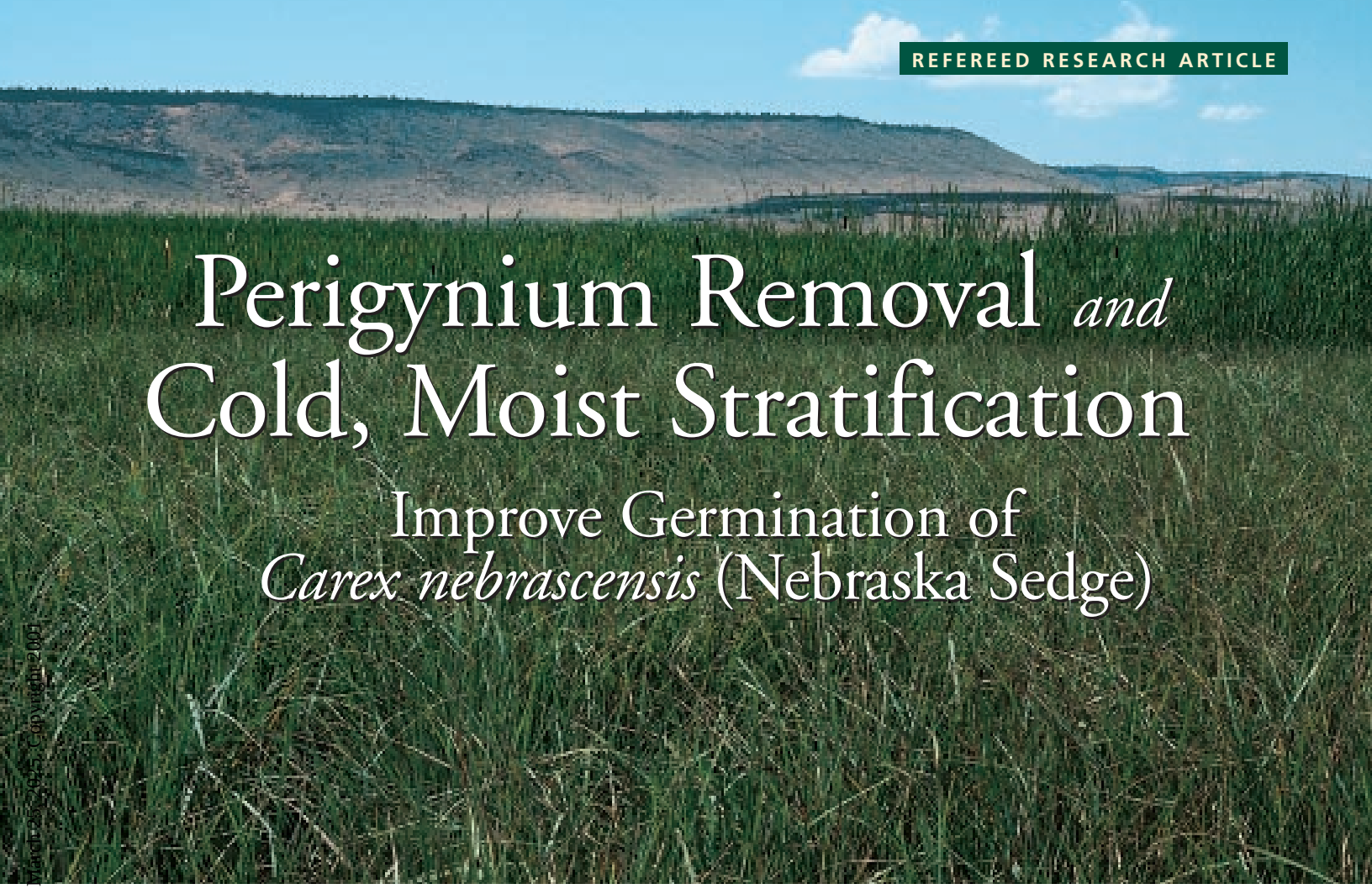
REFEREED RESEARCH ARTICLE



Perigynium Removal *and* Cold, Moist Stratification Improve Germination of *Carex nebrascensis* (Nebraska Sedge)

J Chris Hoag, R Kasten Dumroese, and Michael E Sellers

A wet meadow dominated by Nebraska sedge (Carex nebrascensis).

Photo by J Chris Hoag

ABSTRACT

For 2 populations of Nebraska sedge (*Carex nebrascensis* Dewey [Cyperaceae]), removal of the perigynium, the saclike structure around mature achenes, either with forceps or sandpaper, provided sufficient scarification to significantly increase total germination about 50% compared with that of nonscarified achenes. We also found that a combination of scarification and 32 d of cold, moist stratification resulted in 25% higher total germination than stratification alone. Stratification of scarified achenes with sphagnum peat moss resulted in 17% more germination than when scarified achenes were stratified in distilled water only. Our results indicate Nebraska sedge can be efficiently germinated in nurseries if perigynia are removed by scarification and achenes stratified 32 d at 3 °C (37 °F) with a sphagnum peat moss substrate.

KEY WORDS: *Carex*, perigynium, stratification, germination, achene

NOMENCLATURE: USDA NRCS (1999)

Public and legislative emphasis on wetland riparian restoration using native plants has increased the need for information on the establishment of many wetland and riparian plant species, including sedges (*Carex* spp. A.L. Juss [Cyperaceae]). Nebraska sedge (*Carex nebrascensis* Dewey) is a dominant emergent species in many Intermountain West and Great Basin wetland and riparian areas. Nebraska sedge has an extensive fibrous root system making it desireable for soil stabilization on rangelands and streambanks (Manning and others 1989). Successful establishment of Nebraska sedge in the wild has been accomplished by 2 methods: 1) harvesting sedges from natural populations and transplanting them to a restoration site; and 2) cultivating them from achenes (indehiscent fruits containing seeds) in a greenhouse and trans-

planting them as plugs (Ratliff 1985; Nelson and Williams 1986; Hoag 1994; Hoag and Sellers 1995).

Plug production has several benefits over transplanting wild plants: 1) greenhouse plug production can generate substantially more propagules than can be, or perhaps should be, collected from native stands (see Shaw and Hurd 1992); 2) plug production is more cost effective than digging from native stands (Dawes 2000); 3) plants with larger sized plugs, 350 ml (21.5 in^3), can be produced in about 100 d and can withstand fluctuations in water levels because the aerenchyma is better developed (Hammer 1992; Hoag and others 1992); 4) plugs are uniform in size, facilitating transport and planting; and 5) plugs can be produced for year-round planting windows. Plug production is most cost efficient when inputs (seeds, fertilizer, and labor) are minimized and the number of plants grown is maximized. Prompt and thorough germination of Nebraska sedge achenes would improve nursery efficiency.

In general, *Carex* spp. achenes are known to require relatively high temperatures, light, cold-moist stratification, and other factors for germination (Johnson and others 1965; Grime and others 1981; Baskin and others 1989; Hurd and Shaw 1991; Budelsky and Galatowitsch 1999). However, little is known about Nebraska sedge germination requirements since most studies have concentrated on its shoot life history and biomass production (Ratliff 1983; Bernard 1990; Ratliff and Westfall 1992). For Nebraska sedge, germination data are limited. Some of our previous unpublished work suggested that the perigynium (the saclike structure in which the achene matures) affected germination. Shaw and Hurd (1992) purport that cold, moist stratification improves germination. Jones (1999) found that, in general, scarification with perigynia removal, stratification, and exposure to light improved Nebraska sedge germination. Young and Young (1985) proposed 3 general techniques to improve germination of species with low total germination: 1) light scarification with sandpaper to abrade the seed coat, 2) cold, moist stratification with a sphagnum peat moss substrate; and 3) cold, moist stratification with an activated charcoal substrate, which is often the only effective substrate for some species.

Because of the paucity of information on Nebraska sedge germination, our study objective was to test the effects of perigynium removal and various stratification media on total germination.

MATERIALS AND METHODS

We used 2 populations of *C. nebrascensis*. Achenes were collected from Trout Creek, near Jackpot, Nevada (lat 41°48'N, long 115°7'W), and the Sterling Wildlife Management Area (WMA) near Aberdeen, Idaho (lat 42°57'N, long 112°50'W). We collected achenes during September using a prairie seed stripper (Prairie Habitats, Argyle, Manitoba, Canada) and ran the material through a Jacobson hammer mill (Model "Little Jake," Jacobson Machine Works Inc, Minneapolis, Minnesota) to break up the vegetative material and other large debris collected with achenes. Then the material was run through a Clipper "Office" fanning mill with a No. 8 top screen, a No. 20 bottom screen, and the airflow adjusted to a very slow speed (Clipper, Bluffton, Indiana). Cleaned achenes were stored dry about 8 mo at room temperature (22 °C [72 °F]) before the scarification experiment and about 1 y before the stratification experiment.

Scarification Experiment

We used 4 treatments: 1) control (no perigynium removal or sandpaper scarification); 2) perigynium removed with forceps; 3) perigynium removed with forceps and achene scarified with sandpaper; 4) perigynium removed with sandpaper. Achenes from both populations were randomly assigned to each treatment. We used forceps to remove perigynia after soaking achenes 15 min in deionized water. To scarify achenes with sandpaper, we constructed a scarification box that measured 10 X 14 X 2.5 cm (4 X 6 X 1 in) out of pine lumber. The bottom of the box was lined with 100 grit sandpaper. A small piece of wood that fit into the box was wrapped with 100 grit sandpaper. We put about 60 to 100 achenes in the bottom of the box and using the block, lightly rubbed the achenes for about 10 to 15 s. For each treatment, 4 replicates of 50 achenes were placed on a germination blotter in petri dishes, moistened with deionized water, kept at room temperature (22 °C [72 °F]), and exposed to a 24-h photoperiod (Hurd and Shaw 1991) using a 100-watt fluorescent light placed 61 cm (24 in) above the randomly placed petri dishes. We monitored achenes every 7 d and removed germinates for 7 wk.

Cold-moist Stratification Experiment

For half of the achenes in each population, we removed perigynia by scarifying achenes in the sandpaper box described above (treatment 4). Groups of 50 scarified or nonscarified achenes were placed into 235-ml (8-oz) covered plastic cups filled with 115 ml (4 oz) of deionized water. Achenes were then randomly assigned to 3 treatments replicated 5 times where the following, enclosed within cheesecloth bags, were added to the cups: 1) nothing (control); 2) 8 g (0.3 oz) of sphagnum peat moss; or 3) 8 g (0.3 oz) of activated charcoal. Achenes were refrigerated 32 d at 3 °C (37 °F) before placement onto a germination blotter in petri dishes. We randomly placed the dishes on a ProGro Propagation mat (Hummert International, Earth City, Missouri) with diurnal

temperatures of 26 °C (78 °F) and 37 °C (98 °F) because our prior work indicated increased germination at these higher temperatures. Achenes were kept moist with deionized water and given a 24-h photoperiod as described above. We monitored achenes every 7 d and removed germinates for 7 wk.

Statistical Analysis

For both experiments, cumulative counts of germinated achenes were analyzed by ANOVA using the general linear model (PROC GLM; SAS Institute Inc 1989, 1993). Residuals were plotted and their distribution appeared normal, independent, and homogeneous, making data transformation unnecessary. For the scarification experiment, our sources of variation were fixed and included population, scarification method, and the interaction. For the stratification experiment, our fixed sources of variation were population, presence or absence of scarification, stratification substrate, and the 4 interactions. Means were separated using Tukey's HSD when $P < 0.05$.

RESULTS AND DISCUSSION

In the scarification experiment, total germination after 49 d was affected by treatment ($P = 0.01$) but unaffected by population ($P = 0.15$) or the interaction ($P = 0.2$). Except at 7 and 14 d, germination in the 3 scarification treatments was similar (lacked significant differences among scarification techniques) and significantly higher than the control treatment (Figure 1). Final germination in scarified treatments ranged from 53% to 60%, significantly higher than 38% germination in the control treatment. Germination rate, measured as the number of days to 50% germination of those seeds that eventually germinated (Thomson and El-Kassaby 1993), was also higher in the scarified treatments compared to the control (Figure 1) with nearly all scarified achenes germinating by 28 d. Our results are similar to those reported by Jones (1999): faster germination rate and about a 50% increase in total germination after perigynium removal. We conclude that the benefit of scarification (mitigation of achene dormancy) is due to perigynium removal rather than abrasion of the achene because abrasion of the achene after perigynium removal yielded no further increase in total germination. Jones (1999) speculated perigynia may reduce oxygen flow, light saturation, or moderate temperatures of intact achenes and thereby inhibit germination.

In the stratification experiment, population, scarification, and stratification media were significant ($P = 0.02$, 0.0001, and 0.03, respectively), as were the scarification X stratification media and three-way interactions ($P = 0.03$ and 0.03). For the scarification X stratification media interaction, total germination of nonscarified achenes was similar regardless of stratification medium (56%, $s_{\bar{x}} = 10$) but total germination of scarified achenes stratified with sphagnum peat moss (75%, $s_{\bar{x}} = 8$) was similar to that of achenes stratified with activated charcoal (69%, $s_{\bar{x}} = 6$) but significantly ($P = 0.005$) higher than the control (64%, $s_{\bar{x}} = 6$). Germination of achenes stratified with activated charcoal was similar to germination found with the other 2 substrates. For both populations combined, scarified + stratified achenes germinated better than nonscarified but stratified achenes (70%, $s_{\bar{x}} = 8$ versus 56%, $s_{\bar{x}} = 10$; Figure 2).

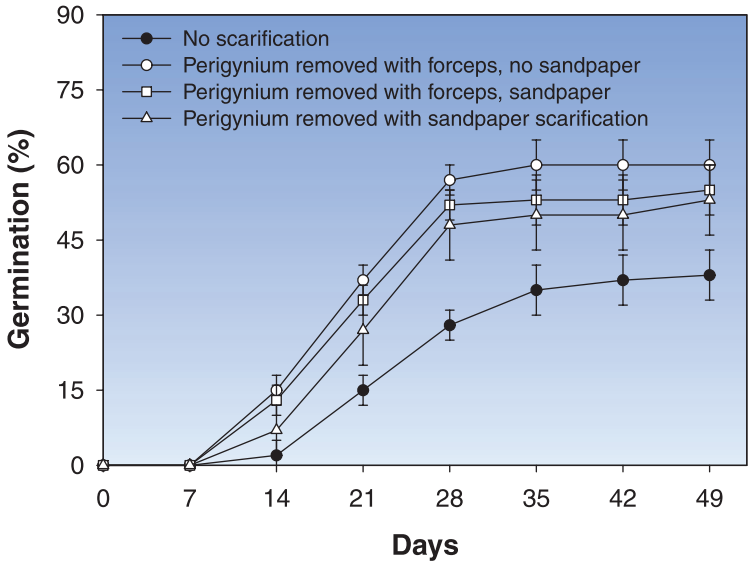


Figure 1 • Mean germination and standard errors of achenes following 4 scarification treatments for both seed sources combined.

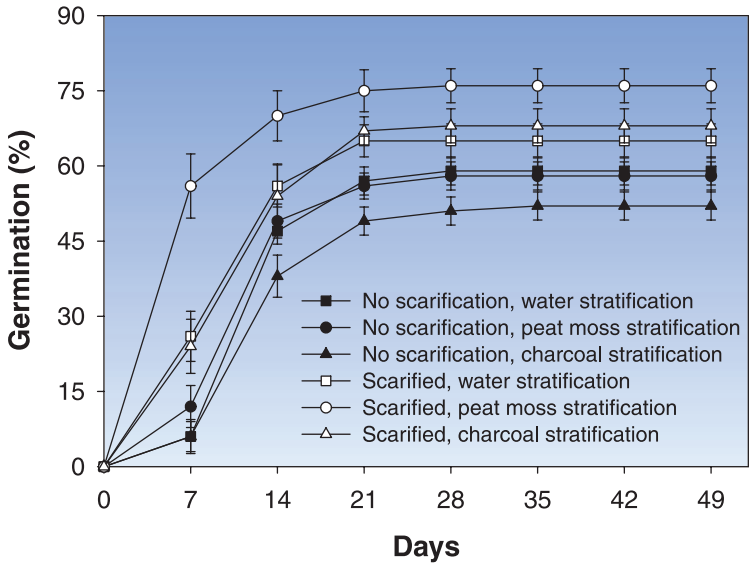


Figure 2 • Mean germination and standard errors of achenes following 2 scarification treatments and subsequent stratification on 3 media for both seed sources combined.

It appears that the three-way interaction was because the Sterling WMA population showed less difference in germination between the nonscarified + stratification media treatment and the scarified + stratification media treatment than did achenes collected at Trout Creek. Overall, achenes from Sterling WMA germinated better than those from Trout Creek (66%, $s_{\bar{x}}$ = 11 versus 60%, $s_{\bar{x}}$ = 10). For the Trout Creek population, stratification with sphagnum peat moss (73%, $s_{\bar{x}}$ = 4) was significantly higher (P = 0.008) than that of achenes stratified with either activated charcoal (67%, $s_{\bar{x}}$ = 2) or the control (65%, $s_{\bar{x}}$ = 4).

Jones (1999) also found that stratification improved total germination but that most of the benefit was realized with 7 d of treatment. Rate of germination was also enhanced by stratification. However, combined data for *C. nebrascensis* and *C. rostrata* Stokes ex With. indicate scarification and stratification increased total germination only when achenes were stratified 7 d, with no improvements observed after stratification durations of 1 or 5 mo (Jones 1999). This discrepancy may be due to our use of achenes with less storage time than those of Jones (1999), 8 to 12 mo versus 24 to 30 mo, or because perigynium removal has little effect on *C. rostrata* germination (Jones 1999).

CONCLUSIONS

The perigynium is a source of achene dormancy in Nebraska sedge. Perigynia can be removed by various methods, but brief, light rubbing of achenes with sandpaper is an easy method for small quantities. Some physiological dormancy also resides within the achene, and it is at least partially dissipated by 32 d of cold, moist stratification. Cold, moist stratification also improved germination rate. Total germination of scarified and stratified achenes was best when sphagnum peat moss was the stratification substrate.

AUTHOR INFORMATION

J Chris Hoag
Wetland Plant Ecologist
chris.hoag@id.usda.gov

Michael E Sellers
former Wetland Biological Technician

Interagency Riparian/Wetland Plant Development Project
Plant Materials Center
USDA Natural Resources Conservation Service
PO Box 296
Aberdeen, ID 83210

R Kasten Dumroese
Research Scientist
Forest Research Nursery
University of Idaho
PO Box 441137
Moscow, ID 83844-1137
dumroese@uidaho.edu

REFERENCES

Baskin CC, Baskin JM, Spooner DM. 1989. Role of temperature, light and date: seeds were exhumed from soil on germination of four wetland perennials. Aquatic Botany 35:387–394.

Bernard JM. 1990. Life history and vegetative reproduction in *Carex*. Canadian Journal of Botany 68:1441–1448.

Budelsky RA, Galatowitsch SM. 1999. Effects of moisture, temperature, and time on seed germination of five wetland *Carices*: implications for restoration. Restoration Ecology 7:86–97.

Dawes D. 2000. Personal communication. Princeton (ID): Wildlife Habitat Institute Inc.

Grime JP, Mason G, Curtis AV, Rodman J, Band SR, Mowforth MAG, Neal AM, Shaw S. 1981. A comparative study of germination characteristics in a local flora. Journal of Ecology 69:1017–1059.

Hammer D. 1992. Creating freshwater wetlands. Boca Raton (FL): Lewis Publishers. 298 p.

Hoag JC. 1994. Seed and live transplant collection procedures for 7 wetland plant species. Aberdeen (ID): USDA NRCS, Plant Materials Center. Riparian/Wetland Project Information Series #6. 3 p.

Hoag JC, Sellers ME. 1995. Use of greenhouse propagated wetland plants versus live transplants to vegetate constructed or created wetlands. Aberdeen (ID): USDA NRCS, Plant Materials Center. Riparian/Wetland Project Information Series #7. 7 p.

Hoag JC, Chernivec T, Walker E. 1992. September 1992 Interagency Riparian/Wetland Plant Development Project progress report. Aberdeen (ID): USDA NRCS. Plant Materials Center. 15 p.

Hurd EG, Shaw NL. 1991. Seed technology for *Carex* and *Juncus* species of the Intermountain Region. In: Landis, TD, technical coordinator. Proceedings: Intermountain Forest Nursery Association meeting; 1991 Aug 12–16; Park City, UT. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-211. p 74–83.

Johnson WM, Blankenship JO, Bram GR. 1965. Exploration in the germination of sedges. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Research Station. Research Note RM-51. 8 p.

Jones KL. 1999. Germination ecology of *Carex rostrata* Stokes ex With. and *Carex nebrascensis* Dewey [MSc thesis]. Provo (UT): Brigham Young University. 112 p.

Manning ME, Swanson SR, Svejcar T, Trent J. 1989. Rooting characteristics of four intermountain meadow community types. Journal of Range Management 42:309–312.

Nelson DR, Williams RL. 1986. Streambank stabilization in Strawberry Valley, Utah. Heber City (UT): USDA Forest Service.

Ratliff RD. 1983. Nebraska sedge (*Carex nebrascensis* Dewey): observations on shoot life history and management. Journal of Range Management 36:429–434.

Ratliff RD, Westfall SE. 1992. Nebraska sedge (*Carex nebrascensis* Dewey): phenology and life history at Tule Meadow, Sierra National Forest, California. Journal of Range Management 45:210–215.

SAS Institute, Inc. 1989. SAS/STAT user's guide. Version 6, 4th ed. Cary (NC): SAS Institute Inc.

Shaw NL, Hurd EG. 1992. Seed propagation of sedges and rushes. Missoula (MT): USDA Forest Service, Technology and Development Center. Rangeland Technology Equipment Council. 1992 Annual Report. 2 p.

Thomson AJ; El-Kassaby YA. 1993. Interpretation of seed-germination parameters. New Forests 7:123–132.

USDA NRCS. 1999. The PLANTS database, Version 3.0. URL: http://plants.usda.gov/plants (accessed 18 May 2000). Baton Rouge (LA): National Plant Data Center.

Young JA, Young CG. 1985. Collecting, processing and germinating seeds of wildland plants. Portland (OR): Timber Press Inc. p 55–65.