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ETHYLENE IMPROVES GERMINATION OF

Arrow-leaved Balsamroot Seeds

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ABSTRACT

Preliminary research indicates that treating arrow-leaved balsamroot *(Balsamorhiza sagittata (Pursh)* Nutt. [Asteraceae]) seeds with ethylene before stratification increases germination without affecting seedling morphology. Arrow-leaved balsamroot is one of the most dominant forbs in sagebrush and grassland ecosystems of the Interior Plateau of northwest North America. Widely used as a food and medicinal plant by indigenous peoples of this region, this plant has shown in recent research that it has potential as a medicinal herb, as a source of inulin, for ecological restoration purposes, and in horticulture. The significance of this species in native ecosystems and the difficulty inherent in wild harvesting of balsamroot identifies it as a candidate for crop development to meet future needs. Improving germination is the first step to meeting the objectives of economic development in First Nations communities and for environmental conservation.

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KEY WORDS

Balsamorhiza sagittata, germination, native plant propagation, Asteraceae

NOMENCLATURE

USDA NRCS (2004)

Figure 1. Balsamorhiza sagittata, commonly known as arrow-leaved balsam root or spring sunflower, Photo by: Tara Luna

Balsamorhiza sagittata (Pursh) Nutt. (Asteraceae), commonly known as arrow-leaved balsam - root or spring sunflower (Figure 1), is among the most versatile food plants used by indigenous peoples of the southern interior of British Colum bia and adjacent areas (Turner 1997).A dominant forb of semiarid grasslands, this long-lived perennial has cultural and ecological significance throughout its growing region. Ethnobotanical studies document use of this species as a food and medicinal source by North American indigenous peoples (for example, Mullin and others 1997; Turner 1997; Peacock 1998; Bannister 2000; Turner and others 2000). Also documented are a range of complex management strategies and harvesting techniques that enhance the productivity of this plant resource (for example, Peacock and Turner 2000; Tu rner and others 2000) (Figure 2).

Arrow-leaved balsamroot has a variety of economic and ecological applications. It has value as an ornamental, an inulin source (a polysaccharide that yields fructose), an herbal medicine (because of its antimicrobial properties), a restoration species (especially in slope stabilization and mine reclamation), and as an edible

Figure 2. Stl'atl'limx Elder Sam Mitchell harvesting *Balsamorhiza sagittata* using a traditional digging stick.

Figure 3. Balsamorhiza sagittata seed heads and cleaned seeds.

vegetable (Chambers and others 2002). The species has potential for production in native plant nurseries and also as a cultivated field crop (Chambers 2001). Given the concern that market demand may exceed sustainable wild harvesting (American Botanical Council 1999; Crawford 1999; Glick 1999), we need to know how to germinate seeds of arrow-leaved balsamroot so that it can be propagated. The purpose of this study was to determine the feasibility of cultivating arrow-leaved balsamroot in an agronomic or horticultural cropping system.

Our research objectives were influenced by the difficulties inherent with propagating and cultivating arrow-leaved balsamroot. First, this species has low seed viability (Young and Evans 1979). Furthermore, preliminary trials by Young and Evans (1979) determined that freshly matured seeds are dormant, and this dormancy is not broken in dry storage. Kitchen and Monsen (1996) concluded that seed dormancy in this species prevents summer or fall germination. Experiments aimed at finding methods to enhance seed germination and to find optimal conditions for breaking dormancy. Second, arrow-leaved balsamroot is adapted to arid growing conditions, therefore, we wanted to determine if seedlings would survive in a greenhouse environment (usually humid), which often leads to accelerated plant development.

MATERIALS AND METHODS

Seed Collection and Preparation

Seeds were hand harvested at 3 separate locations between Lytton and Xaxl'ep (Fountain, near Lillooet), British Columbia, in late June 1999. Seeds from all locations were combined, and shortly after harvesting the seeds were manually cleaned. We determined achenes to be mature when they released from dried seed heads with little or no manual stimulation (Figure 3). Clean arrow-leaved balsamroot seeds were stored for approximately 5 mo in paper bags in a dry, well-ventilated room.

Greenhouse Germination Experiments

Two experiments were conducted at the Pacific Agri-Food Research Center, Agriculture and Agri-Food Canada in Agassiz, British Columbia. Germination experiments were conducted in the dark except when seeds were inspected for germination. The first experiment had 2 treatments: 1) ethylene; and 2) a no-ethylene control. Ethrel ethephon is a commercially available ethylene-releasing substance. Ethylene has been shown to stimulate seed germination (for examples, see Slade and Causton 1979; Feg ha hati and Reese 1994; Korkmaz and others 2004). Each treatment was replicated 4 times with 50 seeds per replicate. Eight circular planting trays, approximately 3 cm deep x 23 cm in diameter (1.2 in x 9.2 in) and with drainage holes, were tilled with moistened peat-based potting medium (Sunshine Mix; Sun Gro Horticulture, Vancouver, British Columbia). Seeds were evenly sown on the surface of the medium and covered with a light dusting of medium (5 mm [0.2 in]). Ten ml (0.4 oz) of ethrel ethephon was mixed in 14.41 (3.8 gal) of water and used to saturate the medium in 4 trays. In the remaining 4 trays the medium was saturated with water. All 8 trays were sealed in individual polyethylene bags and placed in a 0 °C (32 °F) walk-in cooler until seeds began to germinate.

The second experiment had 2 treatments: 1) chilling and freezing seeds before an ethylene treatment and stratification; and 2) an ethylene treatment and stratification. Each treatment was replicated 4 times with 50 seeds per replicate. For both treatments, seeds were placed on a paper towel soaked in the same ethrel ethephon solution described above. The towel was rolled and placed into a self-sealing plastic bag. Four bags were placed in a 4 °C (39 °F) refrigerator for 2 d followed by 7 d in a –16 °C (3.2 °F) freezer. All 8 bags were then placed in a 0 °C (32 °F) cooler until they began to germinate.

For both experiments, *we* minimized damage to germinating seedlings through daily monitoring of seeds and frequent transplanting of germinants. Seeds were considered to be germinated when radicles and cotyledons became visible. Germinants were transplanted into sterilized polystyrene blocks with 112 cavities (105 ml volume, 4 cm wide x 15 cm deep 16.6 in^3, 1,6 in x 6 inn containing a 2:1:1 (v:v:v) medium of Sunshine mix, screened river sand, and perlite adjusted with ground limestone to bring the pH up to approximately 7.0—the resulting medium had similar drainage and pH of soils where seeds were collected. Germinants were transferred to the greenhouse as soon as they were transplanted.

Data Collection and Analyses

We collected germination counts for the stratification treatments every 2 wk from February through May 2000 and

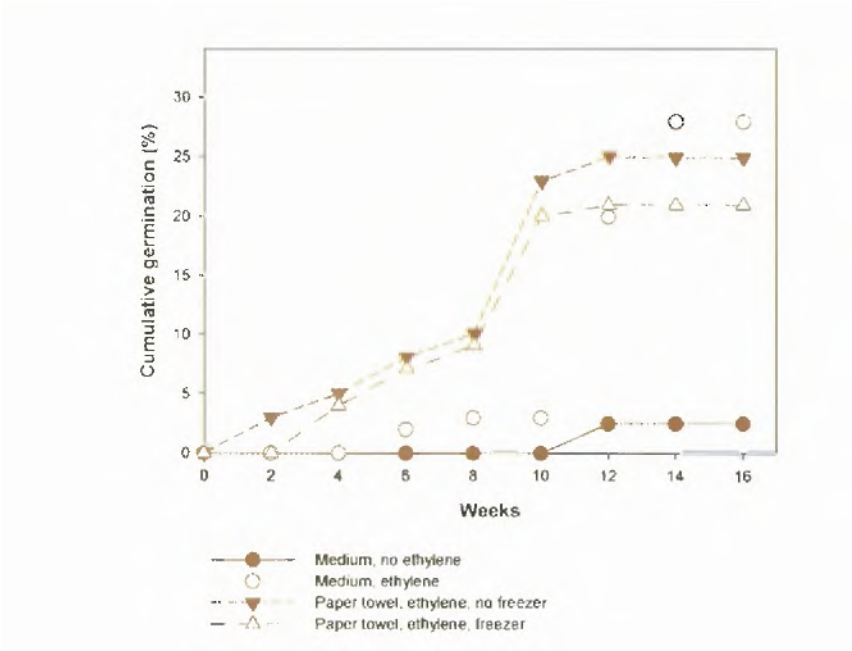

Figure 4. Cumulative percentage of germination of *Balsamorhiza sagittata* seeds in response to ethylene, medium, and low temperature treatments.

measured seedling leaf height (cm) and number of leaves on seedlings every 2 wk (for 7 collections).

Germination data were analyzed using ANOVA with a single degree of freedom. Contrasts analyzed include ethylene treatment on medium as compared with ethylene on paper towel, medium without ethylene as compared with soil with ethylene, and freezer versus non-freezer ethylene on paper towel. For all contrasts the percentage germination, number of leaves per plant, and seedling height (cm) were compared.

RESULTS AND MANAGEMENT IMPLICATIONS

Of the seeds sown on medium saturated with ethylene solution 28% germinated

TABLE 1

Analysis *of variance contrasts to determine the effect on percentage of germination, leaf number, plant height, and seedling survival of ethylene versus no ethylene, medium versus paper* towel, *freezer stratification* versus *refrigerator and freezer stratification.*

Treatment	Total number seeded	Total germination	Percentage germination	Leaves per plant Mean ± standard error	Height (cm)
Medium, no ethylene	200	6	2.4 ± 1.0	1.0 ± 0.4	3.2 ± 1.8
Medium, ethylene	200	56	28 ± 3.7	1.2 ± 0.2	3.7 ± 0.6
Paper towel, ethylene, no freezer	200	50	25 ± 3.1	2.2 ± 0.2	4.4 ± 0.4
Paper towel, ethylene, freezer	200	42	21 ± 1.7	2.0 ± 0.4	3.7 ± 0.7
Contrasts			*P*	*P*	*P*
Medium-ethylene versus paper towel ethylene			0.4592	0.0587	0.6576
Medium-no ethylene versus medium-ethylene			0.0001	0.6110	0.7225
Paper towel-ethylene-freezer versus paper towel-ethylene			0.3272	0.6110	0.6576

significantly more than the 2.5% germination for seeds on nontreated medium (Table 1; Figure 4). Chilling and freezing seeds before stratifying them on ethylene-soaked paper towels yielded similar germination (25%) as those seeds not chilled or frozen before stratification (21%). We observed differences in the speed of germination as well. One useful description of germination speed is germination rate prime (GR'_{50}), which indicates the number of days required for 50% of the seeds to germinate (Thomson and El-Kassaby 1993). The GR'_{50} was 83 d for medium saturated with ethylene, 75 d for medium without ethylene, and 65 d for paper towels with or without ethylene. Plants germinated on ethylene-treated paper towels tended to have more ($P = 0.059$) leaves than those germinated on ethylene-saturated medium, hut overall plant heights were similar (Table 1).

Out results suggest that germination of arrow-leaved balsamroot seeds can he improved by exposing them to ethylene before stratification. Although stratifying seeds in ethylene-soaked paper towels improved the rate of germination, caution is needed because emerging radicles and not hairs may become embedded in the paper substrate and removal can cause root damage (Hendry and Grime 1993). This problem *can* be minimized by transplanting germinates soon after germination, preferably while the emerging root is < 1 cm (0.4 in) in length.

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