BREAKING SEED DORMANCY *IN ECHINACEA ANGUSTIFOLIA* AND ARROWLEAF BALSAMROOT

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Abstract

Echinacea angustifolia and arrowleaf ba1samroot are valuable native plants that are difficult to germinate. Three hormones (kinetin, gibberelic acid, and ethylene) were tested along with a potassium nitrate treatment to evaluate their effect on breaking seed dormancy. Germination of *E. angustifolia* responded very strongly to treatment with ethephon (a source of ethylene), though field emergence was poorer than one would expect from the laboratory results. Ethephon and gibberelic acid treatments showed a trend to increase germination of arrowleaf balsamroot, but the response was weak.

Introduction

Echinacea angustifolia has enjoyed immense popularity as a medicinal plant in the last several years (Landes, 1998). Strong seed dormancy has been a large factor limiting its production. Arrowleaf balsamroot *(Balsamorhiza sagittata)* has some value as a medicinal herb as well as an ornamental, but its production also has been limited by problems with seed dormancy. Breaking seed dormancy in these plants would help open a door for their production and for field-level agronomic studies. Feghahati and Reese (1994) reported that application of ethephon (which releases ethylene when it breaks down) greatly enhanced germination of *E. angustifolia* in conjunction with a stratification treatment of two to four weeks at 5°C. Based on this report, it was decided to see if the stratification requirement could be decreased further or eliminated with larger doses of ethephon, and to see if arrowleaf balsamroot also would respond to ethylene.

Methods

Initial study. Collections of *E. angustifolia* and arrowleaf balsamroot were obtained from Round Butte Seed Growers (Culver, Oregon) and Horizon Herbs (Williams, Oregon), respectively. Seeds were treated with Vitavax according to Feghahati and Reese (1994). Seeds were counted out into lots of 50 for imposition of treatments. The seed was placed in germination trays (4 x 4 inches) on two sheets of blotter paper. The blotter paper was treated with 20 mL of one of the following solutions:

1. deionized water (control)
2. kinetin 10 p.M
3. gibberelic acid (GA_3) 10 [tM
4. ethephon 1 mM
5. equal mixture of gibberellic acids ($GA_{3+4,7}$) 10 1.1M total concentration
6. potassium nitrate 200 mM

There were two replications per treatment. All trays were kept at 5°C for four weeks and rewetted in deionized water as needed to keep the trays moist. After four weeks, the trays were placed in a germination chamber set to 25/15°C day/night temperature with an 8-hour day period provided by flourescent lights (General Electric, F4OCW cool white). Germination counts were made at 5 and 10 days after placement of the trays in the germination chamber.

Ethephon concentration and timing studies. Using the same collection of *E. angustifolia* employed above, seed was again counted out into lots of 50 seeds each and placed in germination trays. In a trial with three replications, ethephon rate and duration of stratification period at 5°C were varied as follows:

1. 10 mM ethephon, 3 days stratification
2. 10 mM ethephon, 6 days stratification
3. 10 mM ethephon, 9 days stratification
4. 10 mM ethephon, 12 days stratification
5. 10 mM ethephon, 14 days stratification
6. 1 mM ethephon, 14 days stratification
7. 0.1 mM ethephon, 14 days stratification
8. 0.01 mM ethephon, 14 days stratification
9. no ethephon, 14 days stratification (control)

Trays were placed in a germination chamber as above and three counts made for each treatment over a 14-day period.

Because all the 10-mM ethephon treatments showed good germination, a further trial was initiated to see if any stratification was required. Conditions in the germination chamber and counts were as already noted for the above trial. The treatments for this trial (with three replications) were:

1. no ethephon, no stratification
2. no ethephon, 3 day stratification
3. 10 mM ethephon, no stratification
4. 10 mM ethephon, 0.5 day stratification
5. 10 mM ethephon, 1.0 day stratification
6. 10 mM ethephon, 2.0 day stratification
7. 10 mM ethephon, 3.0 day stratification

Tray and field studies. In order to see if the positive response to ethephon would occur outside the germination chamber, studies were conducted with treated seed being planted in trays filled with potting soil, and in the field. For the potting soil trial, 100 seeds were counted out for each replicate. There were three replicates. The seeds were treated and then spread over a 12 by 12-inch area in a greenhouse tray. Then 3 mm (1/8 inch) of potting soil was sprinkled over the top of

the seed and the trays were watered with tap water. The treatments were as follows:

1. Dry seed - control
2. Dry seed dipped in 10 mM ethephon
3. Imbibed seed - 24 h in a 10 mM ethephon solution
4 Imbibed seed - 24 h in deionized water
5. Imbibed seed - 24 h in water followed by an ethephon dip
6. Apple slice - 2.5 to 3.0 g of fresh apple slices placed in a covered tray with seed on moist blotter paper for 18 hours

The ethephon dip consisted of placing 100 seeds in a 50 mL beaker, adding 5 mL of 10 mM ethephon solution, briefly mixing the seed to ensure uniform coverage, and then immediately removing the seed. The trays were kept indoors (20°C) under flourescent lights. Emerged seedlings were counted at 8 and 10 days after planting.

To provide a second seed source for a field study, seed of *E. angustifolia* was purchased from Horizon Herbs (Williams, Oregon), and treated with Vitavax. Treated seed were planted at a rate of 80 seeds per row in 20-foot, single-row plots. Seeds were planted by hand on a field that had been rototilled to a depth of 4 inches Immediately after planting, the area was culti-packed perpendicular to the row direction. The plots were irrigated as needed to keep the soil moist within 3 mm of the surface. Number of emerged seedlings was counted at 28 days after planting. Seed treatments were:

1. imbibed in water for 24 h
2. dry
3. dry seed dipped in ethephon
4. imbibed in ethephon solution (10 mM) for 24 h.

All percent data were arc-sine square-root transformed and subject to analysis of variance using the PROC GLM procedure of SAS software (SAS Institute, Cary, NC).

Results and Discussion

While differences were not statistically significant, treatment of arrowleaf balsamroot with ethephon and with gibberellic acid appeared to approximately double germination rate (Table 1). The kinetin and potassium nitrate treatments were intermediate in their apparent response. Because there were only two replications in this trial, the effects would have to be quite strong to be detected statistically. For *E. angustifolia,* treatment with ethephon increased germination rate from about 25 percent up to almost 70 percent. The other treatments (kinetin, gibberellic acid, and potassium nitrate) did not appear to influence germination rate very much.

All treatments in the first trial received a four-week stratification period at 5°C. Because the ethephon treatment worked so well with *E. angustifolia,* it was decided to see if the stratification

period could be shortened. The result was that, at least for the seedlot we worked with in two trials, no stratification was required when the seed was treated with 10 mM ethephon (Fig. 1A). Eliminating the stratification step greatly simplifies breaking seed dormancy for this crop. This raises the question of whether more or less ethephon might give a better result. Accordingly, germination was evaluated across several concentrations (0, 0.01, 0.1, 1.0, and 10 mM) of ethephon. Germination response leveled off at a concentration of 1.0 mM ethephon and did not increase much at the greater level of ethephon (Fig. 1B). Note that the germination rate of the no ethephon treatment was rather high (about 70%) in this part of the trial. We are uncertain what may have caused this, unless there was some contamination of the controls with ethephon or ethylene.

Ethephon treatment of *E. angustifolia* then was evaluated for seed planted in potting soil and finally in the field to see if the enhanced germination effect would carry through from the germination tray in the laboratory out into the field. Ethephon doubled germination rate from about 25 percent up to about 50 percent for seed planted in potting soil (Table 2). Of special interest is that treatment of dry seed just prior to planting still resulted in enhanced emergence. Not having to treat seed ahead of time means that one could wait until conditions are right to plant, treat seed, and put it in the field. The treatment with sliced apple was to see if ethylene released from the apple would have the same effect as the ethephon treatment (ethephon breaks down to ethylene). However, the apple treatment did not appear to have any effect.

Emergence was much lower in a field environment than in potting soil (Tables 2 and 3). The seed from one source was of much poorer vigor than the other. Analysis of variance with seed source, ethephon, and pre-soaking as main effects with all possible interactions included indicated that the ethephon effect was highly significant. Even with ethephon, percent emergence was only half that observed for seed planted in potting soil, and only a third to a quarter of that observed when seed was germinated on blotter paper. Presumably, the difference is because most of the seed germinated, but did not manage to emerge. Apparently *E. angustifolia* seed is of low vigor (or at least the seed we planted was). This trial would suggest that the best emergence one could expect would be near 20%.

Conclusion

A 10 mM treatment of ethephon was able to break seed dormancy in *E. angustifolia* without having to impose any cold treatment (stratification) in experiments conducted at COARC. These experiments need to be repeated to confirm the results, but it appears that an ethephon treatment applied to dry *E. angustifolia* seed immediately prior to planting will break dormancy in most of the seed. This may not ensure a good stand, however, as field emergence appears to be only about one-third the rate of germination observed in laboratory trials. More work needs to be done to develop a practical method for breaking seed dormancy in arrowleaf balsamroot.

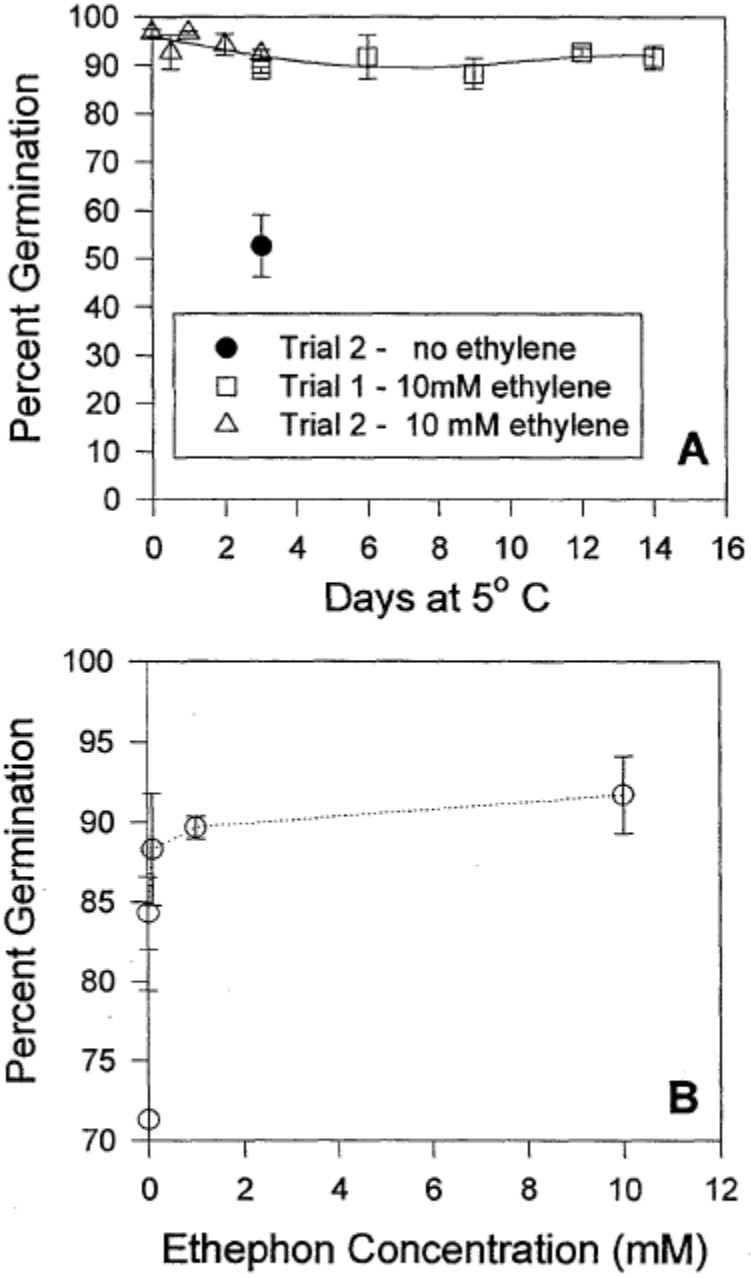

Fig. 1. Response of seed germination in *E. angustifolia* versus duration of stratification in two trials with a seed treatment of 10 mM ethephon (A), and versus concentration of ethephon in the water added to germination trays (B).

Table 1. Effect of several different hormones on germination of arrowleaf balsamroot and *E. angustifolia.* All treatments were stratified at 5 °C for four weeks. Differences among treatments were nonsignificant for arrowleaf balsamroot; the ethephon treatment had significantly greater germination than did the other treatments.

Plant Variety	Germination (%)
Arrowleaf Balsamroot	
Ethephon	21.0
GA3	21.0
GA3+4+ 7	18.0
Kinetin	16.0
KNO3	14.0
Water	9.0
Echinacea angustifolia	
Ethephon	69.0
GA3	29.5
GA3+4+7	30.5
Kinetin	32.0
KNO3	24.5
Water	27.5

Table 2. Effect of ethephon, exposure to apple slices, and pre-soaking on emergence of *E. angustifolia* planted in greenhouse trays filled with commercial potting soil. Means followed by the same letter are not significantly different ($P < 0.05$).

Treatment	Germination (%)
Imbibed / Ethephon soak	59.7 a
Dry/ Ethephon dip	45.0 ab
Imbibed / Ethephon dip	45.0 ab
Dry / Control	28.7 b
Imbibed / Water only	23.7 b
Apple	23.3 b
mean	37.6
CV (%)	36.3

Table 3. Effect of ethephon and pre-soaking on emergence of *E. angustifolia* planted on the surface and rolled into the soil with a culti-packer. Means followed by the same letter are not significantly different (P< 0.05).

Seedlot	Seed Moisture	Ethephon	Germination
			(%)
1	Imbibed		0.6a
1	Dry	-	0.3a
1	Dry	+	5.0 a
1	Imbibed	+	4.1 a
2	Imbibed		5.5 ab
2	Dry		9.7 b
2	Dry	+	27.5 c
2	Imbibed	+	15.9 b
mean			8.6
CV(%)			3.9

Literature Cited

Feghahati, S.M.J. and R.N. Reese. 1994. Ethylene-, Light-, and prechill-enhanced germination of *Echinacea angustifolia* seeds. J. Amer Soc. Hort. Sci. 119: 853-858.

Landes, P. 1998. Market report. Herbalgram 43: 60-61.