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Effect of Plant Spacing on Strawberry Yield in Two Cultural Systems[1]

J. B. MASIUNAS,[2] S. C. WELLER,[3] R. A. HAYDEN,[4] AND J. JANICK[4]

Abstract

The effects of mother plant spacing of 'Redchief' strawberry on yield were evaluated with two cultural systems: runnerless and matted row. In both systems, the plots with narrowest between-row spacings (30 cm for runnerless rows and 45 cm for matted rows) had the greatest yields per unit area. Decreased within-row spacing decreased berry weight and number per plant but did not affect yield per unit area. Because of high plant cost for the runnerless row system, the matted row system was clearly superior for 'Redchief' in our trials.

Introduction

Midwestern strawberries are commonly grown in matted rows on flat beds with 0.9 to 1.0 m between rows and 30 to 45 cm row widths (23). Runnering during the growing season fills in the row with plants. Runnerless systems are being tested in the Midwest using raised beds. These systems, also called ribbon or narrow rows, are modifications of the "hill system" used

[1]Received for publication August 6, 1990, Purdue Agr. Expt. Sta. Journal Series No. 12,322.
[2]Assistant Professor, Dept. of Hort., Univ. of Illinois, 1103 W. Dorner Dr., Urbana, IL 61801
[3]Associate Professor, Dept. of Hort., Purdue Univ., W. Lafayette, IN 47907.
[4]Professor, Dept. of Hort., Purdue Univ., W. Lafayette, IN 47907.

in California and Florida. Runnerless systems are commonly spaced 70 to 90 cm between rows and 7.5 to 15 cm within rows requiring 74- to 190-thousand plants ha^{-1} (21, 23).

Culture system success is dependent upon location and cultivar adaptability. Matted rows are less costly to establish, and have greater plant survival under stress than runnerless rows (19). Runnerless plants are easier to pick, have fewer disease problems, and some berries can be harvested the year of planting (12, 14, 21), although first year fruit in the Midwest is often poor in quality and matures after the normal strawberry harvest has ended (24). The biggest disadvantages of runnerless rows are their greater establishment costs and greater plant losses if winter temperatures are lethal (19). Runnerless rows may offer some advantages in geographical areas where matted rows are difficult to establish (9). In North Carolina, matted rows often produce weak plant stands leading to reduced yields and a shorter life of the planting due to competition from weeds and increased disease susceptibility (19). In Michigan (10), matted rows were more productive and had larger fruit than runnerless rows of 'Midway' and 'Guardian.' However, in a New Hampshire study with 12 cultivars, yields per unit area were similar in both systems (13).

Mother plant spacing can influence yield in various ways: by affecting the number of early rooted runner plants in matted row systems (19, 20), and by affecting final plant density and/or the number of row edges per acre (17, 22). Plants on the edge of 0.6 m wide rows of 'Surecrop' and 'Redcoat' yielded about 50% more berries than plants in the center of the row (22). Narrow matted rows, which eliminate the less productive centers, have a higher leaf area index than wide matted rows, indicating that plants are more efficiently intercepting available sunlight (23).

The optimal plant spacing in matted rows varies depending on the vigor of the cultivar. Craig et al. (4) reported increased yields from vigorous cultivars in matted rows with a combination of thinning and narrower rows. High mother plant population resulted in increased yields of a poor runner producer, 'A-5344,' but did not increase yields of 'Cardinal,' a prolific runner producer (18).

Although research in the Midwest indicates the greater adaptability of the matted row system (6), interest in the runnerless system persists. Since the optimal spacing remains to be established for each system, our objective was to determine the optimum mother plant spacings within and between rows for 'Redchief,' a popular midseason cultivar in Indiana and Illinois, grown in runnerless and matted rows.

Materials and Methods

The study was conducted at two locations in Indiana: the Purdue Horticultural Farm in West Lafayette and the Southwestern Purdue Agricultural Center in Vincennes. The soil at Lafayette was a Brookston silt loam (pH 5.5 and organic matter 2.2%) and the soil at Vincennes was a Princeton loamy fine sand (pH 5.5 and organic matter 0.8%). In April 1985, two experiments were established side by side at each location. An experiment consisted of various between row and within row plant spacings in either a matted or runnerless row system. Raised beds were not used since drainage was not a problem (7). Each experiment was a complete factorial using a randomized complete block design with 4 replications. Each plot consisted of three rows 3 m in length with data collected only from the center row.

Between-row spacing consisted of 30, 45, 60, 75 or 90 cm for the runnerless row system and 45, 60, 75 or 90 cm for the matted row system. Within-row spacings were 7.5 and 15 cm for runnerless rows and 15, 30, 45, and 60 cm for matted rows. In the matted row system, runnering was undisturbed but the bed width was maintained at 39 cm for all treatments. In the runnerless system, runners were periodically removed manually to maintain a single row of mother plants.

The strawberries were irrigated as needed throughout the experiment. Fertilizer and pesticides were applied according to standard midwestern practices. DCPA at 11 kg ha^{-1} was applied immediately after planting, and diphenamid at 4.4 kg ha^{-1} was applied approximately 6 weeks later. Plots were also hand-weeded to remove emerged weeds. The strawberries were covered with straw mulch for winter protection in late November, and the mulch removed when growth began in the spring. Over-head sprinkler irrigation was used for frost protection.

Strawberries were harvested approximately every two days for three weeks beginning on May 15, 1986 at Vincennes and May 30 at Lafayette. In 1987, the harvest began May 21 at both Vincennes and Lafayette. The number of berries and weight per berry was determined for each plot by sampling. Yields were summed by week, to give early (week 1), intermediate (week 2), or late (week 3) yield.

After the final harvest in 1986, the plots were renovated using standard practices. The matted row plots were narrowed to a 7.5 cm strip of plants. Both the runnerless and matted row plots were mowed and terbacil at 0.56 kg ha^{-1} applied. In the runnerless row system, runners were removed as the plants regrew. In the matted row system, runner plants were allowed to regrow and establish 39 cm wide beds. At Vincennes in 1987, a significant number of plants were winter-killed in the matted row system, so it was not harvested.

The results were analyzed using analysis of variance and regression procedures. When there were no significant interactions with location or year, regression analyses used averages.

Results and Discussion

In matted rows, the greatest total yields were in the narrowest between row spacing (45 cm). As the spacing between-row centers increased, yield per unit area decreased linearly (Fig. 1). Yields were similar for early (week 1) and intermediate (week 2) harvests, and these were always greater than the late harvest (data not shown). The total numbers of berries harvested per hectare decreased as between-row spacing increased. There was a quadratic relationship between the number of strawberries per hectare and between-row spacing (Fig. 1). The greatest rate of reduction in number of berries per hectare occurred when between-row spacings increased from 75 to 90 cm.

There was no effect of within-row spacings of mother plants on yield per hectare in matted rows (data not shown). This is probably due to the prolific number of early runner plants produced; thus, the initial within-row

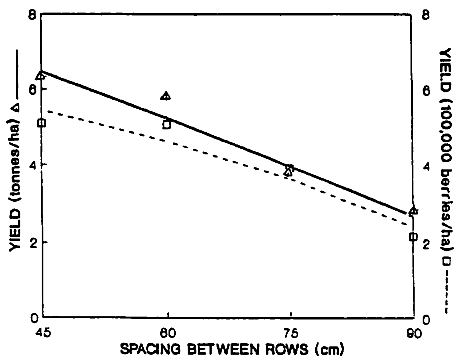

Figure 1. The effect of spacing between matted rows on total strawberry yields. Yields are the average of 1986 and 1987 results at Lafayette. Strawberry yields are expressed either in t ha^{-1} or number of berries ha^{-1}. The regression equations are $Y = 10{,}300 - 84.6X$ (t ha^{-1}) or $Y = 646 - 0.05X^2$ (number of berries ha^{-1}). The regression coefficients are 0.82* and 0.62**, respectively.**

spacing did not affect the total number of early rooted runner plants. Among plants in the matted row, early established runner plants are the greatest contributors to yield (5). The lack of an effect from within-row spacing differs from results in Nova Scotia (2) where 45 cm spacing within the row was not close enough to give maximum yields; the discrepancy in results may be accounted for by differences in cultivar and growing season.

Although yields of runnerless rows in 1987 were twice those in 1986, there was no interaction between year or harvest period within year and plant spacing. Therefore, results were averaged over both years, and only the results for total harvest are discussed. The narrowest spacing between-row centers (30 cm) had the greatest yields; yield per hectare decreased quadratically with increasing spacing between-row centers (Fig. 2). Yield decreased approximately 2.8 t ha^{-1} as between-row spacing increased from 30 to 60 cm, and decreased approximately 2.0 t ha^{-1} as between-row spacing increased from 60 to 90 cm (Table 1, Fig. 2). Berry size was unaffected by between-row or within-row spacing. Yields in t ha^{-1} were similar in matted and runnerless row experiments at the same

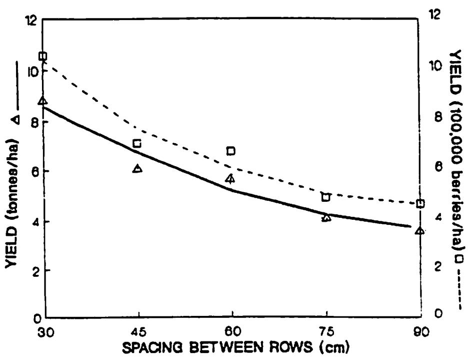

Figure 2. The effect of spacing between runnerless rows on yield. The yield is averaged over locations and years. The regression equations are $Y = 14{,}200 - 221X + 1.15X^2$($t\ ha^{-1}$) and $Y = 1740 - 28.5X + 0.16X^2$ (number of berries ha^{-1}). The regression coefficients are 0.94* and 0.91**, respectively.**

Table 1. The effect of spacing, either between rows or between plants within the row, on the yield per strawberry plant in a runnerless row system. The results are averaged over locations (Vincennes and Lafayette) and years.

Within row spacing (cm)	Berry yield per plant and per hectare					
	Between row spacing					
	30 cm	45 cm	60 cm	75 cm	90 cm	LSD 5%
	g plant^{-1}					
7.5	21[a]	21	28	26	24	4.0
15.0	40	43	46	43	52	
	No. berries plant^{-1}					
7.5	2.5[b]	2.3	3.4	3.1	3.0	0.6
15.0	4.8	5.2	5.7	5.2	7.1	
	g berry^{-1}					
7.5	8.4	9.1	8.2	8.4	8.0	0.9
15.0	8.3	8.3	8.1	8.3	7.3	
	t ha^{-1}					
7.5	9.3	6.2	6.2	4.6	3.6	0.4
15.0	8.9	6.4	5.1	3.8	3.9	

[a]The interaction of between and within row spacings on strawberry yield per plant is predicted by the regression equation: Yield per plant (g $plant^{-1}$) = 297 + 2.14 (within row spacing) + 0.011 (between row spacing) (within row spacing); r^2 = 0.96***.

[b]The interaction of between and within row spacings on the number strawberries per plant is predicted by the regression equation: Berries $plant^{-1}$ = 0.18 + 0.24 (within row spacing) + 0.0092 (within row spacing) (between row spacing), r^2 = 0.92***.

between-row spacing. For example, with 45 cm between-row spacing the yield in matted and runnerless rows were both about 6.3 t ha^{-1} (Fig. 1 and 2).

When the results for the runnerless rows were expressed on a per plant basis, there was a significant interaction of between and within row spacing (Table 1). The highest number of berries and the highest yield per mother plant occurred in the widest spacings (15 cm within-rows and 90 cm between-rows), but the yield and number of berries per hectare were lowest at this spacing. For example, in runnerless rows at 30 cm between-row spacing, yield was 9.1 t ha^{-1} and 40 g $plant^{-1}$, while for the 90 cm spacing the yield was 3.7 t ha^{-1} and 50 g $plant^{-1}$. These results are similar to those reported for 'Midway' and 'Guardian' (8, 11). According to Hesketh et al. (15), the higher number of berries per mother plant at wider between plant spacings is due to increased production of trusses and flowers but this did not compensate for reduced plant populations per hectare.

In deciding which cultural system or plant spacing to use, increased yield with close between-row spacings must be balanced against the higher plant costs. In the runnerless rows, the maximum yield (9.3 t ha^{-1}) was with the 30 cm between-row spacing. With this spacing 222,000 plants would be required even with the 15 cm within row spacing. The costs for plants, planting, and runner removal would be approximately $35,000, an investment of $3.75 kg^{-1} of strawberries. In the matted row cultural system the maximum yield (6.5 t ha^{-1}) was with the 45 cm between-row spacing. The costs for plants and planting would be less than $3,000 or $.50 kg^{-1} of strawberries. In the runnerless system, the large numbers of mother plants required for the close between-row spacings needed for maximum yields make it uneconomical. In the matted row, close between-row spacings can be obtained without large increases in plant numbers by using wider within-row spacing, and allowing runner plants to fill in the bed (16).

In conclusion, the matted row system was clearly superior to the runnerless row system for 'Redchief' in our trials, and would probably be superior for other prolific runner producers grown in the North Central Region of the U.S. The runnerless row system is uneconomical principally because of higher plant costs for establishment. Better distribution of plants in the matted row system through increased within-row spacing and decreased between-row spacing should increase profitability.

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Stone Fruit Cultivars and Breeding in Hungary

Z. SZABÓ,[1] F. NYUJTÓ,[2] J. APOSTOL,[3] AND E. APOSTOL[4]

Abstract

Selection of stone fruits has a long tradition in Hungary. The proportion of Hungarian cultivars is high among cherries and apricots. The local selection and controlled hybridization of sweet cherry, tart cherry and apricot have improved dramatically the cultivar choice for the last two decades. The wide choice of Hungarian local cultivars and hybrids is a considerable source of breeding not only in Hungary but in other countries as well. The characteristics of the best selections are summarized.

Testing and evaluating of foreign peaches, nectarines and plums is necessary. Starting of their controlled hybridization is important in order to realize cultivars most adaptable to the Hungarian environmental conditions and most suitable to the market.

Introduction

Prior to the 1970's, Hungarian fruit cultivars had changed little from earlier times. Important reasons for this were as follows: fruit research was not well financed, cultivar evaluation was restricted and not well organized, state farms and cooperatives were not interested in changing cultivars, home gardeners did not have access to enough information, fruit markets were conservative and lacked adequate grade standards.

These factors resulted in reliance on outdated fruit cultivars which had already disappeared from the Western-European and American orchards. However, since the 1970's, there has been growing interest in new cultivars as the fruit industry strives to become more competitive in export markets and to improve the quality and variety of fruits available for domestic markets.

Many of the stone fruit cultivars permitted for propagation are of Hungarian origin (Table 1). The majority of them are derived from local cultivars and clonal selections of main cultivars. Some important stone fruit cultivars grown in Hungary such as

[1]Research Scientist, Fruit Growing Department, University of Horticulture, H-1118 Budapest, Villányi ut 35-43. Hungary.
[2]Retired Director, Enterprise for Extension and Research in Fruit Growing and Ornamentals, Research Station, H-2701 Cegled, Szolnoki ut 52, Hungary.
[3]Research Horticulturist, Enterprise for Extension and Research in Fruit Growing and Ornamentals, H-1223 Budapest, Park u.2, Hungary.
[4]Research Horticulturist, Research Co-ordination Department, University of Horticulture, H-1118 Budapest, Villányi ut 35-43, Hungary.