Manipulating Transplant Morphology to Advance and Enhance Fruit Yield in Strawberry

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Abstract

Strawberry plants are vegetatively propagated in northern nurseries to supply fruit production farms in the southern United States of America. Digging actively growing plants in the fall from northern nurseries, and transplanting them into southern fields at a time of seasonally high temperatures makes it difficult for transplants to re-establish. Tall transplants are prone to leaf damage during shipping, and excessive leaf area causes more wilting after transplanting, leading to plant death in the southern fields. Improving strawberry plant morphology in the northern nurseries can produce more robust transplants, resulting in better post-transplant growth, higher fruit yields and earlier fruit production. Experiments to alter plant morphology used two methods: mechanical leaf removal by mowing, and chemical control using the growth regulator prohexadione-calcium. Two cultivars, 'Sweet Charlie' and 'Camarosa', were mowed in a nursery field in Nova Scotia (45º 26' N, 63º 27' W) on one of four dates (Aug. 22, Sept. 7, Sept. 22 and Oct. 5) during the growing season in 2000. Plants were dug on October 5, and transplanted in Dover, Florida (28º 00' N, 82º 22' W). Fruits were collected twice weekly from late November, 2000 to mid-February, 2001. Mowing reduced plant height and total leaf area. At time of digging, plants which were mowed later were shorter than those mowed earlier. By the end of December 'Camarosa' plants mowed on Sept. 7, had produced 51 % more fruit by weight than the unmowed controls; total yield (to mid-February) was increased by 20%. Plants of 'Sweet Charlie' treated with prohexadione-calcium on Sept. 7 in Nova Scotia were more compact, and in turn produced 29 % more fruit by weight by the end of December, and greater total fruit yield (18 %) relative to non-treated transplants in Florida.

INTRODUCTION

In spring, strawberry plants are vegetatively propagated in northern nurseries for production of transplants to be used in fruit production in the southern United States. Bare root daughter plants are dug in the fall from nurseries in Nova Scotia and immediately shipped to the U.S.A. to be transplanted in the annual hill plasticulture winter fruit production system (Hancock, 1999) . Previous studies have shown that northern-grown transplants produced fruit 2 to 3 weeks earlier (Chandler et al., 1989) and in significantly greater quantity (Himelrick et al., 1994) than those grown in southern nurseries. The

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transplant system nevertheless causes physiological stress since plants are still actively growing at the time of digging. Furthermore the warm environment into which plants are introduced in September and October creates additional stress making re-establishment difficult. The nursery growing environment frequently produces plants with long petioles and large leaves that are prone to damage in shipment, and can exacerbate water loss following planting to the hill system (Duval et al., 2002). To overcome these problems, overhead irrigation may be required for up to 10 days immediately post-transplant, a management practice that places a heavy burden on water resources.

Procedures to limit plant height and increase compactness of daughter plants in the northern nurseries can alleviate plant injury associated with transport and may facilitate re-establishment in the southern production fields. Faster establishment may in turn lead to earlier fruit production, a factor which has the potential to significantly improve economic returns from the crop (Stapleton et al., 2001).

Transplant morphology can be altered mechanically by mowing (removal of leaf laminas and part of the petioles), or chemically with a growth regulator. Mowing at a specified number of days before transplanting allows growth of new leaves. Vegetative growth of strawberry is regulated by photoperiod and temperature (Heide 1977): shorter day-lengths and lower temperatures generally experienced later in the growing season will reduce petiole growth. Moreover, the reduced time available for growth when plants are mowed in mid to late summer means that overall height is reduced compared to plants that have not experienced defoliation. Plant growth can also be manipulated chemically. Prohexadione-calcium (chemical name: calcium 3-oxido-4-propionyl-5-oxo-3-cyclo-hexane-carboxylate) is a gibberellin synthesis inhibitor which can reduce cell elongation (Evans et al., 1999) and may be useful in reducing leaf growth.

The purpose of this study was to determine possible strategies to optimize strawberry plant morphology for rapid transplant establishment and early cropping in southern fruit production fields. We have investigated: 1. Mechanical leaf removal — mowing plants on different dates during the growing season to determine the impact of mowing on winter crop earliness and seasonal fruit yield, and 2. Chemical height control — using the growth regulator, prohexadione-calcium.

MATERIALS AND METHODS

The experiments took place in two locations. Initially all strawberry plants were treated in a nursery field in Nova Scotia (45º 26' N, 63º 27' W). Two cultivars, 'Sweet Charlie' and 'Camarosa' were mowed on one of four dates: Aug. 22, Sept. 7, Sept. 22 and Oct. 5, or left unmowed during the growing season in 2000. Air temperature in the field was recorded each hour using a shielded thermistor and a datalogger. Growing degree days of 5 and 10 ^{0}C base were calculated for each mowing date. For chemical height control, ‘Sweet Charlie’ plants were sprayed with prohexadione-calcium on Sept. 7 at a concentration of 62.5 ppm, or left unsprayed. All treated plants were dug early in October, and immediately transported to Dover, Florida (28º 00' N, 82º 22' W).

In Dover, bare-roots were transplanted in a winter fruit production system using annual hill plasticulture. Plants were set with 30 x 30 cm spacing on double row beds which were 60 cm wide with 122 cm centers. There were eight replicates for each mowing treatment in the leaf removal experiment, and four replicates for the prohexadione-calcium, and unsprayed treatments in the chemical height control study. The experiments were arranged in randomized complete blocks (in both the nursery, and production fields). Starting in late November, un-blemished, marketable fruits weighing over 10g (Butler et al., 2002) were collected twice weekly and weighed. The experiment was terminated in February. Fruit yield was calculated on a per plant basis. Analysis of variance was conducted for early yield (up to and including December 31) and seasonal fruit yield (cumulative yield to February 15).

RESULTS AND DISCUSSION

Mechanical Leaf Removal

Predictably, all mowed strawberry plants had fewer leaves than the controls at time of digging (Table 1). Plants were also progressively shorter at later mowing dates and had reduced crown diameters as compared with the controls, and those in which leaf removal was delayed until digging. There is a direct relationship between establishment success and fruit yields in annual hill systems (Albregts and Howard, 1982). Strawberry plants that establish faster in production fields following transplant are likely to produce more early fruit and higher seasonal yields than those that suffer delayed establishment. Modifying plant morphology, by for example, reducing transplant leaf area might be expected to affect establishment, and subsequent yield. Following transplanting, the two cultivars responded differently to the nursery mowing treatments. Transplants of 'Camarosa' (Figure 1A) mowed on September 7 (GDD 1699 and 1099 for 5 C and 10 C base, respectively) produced 50.6 % more fruit by weight by the end of December; seasonal yield was increased by 20 %. 'Sweet Charlie' did not respond positively to any mowing treatment (Figure 1B) either in terms of early, or total yield. The effects of leaf removal on transplant physiology are likely complex. On one hand, reduced leaf area provides less transpirational surface and therefore lower potential water loss immediately after transplanting as has been demonstrated in woody plants (Struve and Joly, 1992). However, removing leaves also reduces photosynthetic potential and the capacity of the plant to restore carbohydrate reserves (Whitcomb, 1979). Leaves removed in pre-transplant pruning also remove significant quantities of mobile nutrients that may help establishment and re-growth (Whitcomb, 1976). The fact that strawberry plants mowed before transplanting in our experiments had significantly reduced crown size points to a relationship between leaf area and growth of other plant organs. Crown size itself is directly related to yield (Le Miere et al., 1998) so there is likely an optimum relationship between leaf area and crown size at time of transplanting. The balance may be achieved by mowing early enough to allow adequate re-growth. For 'Camarosa' this may occur with mowing around September 7 (or, perhaps, on a date established by the accumulation of a requisite number of growing degree-days). In 'Sweet Charlie' mowing appears to have no beneficial effect on subsequent growth and fruiting potential. While early yield was unaffected by mowing on August 22, September 7 or September 22, total seasonal yields were all lower than in the control.

Total leaf removal at time of transplant proved detrimental to early and seasonal yields in both cultivars. We have previously observed root regeneration rates in strawberry transplants from which all leaves had been removed to be slower than their fully-leafed counterparts (unpublished data). Growth rate of crowns has also been shown to be significantly reduced by complete defoliation (Mohamed, 2002). Taken together these results suggest an important role for existing leaves in transplant establishment and subsequent growth and contraindicates complete leaf removal at time of transplanting.

Chemical Growth Regulation

Both early and total yield were increased in 'Sweet Charlie' plants by a single application of prohexadione-calcium (Table 2). Early yield was increased by 29 % and total yield by 18 % as compared with the unsprayed controls. Our previous studies have shown that, within 21 days of application, prohexadione-calcium limits petiole growth, increases crown size and thickens leaves (Reekie and Hicklenton, 2002). As with leaf removal treatments, these changes in plant morphology are likely to have complex effects on subsequent plant growth and development including changes in carbohydrate partitioning (Guak et al., 2001) and water relations (Hicklenton and Reekie, 2002). The mechanism and link between observable effects of prohexadione-calcium and transplant yield, and the effects on other cultivars have yet to be determined.

CONCLUSION

Both mechanical (mowing) and chemical (prohexadione-calcium) treatments applied in these experiments were effective in altering strawberry plant morphology. Smaller transplants with less foliage are easier to transport and may require less irrigation for transplant establishment in the plasticulture system in Florida. The impact of mowing on early and total fruit yield was cultivar specific, and the timing of treatment was crucial to success. While fruit yield of 'Sweet Charlie' did not increase due to mowing treatments, mowing of 'Camarosa' on September 7 significantly advanced and increased fruit yield. The application of prohexadione-calcium to 'Sweet Charlie' on September 7 at a concentration of 62.5 ppm was successful in advancing and increasing strawberry fruit production. More research is underway to investigate the physiological processes of the plant which may have been affected by the mechanical and chemical treatments.

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Tables

Table 1. Morphological traits of strawberry daughter plants in relation to mowing date (Data are means of 32 plants measured on October 2).

Mowing Date	'Sweet Charlie'			'Camarosa'		
	Number of Leaves	Plant Height (cm)	Crown Diameter (mm)	Number of Leaves	Plant Height (cm)	Crown Diameter (mm)
Aug. 22	4.8	16.7	14.3	4.4	15.8	14.6
Sept. 7	3.9	14.9	14.4	3.4	15	14.7
Sept. 22	3.0	13.7	17	2.6	12.5	15.9
Oct. 2	0	0	18.5	0	0	17.8
Control	6.1	20.3	18.8	5.8	19.3	19

LSD (5% level)	Number leaves	Plant height	Crown diam.
Mowing (M)	0.29	0.68	0.86
Cultivar (C)	0.19	0.43	0.54
M x C	0.42	0.95	1.22

Table 2. Early (to December 31) and total season (to February 15) yield (g marketable fruit per plant) of 'Sweet Charlie' plants treated with 62.5 ppm prohexadione-calcium spray on September 7.

Treatment	Early yield	Total yield
Treated	76.7	226.5
Un-treated control	59.5	191.4
	Early yield	Total yield
LSD (5% level)	29.16	60.43

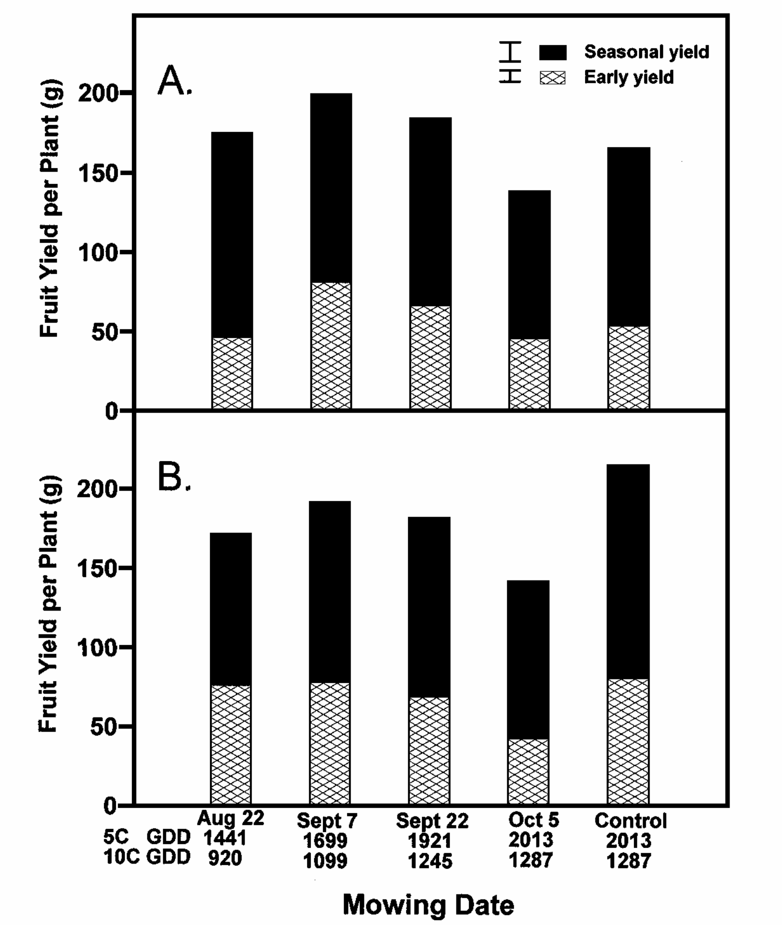

Fig. 1. Early (to December 31) and total season (to February 15) yield (g marketable fruit per plant) of 'Camarosa' (A) and 'Sweet Charlie' (B) plants mowed on four dates during the growing season in 2000. Vertical bars represent standard errors of the means.