

## Annual Strawberry Systems in Missouri

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### Abstract

Annual systems of strawberry production were investigated in southern Missouri. In 1996 'Tribute' had moderate total yield, and 'Tristar' had high total yield. Marketable yields and berry weights were low for both of these day-neutrals. In 1997 'Chandler' yielded better from early September planting compared to late September. In 1998 yields did not differ between early, mid, and late September plantings. Total yield of 'Chandler' was moderate in 1997 and high in 1998. Berry weight varied inversely, larger in 1997 and smaller in 1998. Crown number and harvest season length were not as high or long, respectively as obtained in the southeastern U.S. Total yields of 15 June-bearing strawberry cultivars ('Allstar', 'Delmarvel', 'Earliglow', 'Honeoye', 'Jewel', 'Lateglow', 'Lateglow', 'Mira', 'Northeast', 'Primetime', 'Redchief', 'Seneca', 'Surecrop', 'Sweet Charlie', 'Winona') were low to moderate in an annual system in 2001. Berry weights were greater than 'Tribute' and 'Tristar' but usually less than for 'Chandler'. Branch crown number varied depending on cultivar. Harvest season length averaged four and a half weeks as occurred for 'Chandler' in 1997. There was no benefit to carrying-over the 15 June-bearing cultivars for a second fruiting season in 2002. Productivity of 'Chandler' was less at Mountain Grove, MO than where it is better adapted. This is likely due to colder temperatures during late autumn and winter seasons. Day-neutrals are not recommended. 'Allstar', 'Chandler', 'Lateglow', 'Lateglow', 'Northeast', 'Primetime', and 'Sweet Charlie' were reasonably productive in an annual system under our environmental conditions.

### Introduction

Perennial matted-row strawberry production is the recommended system for cold climate areas (6,16). In California and Florida, the number one and two producing states, strawberries are treated as an annual winter or spring crop (1,3). In the southeastern U.S., moderate temperatures during autumn and early winter seasons allow for strawberry culture using the annual hill or plasticulture system for spring fruit production (14,15). The shorter time interval from planting to harvest, reduced weed growth and disease incidence, ease of fruit harvest, and longer harvest season are important advantages that make the system popular with growers. There is a limit to how far north in the U.S. this system can be used because colder temperatures during late autumn and winter seasons limit plant development and survival. Perennial matted-row production

will continue to be used in these latter areas.

Missouri growers are interested in the annual hill or plasticulture system as well as new strawberry cultivars. The State Fruit Experiment Station of Southwest Missouri State University evaluates strawberry cultivars as ongoing research projects. New cultivars are compared to standards that have been used in the industry for a number of years. Strawberry cultivars must be adapted to the mid-continental climate of Missouri which is rated 5 and 6 in the USDA plant hardiness zones. The experiment station is located in the southern part of the state at 37° 9' N latitude and typically has wet spring weather, high summer temperature and humidity, and fluctuating winter temperature with little or no snow cover. It is rated 6a on the USDA plant hardiness zone map with an average annual minimum of -23.3 to -20.6 °C (-10 to

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-5 °F). Foliar and fruit diseases, and winter crown injury can readily occur in this environment if protective measures are not taken.

Matted-row production is the system best adapted to zone 5 and lower, and for those cultivars that are prolific runner producers (6,11). We are uncertain whether strawberries can be consistently produced using annual systems in Missouri. Annual production requires a close adherence to a series of cultural practices in order to be successful. Soil fumigation, raised plastic mulch covered beds, and use of plug plant nursery stock are three practices most Missouri growers are not experienced with. Soil fumigation is normally not practiced unless the ground has been continually planted to strawberries. We investigated annual systems of strawberry production using 'Tribute' and 'Tristar', 'Chandler', and 15 additional June-bearing cultivars over several years and plantings.

#### Materials and Methods

Trials were conducted at the State Fruit Experiment Station of Southwest Missouri State University, 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 which can limit rooting depth for some perennial crops. However, strawberry rooting was probably not limited. 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. Soil reaction is slightly acidic with pH 6.5 to 6.8. Organic matter content is 2.5 to 3.0%.

Tall fescue (*Festuca elatior*) grass was the permanent ground cover in the years prior to planting establishment. 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 sagittatum*) and

cereal rye (*Secale cereale*), respectively. The sites were not fumigated because the ground was not previously planted to strawberries.

Soil was sampled from the planting sites and tested for nutrients. Macronutrients were added based on soil test results. Nitrogen was applied preplant at 67 kg / ha (60 lb / acre) to 'Chandler' and the 15 June-bearing cultivars. Fertilizers were broadcast and incorporated into the soil prior to bedding and planting. Raised, white plastic mulch covered beds were formed on a 1.5 meter (5 ft) spacing center to center. Bed width was 75 cm by 20 cm high (30 x 8 in) in the center.

Strawberry plugs and crowns were obtained from several nurseries, including Davon Crest Farms (Hurllock, MD), Indiana Berry & Plant Co. (Huntingburg, IN), and Nourse Farms, Inc. (Deerfield, MA). The cultivars included releases from California ('Chandler'); Florida ('Sweet Charlie'); Maryland Ag. Exp. Sta. and/or Maryland USDA ('Allstar', 'Delmarvel', 'Earliglow', 'Lateglow', 'Latestar', 'Northeast', 'Primetime', 'Redchief', 'Surecrop', 'Tribute', 'Tristar'); Minnesota ('Winona'); New York ('Honeoye', 'Jewel', 'Seneca'); and Nova Scotia, Canada ('Mira').

'Tribute' and 'Tristar' dormant crowns were planted on April 25, 1996. For six weeks, all flowers and runners were removed. 'Chandler' plug plants were set in early, mid, and late September 1996 and repeated again in 1997. Flowers and runners were removed into the fall season. June-bearing cultivars 'Allstar', 'Delmarvel', 'Earliglow', 'Honeoye', 'Jewel', 'Lateglow', 'Latestar', 'Mira', 'Northeast', 'Primetime', 'Redchief', 'Seneca', 'Surecrop', 'Sweet Charlie', 'Winona' were planted on September 14, 2000. All were established as plug plants, and three cultivars were also set as dormant crowns ('Allstar', 'Northeast', 'Seneca'). Runners were removed into the fall season. Following harvest in 2001, foliage was mowed

above the crowns on two replications, and the planting was cropped a second year.

Plastic mulch covered beds required planting at higher density and not relying on daughter plant production. A plant spacing of 30.5 cm between plants and 30.5 cm between double rows (12 x 12 in) was used on the beds, giving a plant density of 42,995 / ha (17,400 / acre). Weed growth was managed by hand pulling, hoeing, and herbicide application (DCPA, Napropamide) to row middles. Benlate and Captan were used for foliar and fruit rot control. A floating row cover (51 g / m<sup>2</sup>, 1.5 oz / yd<sup>2</sup>) was used for winter protection of 'Chandler'. Straw mulch was applied to the 15 June-bearing cultivars in December and raked into the aisles in April. Drip irrigation supplemented rainfall during the growing season and overhead irrigation was used for spring frost control. Weekly nitrogen fertigation of 'Tribute' and 'Tristar' (5 kg / ha, 4.5 lb / acre) was done from early May through August for a total of 90 kg / ha (80 lb / acre) (16,17). Weekly nitrogen fertigation of 'Chandler' and the 15 June-bearing cultivars (4 kg / ha, 3.5 lb / acre) was done from late March through May for a total of 45 kg / ha (40 lb / acre) (13,15). The experiments were randomized complete blocks with four replications. Each replicate consisted of thirty plants per 4.6 m (15 ft) of row.

Plantings were harvested approximately two times per week over four to five weeks. Marketable and cull fruit weight per replication were recorded. Total yield per plant (g) and marketable yield (%) were reported. Marketable yield was based on the formula:

[ ( total fruit weight – cull fruit weight ) ÷ ( total fruit weight ) ] X 100. Berry weight (g) average was determined from a random 25-fruit sample taken at every picking. Crown number per plant was determined after final harvest by counting the total crown number per replication and dividing by thirty plants. Season length (days) was the length of the harvest period for each cultivar. Leaf spot (*Mycosphaerella fragariae*) was rated using the scale of 1 = trace to 10% infection, 2 = 11 to 20% infection ... 10 = 91 to 100% infection and reported. Data were analyzed by ANOVA and means separated by Tukey-Kramer HSD.

### Results and Discussion

Productivity of 'Tribute' and 'Tristar' day-neutrals are shown in Table 1. 'Tristar' was significantly more productive than 'Tribute'. These yields were close to and in some cases exceeded the expected yields for day-neutral plantings in the eastern U.S. (4,5,16,17). Marketable yield percentages were low for both cultivars and not significantly different. These low percentages were due to many small unmarketable berries. Berry weight was significantly higher for the lower yielding 'Tribute'. However, overall berry size was low for these day-neutrals in comparison to the June-bearing cultivars. A non-replicated trial in 1997 using the same cultivars showed similar results (data not shown). Based on productivity results, we recommend that these cultivars not be grown in an annual system in Missouri.

Based on 1996 day-neutral trial results, it was decided to investigate the more productive 'Chandler' cultivar in an annual system.

**Table 1. Performance of Tribute and Tristar in an annual system at Mountain Grove, MO in 1996.**

Cultivar	Total yield per plant (g)	Marketable yield (%)	Berry weight (g)
Tribute	374 b <sup>2</sup>	44 a	6.7a
Tristar	495a	49 a	6.3 b

<sup>2</sup>Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD,  $P \leq 0.05$ .

Southern Missouri has variable autumn season weather with frosts occurring as early as mid-October. Planting in September rather than October as is practiced in southeastern U.S. would likely be needed to have enough time for branch crown development of 'Chandler'. The trade-off is that plant resources are used in the formation of runners which must be removed. Productivity of 'Chandler' is shown in Table 2. Early September planting resulted in the highest total yield per plant in 1997. In 1998, there were no significant differences in total yield per plant across the planting dates. However, early planting did show a trend toward higher yield. Although per plant yield multiplied by plant number can give potential yield per hectare (acre), extrapolation of yield to larger size plantings from per plant yield is problematic. A conservative estimate of what commercial strawberry growers might obtain is two-thirds of cultivar trial yields (6,16). In North Carolina, 'Chandler' is highly productive with per plant yields of 454 g (1 lb) or more per plant (14,15). Marketable yield percentages showed no significant differences across planting dates in either year. Marketable yield approached 90% in 1997 and was about 80% in 1998, both percentages are acceptable for commercial production in Missouri (8,9,10). Berry weights did not differ among planting dates in either year, but were higher in 1997 than in 1998. These berry weights would be considered high (1997) to moderate (1998) by most Missouri matted-row strawberry

growers (8,9,10). Crown branching is necessary for high production in 'Chandler' with a minimum number of five to six needed (15). There were significant differences in crown number in 1997 with the early and mid September plantings having the higher number. In 1998 no significant differences occurred across planting dates. Crown number was determined after harvest rather than late the previous fall season. Fall branch crown numbers could be less than reported, since some branching can also occur in the spring. If so, this could account for lower yield, particularly in 1997. In both years harvest season length was short, particularly in 1998. Normally, six weeks of harvest season occurs in southeastern U.S., but it can be shorter if it is warm in the spring (13,14). Likely, the short seasons in these trials were a result of low crown number, cold tenderness of 'Chandler', and warm spring temperatures. Temperatures of -20 °C (-4 °F) and -15 °C (5 °F) occurred during the winters of 1996-1997 and 1997-1998 which probably caused some winter injury in our plantings, particularly in 1997. May 1997 and 1998 average monthly temperatures were 15.2 and 20 °C (59.4 and 68 °F), respectively. Cultural practices that extended plant development into the autumn season, such as floating row cover and nutrient management could increase crown branching. Winter protection with heavier weight, floating row covers is necessary in our climate, but the additional protection of straw mulch may also be needed.

**Table 2. Performance of 'Chandler' in an annual system at Mountain Grove, MO in 1997 and 1998.**

September planting period	Total yield per plant (g)		Marketable yield (%)		Berry weight (g)		Crown number		Harvest season length (days)	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Early	353a <sup>2</sup>	498 a	89 a	82 a	16.6 a	13.2 a	5.3a	5.4 a	31	22
Mid	301ab	416 a	89 a	83 a	16.6 a	12.9 a	4.7a	5.2 a	31	22
Late	245 b	455 a	89 a	82 a	16.2 a	12.4 a	4.0 b	5.4 a	31	22

<sup>2</sup>Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, P ≤ 0.05.

North Carolina has moderate temperatures during autumn and early winter seasons that allow for good plant development of 'Chandler' with October planting dates (14,15). In more northern states, a grower must plant earlier to obtain enough plant development before the onset of cold weather (4,12). At the time of this trial, nursery stock of 'Chandler' was not readily available in early August when the runner tips needed to be rooted. Runner production is also excessive with late summer and early autumn planting. There is also the possibility for winter injury to crowns. For these reasons, alternative cultivars to 'Chandler' are needed in Missouri.

June bearing strawberries have been grown in matted-row culture at the Missouri State Fruit Experiment Station with success (8,9,10). A number of these were grown in an annual system and their productivity is shown in Table 3. Mean total yield per plant was 245 g. Some of the better yielding cultivars that exceeded the mean total yield were 'Allstar', 'Lateglow', 'Latestar', 'Northeast', 'Primetime', 'Redchief', 'Seneca' (dormant crown), and 'Sweet Charlie'. None of these cultivars were as productive as 'Chandler' at the earliest planting date in the previous trial (Table 2). However, 'Chandler' was not included in this latter trial, so a statistical comparison can not be made. A Maryland trial showed 'Allstar' and 'Northeast' to be productive in an annual hill system with per plant yields of 454 g (1 lb) or more per plant (2). In another Maryland trial, per plant yield of 'Latestar' exceeded 'Chandler'; whereas, 'Allstar' and 'Northeast' yielded the same as 'Chandler' (7). In the present trial, mean marketable yield was 90%, an acceptable level in Missouri (8,9,10). Mean berry weight was 12 g which is similar to what we have obtained when growing many of these same cultivars in matted-row culture (8,9,10). A berry size

above 10 g is needed for commercial matted-row production in Missouri (8,9,10). All but 'Redchief' in the previously mentioned group of best yielding cultivars had berry weights above 10 g. 'Allstar', 'Lateglow', 'Northeast' (dormant crown), 'Primetime', and 'Sweet Charlie' had berry weights above 13 g. Crown number was counted at the end of the second harvest in 2002. It did not give a true indication of the number of crowns from which the 2001 yield would have occurred. However, cultivars can be compared for their relative crown formation. Some cultivars with higher total yield per plant also had greater crown numbers, but this was not always true. Leaf spot (*Mycosphaerella fragariae*) ratings were taken in 2002. The mean leaf spot rating was 2.5 or 25% of the leaves showing spotting. This was acceptable since an annual planting would not be cropped again. Harvest season length showed a mean of 32 days for all cultivars. In matted-row culture several of these cultivars produced fruit over a four to five week period, which we obtained here.

In the second harvest season, mowed plants yielded more with a higher percent marketable yield than non-mowed plants (data not shown); however, overall plant productivity was reduced for both compared to the first harvest season. Low yields would not warrant maintaining a planting for a second harvest using this practice. Crown number was not reduced from the previous year, and berry weight was lower (data not shown). Mowing alone did not reduce crown numbers sufficiently. A combination of mowing and Gramoxone application to half of the plant has been shown to maintain yield in the second year in Virginia (12,13). More typically in an annual strawberry system, the plant is removed following harvest and beds are re-used for growing another crop (1,13).

Strawberry blossoming can occur in southern Missouri anytime through the month

**Table 3. Performance of 15 June-bearing cultivars in an annual system at Mountain Grove, MO in 2001.**

Plant type and cultivar	Total yield per plant (g)	Marketable yield (%)	Berry weight (g)	Crown number <sup>z</sup>	Leaf spot rating <sup>y</sup>	Harvest season length (days)
<b>Dormant Crowns</b>						
Allstar	403a <sup>x</sup>	93a	15.1a	9.2 bcd	1.0 c	33
Northeast	291 bc	92ab	13.7ab	13.3a	2.5abc	27
Seneca	261 bcd	92a	11.6 cd	8.2 bcd	2.3abc	33
<b>Plug Plants</b>						
Allstar	312 b	93a	13.7ab	6.5 d	1.3 bc	37
Delmarvel	198 cde	92a	12.3 bcd	10.0abcd	1.8abc	29
Earliglow	193 cde	81 c	8.9 ef	8.7 bcd	2.0abc	32
Honeoye	117 e	86abc	11.4 cd	6.4 d	1.3 bc	32
Jewel	201 cde	92a	11.0 de	11.0abc	2.3abc	35
Lateglow	287 bc	91ab	13.5abc	11.6ab	4.5a	35
Latestar	269 bcd	87abc	10.7 def	9.5abcd	1.8abc	40
Mira	243 bcd	92a	11.4 cd	9.7abcd	3.0ab	27
Northeast	271 bcd	89abc	11.8 bcd	11.1abc	3.5a	27
Primetime	351 b	92a	13.7ab	7.9 cd	4.3a	29
Redchief	263 bcd	92a	8.8 f	8.4 bcd	2.8abc	27
Seneca	141 e	88abc	12.2 bcd	11.9ab	2.5abc	33
Surecrop	178 de	90ab	10.4 def	10.2abcd	3.5a	29
Sweet Charlie	315 b	93a	15.3a	6.6 d	2.0abc	37
Winona	110 e	84 bc	11.3 d	6.5 d	3.0ab	27
Means	245	90	12.0	9.2	2.5	32

<sup>z</sup>Crown number counts taken on 6/27/02.

<sup>y</sup>Leaf Spot (*Mycosphaerella fragariae*) visual assessment on 6/27/02 using a rating of 1 = trace to 10% infection, 2 = 11 to 20%...10 = 91 to 100%.

<sup>x</sup>Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD,  $P \leq 0.05$ .

of April. The blossoming period is usually seven to ten days long with only several days separating early and mid-season cultivars (data not shown). The first harvest date is usually mid through late May (8,9,10). Five to seven days usually separate early from mid-season cultivars. Peak harvest is one to two weeks later. Last harvest is another one to two weeks following peak harvest. Considerable variation blurred the distinction between early, midseason, and late cultivars

in our trial. Consequently, cultivars were not placed in seasonal categories. Nursery listings of these cultivars place 'Earliglow' and 'Sweet Charlie' in early season; 'Chandler', 'Delmarvel', 'Northeast' and 'Tristar' in early midseason; 'Honeoye', 'Mira', 'Primetime', 'Redchief', 'Surecrop' and 'Tribute' in midseason; 'Allstar', 'Jewel', 'Seneca' and 'Winona' in late midseason; and 'Lateglow' and 'Latestar' in late season.

### Conclusion

Day-neutrals were not productive enough and berry weight was low; consequently, 'Tribute' and 'Tristar' are not recommended to growers in southern Missouri. 'Chandler' can be grown in an annual hill system in our area, but its productivity was less consistent than where it is better adapted. Winter cold injury to 'Chandler' will likely occur in some years. Late summer planting and additional winter protection would probably enhance 'Chandler' productivity. June-bearing cultivars will work in an annual system. There are several that have reasonable productivity such as 'Allstar', 'Lateglow', 'LATESTAR', 'Northeast', 'Primetime', and 'Sweet Charlie'. The disadvantage of these cultivars

in an annual system is that yield and berry weight will probably be less than for 'Chandler'. The trade-off is that their winter hardiness is likely better. Most eastern U.S. June-bearing strawberries are planted as dormant crowns rather than plug plants. Availability of these cultivars as plug plants or runner tips is limited. A commercial grower will have to balance these competing advantages and disadvantages when making a decision on which cultivar to plant. Traditional matted-row strawberry culture is still recommended for Missouri, particularly in northern areas, but use of the annual hill system is increasing with our more experienced growers.

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### Literature Cited

1. Brown, M. 2003. Florida strawberry production and marketing, p. 31-42. In: N.F. Childers (ed.). *The Strawberry*. Horticultural Publications, Gainesville, FL.
2. Black, B.L., J.M. Enns, and S.C. Hokanson. 2002. A comparison of temperate-climate strawberry production systems using eastern genotypes. *HortTechnology* 12:670-675.
3. Childers, N.F. 2003. California strawberry production, p. 75-87. In: N.F. Childers (ed.). *The Strawberry*. Horticultural Publications, Gainesville, FL.
4. Fiola, J.A., R.J. Lengyen, and D.A. Reichert. 1995. Planting density and date affect productivity and profitability of 'Chandler', 'Tribute', and 'Tristar' in strawberry plasticulture. *Adv. Strawberry Res.* 14:49-52.
5. Galletta, G.J., A.D. Draper, and H.J. Swartz. 1981. New everbearing strawberries. *HortScience* 16:726.
6. Hancock, J.F., B.L. Goulart, J.J. Luby and M.P. Pritts. 1997. The strawberry matted row: Practical cropping system or dated anachronism? *Adv. Strawberry Res.* 16:1-4.
7. Hokanson, S.C., F. Takeda, J.M. Enns, and B.L. Black. 2004. Influence of plant storage duration on strawberry runner tip viability and field performance. *HortScience* 39:1596-1600.
8. Kaps, M.L., M.B. Odneal, and P.L. Byers. 2003. Strawberry cultivar performance in Missouri, 1997-1999. *J. Amer. Pomol. Soc.* 57:19-25.
9. Kaps, M.L., M.B. Odneal, J.F. Moore, Jr. and R.E. Carter. 1990. Strawberry cultivar evaluation in Missouri. *Fruit Var. J.* 44:158-164.
10. Kaps, M.L., M.B. Odneal and J.F. Moore, Jr. 1987. Strawberry cultivar evaluation in the Missouri Ozark region. *Adv. Straw. Prod.* 6:36-40.
11. Masiunas, J.B., S.C. Weller, R.A. Hayden and J. Janick. 1991. Effect of plant spacing on strawberry yield in two cultural systems. *Fruit Var. J.* 45:146-151.
12. O'Dell, C. 2003. Ten years experience with plasticulture strawberries for colder areas, p. 43-50. In: N.F. Childers (ed.). *The Strawberry*. Horticultural Publications, Gainesville, FL.
13. O'Dell, C. and J. Williams. 1999. Hill system plastic mulched strawberry production guide for colder areas. *Virginia Coop. Ext. Pub.* 438-018.
14. Poling, E.B. 2003. Strawberry plasticulture - A possibility for local growers, p. 11-18. In: N.F. Childers (ed.). *The Strawberry*. Horticultural Publications, Gainesville, FL.
15. Poling, E.B. 1993. Strawberry plasticulture in North Carolina: II. Preplant, planting, and post-plant considerations for growing 'Chandler' strawberry on black plastic mulch. *HortTechnology* 3:383-393.
16. Pritts, M. and D. Handley (eds). 1998. *Strawberry production guide*. Northeast Regional Agricultural Engineering Service. Ithaca, NY. 162p.
17. Pritts, M. and A. Dale. 1989. Day-neutral strawberry production guide. *Cornell Coop. Ext. Info. Bull.* 215.