Research Reports

Micropropagation of Cascade Huckleberry, Mountain Huckleberry, and Oval-leaf Bilberry Using Woody Plant Medium and Murashige and Skoog Medium Formulations

Danny L. Barney^{1,3}, Omar A. Lopez², and Elizabeth King²

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SUMMARY. Two concentrations of two in vitro media formulations were evaluated for their effects on survival, shoot growth, and percentage rooting of cascade huckleberry (*Vaccinium deliciosum*), mountain huckleberry (*V. membranaceum*), and oval-leaf bilberry (*V. ovalifolium*). Two-node stem sections from established microshoots were cultured on full- or half-strength modified Murashige and Skoog medium (FSMS and HSMS) or full- or half-strength modified woody plant medium (FSWPM and HSWPM) unamended with plant growth regulators. Cultures were maintained at 21 °C with a 16-hour photoperiod for 98 days. Survival on FSMS was reduced by ~44% for cascade huckleberry, 63% for mountain huckleberry, and 18% for oval-leaf bilberry compared with average survival on HSMS, HSWPM, and FSWPM. Explants on FSMS also produced new shoot growth having the lowest dry weights, fewest shoots, and shortest shoots of the four media. Explant rooting percentages were also least on FSMS. For cascade huckleberry and oval-leaf bilberry, HSMS, HSWPM, and FSWPM all appeared suitable for general culture. For mountain huckleberry, both woody plant medium formulations produced greater microshoot dry weights, average shoot lengths, and explant rooting percentages compared with HSMS. These results are the first published on micropropagation for cascade huckleberry and oval-leaf bilberry, and provide starting protocols for commercial propagation and further research on micropropagation of these species.

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¹Department of Plant, Soil, and Entomological Sciences, University of Idaho, Sandpoint Research and Extension Center, 1904 North Boyer Avenue, Sandpoint, ID 83864.

²University of Idaho, Department of Plant, Soil, and Entomological Sciences, Moscow, ID 83844-2339.

³Corresponding author. E-mail: dbarney@uidaho.edu.

The fruits of huckleberries and bilberries found in genus *Vaccinium* section *Myrtillus* and indigenous to the northwestern United

States and western Canada are popular for commercial culinary and botanical products. Mountain huckleberry (synonymous with black huckleberry, thin-leaf huckleberry, or mountain bilberry), and cascade huckleberry (synonymous with cascade bilberry or blue huckleberry) are tetraploid species (Vander Kloet, 1988) rich in aroma and flavor chemicals (Fellman et al., 1998) and are highly sought after in the northwestern United States and western Canada for sales in fresh, frozen, and processing markets. These species are also moderately rich in antioxidant compounds, being similar to domestic blueberries (Lee et al., 2004; Taruscio et al., 2004). Oval-leaf bilberry [synonymous with oval-leaf blueberry or alaska blueberry (*V. alaskaense*)] is the third tetraploid [occasionally diploid (Vander Kloet, 1988)] species found in taxonomic section *Myrtillus*. Although its fruits lack high concentrations of flavor and aroma compounds (Fellman et al., 1998), they are particularly rich in antioxidant capacity (Lee et al., 2004; Taruscio et al., 2004), creating opportunities for value-added nutritional products. Currently, virtually all fruits of these three species are harvested from naturally occurring stands, most of which are on public lands in the northwestern United States. Oval-leaf bilberry is also harvested from the wild in southeastern Alaska. Demand for these fruits has increased while supplies from wild forest stands have decreased (Minore, 1972). The strong demand and limited supplies create opportunities for commercial production of these crops (Barney, 2003), and efforts are under way at the University of Idaho to produce cascade huckleberry, mountain huckleberry, and oval-leaf bilberry cultivars for field cultivation and managed forest systems. Vegetative propagation, however, has been problematic. Minore et al. (1979) reported

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
0.3048	ft	m	3.2808
25.4000	inch(es)	mm	0.0394
1	mmho/cm	mS·cm ⁻¹	1
28,350	oz	mg	3.5274 × 10 ⁻⁵
0.001	ppm	g·L ⁻¹	1000
1	ppm	mg·L ⁻¹	1
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

no success in rooting mountain huckleberry stem cuttings. Stark and Baker (1992) reported only limited success in propagation of montana huckleberry [*V. globulare*; synonymous with *V. membranaceum* (Vander Kloet, 1988)] from stem cuttings. In the latter trials, $\approx 20\%$ of cuttings rooted, but only when collected during a 2-week period during May. We have successfully propagated mountain huckleberry from rhizome cuttings (D.L. Barney, unpublished data), but this method was slow and the amounts of stock material limited. A literature search through the U.S. Department of Agriculture National Agricultural Library failed to reveal research publications related to vegetative propagation of cascade huckleberry or oval-leaf bilberry.

In vitro culture offers one method for rapidly producing many genetically uniform plants for evaluation and distribution to growers. Little information has been published on in vitro culture of *Vaccinium* section *Myrtillus* species, however. Barney (1999) reported on the effects of plant growth regulators on in vitro culture and microshoot rooting of mountain huckleberry, although those trials were limited to modified woody plant medium (WPM) (Lloyd and McCown, 1980). Reed and Abdelnour-Esquivel (1991) reported on in vitro trials involving section *Myrtillus* diploid species red huckleberry (*V. parvifolium*) and bilberry (*V. myrtillus*). They obtained 100% explant survival during establishment of red huckleberry on WPM modified by doubling the calcium nitrate [$\text{Ca}(\text{NO}_3)_2$] concentration and adding $4 \text{ mg}\cdot\text{L}^{-1}$ zeatin. Initiation rates for bilberry were reported to be intermediate on the same medium, but data and additional details were absent from the paper. Shibli et al. (1997) investigated the causes of hyperhydration of bilberry explants, testing various combinations of Fe sources, N^6 -[2-isopentenyl]adenine (2iP), zeatin, and zeatin riboside in WPM. Hyperhydration and chlorosis were absent on media amended with 2iP, although growth was less than on zeatin- or zeatin riboside-amended media. In combination with ferric ethylenediamine tetraacetate as the sole iron source, however, the latter two growth regulators induced

explant hyperhydration and chlorosis. Adding supplemental Fe in the form of sodium ferric ethylenediamine di-(o-hydroxyphenylacetate) in combination with zeatin or zeatin riboside dramatically reduced the incidence of hyperhydration and eliminated chlorotic symptoms. Jaakola et al. (2001) also reported on in vitro culture of bilberry using Murashige and Skoog (MS) medium (Murashige and Skoog, 1962) modified according to Economou and Read (1984) and containing various concentrations of 2iP. In these trials, the MS medium was modified by reducing the concentrations of ammonium nitrate (NH_4NO_3) and potassium nitrate (KNO_3), adding ammonium sulfate [$(\text{NH}_4)_2\text{SO}_4$], omitting potassium iodide (KI), and providing iron as diethylenetriaminepentaacetate containing 10% Fe. A 2iP concentration of $10.0 \text{ mg}\cdot\text{L}^{-1}$ was found to be optimal for establishment, with higher concentrations causing an increase in the number of brownish explants. Explants collected during the spring established better than those collected in autumn.

Extensive work has been published on micropropagation of other *Vaccinium* species, including highbush blueberry (*V. corymbosum*) (Reed and Abdelnour-Esquivel, 1991), lowbush blueberry (*V. angustifolium*) (Brissette et al., 1990; Debnath, 2004), cranberry (*V. macrocarpon*) (Marcotrigiano and McGlew, 1991), and lingonberry (*V. vitis-idaea*) (Debnath, 2005; Jaakola et al., 2001). Wolfe et al. (1983) evaluated seven media for micropropagating highbush blueberry, concluding that WPM produced the best growth and highest number of shoots 10 mm or longer. Other media evaluated by Wolfe et al. (1983) included full- and half-strength modified MS (FSMS, HSMS), Zimmerman's medium, both original and modified (Zimmerman and Broome, 1980), and Lyrene's medium (Lyrene, 1980).

The objectives for our trials were to identify suitable media for micropropagation of cascade huckleberry, mountain huckleberry, and oval-leaf bilberry to facilitate cultivar development and commercialization of these emerging crops, and to establish baselines for additional research on media formulations.

Our approach was to evaluate modifications of MS and WPM media, focusing on mineral nutrient concentrations.

Materials and methods

ESTABLISHMENT AND MAINTENANCE OF IN VITRO SHOOT CULTURES. Seeds from the three species were collected from geographically distinct sources in Idaho and Washington. Cascade huckleberry clone UIVADE 003A was derived from a seed accession collected from a 1300-m-elevation site in Washington State's Olympic National Forest, and UIVADE 005A from a 1300-m-elevation site near Stevens Pass in Washington's Wenatchee National Forest. Mountain huckleberry clone UIVAME 002A was derived from a 745-m-elevation seed collection site near Priest Lake in Idaho's Kaniksu National Forest, and UIVAME 031C from a 1600-m-elevation site near Lake Pend Oreille in the Kaniksu National Forest. Oval-leaf bilberry clone UIVAOF 007C was derived from seeds collected from a 360-m-elevation site in the Olympic National Forest. This was the only oval-leaf bilberry clone available for the micropropagation trials during both 2004 and 2005. One vigorous seedling from each seed source was selected for in vitro establishment, and each seedling served as the stock plant for one clone. The same clones were used for all treatments during both years of the trials. Explants were established on full-strength modified WPM (FSWPM) using single-node sections from actively growing 2-year-old seedlings. Either $4 \text{ mg}\cdot\text{L}^{-1}$ zeatin or $5 \text{ mg}\cdot\text{L}^{-1}$ 2iP was added to the medium during establishment. Before the trials described herein, the clones were subcultured at least twice over a minimum of 6 months on modified FSWPM prepared without plant growth regulators to minimize the residual effects of the 2iP and zeatin used during establishment. Inclusion of zeatin or 2iP in the micropropagation medium induces these species to produce clumps of numerous, short, heavily branched microshoots. All stock cultures exhibited individual, tall, unbranched, or lightly branched microshoots, suggesting no residual effects of these plant growth regulators.

MEDIA TRIALS. Two-node explants from microshoots were subcultured onto FSMS and HSMS, and FSWPM and half-strength modified WPM (HSWPM). The FSWPM was modified from the original formulation by replacing manganese sulfate monohydrate ($\text{MnSO}_4 \cdot \text{H}_2\text{O}$) at $22.3 \text{ mg} \cdot \text{L}^{-1}$ with manganese sulfate (MnSO_4) at $22.3 \text{ mg} \cdot \text{L}^{-1}$. The FSMS medium was modified by replacing manganese sulfate tetrahydrate ($\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$) at $22.3 \text{ mg} \cdot \text{L}^{-1}$ with MnSO_4 at $15.1 \text{ mg} \cdot \text{L}^{-1}$ and replacing zinc sulfate tetrahydrate ($\text{ZnSO}_4 \cdot 4\text{H}_2\text{O}$) at $8.6 \text{ mg} \cdot \text{L}^{-1}$ with zinc sulfate heptahydrate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$) at $10.6 \text{ mg} \cdot \text{L}^{-1}$. The modifications to the MS medium produced Mn and Zn concentrations equivalent to the original formulation. The modification of the WPM increased the Mn concentration from $7.3 \text{ mg} \cdot \text{L}^{-1}$ in the original formula to $8.1 \text{ mg} \cdot \text{L}^{-1}$ in our full-strength medium. Composition and concentrations of organic components were the same as used in the original WPM (Lloyd and McCown, 1980) and were identical for all media tested. The media were adjusted to pH 5.2 using potassium hydroxide (KOH) and were solidified with $7 \text{ g} \cdot \text{L}^{-1}$ agar, except for FSMS, which required $8 \text{ g} \cdot \text{L}^{-1}$ to solidify properly. Mineral nutrient concentrations in the media are shown in Table 1.

Baby food jars (200-mL capacity and 96 mm tall; Sigma Chemical Co., St. Louis) containing 50 mL medium served as culture vessels. Translucent polyethylene lids were sealed to the jars with self-cling plastic film. The cultures grew for 98 d at $21 \pm 1^\circ \text{C}$ under cool-white fluorescent lights at an average $30.5 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ with a 16-h photoperiod. Tetraploid species in *Vaccinium* section *Myrtillus* often grow slowly in vitro, and the extended cultivation time was required to develop sufficient new microshoot tissues for evaluation. After 98 d, the tallest microshoots were $\approx 55 \text{ mm}$ tall. The cultures were destructively harvested and percentage survival, percentage of explants forming roots, shoot dry weight (less original explants), and numbers and lengths of microshoots were recorded. For microshoot measurements, we counted and measured initial shoots arising from the original explants as well as secondary lateral shoots without distinguishing be-

Table 1. Mineral nutrient concentrations in the Murashige and Skoog (MS) and woody plant media (WPM) used for micropropagating cascade huckleberry, mountain huckleberry, and oval-leaf bilberry.

Nutrient	FSMS concn ($\text{mg} \cdot \text{L}^{-1}$) ^z	HSMS concn ($\text{mg} \cdot \text{L}^{-1}$) ^z	FSWPM concn ($\text{mg} \cdot \text{L}^{-1}$) ^z	HSWPM concn ($\text{mg} \cdot \text{L}^{-1}$) ^z
N	551.9	276.0	135.9	68.0
NH ₄	371.9	186.0	90.2	45.1
NO ₃	2443.4	1221.7	601.8	300.9
P	38.7	19.3	38.7	19.3
K	783.8	391.9	493.2	246.6
S	55.7	27.9	239.2	119.6
SO ₄	167.0	83.5	716.7	358.4
Ca	119.9	60.0	120.5	60.3
Mg	36.5	18.2	36.5	18.2
B	1.084	0.542	1.084	0.542
Cl	212.2	106.1	46.3	23.1
Co	0.006	0.003	0	0
Cu	0.006	0.003	0.064	0.032
Fe	5.585	2.793	5.585	2.793
Mn	5.493	2.747	8.113	4.056
Mo	0.099	0.050	0.099	0.050
Zn	2.410	1.205	1.956	0.978

^z1 $\text{mg} \cdot \text{L}^{-1}$ = 1 ppm.

FSMS, full-strength modified MS medium (Murashige and Skoog, 1962); FSWPM, full-strength modified WPM (Lloyd and McCown, 1980); HSMS, half-strength modified MS; HSWPM, half-strength modified WPM; MS, Murashige and Skoog; WPM, woody plant medium.

tween the two. The species studied in these trials often develop adventitious roots on original explants and new microshoots, even in the absence of root-promoting plant growth regulators in the media. Roots at or below the medium surface are typically plump and white. Aerial roots arising at leaf axils above the medium are thin, brown, and wiry. For these trials we considered a culture to have rooted if either root form could be visually distinguished, without magnification, on the original explant or new microshoots. Quantities of roots formed were usually insufficient for accurate quantitative measurement. Separate studies are underway to evaluate the effects of root-promoting growth regulators on in vitro and ex vitro rooting of these species.

EXPERIMENTAL DESIGN AND DATA ANALYSIS. The experiment was set up as a randomized complete block design. An experimental unit consisted of one baby food jar containing five explants of a single clone. Each clone and treatment combination was replicated with three jars per block. Within each block, the three jars representing a clone-treatment combination were kept together in a randomly assigned location within that block. The experiment was repeated in 2004 and 2005. Survival and

rooting percentages, dry weights, and shoot lengths were normally distributed. We analyzed these data with analysis of variance (ANOVA) or general linear model estimate models using SYSTAT software (version 10; SPSS, Chicago). Data for the number of microshoots were square root transformed and analyzed by the same method. Tukey's HSD model was used to compare treatment means if ANOVA indicated statistically significant differences at $P \leq 0.05$.

Results and discussion

Results for all species and clones were generally similar for 2004 and 2005 trials. Although parameter values differed significantly between years for all species and most parameters, the patterns of plant responses to the treatments were similar for both years and the data were combined for analyses (Table 2). The differences in growth between the 2 years may have been the result of aging of the stock cultures and variations in laboratory environmental conditions.

Survival was consistently lower on FSMS during both years for all species and clones. Compared with survival on the other media, survival on FSMS averaged $\approx 44\%$ less for cascade huckleberry, 63% less for

Table 2. Explant and microshoot survival, growth, and rooting of cascade huckleberry, mountain huckleberry, and oval-leaf bilberry as affected by media formulations and concentrations.

Treatment	Survival (%)	Dry wt (mg) ^z	Shoots (n)	Average shoot length (mm) ^z	Rooting (%)
Cascade huckleberry ^y					
HSMS	94.4 a ^x	43.1 a	10.6 a	29.1 c	64.7 b
FSMS	53.7 b	7.6 b	3.6 c	12.20 d	6.3 c
HSWPM	98.9 a	38.6 a	6.7 b	45.7 a	97.8 a
FSWPM	99.4 a	47.4 a	8.8 a	37.1 b	91.7 a
Mountain huckleberry ^y					
HSMS	90.0 a	32.6 b	8.6 a	20.5 b	34.9 b
FSMS	33.0 b	9.6 c	3.8 b	9.0 b	1.2 c
HSWPM	99.4 a	42.8 a	7.3 a	39.6 a	93.9 a
FSWPM	99.4 a	50.2 a	8.5 a	35.2 a	78.9 a
Oval-leaf bilberry ^y					
HSMS	100.0 a	62.1 ab	11.7 a	31.1 a	76.7 b
FSMS	81.1 b	24.6 c	5.9 b	13.7 b	23.3 c
HSWPM	98.9 a	56.1 b	7.8 ab	42.2 a	98.9 a
FSWPM	98.9 a	75.2 a	12.9 a	35.0 a	91.1 ab

^z1 mg = 3.5274 × 10⁻⁵ oz, 1 mm = 0.0394 inch.

^yResults represent means of combined samples of two clones each of cascade huckleberry and mountain huckleberry, and a single clone of oval-leaf bilberry. Means also represent combined 2004 and 2005 data.

^xAny two means within a column (for a particular species) not followed by the same letter are significantly different at *P* ≤ 0.05.

FSMS, full-strength modified MS medium (Murashige and Skoog, 1962); FSWPM, full-strength modified WPM (Lloyd and McCown, 1980); HSMS, half-strength modified MS; HSWPM, half-strength modified WPM; MS, Murashige and Skoog; WPM, woody plant medium.

mountain huckleberry, and 18% less for oval-leaf bilberry. Survival on HSMS was generally high, averaging 94% for cascade huckleberry, 90% for mountain huckleberry, and 100% for oval-leaf bilberry. With the exception of one mountain huckleberry clone in 2005 (44% survival on FSWPM), survival on FSWPM and HSWPM ranged between 98% and 100% for all species, clones, and years.

As for survival, the dry weights of shoots formed after placing explants onto the test media were significantly lower on FSMS than on other media for all species, clones, and years (Table 2). Dry weights were similar for shoots produced on HSMS, HSWPM, and FSWPM for cascade huckleberry, and were significantly lower on HSMS than on either WPM formulation for mountain huckleberry. For oval-leaf bilberry, dry weights were similar on HSMS and both WPM formulations, although dry weights were significantly less on HSWPM than on FSWPM.

Culturing cascade huckleberry and mountain huckleberry explants on FSMS reduced the number of new shoots compared with the other media for all clones and years (Table 2). Shoot numbers were similar for explants cultured on FSMS and

HSWPM, and were significantly less than for explants grown on the other media for oval-leaf bilberry. For cascade huckleberry and oval-leaf bilberry, explants grown on HSMS and FSWPM produced significantly more shoots than did explants cultured on HSWPM. The latter three media produced generally similar numbers of new shoots from mountain huckleberry explants.

Average shoot lengths were significantly reduced on FSMS compared with all other media for cascade huckleberry and oval-leaf bilberry (Table 2). Shoots produced on HSMS were also significantly shorter than for those produced on either WPM formulation for cascade huckleberry. The HSMS and both WPM formulations produced similar average shoot lengths for oval-leaf bilberry. For mountain huckleberry, HSMS and FSMS formulations produced similar average shoot lengths, which were significantly shorter than for shoots produced on either WPM formulation.

Although root-promoting plant growth regulators were excluded from the media, we determined the percentages of explants and newly formed shoots that formed roots (Table 2). Adventitious root

formation percentages were significantly reduced on FSMS compared with other media for all species, clones, and years except for mountain huckleberry in 2005 when the two MS formulations produced similar rooting percentages (data not shown). Explants cultured on HSMS tended to produce lower rooting percentages than on either WPM formulation for all of the species, although the differences were not significant for oval-leaf bilberry explants cultured on HSMS and FSWPM.

For cascade huckleberry and mountain huckleberry, we observed genotypic differences in all evaluation criteria except survival percentages. Accessions × medium interactions were also generally significant. The differences were not always consistent or significant for both years. Clones UIVADE 003A and UIVADE 005A generally provided similar results except that UIVADE 003A usually produced greater dry weights and UIVADE 005A usually rooted at higher percentages. For mountain huckleberry, clone UIVAME 031C consistently produced greater total shoot growth, individual shoot lengths, and dry weights, and usually produced greater rooting percentages than clone UIVAME 002A. Only a single oval-leaf bilberry clone was available for the full course of the 2-year study. Despite the observed genotypic differences in growth parameter values, the overall responses of all clones to the test media were generally similar. Variability in responses of *Vaccinium* genotypes to in vitro formulations has also been observed in rabbiteye (*V. ashei*) and northern highbush blueberries (Reed and Abdelnour-Esquivel, 1991), cranberry (Marcotrigiano and McGlew, 1991), and lingonberry (Debnath, 2005).

The results we observed were generally similar to those obtained by Wolfe et al. (1983) with 'Bluecrop' highbush blueberry. The salt concentrations in FSMS may be too high for optimal in vitro survival and growth of cascade huckleberry, mountain huckleberry, and oval-leaf bilberry. Electrical conductivity values for the media were 1.61 and 2.93 mmho/cm for HSWPM and FSWPM, and 3.08 and 5.78 mmho/cm for HSMS and FSMS respectively. The chloride

concentration was 358% greater in FSMS than in FSWPM (Table 1). Eck (1988) noted that blueberries are less tolerant of high soluble salt levels than most other crops, with high chloride concentrations causing toxicity symptoms. Ballinger (1962) suggested that a high chloride-to-S ratio favored Ca uptake in blueberries, noted as being calcifuges, whereas high S-to-chloride ratios favored blueberry growth. The MS media in our trials had a S-to-chloride ratio of 0.3:1, whereas the WPM formulations had a S-to-chloride ratio of 5.2:1. The high salt concentrations may also have interfered with gelling of the agar in FSMS, which required 8 g·L⁻¹ of agar to gel compared with 7 g·L⁻¹ for the other media. The higher agar concentration in FSMS was unlikely to have affected survival and growth. In previous trials we successfully micropropagated these species using 6 to 8 g·L⁻¹ agar (D.L. Barney, unpublished data).

Several marked differences in mineral nutrient concentrations between the media may have contributed to the different growth responses observed (Table 1). Total N, NH₄, and NO₃ concentrations were ≈200% to 400% higher in HSMS and FSMS respectively than in FSWPM. The ratio of NH₄ to NO₃ was similar for all media: ≈0.15:1. For related *Vaccinium* species, results have been mixed in trials comparing physiological and growth responses with NH₄ and NO₃ forms of N. Perhaps pertinent to our results was the observation by Herath and Eaton (1968) that high NO₃ concentrations caused marginal necrosis and leaf abscission in container-grown highbush blueberry. Nitrate concentrations were particularly high in the FSMS treatment, in which we observed explant necrosis and death. Eck (1988) concluded that highbush blueberry can use either form of N at soil pH values less than 5.0, but favored NH₄ nitrogen at pH values more than 5.0. The relationship between medium pH and N utilization in micropropagated *Vaccinium* has not been determined. The media pH in our trials was adjusted to 5.2. Although the K concentration in FSMS was comparatively high, Eck (1988) noted that blueberries tolerate high K concentrations without toxicity.

For cascade huckleberry, the HSMS and both FSWPM and HSWPM formulations produced high explant survival rates and high new shoot dry weights. Although the WPM formulations generally produced higher rooting percentages and longer microshoots than the HSMS, all three formulations produced suitable results for in vitro propagation of cascade huckleberry.

For mountain huckleberry, the FSWPM and HSWPM formulations produced longer shoots, greater dry weights, and higher rooting percentages than either MS media. Both WPM formulations provided acceptable results. The HSWPM tended to favor in vitro adventitious root formation, although we did not determine how the explants would have responded to the various formulations if the explants were treated with indole-3-butyric acid or other root-promoting growth regulators, or whether those growth regulators were incorporated into the media.

Oval-leaf bilberry survived and grew equally well on HSMS, HSWPM, and FSWPM. The WPM formulations favored higher percentages of in vitro adventitious root formation than HSMS in the absence of root-promoting growth regulators. All three formulations proved suitable for in vitro propagation of oval-leaf bilberry.

These results provide baseline protocols for commercial or research micropropagation of cascade huckleberry, mountain huckleberry, and oval-leaf bilberry. The ability to propagate these species vegetatively in large numbers will facilitate evaluation of select genotypes, and development and production of cultivars that provide commercially viable yields and fruit quality.

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