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Strawberry Runnering and Leaf Size Depend on Plant Spacing

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Abstract

The efforts of plant spacings on runner production and leaf size were examined for 'Rainier,' 'Shuksan,' 'Sumas' and 'Totem' strawberry cultivars grown as ribbon rows in a commercial planting. The largest contribution to variation in total runner number in order of importance were the main effects of year, cultivar and spacing. For leaf size the major contributors, in descending order of importance, were the interactions of cultivar by spacing, the three-factor interaction, year by cultivar and year by spacing. Both runner production and leaf size decreased as the spacings became more dense.

Introduction

The ribbon row system shows promise in British Columbia to extend the harvest season and meet an increasing demand for fresh strawberries (1, 15). The ribbon row is a raised bed system that uses a plastic mulch and trickle irrigation. This system is planted at higher densities than the matted row system. With closer plant spacing, harvest is possible approximately 6 to 8 weeks after planting, resulting in a quicker return on investment when compared to the matted row system. The harvest season can be extended by sequential plantings (1).

There are many other advantages of the ribbon row system. Plants in raised beds have a more efficient plant canopy and earlier yields (8). Raised beds also improve drainage and decrease soil compaction (9). Plastic mulch on raised beds increases fruit size and yield, enhance earliness and fruit quality (2), reduces fruit rot, and increases fruit visibility (20). Berry yields were increased with plastic mulch and trickle irrigation (2).

Cultivars selected on the basis of performance in matted rows (12) differ in their suitability for ribbon rows (10). Specific cultivars for ribbon rows should be selected for their yield and growth habit (9, 22). In ribbon rows the runners are removed to favor growth of the mother plant and to encourage formation of branch crowns (14). The choice of a cultivar with few runners would decrease the expense of their removal. Runner production per plant decreases with closer spacings (6) and in plantings harvested in the year of planting (11). Plastic mulch (16), mowing after harvest (3), and runner removal (Baumann, unpublished) increase runner production.

Leaf areas per plant and per crown and leaf area index are greater in ribbon rows than in matted rows (8, 19). Leaf area influences yield through association with several yield components such as size and number of fruits per truss (13). Leaf area per plant and crowns per plant increased at wider spacings although leaves per crown did not (6, 7). The denser canopy of closely spaced plants caused an increase in culls and made harvesting more difficult (7). Vigorous and leafy cultivars may become too shaded (22) and large leaves are not necessarily associated with high yields (6). Plants harvested in the year of planting have smaller leaves before harvest compared to non-fruiting plants (11) but after harvest leaf size becomes equal (4).

The objective of the present study was to compare the effects of spacings within the row upon runner production and estimated leaf size of four strawberry cultivars commonly grown in the Pacific Northwest. The question of yields has been addressed in a companion paper (15).

Materials and Methods

A factorial experiment was used with four cultivars and four spacings in each of five randomized complete blocks. The two years were analyzed as a sub-plot effect in a split-plot design after a preliminary covariance analysis detected no residual regression of the second year data upon the first (18). In July 1987, cold-stored runner plants of 'Rainier,' 'Shuksan,' 'Sumas' and 'Totem' were planted as ribbon rows. The spacing between the rows was 107 cm (42 inches). The spacings within the rows were 7, 12, 19 or 32 cm for which the corresponding densities were 133,912, 78,155, 49,336 or 29,293 plants per hectare. There were twelve plants per plot including two guard plants. The beds were mulched with plastic and irrigated with a trickle system. Runners were removed to favor growth of the mother plant and to encourage branch crowns. Data on leaf size and runner numbers were collected during the planting year and again in 1988.

In 1987, few runners had been produced by the end of the growing season when a runner count was recorded. In 1988 two runner counts were taken. In each year, the total number of runners was recorded for two randomly chosen plants per plot. The number of runners was transformed to an average number of runners per square meter.

The area of a compound leaf can be estimated from measurements of length and width in ginseng (17) and strawberry (5, 21). In a preliminary calibration study, regression equations relating leaflet area to leaflet length and width (Table 1) for each cultivar were developed. Known areas of paper as well as leaf tracings were weighed to calibrate the regression equations.

In the main study, as in the calibration, each leaflet was measured separately and the area of the trifoliate leaf was taken as the sum of its three parts. The data are presented as leaf sizes rather than areas since they could not be expressed on a per plant basis. The measurements were made on two trifoliate leaves per plant in 1987 and on one trifoliate leaf per plant in 1988. Determinations were carried out on two randomly chosen plants in each plot in each year.

Results and Discussion

The main effects of year, cultivar, and spacing accounted for most of the total variation in runner number per square meter (Table 2). The interactions were less important. Thus, cultivar by spacing, year by cultivar, and year by spacing made statistically significant but relatively minor contributions.

There were more runners in the first year of the planting than in the second (Table 4). The year differences accounted for 21% of the total variation (Table 2). Cultivar differences accounted for 17% and most (15%) of this variation arose from the greater runner numbers in 'Shuksan' than in 'Rainier' while less variation (1%) was due to the greater runner numbers of 'Totem' compared to 'Sumas' (Table 3).

Runner numbers per square meter generally increased in a simple linear fashion with closer spacings (Table 3). This finding suggests that there was little or no effect of crowding upon runner production at the closest spacing used and the cultivars were fairly consistent in their response.

Table 1. Regression equations and R-squared values for trifoliate leaf size calculations.

Cultivar	Regression equation[z]	R-squared (%)[y]
Rainier	9.34 + (0.61 × L × W)	41.0
Shuksan	-2.15 + (0.78 × L × W)	88.2
Sumas	9.49 + (0.70 × L × W)	76.0
Totem	14.71 + (0.60 × L × W)	63.4

[z]L and W were the length and width of a single leaflet; the size of the trifoliate leaf was the sum of three computed values.
[y]R-squared values required for significance at the 5% and 1% levels were 33.1% and 50.1% respectively.

The cultivar differences were not entirely consistant in the two years of the study. Years by cultivar accounted for 4% of the total variation (Table 2). This was partly (2% of total variation) due to larger differences in 1987 than in 1988 between the two cultivar groups (Table 4). There was a further yearly inconsistency (2% of variation) as 'Totem' had more runners than 'Sumas' in 1987 but not in 1988 (Table 4).

Leaf size was influenced by the two-factor interactions (Table 2) cultivar by spacing (21% of the total variation), year by cultivar (18%) and year by spacing (9%) and the three-factor interaction, year by cultivar by spacing (19%). The main linear effect of spacing also accounted for 7% of the total sum of squares.

Generally leaves were smaller as plants were planted closer together. Close spacings caused a greater de-

Table 2. Analysis of variance for leaf size and runner number in a strawberry plant spacing trial.

Source of variation	df	Sum of squares: Leaf size	Sum of squares: Runners
Total	159	100[z]	100[z]
Block	4	1 ns	2 ns
Cultivar	(3)	(4 ***)	(17 ***)
Rain, Shu/Sum, Tot[y]	1	0 ns	1 ns
Rain/Shu	1	3 ***	15 ***
Sum/Tot	1	1 **	1 *
Spacing	(3)	(9 ***)	(11 ***)
Linear density (log)	1	7 ***	11 ***
Quadratic density (log)	1	1 **	0 ns
Deviation	1	0 ns	0 ns
Cultivar × spacing	(9)	(21 ***)	(5 *)
Rain, Shu/Sum, Tot × linear	1	5 ***	0 ns
Rain/Shu × linear	1	8 ***	4 ***
Sum/Tot × linear	1	0 ns	0 ns
Rain, Shu/Sum, Tot × quadratic	1	2 ***	0 ns
Rain/Shu × quadratic	1	5 ***	0 ns
Sum/Tot × quadratic	1	0 ns	1 ns
Rain, Shu/Sum Tot × deviation	1	0 ns	0 ns
Rain/Shu × deviation	1	1 *	0 ns
Sum/Tot × deviation	1	0 ns	1 ns
Error (a)	60	7 ns	17 ns
Year	1	5 ***	21 ***
Year × cultivar	(3)	(18 ***)	(4 **)
Y × Rain, Shu/Sum, Tot	1	12 ***	2 *
Y × Rain/Shu	1	4 ***	1 ns
Y × Sum/Tot	1	2 ***	2 *
Year × Spacing	(3)	(9 ***)	(3 *)
Y × Linear	1	6 ***	2 **
Y × Quadratic	1	3 ***	1 ns
Y × Deviation	1	0 ns	0 ns
Year × Cultivar × Spacing	9	19 ***	2 ns
Error	64	7	18

[z]The total sums of squares were 1,257,400 and 75,316 for leaf size and runner number respectively.
[y]Rainier, Shuksan, Sumas, Totem.
*, **, *** — statistical significance at 0.05, 0.01 and 0.001 levels.

Table 3. Calculated means of average trifoliate leaf size and runner number for cultivar and spacings.

Culivar	Spacing (cm)	Leaf size (cm^2)	Runner number (per m^2)
Rainier	7	123	25
Rainier	12	139	25
Rainier	19	150	28
Rainier	32	146	21
Shuksan	7	119	65
Shuksan	12	117	56
Shuksan	19	141	40
Shuksan	32	344	32
Sumas	7	169	40
Sumas	12	194	29
Sumas	19	183	28
Sumas	32	187	21
Totem	7	156	43
Totem	12	161	47
Totem	19	159	33
Totem	32	162	23
Contrasts			
Rain, Shu/Sum, Tot[z] × Linear		°°°	ns
Rain/Shu × Linear		°°°	°°°
Sum/Tot × Linear		ns	ns
Rain, Shu/Sum, Tot × Quadratic		°°°	ns
Rain/Shu × Quadratic		°°°	ns
Sum/Tot × Quadratic		ns	ns
Rain, Shu/Sum, Tot × Deviation		ns	ns
Rain/Shu × Deviation		°	ns
Sum/Tot × Deviation		ns	ns

[z]Rainier, Shuksan, Sumas, Totem.
°, °°° — statistically significant at 0.05, and 0.001 respectively.

crease in leaf size in 'Rainier' and 'Shuksan,' than in 'Sumas' and 'Totem' (Table 3). In 1987 'Rainier' and 'Shuksan' had larger leaves than 'Sumas' and 'Totem' while the reverse was true in 1988 (Table 4). While the leaf sizes are averages for plants grown at different spacings, there generally would have been more crowding in the second year.

The year by spacing interaction indicated that while leaf size was inhibited at closer spacings in both years, the effect was greatest in the first year (Table 5). The larger leaves in the second year were less sensitive to crowding than were the generally smaller leaves of the first year. The largest leaves however were those of the first year at the widest spacing (Table 5).

In summary, runner numbers generally increased at closer spacings indicating little or no crowding effects. However, runner numbers decreased in the second year and differences were found among cultivars. Leaf size generally decreased at closer spacings and differences among cultivars were prevalent. Although there are possible effects due to crowding, the greatest yields of marketable fruit were obtained at the closest spacings (15).

Table 4. Calculated means of average trifoliate leaf size and runner number for years and cultivar.

Year	Cultivar	Leaf size (cm²)	Runner number (per m²)
1987	Rainier	126	34
1987	Shuksan	215	64
1987	Sumas	113	32
1987	Totem	127	48
1988	Rainier	153	15
1988	Shuksan	146	33
1988	Sumas	254	26
1988	Totem	192	26
Contrasts			
Year × Rain, Shu/Sum, Tot[z]		°°°	°
Year × Rain/Shu		°°°	ns
Year × Sum/Tot		°°°	°

[z]Rainier, Shuksan, Sumas, Totem.
°, °°° — statistically significant at 0.05, and 0.001 respectively.

Table 5. Calculated means of average trifoliate leaf size and runner number for year and spacings.

Year	Spacing (cm)	Leaf size (cm²)	Runner number (per m²)
1987	7	105	55
1987	12	113	53
1987	19	126	42
1987	32	236	29
1988	7	178	31
1988	12	192	25
1988	19	191	23
1988	32	184	20
Contrasts			
Year × Linear (log)		°°°	°°
Year × Quadratic (log)		°°°	ns
Year × Cubic (log)		ns	ns

°, °°° — statistically significant at 0.01, and 0.001 respectively.

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Book Review

Geschichte der Pomologie in Europa (History of Pomology in Europe) by Silvio Martini, Bern, Switzerland. Printer: Stutz & Co. AG, 8820 Waedenswil, Switzerland 1988; 184 p. in German, ISBN 3-85928-0163.

The book consists of 4 chapters. The first covers fruit production during the "father of agriculture time" from ancient Greece and Rome, and the Middle Ages to the Renaissance. The influence of men such as Theophrastus, Cato, Plinius and others is described. The second, dealing with the "forerunners of pomology," contains 21 biographical sketches of persons who lived in Europe between 1550 and 1750. The third reviews the "founders of pomology as a science." Two men were singled out, J. H. Knoop, the first real pomologist, and H. L. Duhamel du Monceau, the promoter of fruit growing and pomology. It also has a graphical scheme of the "Genealogy of Pomology." The fourth chapter gives short biographical sketches of about 100 pomologists in 25 European countries and the fruit crops on which they worked.

According to the author, this is the first book written on the history of European pomology. Material is mainly on fruit breeding and cultivar introductions. The book fails to mention the famous pomology research stations in England (the Long Ashton Research Station and the East Malling Research Station), and the research station and horticultural school at Versailles in France, where a significant amount of important fruit growing and pomological work was done. Also omitted are references to studies on pruning methods and tree forms, orchard systems, plant nutrition and analysis, plant growth regulators, rootstock-scion relationships, rootstock breeding and evaluation, and yield prediction. All of these are important areas of pomological research leading to current fruit growing and production technology. Further, many leading European pomologists are not included.

The book would be of value to one interested in those individuals who worked in the furtherance of European pomology. However, it is not a complete history, being limited mainly to fruit breeding and cultivar introductions.

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