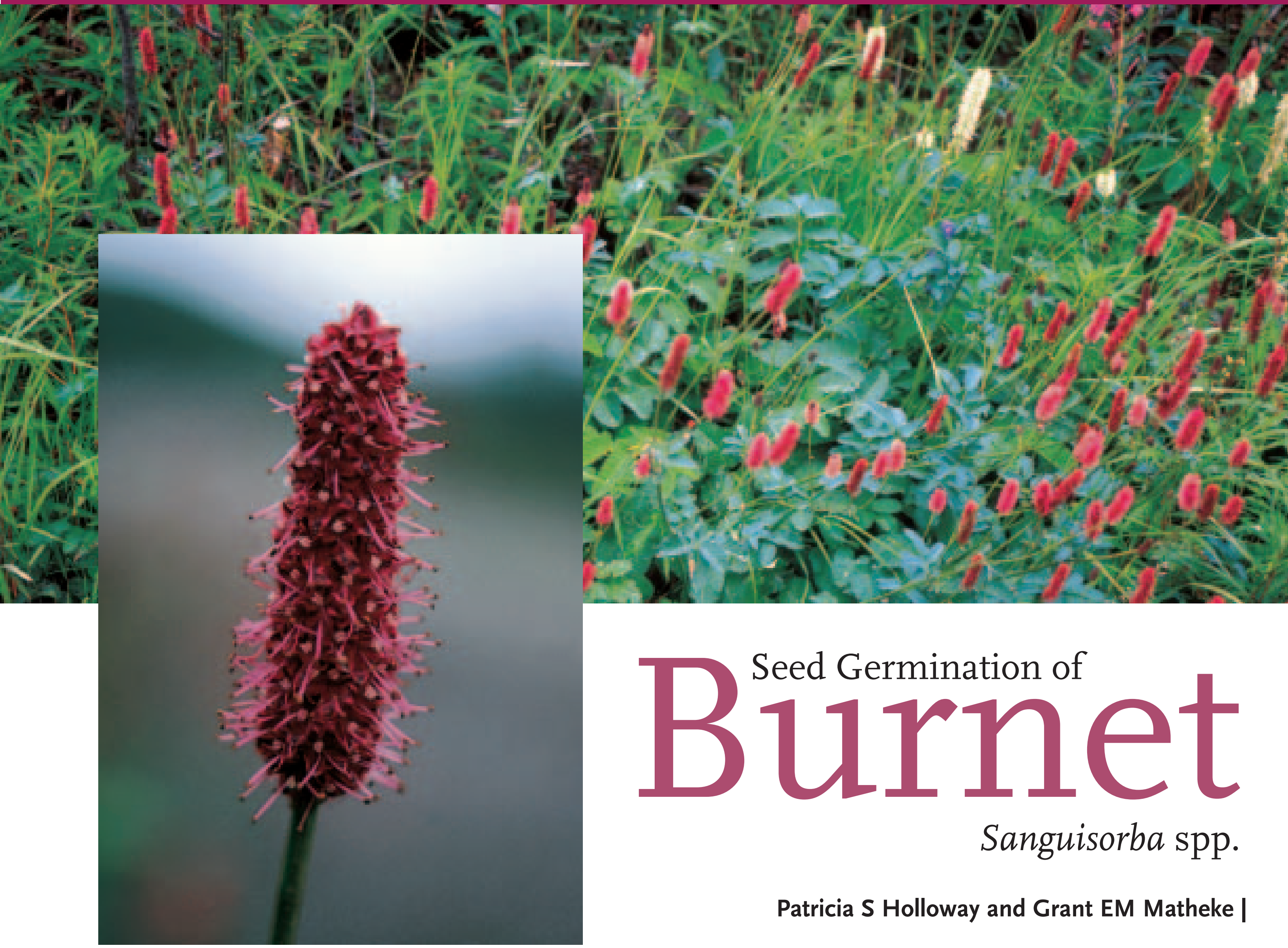

Seed Germination of Burnet *Sanguisorba* spp.

Patricia S Holloway and Grant EM Matheke |

ABSTRACT

Seeds of great burnet (*Sanguisorba officinalis* L. [Rosaceae]), Menzies' burnet (*S. menziesii* Rydb.), and Canadian burnet (*S. canadensis* L.) germinated most rapidly and completely at 24 to 25 °C (75 to 77 °F) constant temperatures following 6 mo dry storage at 4 °C (39 °F). Presence or absence of light (150 µmol/(m^2•s) 18-h photoperiod), removal of the calyx hull or dry storage at 4 °C (39 °F) for 1 y did not affect germination percentages of great and Canadian burnet. Canadian burnet and Menzies' burnet showed little or no germination at 5 °C (41°F), and poor germination (<50%) at 30 °C (86 °F). In contrast, great burnet germinated at all temperatures from 5 to 30 °C (39 to 86 °F). All 3 species have potential in roadside revegetation, wildflower meadows and home landscapes. Germination under controlled conditions is rapid and requires no special pretreatments for optimal results.

KEY WORDS
seed dormancy, temperature, light, wildflowers, Alaska

NOMENCLATURE
ITIS (2000)

Figure 1. Menzies' burnet (*Sanguisorba menziesii* Rydb. [Rosaceae]).
Photos by Verna Pratt

Three species of wild burnet have potential in northern landscapes for wildflower meadows, home and commercial landscapes, and highway revegetation projects: great burnet (*Sanguisorba officinalis* L. [Rosaceae]), Menzies' burnet (*S. menziesii* Rydb.), and Canadian burnet (*S. canadensis* L.). Menzies' and Canadian burnet are primarily coastal species in Alaska, growing in wet meadows and roadside ditches (Figure 1). Menzies' burnet has the most restricted distribution, occurring in coastal areas from Alaska to Oregon. Canadian burnet grows in North America from Alaska to Labrador and south to Georgia, Indiana, and Illinois. Great burnet is a circumpolar species and grows throughout Europe and Asia to the Far East (Hultén 1974). It is known primarily as a medicinal plant in Europe and Asia (Krylova and Orishchenko 1982; Grieve 1995). Great burnet is found along the Yukon River drainage in Alaska and is used occasionally in wildflower seed mixes. All species are grown in perennial ornamental landscapes.

The 3 species form rosettes of pinnately compound leaves with tall, willowy scapes topped with maroon or white, thimble-shaped, dense flower spikes (Figure 1). Achenes persist in dense spikes until late autumn when they shatter, scattering most seeds within a 1 m^2 (11 ft^2) area around the plant. When harvested, a dry, papery calyx hull that cannot be removed with air-screen seed cleaners often surrounds achenes.

All species can be propagated by seeds and division, but germination requirements for controlled environment propagation and commercial production are unclear. MaGuire and Overland (1972) reported 28% germination of great burnet at alternating 20 to 30 °C (68 to 86 °F) temperatures. Rutledge (1995) field-seeded great burnet as part of a wildflower seed mix in Fairbanks, Alaska. Germination occurred in spring after fall sowing, but seeds sown in spring without an overwintering period did not germinate. Under controlled conditions (constant 21 °C (70 °F), 18-h photoperiod), the same seed lot without chilling treatment had 60% germination. In a preliminary unpublished investigation, we found that 1 wk to 5 mo of cold stratification at 4 °C (39 °F) followed by a temperature of 21 °C (70 °F) in light did not improve germination compared to seeds without the chilling. Serigstad (1998) found that light was necessary for germination of great burnet seeds.

Baldwin (1997) reported poor (8%) germination of Menzies' burnet seeds 30 d after harvest, whereas seeds stored in a cool, dry place for 120 d had 82% germination. The popular gardening literature presents a picture of burnet species that germinate readily without an after-ripening treatment (LH Bailey Hortorium 1976; Grieve 1995; Huxley and others 1999). These few limited experiments hint that germination might require or be enhanced by a chilling treatment, light, or possibly a dry storage treatment. Our project explored seed germination of these species in relation to light, temperature, storage time, and calyx hull removal in order to determine optimum germination conditions for cultivation.

METHODS AND MATERIALS

Wild-harvested seeds of Canadian and Menzies' burnet were obtained from a commercial seed source in Kenai, Alaska. We hand harvested great burnet seeds from plants grown under cultivation in Fairbanks, Alaska. All seeds were cleaned and stored at 4 °C (39 °F) for 6 mo except for the experiment comparing freshly harvested seeds with those stored as above for 1 y. Prior to germination, seeds were floated in water to remove non-filled seeds. We conducted all germination tests in growth chambers at constant temperatures with a light level of 150 $\mu mol/(m^2 \cdot s)$ photosynthetic photon flux at the surface of the bags for an 18-h photoperiod. Experiments consisted of 4 replicates of 100 seeds for each treatment arranged in a completely randomized design. All seeds were sown on filter paper moistened with autoclaved distilled water in glass petri dishes that were enclosed in clear plastic bags to reduce evaporation. We defined successful germination as radicle emergence from the seed coat.

Experiment 1 – Optimum Temperature

Our treatments consisted of 6 constant temperatures ranging from 5 to 30 °C (41 to 86 °F) at 5 $\pm$ 1 °C increments. The 6 temperatures were supplied by separate growth chambers running concurrently, and we counted the number of germinants daily for 30 d.

Experiment 2 – Light Effects

We compared 4 dishes of seeds individually wrapped in aluminum foil to exclude light with 4 dishes receiving the same light levels and duration described above. The growth chamber was a constant 20 °C (68 °F). Germination was counted once after 21 d for both treatments.

Experiment 3 – Fresh Versus Stored Seeds

We sowed 4 dishes each of great burnet and Canadian burnet with freshly harvested and cleaned seeds. Dishes were placed in a growth chamber set at 20 °C (68 °F). An additional 4 dishes of each species were sown with cleaned seeds, enclosed in plastic bags, and stored dry and in complete darkness at 4 °C (39 °F) for 1 y. An identical germination test to the freshly harvested seeds was performed following the storage period.

Experiment 4 – Calyx Removal

We removed papery calyx hulls from 400 seeds each of great burnet and Canadian burnet by gently rubbing them against an aluminum screen. Because hulls separated easily from seeds, this process required about 15 s of mechanical abrasion. Although no visible change occurred to the seed covering, we defined this treatment as hull removal and possible mechanical scarification. Germination temperatures were a constant 20 °C (68 °F), and we examined the seeds daily for 30 d for successful germination.

STATISTICAL ANALYSIS

Following all experiments, nongerminated seeds were examined for empty seeds, of which none were found, and no additional adjustments were made to final germination percentages prior to statistical analysis. Data for Experiment 1 were subject to regression analysis on arcsine transformed data using Proc GLM in SAS (SAS Institute Inc 1997) to identify optimum germination temperature. Data for Experiments 2, 3, and 4 were analyzed on arcsine-transformed data using ANOVA for completely randomized design (SAS Institute Inc 1997).

RESULTS

Experiment 1 — Optimum Temperature

Germination for all burnet species was most rapid at 25 °C (77 °F), beginning 5 d after initiation for great and Menzies' burnet and 4 d for Canadian burnet (Figure 2). The most complete germination occurred within 15 d at 25 °C (77 °F) for great and Menzies' burnet. Both achieved 50% of total germination (T-50) after 7 d and 6 d, respectively. Complete germination of Canadian burnet was accomplished with 50% of the seeds germinating in 9 d.

In all species, the total germination and speed of germination decreased with temperatures above and below the optimum. Canadian burnet did not germinate at 5 °C (41°F) and Menzies' burnet reached 4% germination at this temperature only at termination of the experiment. Germination of great burnet was delayed 5 d at 5 °C (41 °F) and amounted to less than half the total germination at the optimum 25 °C (77 °F). All species showed reduced germination at 30 °C (86 °F) when compared to the optimum.

Curvilinear regression of the total germination percentage across all temperatures generated highly significant third order polynomial models for each species (Table 1). The predicted optimum germination temperature based on these models was nearly the same for all species.

Experiments 2, 3, and 4

Seeds of all species germinated as well in light and dark (Table 2). Germination percentages of freshly harvested seeds of great and Canadian burnet seeds were statistically similar when compared to seeds stored for 1 y at 4 °C (39 °F). Seeds with and without a papery calyx hull germinated equally well.

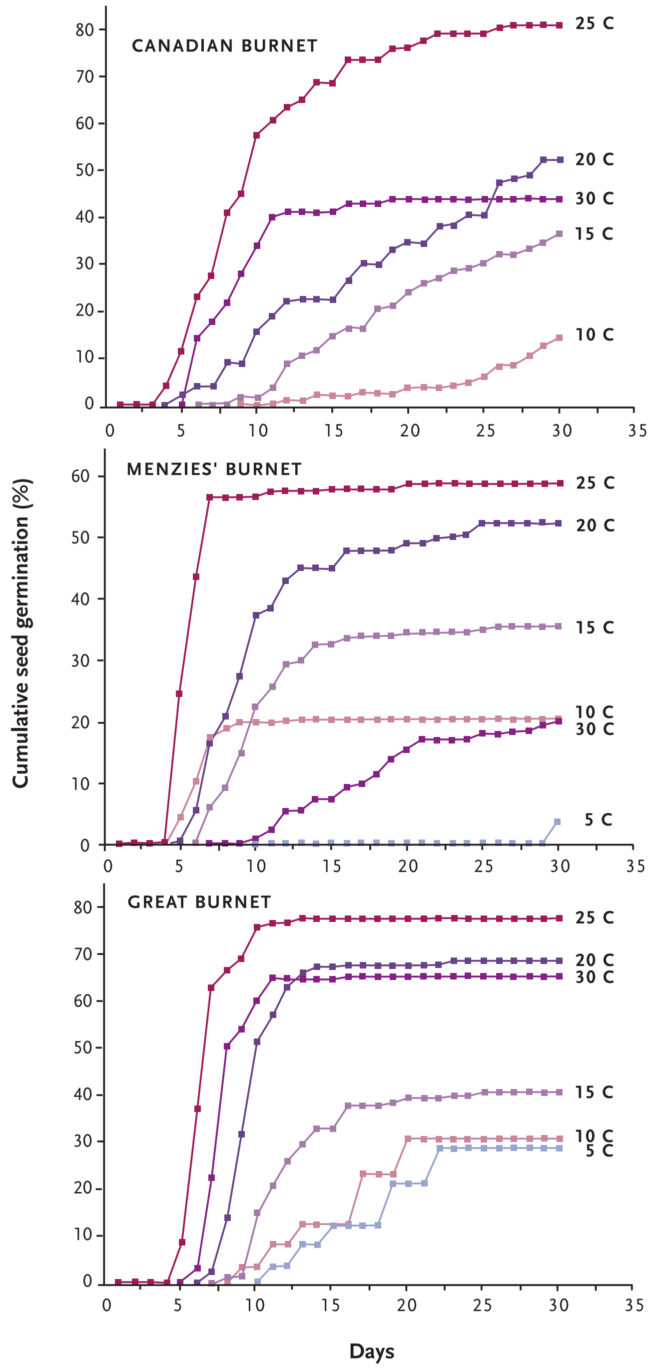

Figure 2. Cumulative germination percent of great, Canadian, and Menzies' burnet seeds germinated at 6 constant temperatures between 5 °C (41 °F) and 30 °C (86 °F).

DISCUSSION AND CONCLUSIONS

All burnet species showed similar germination requirements and optimum germination temperatures. Great burnet showed greater adaptation to extreme temperature conditions by germinating better than Menzies' and Canadian burnet at 30 °C (86 °F). Great burnet also germinated better than the

TABLE 1

Predicted optimum germination temperature for 3 burnet species.

Species	Curve-fit model	R^2	Predicted optimum germination temperature °C (°F)
Great burnet	$y = 72.767 - 13.496x + 1.1171x^2 - 2.2481e\text{-}2x^3$	0.983	25 (77)
Menzies' burnet	$y = 15.333 - 5.0585x + 0.70817x^2 - 1.7741e\text{-}2x^3$	0.971	24 (75)
Canadian burnet	$y = 32.162 - 10.653x + 1.0675x^2 - 2.3188e\text{-}2x^3$	0.936	25 (77)

TABLE 2

Germination of burnet (Sanguisorba *spp.*) *under light exclusion, warm dry storage, and removal of calyx hulls.*

Treatment	Total germination (%) by species		
	Great burnet	Canadian burnet	Menzies' burnet
Light	71 ± 8	72 ± 5	55 ± 5
Dark	69 ± 5	75 ± 6	45 ± 8
Fresh seeds	79 ± 4	56 ± 6	
Storage for 1 y	75 ± 6	50 ± 8	
With calyx hulls	72 ± 5	59 ± 7	
Calyx hulls removed	76 ± 8	61 ± 6	

Means within treatment groups and species did not differ significatly for all experiments, $P \leq 0.05$.

other species at cold temperatures indicating a significant advantage in Alaska's many cold, wet soils, and may help explain this plant's broader geographic range.

The prompt and complete germination of great burnet surprised us. In a previous study on establishment of wildflower mixes on irrigated sites (Rutledge 1995), great burnet seeds failed to germinate the first year but did germinate the following year. This suggests an ecodormancy, but spring field soil temperatures the first year were well within the germinable range of this species. Our subsequent, unpublished laboratory experiments with great burnet seeds treated with up to 5 mo cold stratification showed no improvement in germination percentages over untreated seeds. Other environmental factors such as alternating temperatures, soil moisture, or pH, may influence germination in cultivated fields.

Seeds of all species showed no response to light or dark treatments which was contrary to previous research by Serigstad (1998) who found light was necessary for germination of Canadian burnet. Because phytodormancies often disappear with time, the discrepancy may involve differences in seed age between experiments, although this information was not available from Serigstad's report. Seed pretreatments, such as calyx hull removal or cool dry storage for 1 y, do not enhance germination of great and Canadian burnet.

PRACTICAL IMPLICATIONS

Our experiments support the general horticulture literature that burnet species germinate easily with no special pretreatments (LH Bailey Hortorium 1976; Grieve 1995; Huxley and others 1999). Our recommendation for optimum germination of great, Canadian, and Menzies' burnet seeds under controlled conditions include using cleaned seeds with or without an attached calyx hull, followed by germination at 24 to 25 °C (75 to 77 °F) in light or darkness. Radicle emergence begins within 4 to 5 d and is nearly complete within 30 d. Great burnet and Menzies' burnet show rapid germination within the first 2 wk, while Canadian burnet germination is more gradual, extending at least to 30 d.

ACKNOWLEDGMENT

We thank Mr Richard Baldwin of Seeds for Alaska, Kenai, Alaska for donating seeds for this study.

REFERENCES

Baldwin RL. 1997. Growing Alaska natives. The propagation of Alaska's native plants. Kenai (AK): Seeds of Alaska. 105 p.

Grieve M. 1995. Great burnet and Canadian burnet. URL: http://www.botanical.com/botanical/mgmh/b/burgre88.html (accessed 12 Jun 2000).

Hultén E. 1974. Flora of Alaska and neighboring territories. Stanford (CA): Stanford University Press. 1008 p.

Huxley A, Griffiths M, Levy M, editor. 1999. The Royal Horticultural Society dictionary of gardening. Volume 4. New York (NY): Groves Dictionaries Inc. 888 p.

[ITIS] Integrated Taxonomic Information System. 2000. Biological names. Version 4.0. URL: http://www.itis.usda.gov (accessed 10 Sep 2000).

Krylova IL, Orishchenko ND. 1982. Variability in garden burnet (*Sanguisorba officinalis* L.) in natural populations in west Siberia and the Altai and during cultivation. Soviet Journal of Ecology 13(5):311–317.

LH Bailey Hortorium. 1976. Hortus III. New York (NY): Macmillan Publishing Co Inc. 1290 p.

MaGuire JD, Overland A. 1972. Laboratory germination of seeds of weedy and native plants. Pullman (WA): Washington State University Agricultural Experiment Station. Circular 349. 13 p.

Rutledge O. 1995. Evaluation of wildflower seed mixes for Interior Alaska [MSc thesis]. Fairbanks (AK): University of Alaska Fairbanks. 95 p.

SAS Institute Inc. 1997. SAS/STAT general linear model. Release 8.10 Edition. Cary (NC): SAS Institute Inc.

Serigstad A. 1998. Spiremetoder for stauder metode database. (on-line database). URL: http://www.asles.net/sodata.htm (accessed 10 Sep 2001).

AUTHOR INFORMATION

Patricia S Holloway
Associate Professor of Horticulture
ffpsh@uaf.edu

Grant EM Matheke
Superintendent
fngem@uaf.edu

Georgeson Botanical Garden
Department of Plant, Animal and Soil Sciences
PO Box 757200
University of Alaska Fairbanks
Fairbanks, AK 99775