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Commercial Seed Lots Exhibit Reduced Seed Dormancy in Comparison to Wild Seed Lots of Echinacea purpurea

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Abstract. Seed germination patterns were studied in Echinacea purpurea (L.) Moench grouped by seed source, one group of seven lots from commercially cultivated populations and a second group of nine lots regenerated from 

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mentioned in previous reports on E. purpurea seed germination. Understanding differences in seed dormancy among various E. purpurea populations and determining the cause of dormancy reduction would be valuable, both in terms of the basic science (the genetics and evolution of this species) and in helping growers be more effective in selecting E. purpurea seeds. The objective of this investigation was to determine dormancy differences between E. purpurea seeds from commercially cultivated populations and from wild populations.

Materials and Methods

Echinacea purpurea seeds were grouped into two categories, those from commercially cultivated populations, presumably many generations removed from wild populations, and those from ex situ conserved wild populations. Commercially cultivated samples were purchased from seven seed companies (Ion Exchange Seed Corp., Hamer, Idaho; Johnny's Selected Seeds, Albion, Maine; Prairie Moon Nursery, Westfield, Wis.; Prairie Moon Nursery, Wapena, Miss.; Richters, Goodwood, Ontario, Canada; Stock Seed Farms, Murdock, Neb.; Wind River Seed, Manderson, Wyo.). Seeds from wild populations were provided by the U.S. Dept. of Agriculture—Agricultural Research Service, North Central Regional Plant Introduction Station (NCRPIS) in Ames, Iowa.

Additional information for each seed lot is given in Table 1.

Germination tests of the seed lots were conducted in December 2003 under two treatment conditions, constant light and constant darkness. Each treatment consisted of three

...continued...
replications, 50 seeds per treatment for each lot from commercial sources and 16 seeds for each of the NCRPIS lots. The seed lots from the NCRPIS were retested in February 2004 with the same seed and replication numbers and treatment conditions. First, seeds were soaked in 50-ml beakers with about 20 ml deionized water for 10 min. After soaking, seeds were blotted dry on paper towels and placed in transparent plastic germination boxes (11 x 11 x 3.5 cm) on two layers of filter paper saturated with deionized water. The lids on the boxes then were sealed with Parafilm M (Pechiney Plastic Packaging, Menasha, Wis.). For the treatment in darkness, the germination boxes were wrapped with aluminum foil. Germination tests were conducted in a growth chamber (model 816; Precision, Winchester, Va.) at constant 25°C. Cool white fluorescent lamps mounted in the chamber door produced photosynthetically active radiation at 40 µmol·m⁻²·s⁻¹. Germination (presence of radicles >1 mm long) was recorded at four-day intervals for the treatment in light and two times (on days 12 and 20) for the treatment in darkness. The day-12 count for the treatment in darkness was conducted along with checking moisture level in the boxes, and it has been found that short exposure (<1 min) to light during germination evaluation had little effect on final germination (Qu et al., 2004). Germinated seeds were removed when counted, and the tests lasted for 20 d after initiation.

Each experiment was a completely randomized design. Since there were no significant differences between the two germination test results for the NCRPIS lots, those data were combined for final analysis. Germination percentages were normalized by transformation (arc sin %) before being subjected to analysis of variance, following the methods of Wartling and Geneve (1964). Duncan's multiple range test was conducted on the transformed data after two-way ANOVA (seed lot x light vs. dark) to distinguish among individual lots.

Results and Discussion

Differences in seed germination were evident in the two groups (Table 1). Higher germination percentages were observed in commercial seed lots (99% mean among seed lots in light, ranging from 82% to 95%; 88% mean among seed lots in darkness, ranging from 82% to 97%) than from the wild populations (56% mean among seed lots in light, ranging from 9% to 92%; 37% mean among seed lots in darkness, ranging from 4% to 78%). For all but two populations (PI 633667 and PI 633669), seeds of the wild populations germinated significantly less frequently than did those of the commercially cultivated populations either in light or darkness.

Light vs. darkness during germination had no effect on germination percentage of commercially cultivated populations, but light increased the germination percentage of the wild population (Table 1). Unpublished data from the NCRPIS (Widlrechner, personal communication) indicate that differences observed in this experiment are, at least in part, due to the presence of dormancy in the wild populations. Seven of these nine seed lots from wild populations were tested for germination in February 2003 at the NCRPIS after using dormancy-breaking techniques involving ethephon and moist prechilling (modified from Sari et al., 2001), and all samples germinated within 21 d at levels between 70% and 95%.

All commercial seed lots had similarly high germination percentages (Table 1) in darkness and light, indicating that dormancy was either absent or minimal. Previously, we reported that ethephon had little effect in promoting seed germination of E. purpurea seeds from other commercial sources (Qu et al., 2004), and we recently determined that seeds freshly harvested from plants grown from commercial seeds had no dormancy requirements (92% to 98% germination) (Qu, unpublished data).

The history of cultivation of E. purpurea can help us understand the cause of the differences in germination behavior between these two groups of seeds. To learn more about the commercially cultivated seed samples, we communicated with technical personnel at the seed companies supplying the samples. Although it could not be confirmed with written records, the Echinacea plants used for commercial seed production were likely cultivated for more than ten generations, without dormancy-release treatments to increase germination. Available literature on the history of E. purpurea cultivation (Galambski, 2004) indicates that much of the cultivated material was brought to Europe from wild populations in North America many years ago. We are aware

Table 1. Seed germination results of Echinacea purpurea from different seed lots.

<table>
<thead>
<tr>
<th>Seed lot</th>
<th>Treatment</th>
<th>Mean</th>
<th>Harvest year</th>
<th>Origin in U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commercial populations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-purp 1</td>
<td>Light</td>
<td>95</td>
<td>97</td>
<td>96.0 (1.374) a'</td>
</tr>
<tr>
<td>C-purp 2</td>
<td>Dark</td>
<td>88</td>
<td>91.5 (1.355) ab</td>
<td>1998 Oregon</td>
</tr>
<tr>
<td>C-purp 3</td>
<td>Light</td>
<td>93</td>
<td>90</td>
<td>91.5 (1.283) abc</td>
</tr>
<tr>
<td>C-purp 4</td>
<td>Dark</td>
<td>89</td>
<td>88</td>
<td>89.0 (1.241) bc</td>
</tr>
<tr>
<td>C-purp 5</td>
<td>Light</td>
<td>84</td>
<td>83</td>
<td>85.5 (1.192) c</td>
</tr>
<tr>
<td>C-purp 6</td>
<td>Dark</td>
<td>84</td>
<td>83</td>
<td>83.5 (1.161) c</td>
</tr>
<tr>
<td>C-purp 7</td>
<td>Light</td>
<td>84</td>
<td>86</td>
<td>84.0 (1.161) c</td>
</tr>
<tr>
<td>C-purp 8</td>
<td>Dark</td>
<td>80</td>
<td>88</td>
<td>81.5 (1.161) c</td>
</tr>
<tr>
<td>Mean</td>
<td>Light</td>
<td>90</td>
<td>88</td>
<td>91.5 (1.283) abc</td>
</tr>
<tr>
<td>S * T</td>
<td>Dark</td>
<td>90</td>
<td>88</td>
<td>89.0 (1.241) bc</td>
</tr>
</tbody>
</table>

ANOVA (two-way)

Seed lot Treatment S * T

USDA/NCRPIS accessions

<table>
<thead>
<tr>
<th>PI</th>
<th>Light</th>
<th>Dark</th>
<th>Mean</th>
<th>Harvest year</th>
<th>Origin in U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>633669</td>
<td>73</td>
<td>82.0 (1.153) c</td>
<td>2002 Louisiana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>633667</td>
<td>83.0 (1.161) c</td>
<td>2002 Arkansas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>631307</td>
<td>64.0 (0.933) d</td>
<td>2000 Missouri</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>636688</td>
<td>57.5 (0.861) d</td>
<td>2002 Louisiana</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>631313</td>
<td>50.5 (0.790) e</td>
<td>2002 North Carolina</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>636700</td>
<td>47.3 (0.759) e</td>
<td>2002 Missouri</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>636701</td>
<td>16.0 (0.386) f</td>
<td>2002 Arkansas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>636666</td>
<td>10.0 (0.298) f</td>
<td>2002 Arkansas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>636685</td>
<td>7.0 (0.267) f</td>
<td>2002 Arkansas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>56</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA (two-way)

Seed lot Treatment S * T

n = 50 seeds; three replications.

**Mean separation within columns by Duncan's multiple range test after a combined analysis of transformed data representing all seed lots; transformed means (in parentheses) follow the untransformed data.

n = 32 seeds; three replications.

NS ... Non-significant or significant at P < 0.05 or 0.0001, respectively.
of no publications or other types of information indicating that intentional selection to reduce seed dormancy has ever been conducted in Echinacea. However, our results indicate that application of ethephon to commercial E. purpurea populations is not likely due to unintentional selection during repeated cycles of cultivation.

In nature, Echinacea seeds fall to the ground in the autumn and overwinter in the soil. Before seeds germinate the following season, they may receive a moist chilling treatment, giving dormant and non-dormant seeds similar growth opportunities. But when seeds are harvested in the fall and stored in a dry state until sowing, nondormant seeds would germinate to a greater extent, and dormant seeds put at a selective disadvantage, since they would germinate more slowly if at all (Wattidningshig et al., 1994).

The wild populations of E. purpurea conserved ex situ by the NCRPIS are maintained by regenerating them in screened field cages with pollinating insects (Widllechner and McKeown, 2002), in a manner designed to preserve the genetic integrity of individual populations (Wilson, 1989). Populations are established in the greenhouse by treating seeds with ethephon (Sari et al., 2001) so that selection for non-dormant types would be avoided. Given the geographic diversity of wild populations represented in our experiment (Table 1), dormancy may be a common phenomenon of E. purpurea in nature, although the levels may vary.

Germination percentage of the NCRPIS seed lots was higher in light than in dark (Table 1). A similar phenomenon has been noted for E. angustifolia (Feghahati and Reese, 1994; Qu et al., 2004). Previous authors (Qu et al., 2004; Smith-Jochum and A. Abrecht, 1987; Wattidningshig and Geneve, 1994) have reported variable effects of light on seed germination in E. purpurea. Qu et al. (2004) suggested that while fully dormant Echinacea seeds could not germinate either in light or darkness, germination in light becomes possible with a partial release of dormancy. Differences in seed source and dormancy status may be responsible for observed variation in germination. In addition, since the seeds used in this study have all been stored in a dry state for more than one year, germination differences between the commercial and wild seed lots suggest that dry storage had minimal effect on seed dormancy.

Our results are the first to indicate that selection during cultivation may have unintentionally reduced seed dormancy in E. purpurea. However, we recognize that, by testing seed lots produced under various environmental conditions and by using commercial seed lots of unknown original parentage, our results must be considered preliminary. However, we believe the effects of these confounding factors to be relatively minor for the following reasons:

1) Seed dormancy is commonly a well-defined genetic characteristic that interacts with environmental variation (reviewed by Baskin and Baskin, 1998). In our judgment, the differences among environmental conditions at seed-regeneration sites or among seed-storage conditions used are small relative to genetic effects.

2) It is very difficult, if not impossible, to trace the original population(s) from which the commercially cultivated seed lots were produced. In the worst-case scenario, the commercial seeds may have been supplied from only two production fields, one in Oregon and the other in Colorado. However, these seed lots represent a substantial proportion of the E. purpurea seed used for commercial field production, since we obtained seeds from firms that are among the major suppliers. We expect that commercial seed lots do not trace back to only two production fields. We recently tested E. purpurea seed lots produced in California and Illinois, with germination results not significantly different (data not shown) from the commercial seed lots analyzed in this study.

Our results provide useful information for E. purpurea growers who wish to select populations for reduced seed dormancy. Since Echinacea seed production has not been standardized as it has for many other more established crops, we suggest germination tests to evaluate E. purpurea seed dormancy before sowing, even when seed source information has been provided.

The germination of two other species, E. angustifolia and E. pallida, widely cultivated as medicinal plants (Galambosi, 2004), has been reported to be more erratic than that of E. purpurea (Feghahati and Reese, 1994; Macchini et al., 2001; Qu et al., 2004; Shalaby et al., 1997; Sari et al., 2001), requiring the use of special dormancy-breaking protocols for consistent germination. It may be possible to duplicate the selection process for dormancy reduction in E. angustifolia and E. pallida by using multiple cycles of cultivation through untreated seed propagation, as has occurred in E. purpurea.

Literature cited: