Journal of the American Pomological Society 62(2):70-76 2008

Matted-Row Strawberry Cultivar Productivity in Missouri, 2005-2006

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Abstract

Fifteen June bearing strawberry (*Fragaria* × *ananassa* Duch.) cultivars were evaluated for productivity in south central Missouri. The production system was matted rows on raised beds at 46 cm in-row plant spacing with rows 1.8 m apart. The planting was established in 2004, cropped in 2005 and renovated, and then cropped again in 2006. The highest yielding cultivars in 2005 were 'Brunswick', 'Mesabi', 'Annapolis', and 'Mira', all above 5 kg per linear m of row. In 2006 'Annapolis', 'Mesabi', 'Sable', 'Eros', 'L'Amour', and 'Darselect' were highest yielding, all above 2.5 kg per m. Mean marketable yield for all cultivars was 96% and 91% respectively in 2005 and 2006. Mean weighted average berry size for all cultivars was 12.5 g and 11.7 g respectively in 2005 and 2006. Peak harvest date appeared to be more closely associated with published harvest season than first or last harvest dates. Production season length was 22 to 30 days in 2005 and 15 to 27 days in 2006, depending on cultivar.

Evaluating strawberry (*Fragaria* × *ananassa* Duch.) cultivars is an ongoing research project at the State Fruit Experiment Station of Missouri State University. Our growers are interested in the productivity of newer germplasm in comparison to older standard cultivars. The mid-continental climate of south-central Missouri is rated 6a in the USDA plant hardiness zones with an average annual minimum temperature of -23.3 to -20.6 °C. Average yearly rainfall is 102 to 114 cm. Our trial location is at 37° 9' N latitude and typically has wet spring weather, warm to hot summer temperatures with high humidity, and fluctuating winter temperatures with little or no snow cover. Matted-row strawberry production is well adapted to Midwestern and Northern growing conditions using cultivars with good runner production (3, 12). Missouri growers have long used this system. Nursery availability of runner tips in August has made the annual hill system possible in Missouri although production is not always reliable due to variability in seasonal temperatures from year to year (8). Matted-row strawberries have a lower capital investment and can be very productive if good weed control is practiced. The latter is accomplished using herbicides, mechanical tillage, and hand hoeing or weeding (13, 14). Use of killed cover crop residue is another means of suppressing weeds in a modified (advanced) matted-row system (1). Past reports from the station summarized the productivity of older strawberry cultivars, two of which, 'Allstar' and 'Annapolis', were included in this trial (9, 10, 11).

Materials and Methods

Trials were conducted at the State Fruit Experiment Station of Missouri State University at Mountain Grove, MO. The soil, a Viraton series (Oxyaquic Fragiudalf), is characterized as a silt loam topsoil and a cherty, silty clay loam subsoil. There is a cherty fragipan at 60 to 90 cm depth. While this layer can limit rooting depth for some perennial crops, it probably did not limit strawberry rooting. Permeability is moderate above the fragipan and very low in the pan. Water holding capacity of the soil is low because of its shallow depth to the fragipan.

Tall fescue (*Festuca arundinacea* Shreb.) was the permanent ground cover in the years prior to planting. A rotation of cover crops was used to build soil organic matter and suppress weeds. Sites were plowed and disced, and then summer and winter cover cropped with buckwheat (*Fagopyrum esculentum* Moench) and cereal rye (*Secale cereal* L.) in 2003-04. The site was not fumigated because the ground was

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not previously planted to strawberries. New ground that has good site preparation does not require soil fumigation (13, 14).

Soil was sampled from the planting sites and tested for nutrients. Soil reaction was slightly acidic at pH 6.6. Organic matter content was 2.8%. Macro and micro nutrients other than nitrogen were sufficient. Nitrogen as ammonium nitrate was applied preplant at 51 kg/ha. This was broadcast and incorporated into the soil prior to bedding and planting. Raised beds were formed at 1.8 m spacing center to center. Bed width was 75 cm by 20 cm high in the center.

Fifteen June-bearing cultivars from eight breeding programs were evaluated in this trial. The cultivars, year introduced, origin, and published harvest season are listed in Table 1. Dormant strawberry crowns were obtained from several sources, including 'L'Amour' from Courtney Weber of Cornell University (Geneva, NY), 'Sable' from Coulter Farms (Lockport, NY), 'Bish' from Shingleton Farms (Stantonsburg, NC), and the remaining from Nourse Farms, Inc. (South Deerfield, MA). Crowns were planted on 12 May 2004 at 46 cm spacing within the row. DCPA (dimethyl tetrachloroterephthalate, (AMVAC Chemical Corp., Los Angeles, Calif.) at 11.2 kg/ha W-75, a pre-emergent herbicide, was applied six days following planting. Hand weeding and hoeing were done through the summer. Blossoms were removed during the first growing season. Plants runnered to form a 60 cm wide matted row for fruiting. Napropamide (United Phosphorus Inc., King of Prussia, Penn., 9 kg/ha 50-DF), another pre-emergent herbicide, was used in the early fall season. Straw was applied over rows in early December at a 10 cm depth for winter protection. Mulch was raked to the aisles the following April. Drip and sprinkler irrigation were used to supplement rainfall during the growing season. Sprinkler irrigation was also used for spring frost control. The experiment was a randomized complete block with four replications. Each replicate consisted of 4.6 m of matted row developed from ten plants. Following harvest in 2005, the planting was renovated by narrowing plant rows to 30.5 cm using a rotovator.

Plantings were harvested approximately two times per week over four to five weeks. Marketable and cull yields per plot were

Table 1. Cultivars, year introduced, origin, and published harvest season of strawberries planted at Mountain Grove, Missouri, 2005-2006.

Cultivar	Year introduced	Origin	Published harvest season
Allstar	1981	Maryland, USDA	mid
Annapolis	1984	Kentville, NS, Canada	early
Bish	2002	North Carolina	early-mid
Brunswick	1999	Kentville, NS, Canada	mid
Cabot	1998	Kentville, NS, Canada	late-mid
Clancy	2003	New York	late-mid
Darselect	1997	France	mid
Eros	1994	East Malling, UK	late-mid
Evangeline	1999	Kentville, NS, Canada	early
Idea	1991	Italy	late
L'Amour	2003	New York	early-mid
Mesabi	1997	Minnesota	late-mid
Mira	1996	Kentville, NS, Canada	mid
Ovation	2003	Maryland, USDA	late-mid
Sable	1998	Kentville, NS, Canada	early

recorded in 2005 and 2006. Total yield in kg per linear m row and percent marketable yield are reported. Percent marketable yield was based on the formula: [(total yield - cull fruit weight)/(total yield)] x 100. Dates for first, peak, last harvest, and season length (days) for each cultivar are reported. Berry size was determined from a random 25-fruit sample taken at every picking. A weighted average for berry size was calculated using the formula: summation of picking 1 through N [(berry sample wt on day N/25 berry sample) X (yield on day N/total yield)]. Data were analyzed by ANOVA and means separated by Tukey-Kramer HSD (JMP, SAS Institute Inc., Cary, NC).

Results and Discussion

Blossoming started on 18 April in 2005. Several frost events occurred during the first week of May after most of the fruit had set. The lowest temperature was -1 ºC on 23 May. Heavy weight (51 g/m^2) floating row cover was used during these frosts and no damage was noted following removal. Mean total yield for all cultivars was 4.42 kg per linear m row (24.5 MT/ha) in 2005 (Table 2). This was comparable to our previous cultivar trial (9) but higher than those in previous reports (10,11) in Missouri. Matted-row strawberry cultivar trials in other states have shown comparable (16) or lower yields (4), which may be related to length of growing season. One has to consider that our yields were determined from small research plots. A more conservative estimate of what commercial strawberry growers might obtain is about one-half to two-thirds of cultivar trial yields (3). However, experienced growers may come close to these trial yields.

In the second production year, the first flowers opened on 13 April in 2006. Several low temperature events occurred during the last week of March in 2006. The lowest temperature reached was -6.7 ºC on 25 March. However, plants were still mulched with straw during that time. No frost events occurred during bloom. Mean total yield for all cultivars was 2.31 kg per linear m (12.8 MT/ha) row in 2006 (Table 2). This yield decrease in the

Table 2. Total yield of strawberry cultivars at Mountain Grove, Missouri, 2005-2006.

	Total yield (kg/linear m row)[z]		
Cultivar	2005	2006	Two year means
Allstar	4.54 bcde[y]	1.79 cde	3.16
Annapolis	5.35 abc	3.49 a	4.42
Bish	3.78 def	2.05 cd	2.91
Brunswick	6.47 a	2.42 bcd	4.45
Cabot	4.67 bcd	2.10 cd	3.38
Clancy	3.73 def	1.92 cde	2.83
Darselect	4.70 bcd	2.62 abcd	3.66
Eros	4.71 bcd	2.67 abcd	3.69
Evangeline	3.95 cdef	2.21 bcd	3.08
Idea	3.41 def	0.96 e	2.19
L'Amour	3.08 ef	2.63 abcd	2.85
Mesabi	5.58 ab	3.10 ab	4.34
Mira	5.33 abc	2.30 bcd	3.82
Ovation	2.67 f	1.69 de	2.18
Sable	4.34 bcde	2.76 abc	3.55
Means	4.42	2.31	3.37

[z] To convert to MT/ha multiply by 5.55; to convert to T/A multiply by 2.45

[y] Means within a column not followed by a common letter are significantly different by Tukey-Kramer HSD, P ≤ 0.05.

second production year to about one-half of the first year yield was more than in our previous cultivar trial, which showed a decline in yield of about one-fourth from the first to the second year (9). Missouri growers typically renovate and crop matted-row strawberries for several years if plant vigor and weed control are adequate. A progressive decline in yield occurs over the years due to a combination of factors such as plant and weed competition, and foliar and root diseases. These can cause a matted-row system to become unprofitable after a number of bearing seasons (3, 13, 14). We chose to conclude our trial after the second bearing season because of the lower second year yield. Winter low temperature never went below -23.3 ºC during the years 2004 through 2006. Straw mulch was used during the dormant season to prevent crown injury.

Most cultivars in our trial had yields suitable for commercial production in 2005 (Table 2). 'Brunswick' was highest at 6.47 kg/m row. 'Annapolis', 'Mesabi' and 'Mira' were next highest, all above 5 kg per linear m row. 'Allstar', 'Bish', 'Cabot', 'Clancy', 'Darselect', 'Eros', 'Evangeline', 'Idea', 'L'Amour' and 'Sable' were intermediate, all between 3 and 5 kg per linear m row. 'Ovation' had the lowest yield, at 2.67 kg per linear m row. Some variation occurred in 2006 in the yield ranking. 'Annapolis' was highest yielding at 3.49 kg per linear m row with 'Mesabi' close behind at 3.10 kg per linear m. Because of their high yields the previous year, these were the most consistent producers. A large intermediate group, including 'Bish', 'Brunswick', 'Cabot', 'Darselect', 'Eros', 'Evangeline', 'L'Amour', 'Mira' and 'Sable', had yields above 2 kg per linear m row. All of these were in the high to intermediate yield category in 2005 and would also be fairly consistent producers. Of the remaining cultivars, 'Allstar', 'Clancy' and 'Ovation' were just below 2 kg per linear m row. 'Idea' was the lowest yielding, at just under 1 kg per linear m row.

'Allstar' and 'Annapolis' have been in our previous trials (9, 10, 11) and both performed well in 2005 with 'Annapolis' performing well again in 2006. 'Allstar' continues to be a popular offering by strawberry nurseries (2, 5). 'Annapolis' is broadly adapted, productive, and early maturing (6, 7).

Cull fruit weights were low for all cultivars in this trial, which resulted in high marketable yields of 96% and 91% for the respective years of 2005 and 2006 (Table 3). All cultivars were

Table 3. Marketable yield[z] of strawberry cultivars at Mountain Grove, Missouri, 2005-2006.

	Marketable yield (%)		
Cultivar	2005	2006	2 year means
Allstar	97.3 a[y]	90.2 abc	93.8
Annapolis	93.2 ab	94.9 a	94.1
Bish	95.3 ab	92.0 abc	93.7
Brunswick	95.5 ab	85.5 cd	90.5
Cabot	96.1 ab	78.8 d	87.5
Clancy	96.3 ab	91.0 abc	93.7
Darselect	95.6 ab	93.6 ab	94.6
Eros	97.1 a	95.4 a	96.3
Evangeline	98.0 a	96.0 a	97.0
Idea	95.1 ab	87.6 bc	91.4
L'Amour	94.7 ab	89.6 abc	92.2
Mesabi	91.5 b	90.4 abc	91.0
Mira	96.3 ab	92.7 ab	94.5
Ovation	96.9 a	95.0 a	96.0
Sable	94.2 ab	92.6 ab	93.4
Means	95.5	91.0	93.3

[z] Marketable yield = (total yield - cull yield) x 100

[y] Means within a column not followed by a common letter are significantly different by Tukey-Kramer HSD, P ≤ 0.05

Table 4. First, peak and last harvest dates, and season length of strawberry cultivars at Mountain Grove, Missouri, 2005-2006.

	First harvest date		Peak harvest date[z]		Last harvest date		Season length (days)	
Cultivar	2005	2006	2005	2006	2005	2006	2005	2006
Allstar	5/16	5/22	5/31	5/30	6/13	6/5	29	15
Annapolis	5/16	5/16	5/24	5/22	6/10	6/5	26	21
Bish	5/16	5/16	5/24	5/22	6/13	6/5	29	21
Brunswick	5/16	5/22	5/31	5/25	6/13	6/5	29	15
Cabot	5/20	5/22	6/7	5/30	6/14	6/14	26	24
Clancy	5/16	5/25	6/7	5/30	6/14	6/9	30	16
Darselect	5/16	5/19	6/7	5/30	6/13	6/14	29	27
Eros	5/16	5/16	5/31	5/25	6/14	6/5	30	21
Evangeline	5/16	5/16	5/27	5/22	6/10	6/5	26	21
Idea	5/20	5/30	6/14	6/5	6/14	6/14	26	16
L'Amour	5/20	5/19	5/31	5/30	6/13	6/5	25	18
Mesabi	5/20	5/22	6/7	5/30	6/10	6/5	22	15
Mira	5/16	5/22	6/7	5/30	6/10	6/5	26	15
Ovation	5/24	5/25	6/14	6/5	6/14	6/14	22	21
Sable	5/16	5/16	5/27	5/25	6/10	6/5	26	21

[z] Date of highest yield

above 90% marketable yield in 2005. All but one cultivar were above 85% marketable yield in 2006. 'Cabot' was the lowest at 79% marketable yield due to fruit rots in later harvests. Commercial growers would probably have lower marketable yields because later and smaller fruit are usually not harvested as they were in this trial. Mean total and marketable yields of cultivars in this trial exceeded those of the previous three cultivar trials at our location (9, 10, 11).

Strawberry blossoming can occur anytime through the month of April in southern Missouri (9, 10, 11). The blossoming period usually lasts 7 to 14 days depending on spring temperatures. The first harvest date is usually mid through late May. In 2005 first harvest started on 16 May for the cultivars 'Allstar', 'Annapolis', 'Bish', 'Brunswick', 'Clancy', 'Darselect', 'Eros', 'Evangeline', 'Mira' and 'Sable' (Table 4). 'Cabot', 'Idea', 'L'Amour' and 'Mesabi' started on 20 May. 'Ovation' started on 24 May. Peak harvest followed within two to three weeks. Last harvest followed one to two weeks after peak harvest. Season length was between 22 and 30 days in 2005. In 2006 first harvest started 16 May as in the previous year for the cultivars 'Annapolis', 'Bish', 'Eros', 'Evangeline' and 'Sable' (Table 4). 'Allstar', 'Brunswick', 'Cabot', 'Mesabi' and 'Mira' started on 22 May. 'Clancy' and 'Ovation' started on 25 May. 'Idea' started on 30 May. Season length was between 15 and 27 days in 2006. Variation in first and last harvest occurred in 2005 and 2006 which blurred the seasonal differences among the cultivars (Table 1). Peak harvest appeared to be more closely associated with published harvest season rather than first or last harvest, at least in broad categories of early, mid and late (Table 4).

Berry size can be reported as an average of all harvests (random 25 berry weight at each harvest) or as a weighted average that takes into account yield. This latter measurement appeared to report a somewhat smaller berry size compared to an average of all harvests (data not shown). A weighted average is probably more representative of what a commercial grower would obtain, especially if later and smaller fruit are not harvested. It is also less skewed by a few very large primary berries in early harvests. The greatest variation between average of all harvests and weighted average

berry size was noted for the late season cultivar 'Idea', 16.5 g (data not shown) *vs.* 10.9 g in 2005. A berry size above 10 g was considered good in our previous cultivar trial in Missouri (9). The mean berry size for all cultivars was 12.5 and 11.7 g in the respective years 2005 and 2006 (Table 5). 'Cabot' had the largest berry size in both years at 18.3 and 17.6 g. 'Allstar', 'Annapolis', 'Bish', 'Brunswick', 'Clancy', 'Darselect', 'Eros', 'L'Amour' and 'Mesabi' had berry size above 10 g in both years. 'Evangeline', 'Mira', and 'Sable' had berry size below 10 g in both years and in the second year 'Idea' and 'Ovation' were below this. Berry size did not drop appreciably from 2005 to 2006 even though yield declined by nearly half. About a 10% reduction in berry size occurred from 2005 to 2006 which was consistent with our previous trial (9). However, 'Idea' and 'Ovation' did have a larger decline in berry size at about 20%. With lower yields in the second year one might have expected compensation toward larger berries. Other research has not shown this relationship between yield and fruit size in strawberry. Fruit weight was reported to be negatively correlated to number of crowns per plant, plants per meter, and fruit set (15). Plant and crown numbers would be expected to be higher in the second bearing year, although these were not determined in our trial.

Conclusion

Based on total yield and berry size we could recommend most of the cultivars in this trial. We often consider the Maryland USDA cultivars to be better adapted to our region. 'Allstar' has performed well over many years and has been a favored cultivar by our growers. The only other Maryland USDA cultivar in this trial, 'Ovation', did not yield as well in the first year. The Canadian cultivars from Kentville, Nova Scotia ('Annapolis', 'Brunswick', 'Cabot', 'Evangeline', 'Mira' and 'Sable') performed very well in this trial although the latter three had smaller berry size. 'Cabot' had the largest berry size of all cultivars in this trial. The European cultivars, 'Darselect' from France and 'Eros' from the UK, yielded as well as the Canadian cultivars. 'Idea' from Italy did not perform as well because of low second year yield and smaller berry size. Its late season maturity may make it desirable to those growers that want an extended harvest

Table 5. Berry weight of strawberry cultivars at Mountain Grove, Missouri, 2005-2006.

	Weighted average (g)		
Cultivar	2005	2006	Two-year means
Allstar	12.4 bcd[z]	12.7 bc	12.6
Annapolis	11.9 cde	12.0 cdef	12.0
Bish	13.2 bcd	12.2 bcde	12.7
Brunswick	13.8 bc	12.6 bc	13.2
Cabot	18.3 a	17.6 a	18.0
Clancy	13.7 bc	14.8 b	14.3
Darselect	13.9 bc	11.7 cdef	12.8
Eros	11.9 cde	11.3 cdef	11.6
Evangeline	9.5 ef	9.7 defg	9.6
Idea	10.9 def	7.9 g	9.4
L'Amour	14.8 b	12.8 bc	13.8
Mesabi	12.2 bcd	12.4 bcd	12.3
Mira	9.4 ef	9.6 efg	9.5
Ovation	12.3 bcd	9.5 fg	10.9
Sable	9.1 f	8.0 g	8.6
Mean	12.5	11.7	12.1

[z] Means within a column not followed by a common letter are significantly different by Tukey-Kramer HSD, P ≤ 0.05

season. The Minnesota cultivar 'Mesabi' was equal to the best Canadian cultivars in yield and berry size. The two New York cultivars, 'Clancy' and 'L'Amour', and one North Carolina cultivar, 'Bish', were intermediate performers, somewhat below the best cultivars. Berry size on these latter three held up well in both years.

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CONTROLLING ROSY APPLE APHIDS IN ORGANIC ORCHARDS

Control of rosy apple aphid in commercial apple orchards by spring aphicide applications is often inadequate, especially under organic production methods, where the range of permitted aphicides is very restricted. Scientists in the UK conducted a series of large-scale replicated orchard experiments to evaluate control of rosy apple aphid by autumn applications of aphicides. Control of the aphid in the autumn with pirimicarb or pirimicarb + cypermethrin could be highly effective and, with 2-3 sprays of the organically permitted insecticide pyrethrum, moderately effective. The optimum time for spraying under their conditions was early-mid October, at the start of migration of males and before mating and egg laying. The other organically acceptable materials tested (potassium soap, rotenone, garlic extract, kaolin, neem extract, starch-based plant extracts) did not give useful control. Paraphrased from Cross, J. V. et al. 2007. Autumn control of rosy apple aphid, *Dysaphis plantaginea* (Passerini), with aphicides. Crop Protection 26(8):1140-1149.