Field Evaluation of Two Cultivars of Red Maple From Tissue-Culture and Budded Origins

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The growth of tissue cultured and budded trees of 'Franksred' and 'October Glory' red maple (*Acer rubrum* L.) were compared in a field study. There were no differences between the two propagation methods for the two cultivars in annual mean height or increase in stem caliper, fall coloration, or gas exchange. No rapid screening technique for early detection of bud union failure was developed.

INTRODUCTION

Current methods of propagation for cultivars of red maple (*Acer rubrum* L.) include softwood cuttings (Moller, 1985; Schwab, 1979; Still and Lane, 1984), tissue culture (Bracken, 1988; Suttle, 1992), and budding onto seedling rootstocks (Santamour, 1992). Losses exceeding 50% in the first year and 10 to 20% in the second year as a result of bud union incompatibility have been reported in selected cultivars (Moller, 1985; Schwab, 1979). In a previous red maple evaluation conducted by the Alabama Agricultural Experiment Station (Fare et al., 1990), bud union failure was evident in eight of nine cultivars tested within 3 years after planting. All trees included in the study were budded onto seedling rootstocks. The only cultivar without visible compatibility problems was 'Franksred'. 'October Glory' was not included in previous evaluations.

The objective of this study was to evaluate the influence of tissue-culture and budding propagation systems on the growth of two field-grown cultivars of red maple. Specific characteristics evaluated included mortality, annual growth, morphological characteristics, and gas exchange capacities. Gas exchange measurements were conducted in an effort to develop a rapid screening technique for early detection of stress from bud union failure, prior to physical evidence of bud union failure.

MATERIALS AND METHODS

In March 1988, *A. rubrum* L 'Franksred' (Red Sunset^{TM}), and 'October Glory' tissue-culture-produced microplantlets and budded trees on seedling rootstocks were obtained from A.G. McGill & Son Nursery, Fairview, Oregon. Trees were containerized in 2.8-liter pots in an amended 6 pinebark : 1 sand medium (v/v) and grown in a double layer polyhouse for 3 months, then moved outdoors under overhead irrigation for the remainder of the growing season. In 1989, trees were transplanted to 9.5-liter containers for another 12 months. Trees ranged from 1.2 to 1.5 m (4.2 to 4.9 ft) in height when transplanted in March 1990, into a Cecil gravelly sandy loam soil at the Piedmont Substation, Camp Hill, Alabama (lat. 32° 83' N, long. 85° 65' W). The two cultivars were interplanted within a cultivar trial with 12 other red maple selections in a randomized complete block design with five

blocks of two plants each. The trees were planted on a 9.1 × 10.7 m (30 × 12 ft) spacing and were fertilized with 59 g N, as 13N-5.6P-10.8K (13N-13P_2O5-13K_20) per 2.5 cm (1 inch) of stem diameter at 30.5 cm (1 ft) above ground level, at planting and annually in March prior to bud break. Drip irrigation was supplied to each tree based on 100% replacement of net evaporation from a class A pan. Height and caliper increases were determined by the difference in current and previous year measurements following the 1990 through 1994 growing seasons.

Ten leaves from the midpoint of current season's growth were harvested at random from each tree monthly—May through Sept. 1993—for determination of total leaf area and petiole length.

Leaf area was determined with a transparent belt conveyer accessory leaf area meter, LICOR Mod. LI-3050A (LICOR Inc., Lincoln, NE).

Similar leaf samples were collected from each treatment within one block in Aug. and Sept. 1993. Stomatal density was calculated using an eyepiece reticule with a field of observation of 0.0156 mm^2 at 40× magnification. Means were derived for each cultivar from five leaves per tree from each propagation method, with four fields of observation per leaf, for a total of 20 observations per cultivar per propagation method.

Foliar greenness and N levels were determined in Aug. and Sept. 1993. Leaf greenness was determined with a SPAD-502 Chlorophyll Meter (Minolta Camera Co., Ltd., Japan) and total N with a LECO CHN-600 Analyzer (LECO Corp., St. Joseph, MI). Measurements were made with a SPAD-502 on fresh leaf tissue prior to N analysis. Leaf tissue was dried at 80C, ground in a cyclone mill through a 0.5-mm sieve, weighed, and was analyzed by combustion.

Net CO_2 exchange rate was determined following the procedures of Jurik (1986). Net CO_2 exchange rate of sugar maple leaves measured at light saturation was reported to increase to a maximum near the completion of leaf expansion in early June, was constant until mid-Sept., and then rapidly declined until leaf senescence (Jurik, 1986). Gas exchange measurements (net photosynthesis {Pn}, stomatal conductance, and transpiration) were initiated in June 1992, and taken from 8:00 AM until 2:00 PM CST at an average photosynthetically active radiation (PAR) level of 1474 µmol m^{-2} s^{-1}. Measurements were repeated under similar PAR levels in September 1992, June and August 1993. Gas exchange observations were made with a LI-6250 Portable Photosynthesis System (LICOR Inc.) in a closed mode (Mitchell, 1992), which allowed leaves to draw down ambient CO_2 concentration in a 1-liter chamber over a 20-sec period. Three gas exchange observations were made on each plant within each replication. Non-destructive measurements were made on attached, mature leaves growing in full sun at the mid-point of current seasons growth and tree canopy. Assimilation rates were observed over a 45-minute period within each replication with a CO_2 concentration ranging from 320 to 390 µg l^{-1} at near constant leaf temperatures of 32C (90F).

Night respiration rates were determined in July and August, 1993, on consecutive nights between 10:00 PM and 2:00 AM. Night respiration rates were determined in the same manner in which Pn rates were generated in the day. Measurements were made under full moonlight. The only supplemental light was from the diode on the LI-COR monitor. Treatment differences were determined by Duncan's Multiple Range Test at $P = 0.05$.

RESULTS AND DISCUSSION

During the first five-growing seasons in the field, there were no differences in annual mean height increases between tissue cultured and budded plants for either cultivar (Table 1). Mean height growth attained for budded 'Franksred' was 21 cm greater annually in this study than that reported in previous evaluations at the same substation (Fare et al., 1990). Differences may be attributed to trickle irrigation for the current study, and no supplemental irrigation in the previous evaluations. Final height for 'Franksred' from tissue-culture and budded propagation were 481 cm and 465 cm respectively. Final height for 'October Glory' from tissue-culture and budded propagation were 510 cm (16.7 ft) and 492 cm (16.1 ft), respectively.

Table 1. Annual height and caliper increase of tissue cultured and budded plants of two *Acer rubrum* cultivars outplanted in a field study.

	1991		1992		1993		1994		Average annual increase	
	Height (cm)	Caliper (mm)	Height (cm)	Caliper (mm)	Height (cm)	Caliper (mm)	Height (cm)	Caliper (mm)	(cm)	(mm)
'Franksred'										
Tissue culture	80 a[z]	13 a	73 a	17 a	70 a	23 a	76 a	21 a	75 a	19 a
Budded	74 a	12 a	73 a	19 a	61 a	19 b	76 a	21 a	71 a	18 a
'October Glory'										
Tissue culture	65 a	14 a	88 a	20 a	87 a	29 a	74 a	24 a	81 a	22 a
Budded	62 a	16 a	91 a	22 a	96 a	26 a	74 a	23 a	79 a	22 a

[z] Mean separation by cultivar (tissue culture versus budded) within columns by Duncan's Multiple Range Test, $P = 0.05$.

Annual increases in mean caliper were not different for any of the 5 years for tissue cultured versus budded plants for either cultivar with the exception of 1993, when tissue cultured 'Franksred' trees had more mean caliper growth than the budded trees. Increases seen in the mean caliper growth for budded 'Franksred' were again greater annually under irrigation than those reported in the earlier study (Fare et al., 1990). Final stem caliper for 'Franksred' produced from tissue culture and budded plants were 9.9 cm (3.9 inches) and 9.2 cm (3.6 inches), respectively. Final caliper for 'October Glory' from tissue culture and budded plants were 11.9 cm (4.7 inches) and 10.7 cm (4.2 inches), respectively.

Of the additional evaluations made in an effort to detect differences that might indicate bud union incompatibility (Table 2), the only difference noted for 'Franksred' was a greater stomatal density on the trees from tissue culture than plants budded onto seedling rootstocks. However, tissue-cultured 'October Glory' had greater leaf area and petiole length, and a lower stomatal density than budded 'October Glory' (Table 2).

Table 2. Leaf characteristics[z] of tissue cultured and budded plants of two *Acer rubrum* cultivars outplanted in a field study.

	Average leaf area (cm^2)	Petiole length (cm)	Stomatal # (cm^2)	Nitrogen (%) by LECO	Chlorophyll level (SPAD)
'Franksred'					
Tissue culture	53.37 a[y]	9.26 a	76,410 a	2.17 a	52.0 a
Budded	53.83 a	9.79 a	70,192 b	2.20 a	52.5 a
'October Glory'					
Tissue culture	61.87 a	17.09 a	64,423 b	2.52 a	43.2 b
Budded	57.55 b	15.52 b	73,076 a	2.51 a	44.0 a

[z] Means by column derived from: 80, 80, 40, 1200, 1200 leaf samples, respectively.
[y] Mean separation by cultivar (tissue culture versus budded) within columns by Duncan's Multiple Range Test, P=0.05.

Often leaf greenness is considered to be highly correlated with foliar N levels. However, results of this study indicate 'Franksred', while generally considered by growers to have the deepest green foliage of red maple cultivars, had a lower foliar N than 'October Glory'; conversely, 'Franksred' had higher values for leaf greenness (higher chlorophyll) as determined by the SPAD-502 Meter. The propagation method had no effect on foliar N levels with the two cultivars. Foliar N levels for 'Franksred' were similar to reports by others (Gilliam et al., 1980).

There were no differences in daily gas exchange capacities or night respiration rates for either cultivar (data not shown). No 'Franksred' trees were lost in this study. In June 1993 one 'October Glory' died in this study as a result of bud union incompatibility. No physiological or physical evidence of bud union problems were evident prior to the tree breaking off at ground level during heavy winds.

Either method of propagation appears to be suitable for 'October Glory' and 'Franksred'. Therefore, selecting a propagation method based on production costs of a particular method is justified for these two cultivars. Bracken (1988) and Schwab (1979) address economic concerns for selecting one propagation method over another.

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