Transplant Source Affects Fruiting Performance and Pests of 'Sweet Charlie' Strawberry in Florida

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SUMMARY. The use of locally grown transplants in Florida strawberry (*Fragaria* × *ananassa* Duchesne) production has increased since the release of the cultivar Sweet Charlie by the University of Florida in 1992. Previous research has shown that nursery region can influence production patterns of other strawberry cultivars through differences in photoperiod and temperature exposure. Transplants of 'Sweet Charlie' strawberry (bareroot and plug plants) from sources representing northern (Canada, Massachusetts, Oregon), southern (Alabama, Florida) and mid latitude (North Carolina) transplant production regions were compared for plant vigor, production, and pest incidence at Dover, Fla. in 1995–96 and 1996–97. Total fruit production was not significantly different for

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plants among the plant source regions in 1995–96, but total yield from southern source plants in 1996–97 was significantly lower than northern and mid latitude plant sources. Monthly production of marketable fruits varied among the three plant source regions in December, January, and February, during which time market prices fell 46% in 1995–96 and 56% in 1996–97. Plants from northern and mid latitude sources produced significantly greater fruit yield in December than plants from southern sources. Differences among plant sources were detected for early flowering, initial crown size, incidence of foliar disease, arthropod pests, mortality, and fruit weight. Geographic location of strawberry transplant sources influenced fruiting patterns and other components that may affect profitability of ‘Sweet Charlie’ strawberry production in west central Florida.

The University of Florida released ‘Sweet Charlie’ strawberry in 1992 and this cultivar was planted on 38% of commercial strawberry acreage in Florida in 1996–97 and on over 50% in 1998–99. Interest in using locally grown transplants increased during this period, primarily to reduce costs. The average cost of transplants produced out-of-state exceeded \$607/ha (\$1500/acre) for the 1996–97 season (Smith and Taylor, 1998). Prior research on other cultivars has investigated the influence of nursery locations on yield and plant growth of strawberries in Florida (Albregts and Howard, 1974; Chandler et al., 1989). Initiation and development of flower buds in the strawberry is influenced by photoperiod and chilling temperature (Darrow, 1966; Durner and Poling, 1988). Albregts and Howard (1974) concluded that optimum planting date was more important than plant source when they compared ‘Tioga’ strawberries from California, North Carolina, and Florida. Chandler et al. (1989) compared performance of three clones produced in Ontario, Nova Scotia, and Florida and found plants from the Canadian sources produced ripe fruit 2 to 3 weeks earlier, but there was no clear trend in total yield or fruit weight. In Alabama fruiting fields, Himelrick et al. (1994) found that Canada-grown strawberry plants produced significantly greater yields than plants of the same cultivars from California nurseries. In

this study, differences in environmental preconditioning in the nursery may have been confounded by influences of leaf removal which is a standard treatment for Californian, but not Canadian, strawberry transplants. Virtually all prior research has found the influence of plant source on plant growth and yield to vary with cultivar, suggesting the need to study new cultivars for optimum production recommendations (Durner et al., 1986). Although several studies included plant growth analyses such as runner production in plant source comparisons, few have included pest incidence, which can severely influence production and profitability. This study was conducted to compare the influence of plant source on the performance and pests of ‘Sweet Charlie’ strawberry in west central Florida production.

Materials and methods

In October 1995 and 1996, bareroot ‘Sweet Charlie’ strawberry transplants were obtained from ten and eight plant sources, respectively, representing the major nursery production regions in use today by the commercial Florida industry. Two of these sources provided seedlings grown in containers of soilless media (plug plants) each year. Plants were evaluated prior to planting for arthropod pests, foliar disease, and characteristics of vigor, including crown diameter. Plants were transplanted on 18 Oct. 1995 and 1996 into an annual hill plasticulture system at the Gulf Coast Research and Education Center–Dover (GCREC–Dover) with a Seffner fine sand soil type (sandy, siliceous, hyperthermic Quartzipsammentic Haplumbrepts). Soil in raised beds was fumigated with methyl bromide (98% bromomethane plus 2% trichloronitromethane) at 269 kg·ha⁻¹ (240 lb/acre) and covered with black polyethylene mulch, following recommended cultural practices (Maynard and Hochmuth, 1999). Beds were spaced 1.2 m (4 ft) on center and fertilized with 10N–2.2P–8.3K at a rate of 560 kg·ha⁻¹ (500 lb/acre) before planting. Plants were set at 41 cm (16 inches) spacing in rows and 31 cm (12 inches) between rows with two rows per bed. Four replications of 16 plants from each plant source were arranged in a randomized complete block design. Plants were drip irrigated and fertigated weekly with 4N–0.9P–5K at 94 L·ha⁻¹ (10 gal/acre). Plants received a total of 120 kg·ha⁻¹ (107 lb/acre) N. In both years, predacious mites (*Phytoseiulus persimilis*

Athias-Henriot) were released in mid December to control two-spotted spider mites (*Tetranychus urticae* Koch). Preventative fungicides were applied weekly from November through March, and insecticides were applied as needed. In 1995–96, no miticides were applied and in 1996–97 abamectin was applied twice and hexakis four times. Presence of foliar disease symptoms was evaluated each year prior to planting and in the field until harvest. Arthropod populations were assessed on a sample of 10 leaves per plot initially and throughout the early season. Ripe fruits were harvested, graded, counted and weighed weekly through the end of March. Marketable fruits weighed at least 10 g (0.35 oz) and showed no blemishes. The percent of plants per plot with flowers at anthesis were counted throughout the 1995–96 season and vegetative runners were removed and counted throughout the study. The plant sources were grouped into three regions for characterization: northern, mid, and southern latitudes (Table 1). Analysis of variance was performed on measured characteristics with the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS Institute, Cary, N.C.) using Fisher’s protected Least Significant Difference (LSD) to compare means. Plant mortality, recorded at the end of harvest in both seasons, was transformed with arcsin transformation prior to analysis.

Results and discussion

Initial crown size of the strawberry transplants ranged from 5 to 12 mm (0.2 to 0.5 inches), with the smallest crowns occurring in the plug plants and the Florida bareroots (Tables 1 and 2). Although no consistent correlation of initial crown size to early fruit production was found in this study, a recent field trial which included ‘Sweet Charlie’ bareroot plants from a single source demonstrated a positive correlation of initial crown diameter with December yield (G.J. Hochmuth, unpublished).

Flowering occurred 10 to 14 d earlier in plants from northern sources. On 1 Dec. 1995, flowers were open on over 71% of plants from northern and mid latitude nurseries, compared to 20% of plants from southern sources. Total fruit production from plants from various sources differed significantly in 1996–97 yet no significant differences were detected in 1995–96 (Tables 1 and 2). Northern and mid latitude bareroot plants produced higher

Table 1. Marketable yield, crown diameter, average fruit weight, and mortality of ‘Sweet Charlie’ strawberry transplants from three regions, 1995–96.

Region or plant source	Yield ^z (t·ha ⁻¹)	Crown diam ^y (mm)	Fruit wt ^x (g)	Mortality ^w (%)
Northern latitude				
Ontario	23.1 a ^v	10.3 bc	19.7 ab	3.7 bcd
Nova Scotia	20.6 ab	9.5 cd	19.6 ab	0.5 cd
Quebec	---	---	---	---
Massachusetts	23.1 a	9.8 c	19.8 a	3.7 bcd
Oregon	20.6 ab	10.5 bc	19.3 abc	0.5 cd
Mid-latitude				
North Carolina	23.7 a	11.3 ab	18.0 d	4.7 bc
North Carolina-plug ^u	19.5 ab	6.0 f	18.4 cd	0.5 cd
Southern latitude				
Alabama	20.4 ab	12.0 a	18.6 cd	7.0 bc
Florida 1 ^t	18.1 ab	7.5 e	19.4 abc	9.1 ab
Florida 2	15.0 b	8.3 de	19.2 abc	20.2 a
Florida-plug	23.5 a	7.5 e	18.8 bcd	0 d

^z1.0 t·ha⁻¹ = 0.446 ton/acre.

^yMean diameter of crowns before planting on 18 Oct. 1995, 1.0 mm = 0.04 inch.

^xMean weight of individual marketable fruit, 1.0 g = 0.035 oz.

^wArcsin transformation of mean percent plants dead per plot on 27 Mar. 1996.

^vMean separation within columns by Fisher's protected least significant difference test, *P* = 0.05.

^uPlug plants are from seedlings grown in containers of soilless media.

^tNumbers indicate two individual nurseries in Florida producing bareroot strawberry transplants.

total fruit yield in 1996–97 than mid latitude plug plants and all plants from southern sources. Cumulative early marketable yield (December to February) was consistent with the pattern of differences in total fruit production.

Temperature and precipitation differed markedly between the two seasons of this study, which may help to explain differences in yield dynamics between the two seasons (Table 3). Overall,

1995–96 was cooler and wetter than normal, while 1996–97 was warmer and drier than normal. In both years of this study, total fruit production was lower than the industry average of 29.1 t·ha⁻¹ (13 tons/acre) in 1995–96 and 32.5 t·ha⁻¹ (14.5 tons/acre) in 1996–97 (Florida Agricultural Statistics Service, 1998). Lower yields in the trial were probably due to weekly plot harvests, half as frequent as the industry

standard, and therefore increased number of overripe fruit that were classified as unmarketable.

Time of fruiting is frequently more important to profitability than total fruit volume. Market value for a flat of strawberries fell during December to March 1995–96 from \$17.28 to \$6.12 and in 1996–97 from \$19.20 to \$8.28 (Table 4). Monthly fruit production was significantly greater in December for plants from northern and mid latitude sources than for plants from southern sources (Fig. 1 and 2). Production of marketable fruit in January was consistently high from mid latitude transplants. Plants

Table 2. Marketable yield, crown diameter, average fruit weight, and mortality of ‘Sweet Charlie’ strawberry transplants from three regions, 1996–97.

Region or plant source	Yield ^z (t·ha ⁻¹)	Crown diam ^y (mm)	Fruit wt ^x (g)	Mortality ^w (%)
Northern latitude				
Ontario	---	---	---	---
Nova Scotia	19.8 a ^v	10.0 c	19.7 a	1.5 bc
Quebec	16.5 c	10.3 bc	19.7 a	1.7 bc
Massachusetts	18.7 ab	12.0 a	19.0 ab	2.5 abc
Oregon	17.7 bc	10.5 bc	19.1 ab	0 c
Mid-latitude				
North Carolina	17.6 bc	11.5 ab	18.3 bc	0.5 bc
North Carolina-plug ^u	14.1 d	6.8 d	18.4 bc	0 c
Southern latitude				
Alabama	---	---	---	---
Florida 1 ^t	10.3 e	7.5 d	19.1 ab	12.7 a
Florida 2	---	---	---	---
Florida-plug	11.8 e	5.3 e	17.8 c	8.0 ab

^z1.0 t·ha⁻¹ = 0.446 ton/acre.

^yMean diameter of crowns before planting on 18 Oct. 1996, 1.0 mm = 0.04 inch.

^xMean weight of individual marketable fruit, 1.0 g = 0.035 oz.

^wArcsin transformation of mean percent plants dead per plot on 19 Mar. 1997.

^vMean separation within columns by Fisher's protected least significant difference test, *P* = 0.05.

^uPlug plants are from seedlings grown in containers of soilless media.

^tNumbers indicate two individual nurseries in Florida producing bareroot strawberry transplants.

Table 3. Temperature and precipitation at Gulf Coast Research and Education Center–Dover in 1995–96, 1996–97 and historical mean.

Month	1995–96	1996–97	Historical mean ^z
Temp (°C) ^y			
December	14.7	16.3	16.2
January	14.4	15.8	15.4
February	15.6	19.7	16.3
March	16.6	22.1	18.4
Precipitation (mm) ^x			
December	20.6	73.9	57.9
January	160.3	24.6	60.7
February	74.4	14.7	75.9
March	163.6	45.5	97.3

^zAverage of 1929–1990 (Albregts et al., 1990).

^y°C = 0.56 (°F – 32).

^x1.0 mm = 0.04 inch.

Table 4. Strawberry market value per 5.4-kg (12-lb) flat in 1995–96 and 1996–97^z.

Month	1995–96	1996–97
	\$	
December	17.28	19.20
January	11.16	11.64
February	9.36	8.52
March	6.12	8.28

^zFlorida Agricultural Statistics Service, 1998.

from southern sources produced yields comparable to mid latitude plants in January and February in 1995–96 but significantly fewer fruits in both these months in 1996–97, possibly due to increased levels of colletotrichum crown rot (*Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. in Penz.). Greatest differences in monthly fruit production for plants among the nursery regions occurred in February when plants from northern sources produced the most fruit, nearly 11.5 t·ha⁻¹ (5.1 tons/acre) (Fig. 1 and 2). Early yields from southern plug plants exceeded southern bareroot plant yields, but plug plants from mid latitude sources produced fewer marketable fruits than mid latitude bareroot plants in the same period (data not shown). No differences in fruit yield were detected in March in either year among plants from the three regions. Mean fruit weight differed from plants among plant sources, but differences did not exceed 1.9 g (0.07 oz) and may not be meaningful in the marketplace (Table 1 and 2).

Preventing disease introduction is a serious concern of growers in selecting plant sources. On initial examination, in both years, a majority of the plants from northern latitude sources displayed

symptoms of leaf blotch (*Gnomonia comari* P. Karst) and angular leaf spot (*Xanthomonas fragariae* Kennedy & King) was found on less than half of the northern plants. Plants from southern latitude sources showed no symptoms of these diseases. Bareroot plants from mid latitude sources showed similar, though less severe, foliar disease infection compared with plants from northern plant sources. Conversely, phomopsis leaf blight (*Phomopsis obscurans* (Ellis & Everh.) Sutton) was observed in all plots containing plants from southern latitude sources as well as plug plants from mid latitude nurseries. Plants from northern latitude sources and bareroot transplants from mid latitude nurseries showed no symptoms of phomopsis leaf blight. Although both mid latitude plant sources were in a mountainous area of North Carolina, elevation and hence climate differed, which may partially explain the differences in foliar diseases observed on these plants. Angular leaf spot and phomopsis leaf blight are generally not serious problems in Florida production fields, al-

though angular leaf spot lesions on fruit calyxes can be produced under favorable conditions (extended periods of cool, wet weather) and cause fruit to be unmarketable. The diseases observed prior to planting persisted throughout the early season of this study, becoming more severe under favorable weather. Disease management in the nursery undoubtedly influences the severity of foliar disease on transplants; however, evaluations in this study suggest that plant source location plays a key role in which diseases may actually occur.

Low numbers of twospotted spider mite adults and eggs were found on plants from northern sources, fewer on mid latitude, and none on southern sources prior to planting in both years. The twospotted spider mite is the primary arthropod pest in Florida strawberries (Howard et al., 1985) and can cause significant yield losses. Strawberry root aphids (*Aphis forbesi* Weed) were the only other arthropod pest found on transplants prior to planting and they only occurred on plants from southern sources. Strawberry root aphids are generally only a minor problem in Florida strawberry production. Differences in arthropod pest infestations did not persist through the seasons, probably because these localized infestations were quickly eliminated by predators, parasites and insecticide applications.

Plant mortality in March was typically less than 5%, similar to losses in commercial fields. However, plots with

Fig. 1 Monthly strawberry yield by plants from northern (Canada, Massachusetts, Oregon), mid (North Carolina), and southern (Alabama, Florida) latitude sources in 1995–96, 1.0 t·ha⁻¹ = 0.446 ton/acre.

Fig. 2 Monthly strawberry yield by plants from northern (Canada, Massachusetts, Oregon), mid (North Carolina), and southern (Florida) latitude sources in 1996–97, 1.0 t·ha⁻¹ = 0.446 ton/acre.

plants from southern latitude sources lost from 7% to 20% (Table 1 and 2), except for the southern plug source in 1995–96. Mortality was mainly caused by colletotrichum crown rot, a disease favored by high temperatures, humidity, and frequent rainfall (Maas, 1998), which are typical summer conditions during southern strawberry transplant production.

The performance of ‘Sweet Charlie’ strawberry in west central Florida was influenced by location of transplant source. Early production can be critical to profitability since market prices for strawberries usually peak in December and are severely reduced by March. Earlier fruit production from northern and mid latitude plant sources in this study probably resulted from the influence on flowering of shorter photoperiods and cooler temperatures in the plant nurseries. For west central Florida ‘Sweet Charlie’ strawberry growers, the most consistent early season production with the least risk of pest-induced losses would be achieved by using transplants from northern and mid latitude sources.

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