

Propagation of beaked hazelnut (*Corylus cornuta*) from softwood cuttings

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ABSTRACT

Beaked hazelnut (*Corylus cornuta* Marshall [Betulaceae]) is a characteristic species of some boreal upland plant communities of northeastern Alberta. This shrub is also a desired species for revegetation following oil sands extraction in the region. Limited seed production and competition from wildlife make harvesting sufficient seeds from natural sites a challenge, therefore vegetative propagation is being investigated. We harvested softwood cuttings from 2 sites in Alberta, Canada, in early July, and we tested 4 treatments (control, bottom heat only, 0.8% IBA (indole-3-butyric acid) only, and 0.8% IBA with bottom heat). Root presence, number of roots, maximum root length, and dry root biomass were measured after 7, 9, and 11 wk post-sticking. Application of IBA (with or without bottom heat) was critical to obtain rooting percentages upward of 65% at 9 wk for one site and 90% at 7 wk for the second site as well as increasing root biomass, maximum length, and number of roots. The impact of bottom heat was negligible on its own, but it enhanced rooting of cuttings from one site when combined with IBA.

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KEY WORDS

shrub, rooting, revegetation, indole-3-butyric acid, root development, Betulaceae

NOMENCLATURE

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CONVERSIONS

1 mm = 0.04 in

1 cm = 0.4 in

1 m = 3.3 ft

(°C x 1.8) + 32 = °F

1 mg = 0.00004 oz

In northeastern Alberta, reclamation following resource extraction focuses on establishment of native plant communities that reflect the surrounding boreal forest of the Central Mixedwood Natural Region (Alberta Environment 2010). One such species is *Corylus cornuta* Marshall (Betulaceae) or beaked hazelnut (USDA NRCS 2020). Beckingham and Archibald (1996) classified it as characteristic of mesic upland communities under a mix of primarily aspen (*Populus tremuloides* Michx. [Salicaceae]) and white spruce (*Picea glauca* (Moench) Voss [Pinaceae]) and is therefore recommended for plant community establishment during reclamation (Alberta Environment 2010). Additional priority is given to species, such as *C. cornuta*, that are traditionally used by local indigenous communities (Marles and others 2000).

Currently, the conventional method of native boreal shrub establishment is outplanting seedlings grown from locally harvested wild seed. *Corylus cornuta* is not a prolific seed producer, and although it bears large, high oil content seeds (nuts), they are often preyed upon by wildlife before maturity (Wilkinson 1990). The result is a sporadic and limited supply of seed, which leads to consideration of alternative propagation methods, specifically stem cuttings harvested from a diverse selection of local material.

Few published studies are available for propagation by cuttings of *C. cornuta*. Based on work by Cartabiano and Lubell (2013), softwood stem cuttings harvested in late spring (June/

July), treated with IBA (indole-3-butyric acid), and struck into a peat/vermiculite/perlite mix rooted when the cuttings were kept moist under ideal greenhouse conditions. Similar results were reported by Young (2001). The objective of this study is to evaluate rooting success (root presence, biomass, maximum length, and number of roots) of wild-harvested *C. cornuta* cuttings using IBA. Bottom heat was added to the trial to avoid stress resulting from possible variations in air temperature. Secondly, the study aims to refine a protocol for vegetative propagation, including the period required for optimal rooting to occur.

METHODS

We collected plant material for cuttings from 2 sites in Alberta, Canada (Bellis, 54.176944 N, 112.150833 W and Ardrossan, 53.607222 N, 113.125556 W). Two populations were chosen to include some genetic variation, which is an important consideration for resilience when species are included in revegetation projects. Both sites were relatively healthy with good growth. The Bellis site is a rural roadside that is periodically mowed and brush cut; plants are well established and most of the growth is recent (<7 y). The Ardrossan site is an undisturbed, mixed-wood forest where the estimated average age of *Corylus* is 10 y. For the purposes of this study, we harvested only new growth from each site.



34 Ardrossan site, June 2019.

Recently elongated stems from spring growth were harvested on 5 July 2020 (Bellis) and 9 July 2020 (Ardrossan), placed in plastic bags, kept cool, and transported to the greenhouse facility where they were stored in bags at 4 °C. We kept material from each site separate for this study. Within 48 h of collection, cuttings were trimmed such that each comprised 2 to 4 exposed nodes (20–30 cm long cuttings). We removed terminal buds and sliced the proximal end of the cutting at approximately 45° to expose a larger portion of the cambium (that is, wounding). Lowermost leaves and buds were removed and remaining leaves aboveground were cut in half to reduce transpiration. Cuttings were kept cool and moist during processing.

The experiment comprised 2 populations and 4 treatments, and sampling occurred at each of 3 intervals (7, 9, and 11 wk). We blocked 25 cuttings per site in each tray of 50. A total of 12 trays were prepared, and 3 were given one of the 4 treatments. We destructively sampled cuttings from a single tray in each treatment at 7, 9, and 11 wk. Treatments consisted of control (no bottom heat or IBA), 0.8% IBA (based on a pilot study), bottom heat, or IBA with bottom heat (IBA+H). For both IBA treatments, the lower 3 to 4 cm of each cutting were dipped in water; then into 0.8% IBA powder (Stim-Root #3); and struck into TerraLink6000610 trays filled with perlite, peat, silica sand, and vermiculite (2:1:1:1 by volume). A depression approximately 5 cm deep was made for the cutting, and the growth medium was moistened and lightly tamped to ensure good cutting–soil contact. For treatments without IBA, each cutting was dipped in water and struck as described above. Bottom heat—provided by Jump Start, Hydrofarm mats and digital temperature controls—was set to 21 °C and maintained an average night soil temperature of 19.8 °C compared to 19.0 °C in the unheated treatment as measured with a ZL6 Logger, Meter Group.



Site phenotypic differences demonstrated for Bellis cuttings (left) and Ardrossan cuttings (right).

We set air temperature in the greenhouse at 20 °C, with a 16-h photoperiod (combination of natural and grow lights) and 80 to 90% relative humidity (similar to an intermittent misting system set to 10 s every 6 min) (Cartabiano and Lubell 2013). Cuttings were irrigated daily for 10 min with an overhead irrigation system. Insects were controlled with sticky traps, predatory insects, hand removal, or Safer's miticide/insecticide.

At 7, 9, and 11 wk post-striking, cuttings from a single tray per treatment were carefully removed from the cavity (destructive sampling). We rinsed the roots over a sieve (2 mm pore size, No 10) to collect any root fragments and assessed the belowground portion of each cutting for the following: root presence, maximum root length, number of roots, and callus presence. Roots were removed from the stem using a sharp blade and dried at 40 °C to determine total root biomass. We also counted live (green) axillary shoot buds.

We compared the initial characteristics of struck cuttings (stem diameter, height, and number of nodes) between sites using a linear model and one-way ANOVA. Assumptions were met with either no transformation or a log10+1 transformation. For root variables including total root biomass, number of roots, and maximum root length, data were separated by site and compared among treatments and for each assessment period (7, 9, and 11 wk) using a linear model and a two-way ANOVA. For root, callus, and bud presence, these proportion data were modeled using a generalized linear model (GLM) and binomial family. Further analysis compared root metrics (root biomass, number of roots, and maximum root length) at 9 wk between sites and a subset of treatments (IBA and IBA+H) using linear models and two-way ANOVA. Differences among treatments and sampling intervals were separated with post-hoc multiple comparison tests using emmeans and multcompview ($P < 0.05$) (Lenth 2018; Selzer 2019). R statistical software was used for all analyses (R Core Development Team 2020).

RESULTS

Cuttings from each site differed phenotypically; those from the Ardrossan population had slightly larger stem diameter and were generally longer as a result of greater axillary shoot bud spacing, compared to those harvested from Bellis (Table 1).

TABLE 1

Aboveground cutting characteristics assessed immediately post-striking.

Site	Stem diameter (mm)	Length (cm)	Number of nodes
Ardrossan	2.1±0.29a	14±2.8a	3.0±0.38a
Bellis	1.8±0.16b	12±1.7b	3.23±0.29b

Notes: Means ± standard deviation. Letters indicate significant differences between sites for each attribute.

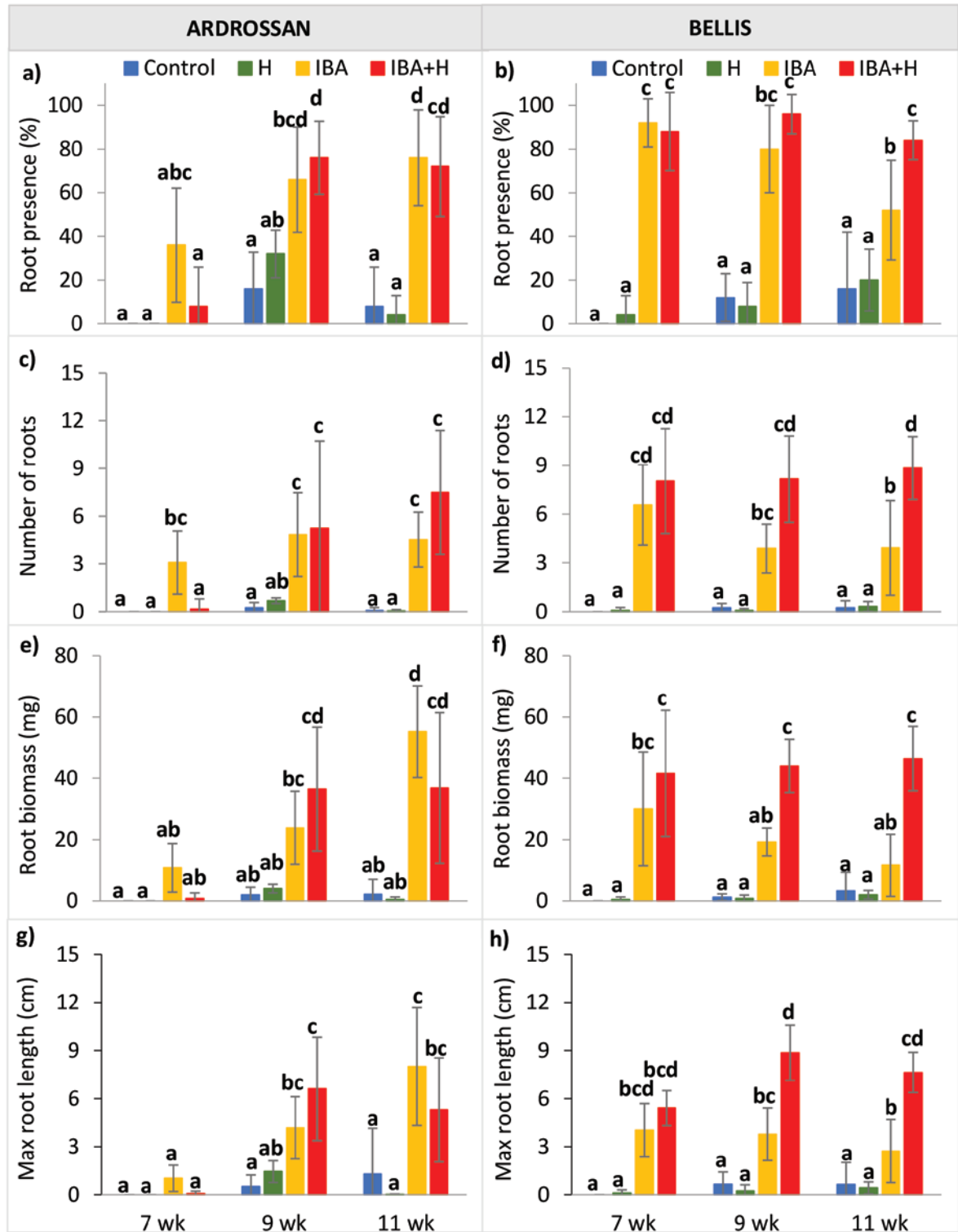


Figure 1. Comparison of root development between treatments after 7, 9, and 11 wk after sticking within each site, Ardrossan and Bellis: a-b) root presence, c-d) number of roots, e-f) root biomass, and g-h) maximum root length. Means \pm standard deviation. Letters indicate groups that are significantly different ($P < 0.05$).

Overall, trends in rooting responses for each treatment were similar for both sites (Figure 1). The IBA and IBA+H treatments were more effective at promoting root development in cuttings from both sites than the control or heat alone (Figure

1). Root development of Ardrossan cuttings at 9 wk was generally greater than at 7 wk, but similar to 11 wk (Figure 1). Cuttings from Bellis, however, had shown similar root development across sampling times (Figure 1).



Sample of one row of rooted cuttings at 9 wk from Bellis treated with IBA+H.

More specifically, cuttings from Ardrossan saw the greatest improvement in rooting success with IBA and IBA+H treatments, notably 66 to 76% cuttings rooted with an average of 5 roots per cutting of 4 to 6 cm maximum length at 9 wk, with no significant improvement after 9 wk (Figure 1a, 1c, 1g). When treated with IBA alone, the greatest biomass was measured after 11 wk, whereas when heat is added (IBA+H) the biomass reaches a peak earlier (9 wk) (Figure 1e).

Cuttings from Bellis treated with IBA+H rooted well at 7 wk (to 88%) with no significant improvement (or loss) in percent rooting, number of roots, root length, and biomass at 9 or 11 wk (Figure 1b, 1d, 1f, 1h). Those treated with IBA+H when compared to those treated with IBA had only more roots on average (8 versus 4) at 9 wk (the difference became significant after 11 wk), and significantly greater average biomass (44 versus 19 mg) and root length (9 versus 4 cm) at 9 and 11 wk (Table 2; Figure 1d, 1f, 1h). We observed some decrease in maximum root length after 11 wk and notable deterioration of root quality (that is, root rot).



Sample of one row of rooted cuttings at 9 wk from Ardrossan treated with IBA.

TABLE 2

Root metrics of 9 wk samples compared between sites and a subset of treatments (IBA, IBA+H).

Site	Treatment	Max length (cm)	Biomass (mg)	Presence (%)	Number of roots
Ardrossan	IBA	4.2±1.9 ^{ab}	24±12 ^{ab}	66±24 ^a	4.8±2.6 ^a
	IBA+H	6.6±3.2 ^{ab}	36±20 ^{ab}	76±17 ^a	5.2±2.8 ^a
Bellis	IBA	3.8±1.6 ^a	19±4.6 ^a	80±20 ^a	3.9±1.5 ^a
	IBA+H	8.9±1.7 ^b	44±8.7 ^b	96±8.9 ^a	8.2±2.7 ^a

Notes: Means ± standard deviation. Letters indicate significant differences between sites for each attribute ($P < 0.05$).

The percentage of cuttings that rooted and (or) produced callus and the number of roots per cutting were similar from each of the 2 sites at 9 wk (Table 2; Figure 2). Although maximum root length and biomass were similar between sites at 9 wk, the addition of heat to IBA treatment improved root

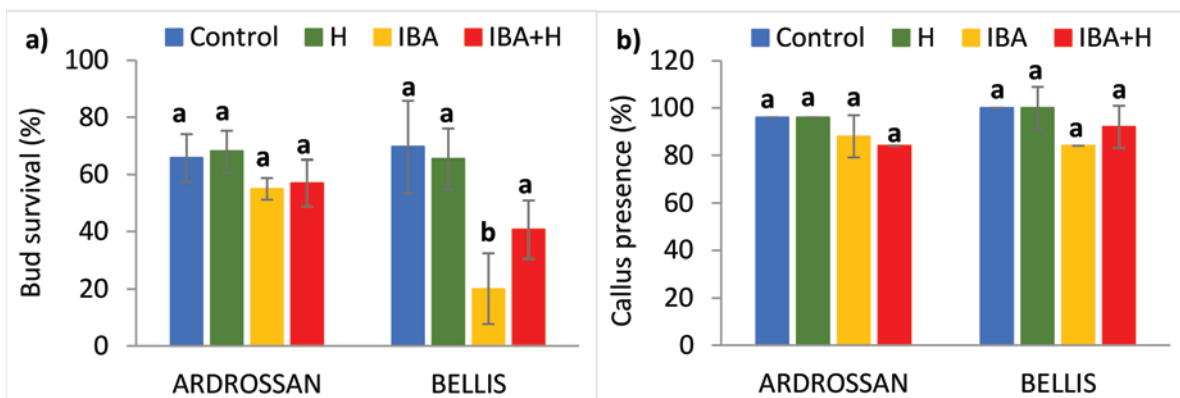


Figure 2. Average a) bud survival and b) callus presence of cuttings compared between treatment and Ardrossan and Bellis sites at 9 wk. Means ± standard deviation. Bars with the same letter are not significantly different from each other ($P < 0.05$).

biomass and length over IBA alone for the Bellis population only (Table 2).

Bud survival varied between cuttings from Bellis and Ardrossan sites. Cuttings from Ardrossan maintained a higher percentage of healthy buds (75%) than did those from Bellis, where bud survival was lowest in cuttings treated with IBA (20%) (Figure 2).

DISCUSSION

Rooting results showed that IBA increased rooting success of local native *C. cornuta* softwood cuttings (from 2 populations), and this aligned well with findings of Cartabiano and Lubell (2013) for percent rooted cuttings, number of roots, and time required for root development. Our results are also supported by similar findings from Young (2001). Although heat alone did not improve rooting percentages or other root metrics when compared with IBA treatments, the addition of heat to the IBA treatment increased number of roots, root biomass, and root length. Perhaps a greater differentiation of air temperature and substrate temperature (bottom heat) may have led to more noticeable effects on rooting.

Cuttings from Bellis had greater root length and biomass than did those from Ardrossan at 9 wk. The smaller size of these cuttings likely resulted from a more open canopy and disparity in site management. The intermittent mowing and brushing at the Bellis site is similar to the practice of extreme pruning applied to many woody shrub species in horticultural stooling beds to increase the number and quality of softwood cuttings (McDonald 1986; St-Pierre 1997).

The production of callus is a reaction to wounding and an indication of healthy, living tissue. Although callus production is the precursor to rooting in some woody species (especially some conifers), it can be detrimental to root formation in others (Davies and others 2017). The rooting success observed in this study indicates that callus did not limit root formation although we have no indication that the roots derived from the callus itself.

A 9 wk rooting period is recommended to ensure that populations with slower rooting are accommodated. Leaving cuttings for 11 wk did not improve rooting, and we observed a slight reduction in maximum root length at 11 wk, which could be a result of dieback caused by excess moisture. Management of irrigation and misting schedules to allow for drying periods after 4 to 6 wk post-striking (as rooting begins) could mitigate root rot. A possible solution to promote further root growth and avoid root rot is to hotplant (outplanting directly from greenhouse to site without acclimation) after 9 wk or to apply dormancy-inducing conditions to stop root development. Further study will examine bud break and shoot development following dormancy and outplanting.

Generally, multiple branching roots were formed and

was unoccupied by roots, and the plug did not remain intact the entire depth of the plug after extraction. Smaller containers (shorter, with less volume) could be used in the future to ensure plug stability. Of concern in this study was the reduced bud survival on rooted cuttings from the Bellis population when treated with IBA. Bud survival and bud break are important to establishment success. Hubert (1977) reported that a high humidity environment rather than an open mist system (as was used in this study) was better for bud survival of *C. avellana* L. Modifications of the greenhouse environment during the rooting period could be tested. Contessa and others (2011) studied *C. avellana* 'Tonda Gentile delle Langhe' and found a respectable balance of root development and bud retention using 1000 mg/l of IBA and 1-MCP (1-Methylcyclopropene) and AgNO₃.

CONCLUSION

Regardless of observed differences between populations, an incubation of 9 wk (at 20 °C with 80 to 90% humidity and bottom heat following application of 0.8% IBA) is recommended for softwood cuttings of *C. cornuta*. Any protocol used must be widely applicable across populations as genetic diversity in the cuttings is important and required for successful reclamation. Improvement is needed to produce a well-rooted plug, and we encourage exploring the combination of treatments and environmental conditions.

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