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ABSTRACT

Studies were conducted from January to October 2005 to determine the effect of root-cutting length on adventitious shoot yield and the management practices necessary to produce nursery-quality primocane-fruiting blackberry plants. The first portion of the study measured the average number of shoots produced from 7.6 cm- and 15.2 cm-long root cuttings of APF-44 blackberry—a primocane-fruiting genotype from the University of Arkansas breeding program. Cuttings were forced in a shallow bin containing a soilless potting medium. The average number of shoots per root cutting from 7.6 cm- and 15.2 cm- long root cuttings averaged 1.6 and 2.7 shoots per root cutting, respectively. Rooting percentage for collected shoots was nearly 100% regardless of root-cutting length source. A qualitative comparison of shoots from the two roots lengths was similar. The latter part of the study included various treatments on the rooted shoots that might affect the productivity and quality of the final product intended for nursery sales in early fall. With the aim of producing a flowering/fruiting shrub by late September, three treatments were applied: pot dimension, fertilizer rate, and shoot tipping. Fertilizer rate had the greatest impact of all treatments with the higher rate producing larger and more attractive plants. Above-normal summer/fall temperatures may explain lack of fruiting on APF-44 blackberries, but the dimension and size of some plants provided a portion of the intended aesthetic.

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INTRODUCTION

Blackberries are a fruiting shrub in the genus *Rubus*, the same genus as raspberries; thus, cultivation of the two plants is very similar (Pritts and Handley, 1991). Traditional propagation methods of blackberries include tip layering, suckering, leaf-stem cuttings, tissue culture, and root cuttings (Caldwell, 1984). These techniques are often used but all have some limitations for propagators. Root cuttings, of all options, can be the most economical and timely way to propagate blackberries and the University of Arkansas uses root cuttings for nearly all blackberry propagation (John R. Clark, personal communication). Based on a study by University of Arkansas undergraduate, Ellen Thompson (Thompson et al., 2004), a "simple modification" to the traditional root-cutting propagation method led to increased propagule yield and rooting success. However, cultivar effects were sometimes significant. This modification of propagation technique allows for space-limited and/or greenhouse production and greatly decreases the time and monetary investment associated with traditional methods. Thompson's study was based on precedents of a Swiss *Rubus* propagation system, and the findings were supported by the idea that forcing multiple adventitious shoots from a single root cutting increases the success and number of blackberry daughter plants. Moreover, the closely related raspberry is propagated in this way with similar results (Pritts and Handley, 1991).

The advent of primocane-fruiting blackberries, first introduced by the University of Arkansas breeding program in 2004, provides for potential increases in fruit yield and extends the growing season well into early fall (Clark et al., 2005). With this in mind, it might be possible to produce a nursery-quality plant that could produce fruit for home-gardeners into the autumn months. Moreover, the ornamental qualities of APF-44 blackberry specifically are conducive to a nursery's aesthetic requirements; the plant is observed to have relatively short internodal length and a "bushy" mounded shape, and produces flowers and fruit in early September through October (John R. Clark, personal communication). Management practices to enhance these qualities—mid-summer tipping, fertilizer rates, and pot dimension—are investigated in this study.

MATERIALS AND METHODS

Experiment I: Adventitious shoot propagation

Root cuttings of two sizes, 7.6 cm and 15.2 cm, were evaluated in greenhouse conditions for propagule yield from January to April 2005. The APF-44 blackberry root cuttings used in propagation were collected from the University of Arkansas Fruit Substation, Clarksville, in late fall, 2004 (APF-44 is a breeding selection and is not released to the public nor is it an item of commerce). The diameter of the roots averaged approximately 5.3 mm. After one month of cold storage, the root cuttings were positioned in drainable plastic bins filled with LC1® soil-less potting mix (SunGro Horticulture; Alberta, Canada) to the fill line. Root cuttings were posi-

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MEET THE STUDENT-AUTHOR

After graduating from Lee's Summit North High School in Kansas City, Mo., I enrolled at the University of Arkansas and graduated in the fall of 2005 with a B.S. in horticulture and a minor in global agriculture, food, and life sciences. While in college, I was involved in choir, a summer research internship in the Department of Plant Pathology, a community design project in Clarendon, Ark., and independent student research such as this project.

My undergraduate research has inspired me to attend graduate school, and I plan to apply for the spring semester of 2007. All of my undergraduate experiences have contributed to my goals for the future, and I cannot wait to apply all I have learned in a graduate program and a career. It has been an honor to be involved in the University of Arkansas' thriving scientific community.

tioned horizontally at a depth of 2.5-3.5 cm below the medium surface. Greenhouse temperatures were maintained at a minimum temperature of 20°C and a maximum temperature of 25°C. Cutting bins were watered as needed. The experimental design was a randomized block of 10 replications of three root cuttings per replication. After the initial planting of root cuttings on 27 Jan. 2005, shoots began to appear on 1 March, and shoots continued to be harvested every 3-4 days as they grew to a length of approximately 5 cm with two partially expanded leaves. This harvest continued until 4 Apr. One hundred-three total shoots from the two root-cutting treatments were transplanted into individual Jiffy® peat pellets (Jiffy Co., Batavia, Ill.), and were subsequently placed under an intermittent mist system that misted the cuttings for 8 s every 10 min until shoots had rooted. Each shoot rooted in approximately 2.5 weeks. Shoot harvest continued until 4 Apr. when shoot production had significantly diminished. Data collection included percent shoot production per week, total number of shoots produced, shoot rooting success, and average number of shoots per root cutting.

Experiment II: Cultural inputs in nursery production of APF-44

Shoot cuttings rooted in peat pellets were transplanted into black plastic pots with the same media volume (9,000 cm^3) but different pot dimensions: a "tall" Classic 1000-C® (25 cm top diam. x 23 cm tall) and a "squat" Classic 1200S-C® (28 cm top diam. x 19 cm tall) (Nursery Supplies Inc. (Chambersburg, Penn.). Transplanting began on 21 March and was completed on 4 April. On 30 April, potted plants were randomly arranged on an outdoor gravel pad. Plants were watered as needed using overhead impact sprinklers. Fertilizer rate and tipping treatments began on 13 May. The design was a randomized block of eight replications of eight of the following combination of treatments: 1) two pot dimensions (described above); 2) PolyOn 18-6-12, 8-9 month fertilizer topdress applied at a rate of 0.65 kg N/m^3 or 1.31 kg N/m^3; and 3) and the tipping treatment applied to half of the plants in mid-summer. On 13 May, all plants were tipped to 30 cm in preparation for the growing season, and the fertilizer treatments were applied. On 15 July, all flowers and developing berries were removed and the tipping treatment was applied to the appropriate plants; these plants were again reduced to 30 cm in length by this tipping. By 12 Oct., the study was concluded and the following data were collected: 1) shoot growth index (GI); 2) shoot fresh weight; and 3) qualitative measurements—flowering and fruiting, plant shape, internodal length, leaf color, etc.

RESULTS AND DISCUSSION

Experiment I:

Root length had a significant effect on the number of adventitious shoots produced. The average number of shoots per root cutting for short (7.6 cm) and long (15.2 cm) root cuttings was 1.6 and 2.7, respectively. This finding supports results from an earlier study (Thompson et al., 2004). Shoot collection began approximately 4 weeks after roots were placed in the medium. Shoot collection was greatest in the first 4 weeks of shoot emergence; after this point, shoot production was significantly decreased (Fig. 1). A total of 72.3% of shoots from the 7.6 cm roots was harvested in the first 4 weeks. Similarly, 84.8% of shoots from the 15.2 cm roots had been harvested in the same time period. All shoots were of similar quality, and shoots were collected at the same point in development. The percent survival was nearly 100% (data not shown). Similar rooting percentages were reported previously (Thompson et al., 2004). These results suggest that this method also is successful for propagation of this blackberry genotype. The shoots grew vigorously in the peat pellets and rooted in approximately 1-2 weeks.

Experiment II:

Fertilizer rates of 0.65 kg $N/m^3$and 1.31 kg N/m^3 had a significant effect on all plant growth parameters. Shoot fresh weights for plants grown at the low and high fertilizer rates were 155 and 400 gm, respectively (Table 1). Fertilizer rate also had an effect on the height of the plants; on average the plants with the lower fertilizer rate were 0.43 m tall versus 0.59 m for the higher rate (Table 1). In a similar way, average plant widths of the high-fertilizer-rate plants were greater than for those receiving the low fertilizer rate (Table 1). The plants that were not tipped averaged 0.47 m tall, whereas the plants that underwent the July tipping treatment were 0.55 m tall (non-signficant difference) (data not shown). All of the plants that were not tipped had a one-dimensional growth habit, with shoots tending to fall over and grow horizontally, while the tipped plants were more spreading and attractive (data not shown). No treatment resulted in plants with consistently different numbers of flowers or fruits (data not shown). Qualitatively, the plants with the best shape, leaf color, and size were the two tipped treatments and the higher fertilizer rate; pot dimension did not cause any aesthetic disparity (data not shown).

The main objective of these studies was to determine the propagation and production methods necessary to produce nursery-quality plants of APF-44 in a timely manner. As previous studies have concluded, root length plays a significant role in forcing adventitious shoots.

Longer roots produce more shoots – this is expected as they are simply longer. On the other hand, analysis of these values indicates that per 15.2 cm of root length, the shorter root produces more shoots on average for a similar length of space (i.e. 2 – 7.6 cm roots can produce 3.2 shoots per 15.2 cm, whereas the 15.2 cm roots produced 2.7 shoots in this study). This finding is of potential value to propagators, who need thousands of shoot cuttings. For instance, 2000 7.6 cm roots cuttings with a total root cutting length of 15,200 cm should yield 3200 shoots. Likewise, 1000 15.2 cm of root cuttings with the same 15,2000 cm total should yield 2700 shoots. On the other hand, shoot quality was the same for the two root lengths. In fact, shoot quality was maintained at an excellent level throughout the first portion of the experiment: all shoots rooted and indicated no nutrient deficiency. Thompson et al. (2004) noted the same observation with 'Apache', 'Arapaho', and 'Ouachita' blackberry cultivars.

Building upon an efficient propagation method, this study is the first to investigate plant management techniques that might create a nursery-quality, primocane-fruiting blackberry marketable to homeowners during autumn. After shoots had been rooted and potted and treatments were applied, disparities began to appear among the plants. Plants that were tipped in mid-summer and fertilized with the higher fertilizer rate displayed the intended mounded shape and short internodal lengths. On the other hand, the main objective of this portion of the experiment was not met; at the conclusion of the study, no plants had plentiful berry or flower displays. The negative effects of heat on flowering have been observed for APF-44, and this may explain the problem (John R. Clark, personal communication). Also, plants remaining in a juvenile state due to pruning may be less likely to flower (John R. Clark, personal communication). In this particular study, flowers were plentiful before the May flower/bud removal; after this time, plants rarely produced buds. Blackberry plants without berries in September are not marketable as a nursery-quality ornamental intended for autumn sale. Fortunately, it is possible that additional breeding might achieve more abundant blooming and increased heat tolerance for flowers and fruits.

Further studies might include use of an adult second-year plant, a different genotype identified with more abundant flowering in heat, or simply moving the study to a more temperate climate. The root cutting method was successful, and no improvements are suggested.

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Table 1. Effect of fertilizer rate on nursery plant shoot and plant growth parameters of APF-44 blackberry (APF-44 is a breeding selection and is not released to the public nor is it an item of commerce).

Fertilizer rate (kg N/m3)	Shoot fresh weight (g)	Shoot height (m)	Plant width 1 (m)	Plant width 2 (m)	GI[z] (m3)
0.65	155.3 b[y]	0.431 b	0.658 b	0.292 b	0.076 b
1.31	400.3 a	0.586 a	1.200 a	0.729 a	0.428 a

[z] GI = growth index. Calculated by the formula hr^2, where h is shoot height, r=0.5d, and d is the mean of two diameter measurements taken at 90° angle from each other.
[y]Mean separation by LSD, P<0.05.

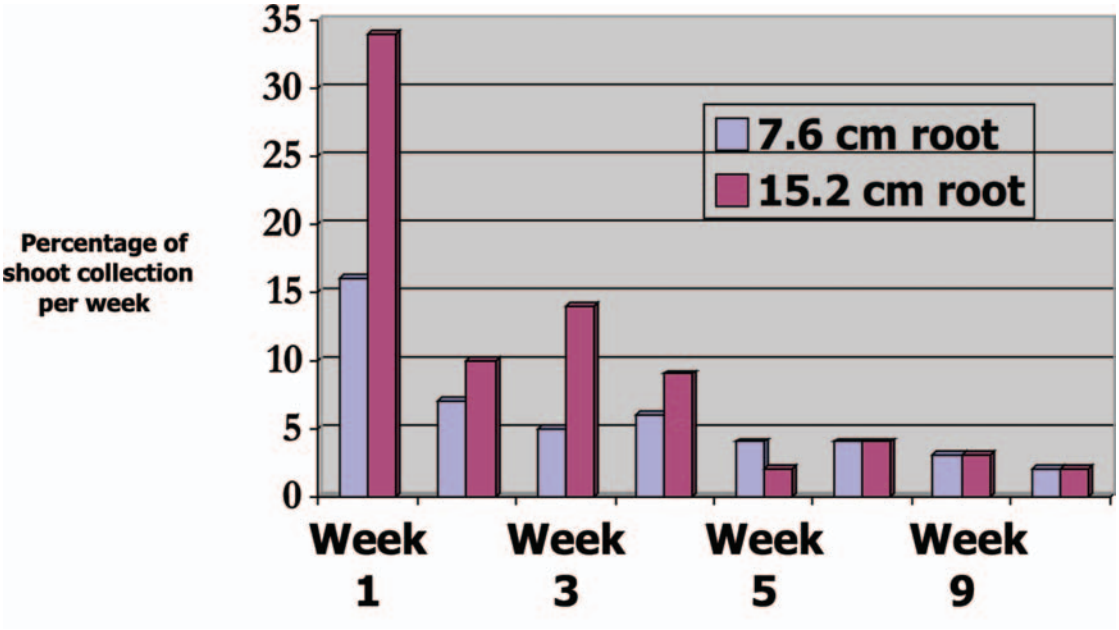

Fig. 1. Dates of adventitious shoot collection from APF-44 blackberry.