acid (PCPA), beta, naphthoxyacetic acid (NOA) and naphthaleneacetic acid (NAA).

The influence of auxins on development of a wide range of horticultural plants has been studied by various investigators. Hartmann (8), McCartney (19), Nitsch (20), Rubinstein (22), Scott and Briggs (23) and Van Overbeek (28).

HISTORY AND CHARACTERISTICS OF THE MARION BLACKBERRY (RUBUS HYBRID)

The Marion blackberry, developed by Waldo (31), came from the cooperative breeding program of the U. S. Department of Agriculture and the Oregon Agricultural Experiment Station, Corvallis. The Marion is the result of a cross, Chehalem x Olallie, made in 1945. It was selected in 1948 as US-Oregon 928, and tested under this number until its release as Marion in 1956. Plant growth resembles the Himalaya in general appearance and growth habit. Generally, there are only a few (three to six) long canes, often 16 to 20 feet in length. These canes are quite brittle and therefore must be handled with care so that breakage is avoided.

The Marion blackberry is productive even though there are few canes. The buds are relatively close together and the internodes are short. Fruiting branches are long with many flowers and fruits per spur. These fruiting spurs are strong and extend out from the cane in arch-like fashion. This type of fruiting habit makes for ease in picking, and thorns are not troublesome to pickers. Marion has produced yields of 6 to 7 tons per acre. The fruit is usually mature for picking by July 15. Fruits are of typical round blackberry shape, somewhat longer than wide, of average firmness and bright black in color.

MATERIALS AND METHODS

Soil

The soil was a deep, well-drained, fertile Willamette sandy shot loam characteristic of soils in which many of the blackberries are grown in Oregon.

General Culture

Minimum tillage along with judicious application of chemical herbicides were used in the cultural system. One year after planting, a solid set irrigation system using semi-rigid plastic pipe was installed. Irrigation usually began in late May, coinciding with the end of the blooming period. The amount of water applied and the irrigation frequency was dependent upon weather conditions. During the harvest season, irrigations were made immediately after each picking. Currently recommended procedures for insect and disease control were used.

Commercial fertilizer in amounts to supply approximately 100 pounds of nitrogen per acre was applied in early spring. Every other year a complete fertilizer such as 20-25-6 was used and a nitrogenous fertilizer such as ammonium nitrate or ammonium sulfate was used on alternate years. Boron requirements were met with annual applications of soluble boron applied as foliage sprays.

Description of Treatments

To resolve the question of optimum plant spacing, 2.5, 5, and 10 feet were used as the distances between plants in the row. Rows were 10 feet apart to acoomodate all mechanical cultural operations. See Figs. 13, 14 and 15 (p. 44).

The dates of training to the trellis were set at August 15, September 15, October 15 and February 15. Deviations of 2 or 3 days were occasionally made neccessary by the weather.

A single variable was used to test the length of cane influence. In the "long" system the entire length of cane was trained, while in the "short" system only enough cane to reach the adjacent plant was used.

Plot Layout

Plots 40 feet in length were randomized in a factorial design using four replications. The rows were oriented east and west and the number of plants per plot varied with plant spacing.

Harvesting

The harvest period was approximately 4 weeks during which five to six pickings were made. Picking was by hand and all fruit from a given plot was weighed and weights recorded separately.

Sampling Technique

Fruit Spur Determination

All fruit spurs within a 5-foot section of row were counted on May 9, 1966, in each of four replicates representing all spacings of the short pruning system and the training periods of August and February. Laterals had been trimmed to about 15 inches in length. Weak areas were avoided and only thrifty sections of the plots were used.

Length of Fruit Spur and Number of Flower Buds Per Spur

On May 12 and 13, 1966, ten fruit spurs per replicate, five from each side of the row, were selected at random from all spacings on August- and February-trained rows. Total length in inches was recorded. Also, the number of flower buds per fruit spur was counted.

Leaf Counts

All leaves, regardless of size, were counted on a 5-foot section of row that included the berry plant. Counts were made November 1 on single replicates of both long and short pruning treatments at all three plant spacings. Only the August-trained rows and those to be trained in February were counted.

Leaves

Trifoliate leaves were collected on November 1 from each of the three plant spacings in both pruning systems on August-trained rows. Leaves from three areas of the plant were sampled, i.e., (1) along the entire length of the main cane, (2) at the base of the laterals and (3) the last-formed, fully expanded trifoliate leaf on the lateral. Leaves were also collected from the rows to be trained in February, although they were still on the ground. Since no laterals were present on these treatments, the three areas sampled were (1) basal (0-5'), (2) mid-section (5-12') and (3) terminal (12-18'). Again, only fully expanded trifoliate leaves were sampled. Each sample consisted of 20 leaves selected at random throughout the plot. While still fresh, they were washed in a solution of 1 per cent HCl plus Tween 20, rinsed thoroughly and oven-dried.

Buds

On August 1, 1965, five representative canes were selected and carefully separated from the cane mass on a row that was to be trained on August 15. A similar group of canes was selected September 1 on a row to be trained on February 15. Canes were numbered 1 through 5 and tagged. Each cane was divided into three sections: (1) basal (0-5'), (2) mid- (5-10') and (3) terminal (10-15'). The cane areas were permanently marked with white paint. Two axillary buds were sampled from each area on each of five canes, making a total of ten buds per sample. Fresh buds were placed directly in a plastic vial containing equal parts of Craf solutions A and B (10). Within a few minutes of sampling, the air was extracted from the vials using a suction device attached to a water faucet.

On the row trained August 15, eight bud samples were collected at approximately 2-week intervals beginning with August 1 and ending on November 15. The canes that were trellis-trained on August 15 produced lateral growth from the axillary buds, particularly in the terminal area; therefore, the "terminal" bud sample starting with the third sampling date (September 2) was collected from the middle area along the lateral. On the row to be trained February 15, the first bud sample was collected on September 2 with subsequent samples collected on the same schedule mentioned above.

Laboratory Analysis

Carbohydrate Determination

The method of analysis of the Association of Official Agricultural Chemists (1), as outlined below, was generally followed. Dried leaves were ground through a Wiley mill. One-gram samples were hydrolyzed with 20 ml of concentrated (11.7N) HCl and 200 ml water in a 300-ml boiling flask fitted with a reflux condensor. They were boiled for 2-1/2 hours. Samples were then filtered and cooled to room temperature. A 50-ml sample was neutralized with about 10 ml of 5N NaOH, then made to volume (250 ml). Five ml of this was used as the sugar solution in the iodometric technique for the sugar determination as outlined by Somogyi (25). In this method it is assumed that the hydrolysis with HCl reduces the majority of carbohydrates to glucose.

Nitrogen Determination

One-gram samples of the dry leaves were used to determine the nitrogen content using the Kjeldahl procedure of digestion with sulfuric acid (33).

RESULTS

Effect of Plant Spacing on Yield

Reference is made to Table 2 (p. 17). When yields for 1962-1965 are combined for all times of training and lengths of pruning, the differences of 6.93 and 16.01 pounds between spacings are highly significant.

Increased yields from the closer plant spacings are most evident in the early years of production. For example, Table 1 (p. 16) indicates the difference between treatments 1 and 17 in 1962 was 45.28 pounds (2.46 tons per acre), 21.66 pounds (1.18 tons per acre) in 1963 and only 10.57 pounds (.57 tons per acre) in 1964. Although production data for 1961, the so-called "baby" crop, is not included in Table 2 (p. 17), the difference in favor of the 2.5-foot spacing over the 10-foot spacing was 58.9 pounds (3.2 tons per acre). As the planting approached maturity, yield differences became more variable and, in general, of less magnitude. Advantages of closer spacing, as indicated by yield, would be greatest the first 2 years after planting.

The data indicate no significant yield difference between long and short pruning. Main comparisons were made using data obtained from the short pruning system. The seasonal mean yields for 4 years in Table 3 (p. 18) indicate no significant difference between 2.5 and 5 feet, regardless of time trained. A highly significant difference in yield was obtained between 5- and 10-foot spacings when trained in August and October, and a significant difference at the 5 per cent level was observed for September. February training was not significant between 5 and 10 feet. Yield differences between 2.5 and 10 feet

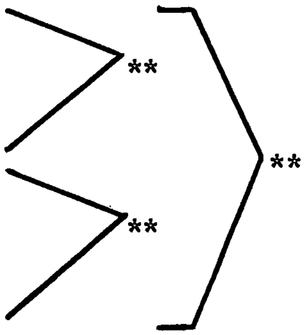
Table 1. Marion blackberries. Influence of age and cultural practices on yield.

Treat-ment	Plant Spacing	Training Time	Cane Length	Mean Pounds per Plot				Ave. Mean 4 Years
				1962	1963	1964	1965	
1	2.5'	Aug 15	Long	114.08	122.25	132.52	158.35	131.80
2	"	"	Short	111.75	130.45	125.75	136.60	126.14
3	"	Sep 15	Long	52.55	116.00	130.15	120.82	104.88
4	"	"	Short	45.25	108.75	117.42	120.32	97.94
5	"	Oct 15	Long	72.85	123.22	99.35	115.12	102.64
6	"	"	Short	62.40	122.30	102.50	98.82	96.51
7	"	Feb 15	Long	63.68	136.53	107.32	108.52	104.01
8	"	"	Short	54.88	133.55	114.10	129.32	107.96
9	5.0'	Aug 15	Long	82.90	119.62	129.88	140.95	118.34
10	"	"	Short	92.12	111.55	144.62	138.88	121.79
11	"	Sep 15	Long	48.10	100.08	100.40	92.10	85.17
12	"	"	Short	48.20	103.72	124.88	101.25	94.51
13	"	Oct 15	Long	60.68	97.32	92.68	88.28	84.74
14	"	"	Short	64.18	133.75	108.08	104.75	102.71
15	"	Feb 15	Long	59.58	136.35	116.18	129.70	110.45
16	"	"	Short	54.52	133.40	92.78	114.12	98.71
17	10.0'	Aug 15	Long	68.80	94.42	121.95	125.25	102.61
18	"	"	Short	72.65	86.65	117.60	121.85	99.69
19	"	Sep 15	Long	46.50	78.08	112.82	92.75	82.54
20	"	"	Short	38.28	82.70	105.15	92.22	79.59
21	"	Oct 15	Long	50.28	80.85	82.75	62.90	69.19
22	"	"	Short	48.15	84.50	70.32	68.25	67.81
23	"	Feb 15	Long	52.18	113.32	97.92	110.62	93.51
24	"	"	Short	48.58	121.60	108.10	95.65	93.38
		LSD	5%	12.591	26.251	19.150	25.040	13.052
			1%	16.722	34.866	25.434	33.257	17.335

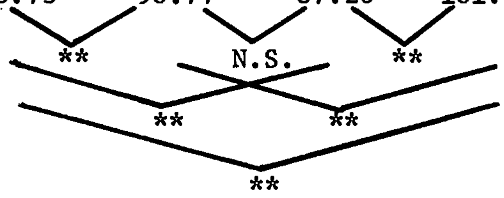
Table 2. Marion blackberries. Four-year (1962-65) combined yield totals.

		Date of Training					
Spacing	Cane Length	8-15	9-15	10-15	2-15		Mean[1] Yield in Lbs
2.5'	Long	2108.8	1678.1	1642.2	164.42	7093.3	
	Short	2018.2	1567.0	1544.1	1727.40	6856.7	
		4127.0	3245.1	3186.3	3391.60	13950.0	108.98
5.0'	Long	1893.4	1362.7	1355.8	1767.20	6379.1	
	Short	1948.7	1512.2	1643.4	1579.30	6683.6	
		3842.1	2874.9	2999.2	3346.50	13062.7	102.05
10.0'	Long	1641.7	1320.6	1107.1	1496.20	5565.6	
	Short	1595.0	1273.4	1084.9	1494.10	5447.4	
		3236.7	2594.0	2192.0	2990.00	11013.0	86.04
		11205.8	8714.0	8377.5	9728.40		
Mean Yield in Lbs[1]		116.73	90.77	87.26	101.34		

LSD 5% = 4.615
** 1% = 6.129



LSD 5% = 4.317
** 1% = 5.691



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[1] Means are an average of long and short pruning, since no significant differences were observed between pruning systems.

Table 3. Marion blackberries. Comparison of 4-year mean yields at various plant spacings (short system of pruning).

Treatment	Spacing	Time of Training	Seasonal Mean Yield in Lbs		
2	2.5'	August	126.14	N.S.	
10	5.0'	August	121.79	**	**
18	10.0'	August	99.69		
4	2.5'	September	97.94	N.S.	
12	5.0'	September	94.51	*	**
20	10.0'	September	79.59		
6	2.5'	October	96.51	N.S.	
14	5.0'	October	102.71	**	**
22	10.0'	October	67.81		
8	2.5'	February	107.96	N.S.	
16	5.0'	February	98.71	N.S.	*
24	10.0'	February	93.38		

*LSD 5% = 13.052
** 1% = 17.335

are highly significant when training was done in August, September and October but significant only at the 5 per cent level when canes were trained in February.

Effect of Time of Training on Yield

August training produced the highest yields at all spacings. Seasonal mean yields for 4 years in Table 4 (p. 20) indicate the differences between August and September as well as August and October training at all three spacings were highly significant. A highly significant difference also occurred between August and February training at the 2.5- and 5-foot spacings. The difference between August and February at the 10-foot spacing was not significant.

February training was significant over September training at the 10-foot spacing. However, no significant differences occurred at 2.5 or 5 feet.

At the 2.5-foot spacing, February training was significantly better than October. No significant difference occurred at the 5-foot spacing; however, at 10 feet the difference between February and October was highly significant. The yield differences between September and October training were not significant regardless of spacing.

In Table 2 (p. 17), where total yields for all spacings and pruning systems are combined, all comparisons between training times are highly significant except between September and October, where no significant difference occurred.

Effect of Pruning on Yield

Differences between long and short pruning are shown in Table 1 (p. 16). When 4-year mean yields are compared, the differences are

Table 4. Marion blackberries. Comparison of 4-year mean yield at various times of training (short system of pruning).

Treatment	Spacing	Time of Training	Seasonal Mean Yield in Lbs				
2	2.5'	August	126.14				
				**			
4	2.5'	September	97.94		**		
				N.S.		**	
6	2.5'	October	94.51				
				*			N.S.
8	2.5'	February	107.96				
10	5.0'	August	121.79				
				**			
12	5.0'	September	94.51		**		
				N.S.		**	
14	5.0'	October	102.71				
				N.S.			N.S.
16	5.0'	February	98.71				
18	10.0'	August	99.69				
				**			
20	10.0'	September	79.59		**		
				N.S.		N.S	
22	10.0'	October	67.81				
				**			*
24	10.0'	February	93.38				

*LSD 5% = 13.052
** 1% = 17.335

slight and in only one case (treatments 13 and 14) are they significant. In four of 12 comparisons the short system produced more than the long system and three of the four were at the 5-foot spacing.

It is clearly evident in Fig. 7 (p. 24) that the smallest differences between the pruning systems occurred at the 10-foot spacing while the greatest variation was at the 5-foot spacing. The magnitude of variation between the times of training is the smallest at the 2.5- and 10-foot spacing.

Time Required for Trellis Training

Training time as used here refers to trellis training only. Staking back the new canes, cutting out old fruiting wood and stripping old canes from the wires are not included, although these operations are part of the overall training.

Prior to 1963, only a single No. 9 wire at the top of the split cedar posts was used. After 1963, the trellis consisted of two No. 9 wires 18 inches apart with the upper wire near the top of the posts and approximately 60 inches above the ground, as seen in Figs. 4 and 5 (p. 23).

The training system used prior to 1963 was a tight wrap of all canes around the single wire, as seen in Fig. 3 (p. 22). Other trials with the Marion blackberry resulted in higher yields from the two-wire system, where the canes were spiraled over the top wire and under the lower wire, as seen in Figs. 4 and 5 (p. 23). The short pruning system, especially in the 2.5-foot spacing, consisted merely of the canes going over the top wire then angling to the bottom wire near the adjacent plant.

Fig. 2. Marion blackberry. October-trained canes. Note lack of fruit spurs and dead cane area between trellis wires.

Fig. 3. Marion blackberry. October-trained canes. Note lack of canes and dead cane area on trellis.

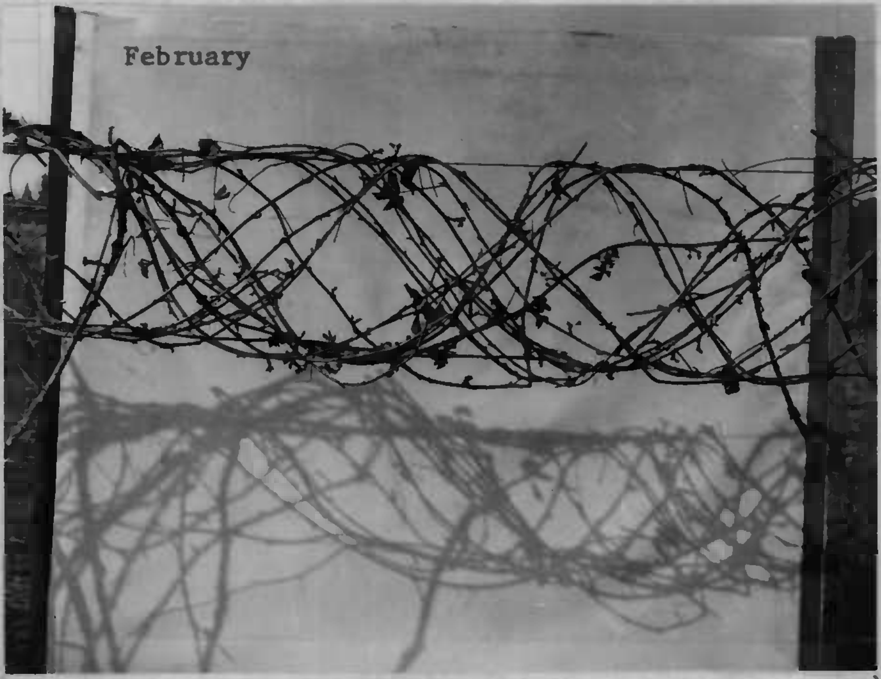

Fig. 4. Marion blackberry. Two-wire spiral-weave trellis between hill area.

Fig. 5. Marion blackberry. Two-wire spiral-weave trellis at hill area.

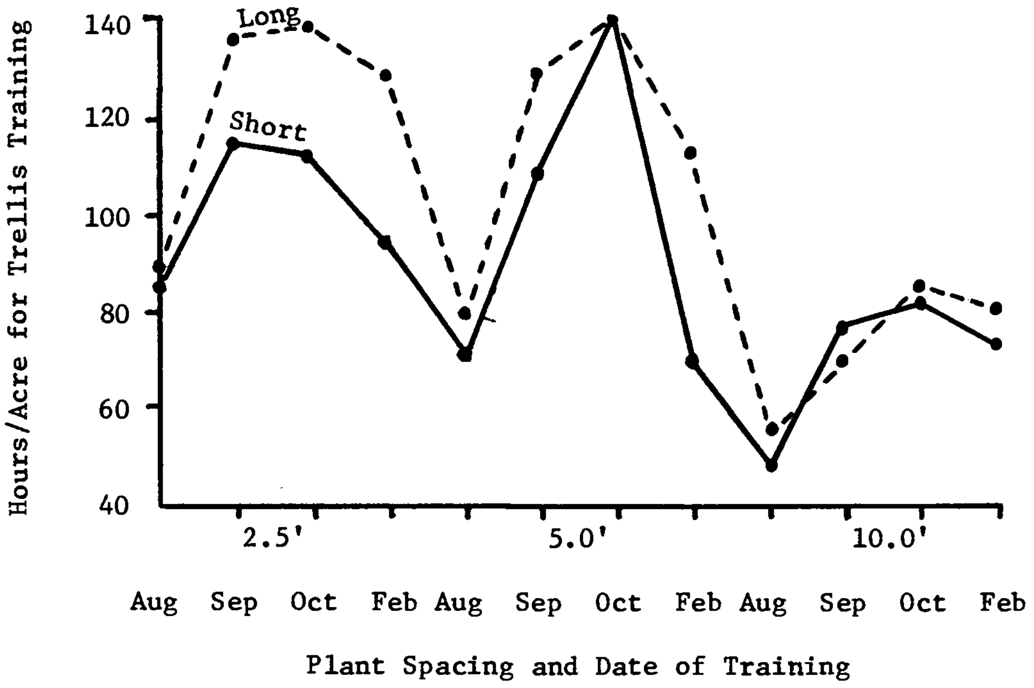

Fig. 6. Marion blackberries. Training time in hours per acre.

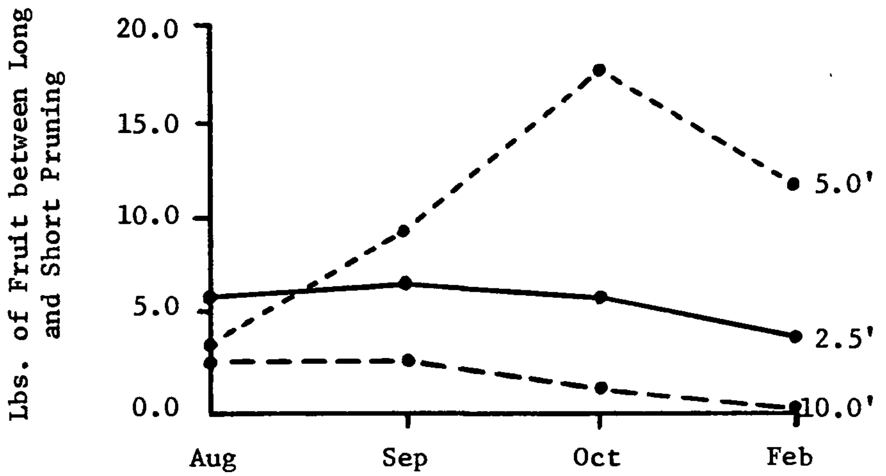

Fig. 7. Marion blackberries. Differences between pruning systems at 3 plant spacings and 4 times of trellising.

Time required for the training process was recorded for each row for 4 years. The time was converted to hours per acre. Trellis training time is presented in Fig. 6 (p. 24). As expected, it required more time to train rows pruned to the long system than to the short. The greatest differential in training time between pruning systems was at the 2.5-foot spacing. The least difference in training time between the two systems of pruning occurred at the 10-foot spacing. August training required the least time at all plant spacings, while October training required the most time at each plant spacing.

Location of Flower Buds on Laterals

Not all buds on a given lateral are flower buds. On May 10, 1966, ten laterals (five from each side of the row) were selected at random from certain August-trained rows at the 2.5- and 5-foot spacing. Table 5 (p. 26) indicates that 57 per cent of the total number of buds on the lateral growth produced by August training had floral capabilities. Starting with the first live bud on the terminal end of the lateral and counting through the fifth bud, 66 per cent of these had flowers, while only 47 per cent of the first five buds from the basal end had flowers. However, the area of lateral between the fourth and eighth bud from the basal end had 75 per cent flower buds. Plant spacing had little effect on the number of flower buds within a given area of the lateral. Average distance between buds was approximately 2-1/2 inches. Average length of lateral, not including the dead area at the terminal end, was 39 inches.

Table 5. Marion blackberries. Location of flower buds on lateral growth from August training.

	Per Cent of Total Buds Having Flowers				
	Bud Location				
Plant Spacing	Entire Lateral	1st to 5th Bud from Term. End	1st to 5th Bud from Basal End	4th to 8th Bud from Basal End	Ave. Distance between Buds in Inches
2.5'	59	70	44	77	2.6
5.0'	54	60	49	72	2.5
Average	57	66	47	75	

Comparison of Number of Fruit Spurs, Fruit Spur Length and Number of Flowers per Fruit Spur on August- and February-trained Canes

An average of all plant spacings, as shown in Table 6 (p. 28), indicates August-trained canes produced approximately nine more fruit spurs per foot of row over February-trained canes. This represents a 40 per cent increase. Within the same dates of training, the 2.5-foot spacing produced the most fruit spurs per foot of row, while the 10-foot spacing produced the fewest fruit spurs.

Individual fruit spurs averaged, for all plant spacings, approximately 3 inches longer on canes trained in February. The 2.5-foot spacing produced the longest fruit spur on both dates of training.

Essentially no difference occurred in number of flower buds per fruit spur between plant spacings or time of training. All spacings in August training averaged 8.5 and February training averaged 8.9 flower buds per fruit spur.

Comparison of Leaf Number and Leaf Weight in Relation to Plant Spacing and Training

Table 7 (p. 29) indicates the 2.5-foot spacing of August-trained canes produced 240 trifoliate leaves per foot of row by November 1. The 5-foot spacing produced 204 and the 10-foot spacing 152 leaves per foot of row. This is a sizeable increase of leaf number over the same plant spacings when the canes remain on the ground. When trained in this manner, the 2.5-, 5- and 10-foot spacings had 122, 102 and 101 leaves, respectively, per foot of row. It is evident that the largest differences of leaf number occur on the trellis-level training.

Table 6. Marion blackberries. Influence of plant spacing and date of training on number of fruit spurs and flower buds and length of fruit spurs.

Plant Spacing	Date of Training	No. of Fruit Spurs per Foot of Row	No. Flower Buds per Fruit Spur	Ave. Length per Fruit Spur in Inches
2.5'	Aug	33.9	8.3	14.7
5.0'	Aug	30.2	8.4	13.3
10.0'	Aug	28.5	8.9	13.8
	Average	30.9	8.5	13.9
2.5'	Feb	25.4	8.8	18.0
5.0'	Feb	21.2	8.5	16.9
10.0'	Feb	19.4	9.4	15.6
	Average	22.0	8.9	16.8

Table 7. Marion blackberries. Influence of cultural methods on number and weight of trifoliate leaves on November 1.

			Weight In Grams	
Plant Spacing	Kind of Training	Average No. Leaves per Ft. of Row*	Dry Wt. Per Leaf	Dry Wt. of Leaves/ Ft. of Row
2.5'	Trellis Level (August)	240	.631	151.4
5.0'	" "	204	.715	145.9
10.0'	" "	152	.721	109.6
2.5'	Ground Level (August)	122	1.228	149.8
5.0'	" "	102	1.596	162.8
10.0'	" "	101	1.303	131.6

*Average of long and short pruning systems

Also shown in Table 7 (p. 29) is the relative difference in size of trifoliate leaves. The leaves on canes trained at trellis level were consistently smaller or approximately half the size of leaves on ground-level canes. Leaves from canes trained on the ground exhibited the greatest differences in size. Although the leaf size does not show a straight-line relationship with plant spacing, the smallest leaves on both kinds of training occurred at the 2.5-foot spacing.

No consistent relationship was observed between plant spacing and amount of leaf material per foot of row on ground-level training; however, on trellis-level training, the 2.5-foot spacing produced the most leaf material while the least material was measured at the 10-foot spacing.

Time of Flower Bud Formation

Longitudinal sections of axillary buds, 10 microns thick, were cut with a rotary microtome. Considerable difficulty was experienced with the microtoming procedure due to the heavy pubescence around the bud scales. This caused the sections to tear rather than cut. Much effort was expended to obtain satisfactory sections without success. It was found that the bud development could be observed with a binocular dissecting scope. Buds were cut longitudinally as near the apex as possible with a razor blade and placed on the microscope stage.

The apex of a vegetative bud is short and very closely surrounded by leaves. As differentiation takes place the apex elongates, leaving the embryonic leaves somewhat below it. The elongation proceeds for some time until, finally, the tip becomes quite broad. The first sign of floral structure is a small ridge which forms just around the broadest part of the apex. This ridge develops into the calyx.

In early samples, buds from canes trained on August 15 were very small with a leafy-type structure. Little change in appearance was observed through August and September. Only the buds from the terminal area of canes and laterals showed much change in structure on October 2, this being expressed as an elongation of the apex as well as becoming more plump. By mid-October, buds from the mid- and basal sections of cane were showing elongation of the apex. By November 1, all buds had increased their diameter as well as overall length. The first and only floral structure was observed in terminal area buds sampled on November 15, the last sampling date. This was expressed as a broadened and flattened apex similar to that observed by Snyder (24).

A somewhat different pattern of development was observed in buds from canes that were to be trained on February 15. These canes were in a horizontal position on the ground during the sampling period in contrast to those trellis-trained on August 15. All samples collected during September were quite leafy; however, by October 2 the apex of buds from the basal and mid-sections of the cane was well defined with definite elongation occurring. By November 1 an embryonic calyx was observed in buds from the basal and mid-sections of canes and well defined floral structures were observed on November 15. Buds from the terminal area of the cane were showing some elongation but no floral structure was evident by mid-November.

Carbohydrate and Nitrogen Analysis of Leaves

Table 8 (p. 33) shows the amount of carbohydrate and nitrogen, expressed as per cent dry weight, in leaves taken from various loci on the canes. Also presented is a C:N ratio. Leaf samples were collected on November 1. Trellis-level training resulted in the lowest per cent nitrogen at the 2.5-foot spacing regardless of the location of the leaves. Nitrogen level of leaves from trellis-level training ranged from 1.73 to 2.82 per cent, while levels from 1.76 to 2.08 per cent were observed in ground-level leaves. The older leaves, regardless of plant spacing, had the lowest nitrogen content. This relationship was true for both kinds of training.

Carbohydrate levels ranged from 4.164 to 6.588 per cent. Carbohydrate content of ground-level leaves was lowest in the 5-foot spacing regardless of their position on the canes.

The average C:N ratio was lowest for the 5-foot spacing in both kinds of training. The leaves from the main cane of those trellis-trained and those from the basal area of ground-trained canes had the highest C:N ratio. Leaf samples from the youngest areas of the canes, regardless of the kind of training, had the lowest C:N ratio.

Table 8. Marion blackberries. Carbohydrate and nitrogen analysis and C:N ratio of leaves* sampled on November 1.

		Plant Spacing in Feet									
		2.5	5	10	2.5	5	10	2.5	5	10	
Position of Leaves	Kind of Training	% N			% CHO			C:N			C:N Ave.
Main Cane	Trellis Level (August)	1.73	1.81	1.82	4.164	5.433	5.536	2.40	3.00	3.04	2.81
Base of Laterals	" "	2.10	2.82	2.23	6.588	5.399	5.948	3.14	2.43	2.67	2.75
Last Trifol. Leaf	" "	2.29	2.36	2.35	5.585	5.948	5.994	2.43	2.52	2.55	2.50
	Average	2.04	2.33	2.13	5.446	5.593	5.826	2.66	2.65	2.75	2.69
Basal	Ground Level (August)	1.76	1.77	1.50	5.582	4.575	4.758	3.17	2.58	3.17	2.97
Mid Section	" "	1.76	2.08	2.00	5.582	4.804	5.948	3.17	2.31	2.97	2.81
Terminal	" "	1.84	2.07	2.03	5.216	4.484	5.582	2.83	2.17	2.75	2.58
	Average	1.79	1.97	1.84	5.460	4.621	5.438	3.05	2.35	2.96	2.79

*See text, page 12, explanation of "position of leaves."

DISCUSSION

The fact that the blackberry is a perennial plant necessitated a somewhat long-term study before meaningful conclusions could be made. Also, since the time of trellis training is associated quite closely with winter hardiness, it was decided that such tests should experience a so-called "test" winter as far as low temperatures are concerned. Observations made at an official U. S. Weather Bureau station located within 600 yards of the planting indicate that in December, 1964, the planting was subjected to a 48-hour period when the maximum temperature was 19° F. and minimum temperature was 8° F. Strong easterly winds accompanied the low temperature. These weather conditions would be considered severe for the main blackberry growing areas of the Willamette Valley.

Throughout the blackberry growing areas of the Pacific Northwest, plant population has varied from 363 (10 feet x 12 feet) to 618 (8 feet x 8 feet) plants per acre. The distance between rows is most often dependent on type of machinery available for cultural operations. Spacing between plants is usually determined by varietal characteristics and, until recent years, the method of weed control used. Thornless Evergreen blackberries, for example, produce canes 20 to 25 feet in length while Boysenberries seldom produce fruiting canes longer than 12 feet.

Before the practice of using chemical herbicides to control weeds, a grape hoe was widely used for cultivating berry fields. The greater distances between plants made in-row cultivation much easier.

Information in these experiments definitely establishes the fact that the Marion blackberry will produce significantly higher yields when the plant population is increased from 435 (10 feet x 10 feet) to 1742 (2.5 feet x 10 feet) plants per acre.

Although the closer spacings produced the most fruit, they are more difficult to train because of the greater number of canes. This difficulty increases as the training time is delayed and by mid-September, cane growth is seriously tangled due to the longer canes and laterals. As training becomes more difficult, cane kinking and breakage increase. If trellis training is delayed until February, tipping down of the canes will occur. This adds to the amount of cane breakage. There will be some cane breakage regardless of time trained. There is sufficient time for the broken canes to be replaced with lateral growth when canes are trained in August. A cane broken during late winter or spring training is a complete loss.

Because of the size of the plots and in order that the training be accomplished within one to two days, it was necessary to utilize more than one person. Although two men did most of the training, there was some assistance from other individuals. This caused some of the variation in recorded training time. Differences in amount of time required for training also depended on how carefully the new canes had been staked back. One cane growing in the opposite direction from the others could tie down all canes, making them difficult to separate.

Results of the research reported here firmly establish that yield differences were greater in the early years of the planting.

This finding could be of considerable importance to growers if prospects for a high berry price were indicated. Higher plant populations could be utilized during the first year or two, then reduced after the third year.

Lowest production was obtained on plots trained in September and October. Cessation of cane and lateral elongation occurs about October 25. Following September training, some buds will slowly develop lateral growth. Depending on the season, this growth may not develop to more than about 15 inches in length and be of small diameter, having few, if any, fruit buds. Regardless of weather conditions during the winter, this wood will often die back to the main cane. If buds producing the weak vegetative laterals are used and no replacements have developed, the number of fruit spurs the following spring will be decreased.

October-trained rows show more dead cane area at the start of the growing season than canes trained in August, September or February. See Figs. 2 and 3 (p. 22). When the training is delayed until mid-October the canes are quite succulent and little hardening takes place prior to freezing temperatures. Differences in yield between September and October, as shown in Table 2 (p. 17), are not significant; however, yields for these two times of training are significantly lower than February or August. Because of the significantly lower yields from September and October training, the major considerations are comparisons between August and February training.

February and March have been the preferred time for many years to accomplish the trellis training of most caneberries. Sufficient evidence was obtained to establish the fact that the Marion blackberry will produce significantly higher yields when trained immediately after harvest or about mid-August. These data are embodied in Table 2 (p. 17). The difference of 15.39 pounds between August and February training represents .83 tons per acre. Using the conservative figure of 12 cents per pound the August training returned a yearly average of $199.20 more than when training was delayed until February.

The increased yields from August training can best be explained by the greater number of fruit spurs present. When canes are trained in August most of the axillary buds produce a vegetative lateral ranging in length from 2 to 5 feet, as seen in Figs. 8 and 9 (p. 38). If favorable temperature exists, the lateral growth depends largely on the amount of soil moisture available. Fields irrigated before and during harvest may not require additional irrigation after training if the weed growth has been controlled. Supplemental water late in the growing season could be hazardous from the standpoint of preventing cane hardening prior to freezing winter temperatures.

The various pruning and training functions performed in this experiment had a definite effect on the development of lateral branches from the current season's canes. The exact cause of the stimulation of lateral bud development was not explored in this study, but it seems worthwhile to discuss this phenomenon in terms of existing information and theories concerned with auxin control of growth.

Thimann and Skoog (26) clearly demonstrated that the apex is the largest source of auxin for the plant and the removal of the apex results in the loss of apical dominance, thus stimulating development

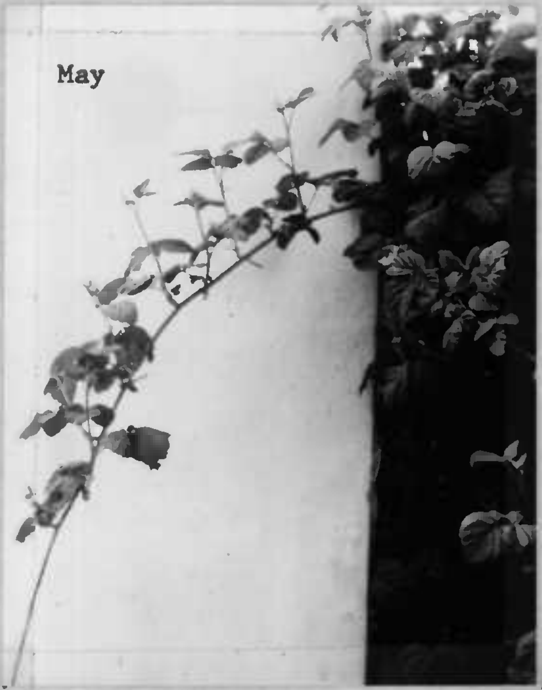

Fig. 8. Marion blackberry. Fruiting spurs on August-trained lateral. Note terminal end of lateral is dead.

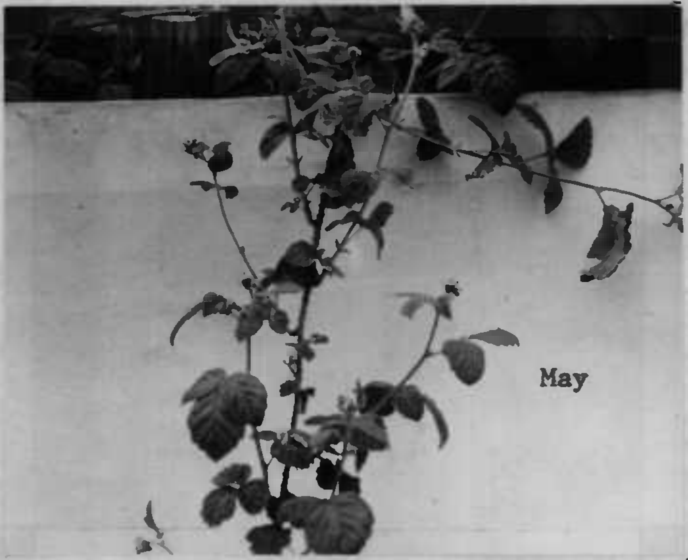

Fig. 9. Marion blackberry. Fruiting spurs on August-trained lateral. Note flower buds on each spur.

of lateral buds. Delisle (6), working with Aster, showed that the production of relatively large amounts of auxin in the apex has been associated with the development of a relatively unbranched plant and, conversely, plants which contain relatively low auxin levels develop a branching habit. The most striking characteristic of auxin movement is its generally strict basipetal polarity. Leopold (14). According to van der Weij (32) and Jacobs (9) this polar transport is most active near stem tips and declines with distance down the plant. In green plants this gradient in polar transport is especially pronounced, giving way in some cases to almost equal transport upward and downward at the base of the stem. Leopold and Guernsey (15). Jacobs (9) found that the age of stems affects their ability to transport auxin. Leopold and Lam (16) also suggest that decreasing activity may be related to increase in age of cells and increasing distances from the growing point. Basipetal polarity in leaves during early growth loses its directional quality as the leaf matures. Mai (18).

Whether the auxin is "free" or in a bound form also has a bearing on transport and effect. Free auxin is capable of moving freely in polar transport and apparently has an immediate effect on growth. Bound auxin can be either active or inactive. Leopold (14). The form in which it is bound, Larsen (13), or whether it may be present in the form of a precursor, Larsen (12), seems to govern the action involved.

The following explanations for the development or lack of development of laterals, depending on time of training or the pruning system used, would seem to be related to the auxin and growth theories cited above.

(1) August-trained canes elevated to the trellis and with terminals removed (short pruning system) produce laterals freely as a result of lower concentrations of auxin.

(2) August-trained canes without terminals removed (long pruning system) and elevated to the trellis position also produce laterals freely. This would correlate with the concept that auxins or growth substances have a strong basal polarity. Inhibiting concentrations would be diminished by a basipetal movement resulting from the method of training.

(3) Canes allowed to remain in the horizontal position at ground level produce laterals slowly. If auxin concentration is diminished by a slow translocation in a basipetal direction, lateral development might be a result of auxin concentration dropping below a certain critical level. Age of cells and tissue and distance would be factors in this situation. Another explanation might be that "free" auxin is converted to the "bound" form as canes mature during fall and winter and therefore loses its inhibiting effects.

(4) Canes allowed to remain at ground level but with terminals removed produce laterals freely. This is explained as a rapid removal of the influence of inhibiting substances present in the terminal area of the canes.

The fact that laterals do develop soon after August training insures growth mature enough that certain buds will differentiate into buds possessing floral capabilities. Figs. 8 and 9 (p. 38) and Fig. 10 (p. 41) show fruiting spurs with flower buds on laterals from

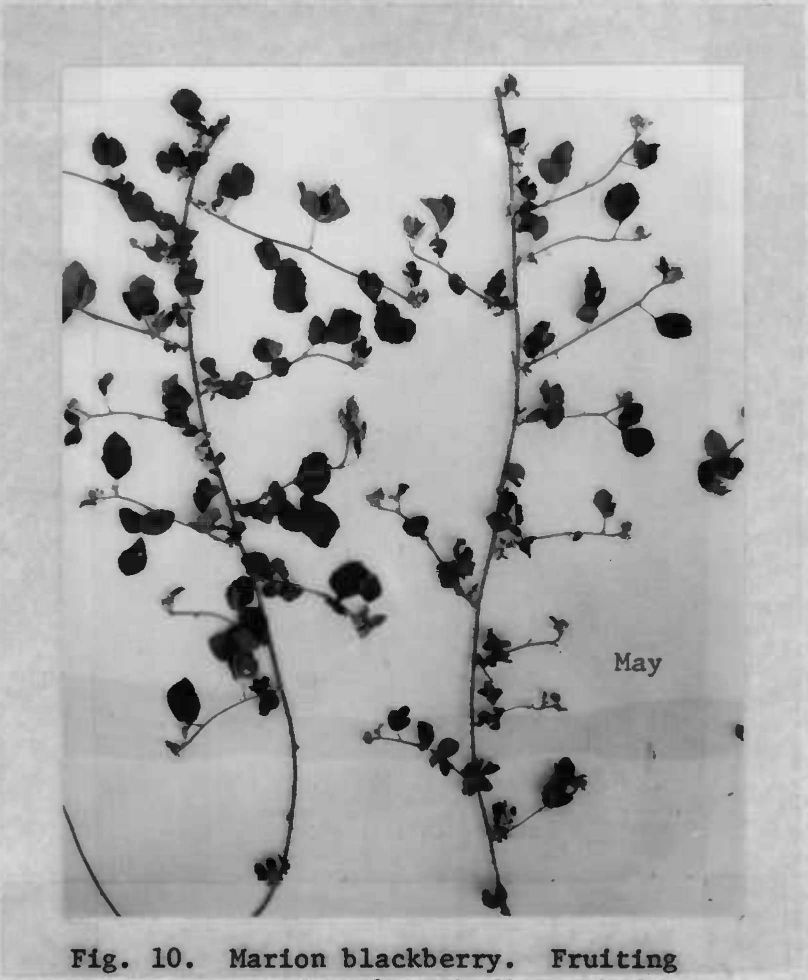

Fig. 10. Marion blackberry. Fruiting spurs each with flower buds on August-trained lateral. Note terminal end on left is dead.

August-trained canes. Note the terminal end of the lateral is dead. This is one reason why the sides of the rows can be trimmed leaving the laterals stubbed to a length of 12 to 15 inches, which include four to six buds.

Table 6 (p. 28) shows the difference in number of fruit spurs and flower buds per foot of row between August and February training. The number of fruit spurs per foot of row was in direct proportion to plant spacing regardless of the date trained. When all spacings were averaged, August training increased fruit spur production by 29 per cent over February training. This increase in number of fruit spurs is clearly shown in Figs. 11 and 12 (p. 43). Plant spacing or time of training had little effect on the number of flower buds per fruit spur.

It has been observed that individual fruit spurs on February-trained canes are longer than those on August-trained canes. This observation was substantiated by actual measurements of individual fruit spurs. Table 6 (p. 28) indicates that the average length of fruit spurs for all plant spacings was nearly 3 inches or 21 per cent longer on February-trained canes. This difference can also be seen by comparing Figs. 11 and 12 (p. 43).

The number of flower buds per fruit spur was only slightly more on February-trained canes. Although plant spacing had little effect on number of flower buds per fruit spur, the 10-foot spacing on both training dates showed a slight increase over closer spacings.

Regarding nitrogen and carbohydrate content of leaves, direct comparison of the data in Table 8 (p. 33) between trellis and ground-level training is difficult for two reasons: (1) the lack of

Fig. 11. Marion blackberry. Trained August 15. Note greater number and shorter length of fruit spurs.

Fig. 12. Marion blackberry. Trained February 15. Note long fruit spurs.

August training on left, September on right

Fig. 13. Marion blackberry.
Plant spacing 2.5 feet.

Fig. 14. Marion blackberry.
Plant spacing 5 feet.

Fig. 15. Marion blackberry.
Plant spacing 10 feet.

replication and (2) the different location of the leaves at sampling time. On November 1, the date of sampling, the canes trained to the trellis in August had produced many vegetative laterals while the canes remaining on the ground had relatively few laterals. Since the leaves from the "main cane" position on the trellis-level training were collected from the entire length of the cane, only these figures could be compared with the "average" figures of the basal, mid-section and terminal areas of the ground-level canes. This comparison reveals that the percentage of nitrogen at all three plant spacings is lower in the trellis-trained leaves. The carbohydrate content and C:N ratio were more variable.

The higher levels of nitrogen at the 5-foot plant spacing over the 2.5-foot spacing may be a reflection of less competition for available soil nitrogen. However, this reasoning does not hold true when 5- and 10-foot spacings are compared. All treatments received the same fertilizer. In general, newest leaves contained more nitrogen. Also, the most juvenile leaves had the lowest C:N ratio.

The carbohydrate content of trellis-trained leaves had a tendency to increase as the distance between plants increased. Carbohydrate content of ground-level leaves did not show a similar relationship. With one exception, the trellis-trained leaves had a higher carbohydrate content than those from canes trained on the ground. This may have been due to the fact that trellis training would give greater exposure to light. Leaves on canes at ground level often shade themselves or are shaded by weed growth.

Slightly more than half of the total buds on the laterals on August-trained canes possessed flower structures, although the percentage differs within certain areas of the lateral. It was found that the terminal 12 inches of the lateral contained 40 per cent more fruit buds than the basal 12 inches. Also, the 12- to 24-inch area, measuring from the basal end of the lateral, had 60 per cent more fruit buds than the 0-12-inch area. These figures, computed from data shown in Table 5 (p. 26), would indicate that trimming of the laterals at certain lengths could definitely affect the number of remaining fruit spurs.

Tests were run concurrently with this study comparing trimming of the laterals on the sides of the row to approximately 12 inches from the trellis wire to weaving the full-length lateral among the canes. It was found that the weaving operation was very time-consuming, hence expensive. There was essentially no difference in the amount of fruit produced. When the long laterals were trained (woven), many more berries developed within the cane area, making the picking more difficult. The trimming or pruning of the laterals resulted in less dense vegetation, thus permitting better coverage during application of certain pesticides. The side trimming of the laterals can be easily and inexpensively accomplished with either a vertically operated sickle bar or a rotary cutting device turned edgewise.

The number of trifoliate leaves was estimated on August- and October-trained canes on October 26, 1965. As mentioned elsewhere in this text, there is essentially no further elongation of canes or laterals after this date; therefore it was assumed that the estimates on the October-trained rows would be somewhat comparable to the number of leaves on the Feburary-trained canes still on the ground. August training increased the leaf number approximately tenfold. With August training, the 2.5-foot spacing had nearly 51 per cent more leaves per foot of row than the 5-foot spacing. The 5-foot spacing had only an 18 per cent increase over 10-foot spacing. October-trained rows had essentially the same number of leaves at all plant spacings.

Actual leaf counts were made November 1, 1966, on August-trained (trellis-level) canes and canes to be trained in February (ground-level). These counts showed a 97 per cent increase at the 2.5- and 5-foot spacings in favor of August training, while only a 50 per cent increase was obtained at the 10-foot spacing. With August training, the number of leaves per foot of row increased as the number of plants per row increased. Where canes were still on the ground, plant spacing had little effect on number of leaves per foot of row, as seen in Table 7 (p. 29). The increase in number of leaves on August-trained canes is associated with the development of lateral growth. It is interesting to note that the difference of 52 leaves per foot of row between 5- and 10-foot spacing on trellis-trained canes is the only comparison that corresponds to a significant difference in yield (4-year average).

To establish the fact that the increased yields obtained from August training might be related to differences in leaf area, leaf size was measured on a dry weight basis. It was found that the smallest leaves occurred on August-trained canes at the 2.5-foot spacing; however because of the greater number of leaves at this training date and plant spacing, the amount of leaf material on a dry weight basis per foot of row was greater than the other plant spacings. The largest leaves and greatest amount of leaf material per foot of row were found on the 5-foot spacing of ground-level training, although the yield was considerably less than the same spacing on trellis-level training.

In observing bud development, a different pattern was seen depending on whether the canes were trellis-trained or on the ground. On canes trellis-trained on August 15, definite floral structure was observed only in buds from the terminal cane area and not before November 15. In contrast, basal and mid-section areas of canes at ground level possessed definite floral structure by November 1, while buds from the terminal cane area were still elongating on November 15. This 2-week differential may in some way be associated with the earlier emergence of bud growth and subsequent earlier blooming of mid-February-trained canes. It has been observed that buds on canes trained in late winter start growth from 10 to 14 days sooner in the spring than buds on summer- and fall-trained canes.

SUMMARY

Yield Related to Spacing

Yield of the Marion blackberry varies with plant population (spacing). When yields for the 4-year period (1962-1965) in this study are combined for all times of training and for the long and short pruning methods used, differences between 2.5-, 5- and 10-foot plant spacings are highly significant.

Average seasonal mean yields for the 4-year period were not significantly different between the 2.5- and 5-foot spacings, regardless of differences in training dates.

Yield differences between 5- and 10-foot spacings were highly significant in comparisons of August and October training and significant at the 5 per cent level for September training. February training at 5- and 10-foot spacings did not produce significant differences.

Increased yields from close spacings were greater for the first 2 years of production.

Yield Related to Pruning and Training

In eight of 12 comparisons the long pruning system produced the highest yield. The yield differences between long and short pruning systems, however, were not significant (with one exception).

Highly significant differences in yield were obtained when mid-August training at the 2.5- and 5-foot plant spacings was compared with the three other training periods.

Comparisons of yield for August and February at the 10-foot spacing showed no significant difference. Data indicated that, if training is not accomplished within a month following harvest, it would be more advantageous as regards to yield to delay training until mid-February.

Training and Labor Requirements

Study shows that less time and labor were required to train canes to the trellis in August, regardless of spacing involved.

Training in October required the most time.

The long pruning method required more time than the short method.

Floral Development Related to Time of Training

Both time and pattern of flower bud formation were affected by time of training. Floral structures discernible by a broadening of the bud apex and the formation of a calyx were observed in buds sampled November 15 from the terminal area of August-trained canes.

Canes trained at ground level in August produced buds containing a discernible calyx by November 15, but only in buds on the basal and mid-section areas of the canes.

Fifty-seven per cent of the total number of buds on laterals of August-trained canes produced flowers. The average length of laterals was 39 inches, with buds 2.5 inches apart. Seventy-five per cent of the buds in the middle 13 inches of the lateral were floral buds.

August- and February-trained canes produced similar numbers (8.5-8.9) of flower buds per fruit spur. Fruit spurs of August-trained canes were 3 inches shorter than February-trained canes but produced approximately nine more fruit spurs per foot of row.

Leaf Development Related to Spacing and Time of Training

Number and size of leaves were affected by both spacing and training.

Canes trained to the trellis in mid-August produced considerably more trifoliate leaves per foot of row by November 1 than canes that remained on the ground.

Canes trained at trellis level produced 240, 204 and 152 trifoliate leaves at 2.5-, 5- and 10-foot spacings, respectively. spacing had no effect on leaf number of canes trained at ground level.

Leaves from canes at ground level were nearly twice as large as leaves from trellis-trained canes.

Leaves of smallest size were produced at the 2.5-foot spacing.

Nitrogen and Carbohydrate Content of Leaves

Leaves sampled November 1 from terminal areas of canes were higher in nitrogen than older basal leaves. Comparable leaves from August trellis-trained canes sampled in November had a higher nitrogen content than leaves sampled at the same time from ground-level training.

Carbohydrate levels of leaves were quite variable and ranged between 4.164 and 6.588 per cent.

Oldest leaves had the highest C:N ratio and youngest leaves had the lowest C:N ratio.

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