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The Relationship between Ethylene and Dormancy Release in *Echinacea* Seeds

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Abstract

Seed germination can be erratic in *Echinacea* species unless they receive chilling stratification to satisfy dormancy. *E. tennesseensis* and *E. simulata* seeds treated with 1-aminocyclopropane-1-carboxylic acid (ACC) were released from dormancy to a level equivalent to chilling stratification. Both treatments improved early and final germination in both species. Stratification and ACC treatments reduced the sensitivity of seeds to abscisic acid (ABA) as evidenced by their ability to germinate on ABA concentrations inhibitory to untreated seeds. The data suggests that both stratification and ACC act through a similar mode of action related to ABA sensitivity. However, treating seeds with the ethylene action inhibitor silver thiosulfate (STS) before or after stratification did not effect germination in either species. This suggests that the release from dormancy promoted by chilling stratification does not require ethylene.

INTRODUCTION

Seeds of *Echinacea* vary in their degree of primary dormancy, but most seed lots appear to have some endogenous physiological dormancy. Moist chilling stratification will break dormancy and improve germination in *Echinacea* seeds (Sari et al., 2001; Wartidiningsih et al., 1994). In some cases, dormancy can be broken without moist chilling by ethylene treatments usually applied as ethephon (Macchia et al., 2001; Sari et al., 2001). Ethylene production does not appear to be generally required for germination, but it is produced in seeds of most species at the onset of germination (Matilla, 2000). The ability to produce ethylene is associated with dormancy release some seeds, but it is not clear whether ethylene production is required to achieve a stratification effect leading to dormancy release.

In this study, the relationship between seed dormancy and ethylene was investigated using two *Echinacea* species (*E. tennesseensis* and *E. simulata*). The specific objective was to investigate whether ethylene (via ACC treatment) would substitute for chilling stratification to relieve dormancy and whether ethylene was required to relieve dormancy by stratification.

MATERIALS AND METHODS

Seeds used in this study were produced at the University of Kentucky Horticultural research farm. Seeds were stored at 10°C until used. Seeds were stratified by placing moistened seeds in sealed Petri dishes for 60 d at 5°C. Seeds for all treatments were germinated in four replicate Petri dishes containing 6 ml water or test solution, two pieces of germination paper, and sealed with parafilm. Treatments included combinations of stratification, ACC (5 mM), ABA (50 µM), and STS (2 mM) as indicated in the tables. Dishes were placed in a 25°C incubator with 16h light. Seeds were assayed for germination (radicle protrusion) after 3 or 12 d.

RESULTS AND DISCUSSION

Germinating seeds in the presence of ACC was as effective as chilling stratification for increasing germination in both *Echinacea* species (Table 1). Germination

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increased by approximately 37% in *E. tennesseensis* and three-fold in *E. simulata* using either treatment. Chilling stratification has consistently improved germination in *Echinacea* species showing dormancy (Parmenter et al., 1996; Wartidiningsih et al., 1994). Ethylene applied as ethephon has also been effective for improving germination in *E. angustifolia* and *E. pallida* (Macchia et al., 2001; Qu et al., 2004; Sari et al., 2001). In the present study, ethephon was also an effective dormancy releasing compound for *E. tennesseensis* and *E. simulata* (data not presented). Results of treating *Echinacea* seeds with ethephon have varied depending on the seed lot. For instance, Sari et al. (2001) showed that ethephon was only effective in improving germination in four of nine seed lots evaluated. ACC is more stable than ethephon, which can spontaneously convert to gaseous ethylene and therefore ACC treatment could provide a more consistent dormancy release response.

ABA was an effective inhibitor of germination in both *Echinacea* species (Table 1). ABA reduced germination by 55 and 68% for *E. tennesseensis* and *E. simulata*, respectively. However, stratification and ACC treatment reduced seed sensitivity to ABA improving germination to nearly the levels of stratification or ACC treatment alone (Table 1). Given that ABA plays a significant role in seed dormancy (Kucera et al., 2005), this evidence suggests that both stratification and ACC treatments have a similar mode of action relative to ABA sensitivity and seed dormancy release.

STS did not reduce germination in untreated *E. tennesseensis* and slightly decreased germination following stratification (Table 1). However, there was still a substantial stratification effect compared to the control in STS treated seeds. In contrast, STS promoted germination in both untreated and stratified seeds in *E. simulata*. STS is an ethylene action inhibitor and these data suggest that ethylene perception was not required for germination in either *Echinacea* species and that stratification effect does not rely on ethylene production.

Both stratification and ACC treatments show a similar mode of action relative to ABA sensitivity (Table 1), but the stratification response does not appear to be mediated by ethylene. It has been suggested that the reduction in ABA sensitivity by ethylene during seed germination is related to hormone cross-talk (Brady and McCourt, 2003). ABA, ethylene and gibberellin share downstream elements in their signal transduction pathways. It could be possible that stratification in *Echinacea* also impacts elements in signal transduction common to ABA ethylene and gibberellin to relieve dormancy.

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Tables

Table 1. Germination percentage in *Echinacea* seeds treated with combinations of 60 d chilling stratification, ACC, STS, and ABA.

Treatment	*E. tennesseensis*	*E. simulata*
Untreated	61c[z]	22d
Stratified	87a	79a
ACC (5 mM)	85a	82a
ABA (50 μM)	23d	7e
Stratified + ABA (50 μM)	79b	65b
ACC (5 mM) + ABA (50 μM)	71b	49c
STS (2 mM)	57c	40c
Stratified + STS (2 mM)	77b	87a

[z] Means in a column followed by the same letter were not different by Tukey's test (α=0.5).