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Reduction of seed dormancy in *Echinacea pallida* (Nutt.) Nutt. by in-dark seed selection and breeding

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ABSTRACT

Strong seed dormancy has been an obstacle for field production of *Echinacea* species. Previous research on overcoming *Echinacea* seed dormancy has been extensive and focused on treatment methods, which involve time and expense, and are incompatible with organic production if synthetic chemicals are used. We have attempted to genetically reduce seed dormancy through selection and breeding in *Echinacea*, by using *Echinacea pallida* as a model species. Three accessions were used in this study. Nine parent plants of each accession selected from early, in-dark germinated seeds (in-dark plants) or from late, in-light seeds (in-light plants) were planted and grouped by accession and germination treatment method for seed production through a polycross method. Germination tests indicated that these in-dark plants produced seed (in-dark seed) with significantly reduced seed dormancy when tested under light or dark condition in comparison to the seed of the in-light plants (in-light seed). Among the three accessions, the in-dark seed germinated at much higher rates than did the in-light seed, more than 2× at 25 °C under light and up to an 83× increase in darkness, and up to an 8× increase over the corresponding parental seed lots under comparable germination conditions. In addition to these increases in germination, the in-dark seed showed early and synchronized germination as compared to the in-light seed. Since these results were achieved through only one cycle of selection and breeding, they strongly suggest that we have developed a very effective method for modifying seed dormancy in *Echinacea*.

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1. Introduction

Seed dormancy, in simple terms, is a phenomenon of blocking intact viable seeds from germinating under favorable conditions and has been an extensively studied area in plant biology (Baskin and Baskin, 2004; Finch-Savage and Leubner-Metzger, 2006; Simpson, 1990). Strong seed dormancy exists in many wild and weedy plant species and in semi-domesticated crops (Finkelstein et al., 2008). Over the years, researchers have developed a wide range of methods to break dormancy for promoting seed germination (AOSA, 2010). For crops that are typically propagated vegetatively, such as tree fruits, breeders and curators often can rely upon complex protocols to germinate their seeds. But when seed-propagation systems are used directly in commercial crop production, the application of dormancy breaking methods may be inconvenient, expensive, or lead to inconsistent results.

Preparations from *Echinacea* species have been among the top botanical dietary supplements in Europe and North America since late 1980s, purportedly for general stimulation of the immune system and for treatment or prevention of the common cold (Barrett et al., 2010; Woelkart et al., 2008). Contradictory laboratory and clinical test results have been published regarding the effectiveness of *Echinacea* products (Barrett et al., 2010; Ross, 2010; Shah et al., 2007; Woelkart et al., 2008), but they are received well in the marketplace, and this trend seems likely to continue (Barrett et al., 2010).

According to the classification system by McGregor (1968), the genus *Echinacea* contains nine species and four varieties, all native to North America. Among them, *Echinacea angustifolia* DC., *Echinacea purpurea* (L.) Moench, and *Echinacea pallida* have been the most widely used as dietary supplements (Kindscher et al., 2008; Li, 1998). In recent years, *E. purpurea* has become the primary species for field cultivation and volume of product, and is also the most researched *Echinacea* species, as reflected in a recent search of the PubMed (National Center for Biotechnology Information, 2011) database. This may be in part because less effort is required for its cultivation, resulting from the fact that it displays little or no seed dormancy in commercial seed lots (Qu et al., 2005), relatively rapid growth, and broad adaptation to various soil types (Li, 1998). However, *E. angustifolia* was the primary species initially used by Native Americans for its medicinal properties (Volker et al., 2001), and, through the 1920s, this species was the most prescribed medicine made from an American plant (Foster, 1991). While the proportion

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