Germination of Water Sedge, *Carex aquatilis*, and Cotton Sedge, *Eriophorum angustifolium*, from Arctic Coastal Wetlands, Prudhoe Bay, Alaska©

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Oil well drilling pads, roads and buildings at Prudhoe Bay Oilfields, Alaska are built on permafrost soils that surface-thaw in summer to form extensive wetlands. To prevent thawing and subsidence of subsurface, ice-rich soils, gravel pads, 6 ft (1.8 m) or more thickness, are built to support these facilities. As the oilfields age, the gravel is removed, and sites must be restored. Since the 1970s, revegetation efforts have included a variety of planting techniques and seed treatments mostly with native grasses (Chapin and Chapin, 1980; Bishop and Chapin, 1989; Ebersole, 1987; Jorgenson, 1988; Kidd and Rossow, 1998; Kidd et al., 2004, 2006; Maslen and Kershaw, 1989; McKendrick, 1987, 1991, 2000; McKendrick and Mitchell, 1978; Mitchell et al., 1974; Schwarzenbach, 1996; Streever et al., 2003).

Water sedge, *Carex aquatilis* Wahlenb, and cotton sedge, *Eriophorum angustifolium* Honck., form large populations that spread clonally by rhizomes and often dominate Arctic wetland environments (Shaver and Billings, 1975). Despite their abundance, these species have not been used for revegetation because clonal methods are time consuming and expensive compared to direct seeding, and little is known about seed germination for these species (Dr. William Streever, BP Alaska, pers. commun.). The objective of this experiment was to explore methods of seed germination for water sedge and cotton sedge, identify dormancy mechanisms, and identify seed treatments to enhance germination for direct seeding or plug production of Arctic wetland revegetation.

METHODS

Achenes were harvested from the Prudhoe Bay oil fields, 70.33°N, 148.81°W and 70.32°N, 149.38°W, 33-98 ft (10-30 m) elevation. The harvest areas were within 492 ft (150 m) of the Spine Road and were representative of moist and wet tundra dominated by sedge species (Walker, 1985). In 2007 and 2008, achenes were collected on seven dates between 30 Jul and 26 Sep. Entire heads were collected and stored at 59°F (15°C) for 5 days. Head length was measured on water sedge, and achenes were removed by hand rubbing and separation. In cotton sedge, achenes were separated by rubbing through a 0.25-mm (60-mesh) soil sieve, and then separated using a head thresher (Precision Machine, New Brunswick, Canada). Data on total number of achenes and filled seeds per head were recorded. For determining filled seeds, the achenes were examined with a lighted dissecting scope and bisected with a razor blade. Three subsamples were taken at random (0.05 g each) from all achenes and were dried for moisture content 265-270°F (130-133°C) for 24 h (International Seed Testing Association [ISTA], 1999, 2003).

Germination tests were conducted with four replicates of 100 filled achenes placed on filter paper, moistened with distilled water in glass petri dishes, and enclosed in plastic freezer bags to reduce water loss. Tests were conducted in lighted growth chambers (CW fluorescent 20W and 40W, PAR 99-108 $\mu mol \cdot m^{-2} \cdot s^{-1}$). Successful germination was defined as radicle emergence within a 60-day period. All trials followed ISTA (1999) protocols for seed testing. Data were analyzed using arc-sin transformation with analysis of variance, $P \leq 0.05$ or 0.01, and mean separation by Tukey's HSD (Graphpad Software, Inc., 2007).

Germination treatments included:

1) Light (24 h) or dark (foil covered), 10°C constant temperature at seven collection dates.
2) 24-h soak in water or 1000 ppm GA_3 with or without perigynium.

3) Filter paper moistened with KNO_3, (0.2%) at 59°F (15°C) constant temperature and 24-h light.
4) 10 and 17 Sep-collected seeds germinated at constant temperature in light at 59-86°F (15-30°C), 5-degree intervals.
5) Cold stratification (40°F, 4°C) for 30, 60, 90, 120, or 150 days then germination at 50°F (10°C) in light.
6) 3, 17, and 16 Sep-collected seeds stored 10 months at 23°F (-5°C) followed by germination 77°F (25°C), 77/59°F (25/15°C) or 59/41°F (15/5°C) for 15/9 h.
7) 77°F (25°C) constant or 77/55°F (25/13°C) alternating temps for 15/9 h light.
8) Light or dark germination under alternating 77/55°F (25/13°C) for 15/9 h.
9) Fresh seeds or cold, dry storage, 40°F (4°C) for 6 months followed by germination at 77/55°F (25/13°C) for 15/9 h.
10) Cold stratification or cold 40°F (4°C) dry storage followed by cold stratification, 30 days each, then germination at 25/13°C alternating temperatures for 15/9 h.
11) 30 Jul., 13, 27 Aug. and 10, 23 Sep. seed collection dates in light and alternating temperatures 77/55°F (25/13°C) for 15/9 h.
12) 27 Aug. and 23 Sep. collection dates and cold stratification 40°F (4°C), 60 days, cold dry storage and a combination of the two as described above.

In 2008, seed heads were collected from 29 sites along a transect paralleling the Spine Road, Prudhoe Bay. Seed heads were air-dried at room temperature for 3-5 days, followed by germination tests as described above to determine the variability among wild populations of the species for amount of filled seeds, germination percentages.

RESULTS

Wild harvested seed heads contained fewer than 20% filled seeds in water sedge and more than 50% filled seeds in cotton sedge. Moisture content decreased 1.27% on average through the season for cotton sedge and 3.07% for water sedge. Active head shattering (dehiscence) occurred in mid to late Aug in cotton sedge with achene moisture content averaging 9% at maturity. In water sedge, dehiscence did not occur through the end of September. Cotton sedge seeds had less than 10% germination under any of the experimental germination conditions. Water sedge germination percentages did not differ among 29 wild populations (min 16%, max 63%, mean 34.9%±12.4). Nor were there any populations with consistently higher germination than others that might reveal superior strains.

Water sedge achenes showed significant germination but only under light and alternating temperatures (Fig. 1). All other treatments showed less than one percent or no germination during the 60-day germination trial. Water sedge achenes maintained viability in cold storage but did not lose their light or temperature requirements over time. Removal of the perigynium did not change light or alternating temperature requirements. Cold stratification did not promote germination of water sedge.

We failed to identify optimum germination conditions for cotton sedge. Water sedge should be harvested widely from many populations in mid to late September, air dried, and the fruit separated by rubbing on a separation board or through a screen. An air screen gravity separator can be used to remove high percentages of unfilled fruits. Achenes may be stored dry and cold, refrigerated or frozen for at least one year. They require light and alternating temperatures for optimum germination under controlled conditions.

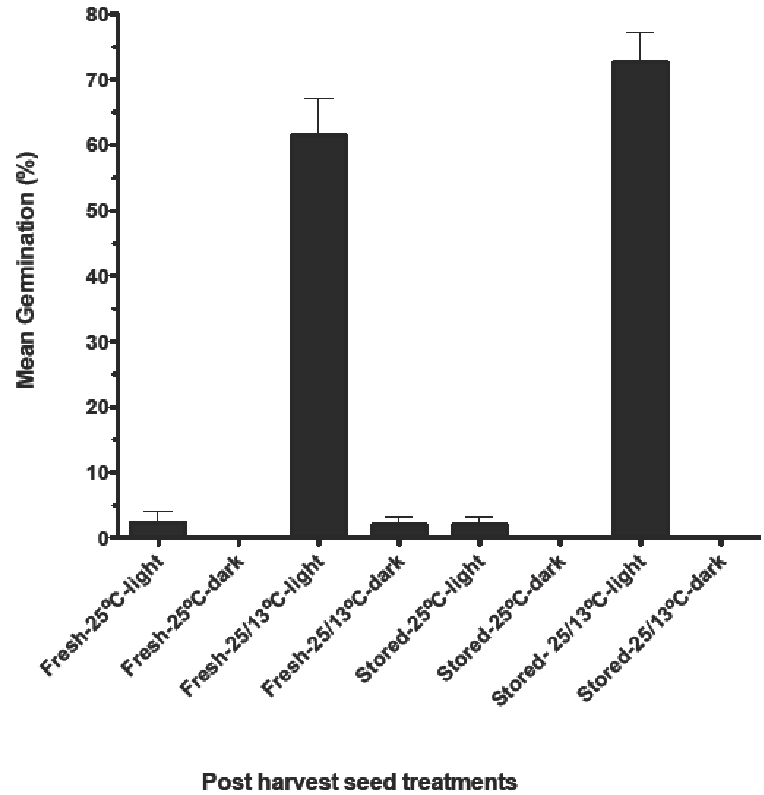

Fig. 1. Percent germination of water sedge, *Carex aquatilis*, with a variety of post harvest achene treatments.

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