Effects of Seed Treatments and Planting Depth on Emergence of Sea Buckthorn Species

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SUMMARY. The influence of seed treatments and planting depth on the percentage of seed emergence of *Hippophae rhamnoides* L. 'Indian-Summer', *H. tibetana* Schlecht., *H. neurocarpa* Liu & He, *H. salicifolia* D. Don, and *H. rhamnoides* subsp. *rhamnoides*, *sinensis*, *turkestanica*, and *mongolica* were studied. Surface seeding had higher percentages of seed emergence and more rapid completion of emergence compared to a 1- or 2-cm (0.4- or 0.8-inch) seeding depth. Seeds soaked in water or potassium nitrate solution at room temperature emerged in higher percentages. Average plant height of the eight species and subspecies varied significantly at the end of first growing season.

Sea buckthorn (*Hippophae rhamnoides*) is a new crop that has great economic potential in North America. It is a hardy, deciduous shrub, ideal for soil erosion control, land reclamation, wildlife habitat enhancement, and farmstead protection (Li and Schroeder, 1996). Recently, sea buckthorn has attracted considerable attention from researchers around the world for its nutritional

and medicinal values (Li and Wang, 1998). Plantations in Canada are mainly found in shelterbelts on the prairies. In the last few years, acreage in orchard-type cultivation of *H. rhamnoides* 'Indian-Summer' has increased rapidly in both British Columbia and Saskatchewan, and seeds or seedlings are in great demand.

The simplest method for propagating sea buckthorn is by seed. Sea buckthorn seeds require no special seed bed preparation, and a large number of seedlings can be produced in a short period of time. Many factors affect seed germination: seed source (Fefelov and Eliseev, 1986), maturity (Eliseev and Mishulina, 1972a; Vernik and Zhapakova, 1986), dormancy (Siabaugh, 1974), preseeding treatments (Li and Schroeder, 1996; Lu, 1992), planting media (Salo, 1991), seeding depth (Li and Schroeder, 1996), and soil and environmental conditions (Vernik and Zhapakova, 1986). Limited information is available regarding seed treatments and germination of *Hippophae* species. The objectives of this study were to investigate the effects of seed treatments [soaking in water at room temperature 20 °C (68 °F), in water initially at 70 °C (158 °F), in 500 mg·L⁻¹ GA₃ or in 0.01 M potassium nitrate solution for 48 h] and seeding depth on the percentage of seed emergence and number of days required to start and complete emergence. Plant height of different sea buckthorn species was also evaluated at the end of the first growing season.

Materials and methods

Seeds of *H. rhamnoides* 'Indian-Summer', *H. tibetana*, *H. neurocarpa*, *H. salicifolia*, and *H. rhamnoides* subsp. *rhamnoides*, *sinensis*, *turkestanica*, and *mongolica* were collected in October 1996, 1 year before the experiment. Seeds were removed from berries, washed with water, air dried and stored in cool [1 to 2 °C (34 to 36 °F)] storage. Five preseeding seed treatments were 1) control (nontreated), 2) soaked in water at room temperature [20 °C (68 °F)], 3) soaked in water initially at 70 °C (158 °F) and allowed to cool to room temperature, 4) soaked in GA₃ (500 mg·L⁻¹) solution, and 5) soaked in 0.01 M potassium nitrate (KNO₃). All seed soaking treatments were for 48 h.

Seeds were planted immediately

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Table 1. Effects of seeding depths and seed treatments on the percentage of seed emergence in sea buckthorn.

Seeding depth [cm (inches)]	Seed treatment ^z	<i>Hippophae rhamnoides</i> and other sp.							
		Indian Summer	subsp. <i>rhamnoides</i>	subsp. <i>turkestanica</i>	subsp. <i>sinensis</i>	subsp. <i>mongolica</i>	<i>H. salicifolia</i>	<i>H. tibetana</i>	<i>H. neurocarpa</i>
0	Control	76.1 b ^y	38.9 a	31.7 c	55.0 a	48.6 b	86.1 b	55.6 b	42.0 b
	Water, RT	85.1 a	22.8 b	45.6 b	45.6 b	58.3 a	80.0 b	54.4 b	44.7 b
	Water, hot	78.3 b	22.2 b	55.6 a	48.9 b	57.0 a	85.0 b	50.6 b	49.3 a
	GA ₃	73.9 b	8.3 c	49.4 b	44.4 b	NA ^x	91.1 a	43.9 c	45.3 b
	KNO ₃	86.1 a	34.5 a	56.1 a	46.7 b	NA	95.6 a	58.3 a	45.3 b
1 (0.4)	Control	7.8 c	5.0 a	7.8 a	2.2 c	1.7 b	28.9 a	8.9 b	0
	Water, RT	11.1 b	0.6 c	6.7 a	3.3 c	1.4 b	30.0 a	1.7 c	0
	Water, hot	0.6 b	0	3.3 b	2.8 c	2.8 a	26.1 a	1.1 c	0
	GA ₃	17.8 a	1.1 c	5.6 a	8.9 a	NA	11.6 c	13.9 a	0
	KNO ₃	17.2 a	2.8 b	2.8 b	6.1 b	NA	18.3 b	1.7 c	0
2 (0.8)	Control	14.4 b	3.3 a	1.1 c	4.4 b	NA	10.0 c	1.7 c	NA
	Water, RT	21.1 a	0.6 c	4.4 a	6.7 a	NA	22.2 b	6.1 b	NA
	Water, hot	10.6 c	0.6 c	1.1 c	3.9 b	NA	21.2 b	5.6 b	NA
	GA ₃	17.2 b	2.2 b	2.8 b	7.2 a	NA	18.9 b	15.6 a	NA
	KNO ₃	9.4 c	1.1 c	2.8 b	1.1 c	NA	31.7 a	1.1 c	NA

^zSeed treatment: water, RT (room temperature) = soaked in water under room temperature [20 °C (68 °F)]; water, hot = soaked in preheated [70 °C (158 °F)] water and allowed to cool to room temperature; GA₃ = 500 mg·L⁻¹ solution; KNO₃ = soaked in potassium nitrate at 0.01 M.

^yValues within each column and within a seeding depth with a common letter are not significantly different ($p = 0.05$) according to Duncan's new multiple range test.

^xNA = not applied.

after treatments at three depths: 1) on the surface, 2) 1 cm (0.4 inch), or 3) 2 cm (0.8 inch). There were eight replications (pot) per combination of five preseeding treatments and three seeding depths [total of 120 pots/species, 30 seeds/pot, 12 cm² (4.7 inches²)]. Due to the limited number of seeds available for *H. rhamnoides* subsp. *mongolica* and *H. neurocarpa*, only two seeding depths—surface and 1 cm—were tested. Pots were filled with Sunshine Mix #2 (peatmoss and perlite mixture, Growers Supply Co., Kelowna, B.C.) and arranged separately by species in a completely random design in growth chamber [25/20 °C (77/68 °F, day/night), with a 16-h photoperiod and a light intensity of 150 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$], 1 m (3.3 ft) above the pot].

Emerged seedlings were counted every 2 d. Percentage of seed emergence and number of days to start and to complete emergence (the first day of achieving the highest number of seedlings emerged) were recorded. In total, 40 seedlings per species were transplanted individually into pots [12 cm² (4.7 inch²)] filled with Sunshine Mix #2 after emergence was complete. Pots were fertigated once every 2 weeks with 250 mL (8.45 fl oz)/pot of 20N–8.7P–16.6K [0.5 g·L⁻¹ (500 ppm)] (Plant Products Co., Brampton, Ont.). After 6 weeks in the growth chamber, seedlings of all eight species or subspecies were transplanted to the field with

sandy loam soil—70% sand, 16% clay, 14% silt—based on Canadian System of Soil Classification [McKeague, 1978; pH 6.9, organic matter 4.3%, salts 0.40 dS·m⁻¹, and (in mg·L⁻¹) 8N–23P–133K–228Mg–1182Ca–22Na–23S–3.06B–0.7Cu–20.8Fe–6.6Mn–32.8Zn. Spacing was 1 m between rows and 0.5 m (1.6 ft) within the row. Eight plants per block per species and four blocks were laid out in a randomized complete-block design. Plant height was measured immediately after transplanting and at the end of the growing season. Analyses of variance by the general linear models (GLM) procedure, and mean comparisons by Duncan's new multiple range test were performed according to SAS methods (SAS Institute Inc., 1990).

Results and discussion

Surface planting significantly improved seed emergence percentage compared to seeding depths of 1 or 2 cm, suggesting that sea buckthorn seeds are light sensitive (Table 1). Good emergence percentage from surface seeding was an important factor in the success of aerial sowing of sea buckthorn in the Loess Plateau of China (Li et al., 1995). Seed emergence varied from 31.7% for *H. rhamnoides* subsp. *turkestanica* to 86.1% for *H. salicifolia* in nontreated controls (Table 1). Higher emergence percentage with similar variation among species were reported by Zu et al. (1993). Percent-

age of seed emergence was poor at a 1- or 2-cm planting depth for all species, and burying the seed prevented emergence completely for *H. neurocarpa*.

When the seeds were planted at the soil surface, preseeding treatments improved seed emergence in all the species tested except *H. rhamnoides* subsp. *rhamnoides* and *sinensis* (Table 1). Generally, soaking seeds either in water or potassium nitrate solution at room temperature for 48 h improved seed emergence compared with the nontreated control. Eliseev and Mishulina (1972b) obtained similar results, as they found that steeping *H. rhamnoides* seeds in 0.02% KI or 0.05% ZnSO₄ solutions increased emergence by 12% and 9.1%, respectively.

Lu (1992) reported, without giving any numbers, that good germination results could be obtained by soaking seeds for 48 h initially in hot water [60 to 70 °C (140 to 158 °F)] and then allowing to cool to room temperature. Similar results were obtained in the present experiment with *H. rhamnoides* subsp. *turkestanica*, and *mongolica* and *H. neurocarpa*, when the seeds were planted at the surface (Table 1).

For surface seeding, seeds soaked for 48 h in water or potassium nitrate solution at room temperature had greater emergence percentage than nontreated control in *H. rhamnoides* 'Indian-Summer'. Preseeding treatments had no effect on emergence for *H. rhamnoides* subsp. *rhamnoides* and

Table 2. Effects of seeding depths and seed treatments on the number of days to start seed emergence in sea buckthorn.

Seeding depth [cm (inches)]	Seed treatment ^z	<i>Hippophae rhamnoides</i> and other sp.							
		Indian Summer	subsp. <i>rhamnoides</i>	subsp. <i>turkestanica</i>	subsp. <i>sinensis</i>	subsp. <i>mongolica</i>	<i>H. salicifolia</i>	<i>H. tibetana</i>	<i>H. neurocarpa</i>
0	Control	3.0 a ^y	5.0 a	9.5 a	5.0 a	10.3 a	16.2 a	7.0 a	6.0 a
	Water, RT	3.0 a	3.0 b	4.5 c	3.0 b	5.0 b	10.0 b	3.0 b	2.7 c
	Water, hot	3.0 a	3.0 b	3.7 c	3.0 b	5.5 b	11.7 b	3.0 b	2.0 c
	GA ₃	3.0 a	5.2 a	8.0 a	3.0 b	NA ^x	11.0 b	3.0 b	4.0 bc
	KNO ₃	3.5 a	3.0 b	6.3 b	3.0 b	NA	10.8 b	3.0 b	2.7 c
1 (0.394)	Control	12.4 b	10.0 a	21.0 a	9.0 ab	NA	19.5 ab	14.4 a	NA
	Water, RT	12.3 b	10.0 a	15.5 b	11.7 a	13.0 b	21.5 a	12.7 a	NA
	Water, hot	9.8 c	---	5.8 d	7.5 b	16.0 a	17.8 b	12.0 a	NA
	GA ₃	11.0 bc	11.5 a	11.3 c	10.0 a	NA	20.2 a	7.0 b	NA
	KNO ₃	14.0 a	6.0 b	18.3 ab	9.0 ab	NA	18.4 b	3.0 c	NA
2 (0.788)	Control	15.8 a	14.7 a	14.0 b	12.8 a	NA	22.0 a	17.0 a	NA
	Water, RT	14.0 b	10.0 b	13.7 b	13.3 a	NA	19.6 a	7.0 c	NA
	Water, hot	13.0 bc	10.0 b	15.5 ab	9.0 b	NA	20.3 a	14.0 b	NA
	GA ₃	14.3 b	10.0 b	16.0 a	10.3 b	NA	21.7 a	5.7 c	NA
	KNO ₃	11.0 c	10.0 b	15.5 ab	13.0 a	NA	19.6 a	---	NA

^zSeed treatment: water, RT (room temperature) = soaked in water under room temperature [20 °C (68 °F)]; water, hot = soaked in preheated [70 °C (158 °F)] water and allowed to cool to room temperature; GA₃ = 500 mg·L⁻¹ solution; KNO₃ = soaked in potassium nitrate at 0.01 M.

^yValues within each column and within a seeding depth with a common letter are not significantly different ($p = 0.05$) according to Duncan's new multiple range test.

^xNA = not applied.

sinensis. Higher emergence percentages were observed for preseeded treatments with GA₃ or potassium nitrate for *H. salicifolia* and the latter for *H. tibetana* and *H. rhamnoides* subsp. *turkestanica* (Table 1).

Lu (1992) reported that seeds of *H. rhamnoides* subsp. *sinensis* required 12 to 18 d to sprout when seeds were sown at the depth of 1 to 2 cm in the field with air temperature of 15 to 20 °C (59 to 68 °F). In the present study,

seeds of the same species planted 1 or 2 cm deep, with 25/20 °C day/night, required average of 9.0 and 12.8 d, respectively to emerge (Table 2). When the seeds were planted at the surface, preseeded water-soaking treatments significantly reduced the number of days to emergence for all species except *H. rhamnoides* 'Indian-Summer' (Table 2). Seeds soaked in water and GA₃ solution shortened the number of days required to emerge for *H. rhamnoides* subsp.

turkestanica. Seeds of *H. rhamnoides* subsp. *rhamnoides* soaked in potassium nitrate solution needed fewer number of days to emerge planted at the depth of 1 cm. All preseeded treatments hastened or speeded emergence of *H. rhamnoides* 'Indian-Summer' and *H. rhamnoides* subsp. *rhamnoides* at the planting depth of 2 cm, however, treatments had no effect on *H. rhamnoides* subsp. *turkestanica* and *H. salicifolia*. (Table 2).

Table 3. Effects of seeding depths and seed treatments on the number of days required to complete seed emergence on in sea buckthorn.

Seeding depth [cm (inches)]	Seed treatment ^z	<i>Hippophae rhamnoides</i> and other sp.							
		Indian Summer	subsp. <i>rhamnoides</i>	subsp. <i>turkestanica</i>	subsp. <i>sinensis</i>	subsp. <i>mongolica</i>	<i>H. salicifolia</i>	<i>H. tibetana</i>	<i>H. neurocarpa</i>
0	Control	20.5 a ^y	7.5 a	9.0 b	12.5 a	11.0 a	18.5 c	13.7 a	10.0 b
	Water, RT	21.2 a	5.5 b	13.2 a	6.2 c	7.7 b	24.5 a	8.0 b	12.2 a
	Water, hot	15.3 c	6.2 b	14.2 a	8.0 b	7.8 b	20.7 bc	7.3 b	10.5 b
	GA ₃	21.2 a	3.8 c	8.8 b	6.2 c	NA ^x	22.8 b	7.2 b	11.3 ab
	KNO ₃	18.7 b	7.3 a	13.2 a	7.8 bc	NA	22.7 b	6.2 b	10.5 b
1 (0.4)	Control	4.4 c	5.0 b	14.0 a	11.3 b	NA	4.0 a	NA	NA
	Water, RT	8.0 b	1.0 c	9.0 a	1.7 d	7.7 a	10.2 b	1.0 b	NA
	Water, hot	9.8 b	NA	6.0 b	4.0 c	NA	11.8 b	1.0 b	NA
	GA ₃	12.7 a	1.0 c	7.3 b	3.3 cd	1.0 b	5.8 c	4.7 a	NA
	KNO ₃	6.0 c	7.0 a	1.0 c	7.0 b	NA	15.8 a	1.0 b	NA
2 (0.8)	Control	7.5 c	1.7 a	4.0 b	2.5 b	NA	18.0 a	4.0 b	NA
	Water, RT	5.2 d	1.0 a	8.3 a	3.3 ab	NA	12.6 b	7.0 a	NA
	Water, hot	9.5 b	1.0 a	1.0 c	2.5 b	NA	9.5 c	1.0 c	NA
	GA ₃	10.7 a	1.0 a	1.0 c	4.0 a	NA	10.0 c	NA	NA
	KNO ₃	5.0 d	1.0 a	4.0 b	1.0 c	NA	9.6 c	---	NA

^zSeed treatment: water, RT (room temperature) = soaked in water under room temperature [20 °C (68 °F)]; water, hot = soaked in preheated [70 °C (158 °F)] water and allowed to cool to room temperature; GA₃ = 500 mg·L⁻¹ solution; KNO₃ = soaked in potassium nitrate at 0.01 M.

^yValues within each column and within a seeding depth with a common letter are not significantly different ($p = 0.05$) according to Duncan's new multiple range test.

^xNA = not applied.

Fig. 1. Average plant height of *Hippophae* species. *Hippophae* species: hris = *H. rhamnoides* L. 'Indian-Summer'; hrsr = *H. rhamnoides* subsp. *rhamnoides*; hrst = *H. rhamnoides* subsp. *turkestanica*; hrss = *H. rhamnoides* subsp. *sinensis*; hs = *H. salicifolia*; ht = *H. tibetana*; hrsm = *H. rhamnoides* subsp. *mongolica*; and hn = *H. neurocarpa*. **Values in each bar with a common letter, in upper and lower case, are not significantly different ($p = 0.05$) according to Duncan's new multiple range test; 2.54 cm = 1.0 inch.

Control seeds took longer to complete emergence when they were planted at the surface than at 1 or 2 cm for all species except *H. rhamnoides* subsp. *turkestanica*, *mongolica*, and *H. salicifolia* (Table 3). However, seed soaked in water or potassium nitrate solution shortened the number of days required to complete germination for *H. rhamnoides* 'Indian-Summer', *H. rhamnoides* subsp. *sinensis*, and *H. tibetana* compared to the control (Table 3). The GA₃ solution reduced the germination period of *H. rhamnoides* subsp. *rhamnoides*, *turkestanica* and *sinensis* at a 1-cm depth and *H. rhamnoides* subsp. *rhamnoides*, *turkestanica*, and *H. salicifolia* at a 2-cm depth. In general, preseedling treatments resulted in fewer days required to start and complete emergence when compared with the nontreated control (Tables 2 and 3). A shorter period to complete seed emergence produced more uniform seed-

lings which is an important factor for the success of orchard-type cultivation.

Seedlings from eight species or subspecies tested had significantly different heights after one growing season. *H. rhamnoides* subsp. *mongolica* and *H. neurocarpa* started their growth vigorously in the growth chamber and slowed down as soon as seedlings were transplanted to the field. On the other hand, *H. rhamnoides* subsp. *sinensis* and *H. rhamnoides* 'Indian-Summer' thrived in the field and had significantly higher growth increments (Fig. 1). These phenomena reflect their growth habits as either tree- or bush-type due to genetic variation within the genus *Hippophae*. *H. salicifolia* and *H. rhamnoides* subsp. *sinensis* are tree forms, which grow up to 10 and 16 m (32.8 and 52.5 ft), respectively. On the other hand, *H. tibetana* is a densely branched dwarf shrub <0.5 m (1.6 ft) high (Rousi, 1971).

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