Germination temperature response of two ecotypes of winterfat [*Kraschenninikovia lanata* (Pursh) Guldenstaedt]

M. P. Schellenberg

Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada, Box 1030, Swift Current, Saskatchewan, Canada S9H 3X2. *Received 18 December 2000, accepted 19 July 2002.*

Schellenberg, M. P. 2003. **Germination temperature response of two ecotypes of winterfat [*Kraschenninikovia lanata* (Pursh) Guldenstaedt]**. Can. J. Plant Sci. **83**: 65–68. Winterfat [*Kraschenninikovia lanata* (Pursh) Guldenstaedt], a drought-resistant native shrub that retains high nutritional value into the fall, has been documented to have a high degree of ecotypic variation. The objective of this study was to determine if ecotypic germination temperature differences occurred between readily available seed lots from New Mexico and the newly developed Saskatchewan Ducks Unlimited winterfat ecovar™. A two-factor factorial experiment was conducted with the two seed sources as one factor and eight germination temperatures ranging from 0 to 35°C as the second. Observations made were time to reach maximum number of germinants (D), and total number of germinants (G). The germination index (GI) and coefficient of velocity (CV) were developed using the data generated. Both seed sources had the greatest number of germinants between 10 to 20°C. The germination and germination indices profiles are distinct for each ecotype. The Saskatchewan ecotype germinated at higher levels below and above 10 to 20°C, a characteristic that should be of use for establishing winterfat in the highly variable environments of the Northern Great Plains.

Key words: *Kraschenninikovia lanata*, winterfat, germination, germination index, coefficient of velocity, ecotype

Schellenberg, M. P. 2003. **Réaction de deux écotypes de *Kraschenninikovia lanata* (Pursh) Guldenstaedt à la température de germination**. Can. J. Plant Sci. **83**: 65–68. La littérature scientifique nous apprend que *Kraschenninikovia lanata* (Pursh) Guldenstaedt, arbuste indigène résistant à la sécheresse d'une grande valeur nutritive en automne, se caractérise par une grande variation au niveau de l'écotype. L'étude devait établir si la température de germination des semences du Nouveau-Mexique et de l'écovar^{MC} récemment créé par la branche de Canards Illimités de la Saskatchewan présente des variations écotypiques. Les chercheurs ont procédé à une expérience factorielle à deux paramètres, le premier correspondant aux deux sources de semences et le second à huit températures de germination, de 0 à 35 °C. Ils ont noté le temps requis pour obtenir le nombre maximal de plantules (D) et le nombre de plantules (G). Ces données ont ensuite servi à calculer l'indice de germination (GI) et le coefficient de vitesse (CV). Le plus grand nombre de plantules enregistré pour les deux sources survient entre 10 et 20 °C. Chaque écotype a son propre profil et indice de germination. L'écotype de la Saskatchewan donne un nombre accru de plantules en dessous et au-dessus de la fourchette de 10 à 20 °C, caractéristique qui aura son utilité pour l'implantation de cette espèce dans les milieux fort variables du nord des grandes plaines.

Mots clés: *Kraschenninikovia lanata*, germination, indice de germination, coefficient de vitesse, écotype

Winterfat [*Kraschenninikovia lanata* (Pursh) Guldenstaedt (syn. *Ceratoides lanata* (Pursh) J.T. Howell, syn. *Eurotia lanata* (Purse) Moq.)] is a drought-resistant, low shrub native to dry sandy or shallow clay loams ranging as far south as Mexico (Springfield 1974) and as far north as the southeastern region of theYukon Territory (Cody 1996). The shrub's late-season feed quality has been noted by several authors (Clarke and Tisdale 1945; Smoliak and Bezeau 1967; Abouguendia 1998). Recommendations for reseeding pastures with this shrub came early because of winterfat's potential as winter pasture forage (Sampson 1924). However, seed production, harvesting, processing and handling have been problematic and its use for range improvement has been limited.

Until recently seed for range improvement in western Canada has been sourced from the United States with the greater proportion coming from New Mexico (Wind River Seeds, personal communication). The Semiarid Prairie Agricultural Research Centre in partnership with Ducks Unlimited Canada (DU) has developed an ecovar™ of winterfat from material collected from sites in Saskatchewan. An ecovar™ is defined as an ecotype collection with minimal selection pressure, and therefore is intermediate between an ecotype and a cultivar but with a greater genetic diversity being retained as an objective (Katepa-Mupondwa and Kielly 1997).

Workman and West (1969) observed ecotypic variation related to soil conditions within the state of Utah. Moyer and Lang (1976) showed a differential ecotypic expression in germination temperature profiles which they suggested could have practical implications for stand establishment.

Abbreviations: **CV**, coefficient of velocity; **D**,time to reach maximum number of germinants; **DU**, Ducks Unlimited Canada; **G**, total number of germinants; **GI**, germination index; **NM**, New Mexico ecotype; **SK**, Saskatchewan DU ecovar™

Table 1. Accumulated analysis of variance for parallel curve analysis of time to maximum number of germinants (D), germinants (G), germination index (GI) and coefficient of velocity (CV)

		D		G		GI		CV	
Change	df	MS[z]	F-Prob.	MS	F-Prob.	MS	F-Prob.	MS	F-Prob.
Temperature	3	106.71	<0.001	1442.9	0.002	12.58	0.002	201.89	<0.001
Seed source	1	0.03	0.39	29.6	0.63	0.00	0.99	10.078	0.19
Temp × Source	1	0.76	0.15	19.9	0.69	0.56	0.47	25.55	0.05
Separate splines	2	0.48	0.26	460.7	0.0	7.56	0.01	15.01	0.1
Residual	8	0.30		118.7		0.99		4.87	
Total	15	21.63		416.6		4.09		47.35	

[z]mean square.

Ecotype characteristics of the Saskatchewan DU winterfat ecovar™ (SK) have not been documented previously. If this source of material is to be used in seedings, its germination characteristics need to be documented. The purpose of this study was to compare the SK temperature profiles of germination characteristics with the New Mexico ecotype (NM).

METHODS AND MATERIALS

The experiment consisted two-factors; ecotype (SK vs. NM) and germination temperature, with eight values ranging from 0 to 35°C in 5°C increments. Each of the 16 treatments was evaluated from four sub-samples of 100 seeds per ecotype. The experiment was replicated once.

Saskatchewan ecotype (SK) was obtained from the DU winterfat ecovar™ nursery at the Semiarid Prairie Agricultural Research Centre (SPARC) (SE 1/4 Section 16 Township 15 Range 13 west 3rd Meridian, elevation of 825 m) from the 1997 seed harvest with a seed viability of 60%. The New Mexico seeds (NM) originated in 1997 from a site near Espanola, New Mexico above an elevation of 1520 m and had a seed viability of 69%. Following an after-ripening period of 20 wk, four sub-samples of 100 seeds per ecotype per temperature were germinated at the same time, with intact bracts, in petri dishes between two layers of Whatman's no. 2 ashless filter paper. The bottom layer consisted of two sheets and the upper layer had a single sheet. The filter paper was wet and excess water was drained. The petri dishes were placed in a germination chamber set to a relative humidity of 60% with no light. Germinants were counted daily. The time to reach maximum number of germinants was determined as the day prior to an observed decline in total daily number of germinants.

The germination index, and coefficient of velocity (Scott et al 1984) were calculated. Both the GI and CV provide a means of determining the rate of germination. The GI is defined as:

$$GI = (T_i N_i)/S$$

where T_i is the number of days after sowing, N_i is the number of seeds germinated on day i, and S is the total number of seeds planted (Scott et al 1984). CV is defined as:

$$CV = 100[N_i/(N_i\, T_i)]$$

where N_i is the number of seeds germinated on the ith day, and T_i is the number of days from sowing.

For each germination characteristic, the two ecotypes had a profile of responses to the eight temperatures. The regression curve fitted to each temperature profile was assumed to be a continuous cubic function with two or fewer inflection points — namely a cubic spline function with three degrees of freedom. A nested series of generalized additive models (Hastie and Tibshirani 1990) was fitted to the two profiles with a procedure known as parallel curve analysis in the statistical programming language, GenStat® (Payne 2000).

The generalized additive models were fitted sequentially and the significance of each additional term was assessed with the F-test, where the error term was calculated from the deviations from the spline curves (Table 1). The order of the terms were:

1. A common cubic spline curve for both profiles (3 df).
2. Vertical separation between two parallel cubic spline curves (+ 1 df).
3. Similar spline curves, but with a linear trend between them (+ 1 df).
4. Two separate cubic spline (nonparallel) curves for the two temperature profiles (+ 2 df).

Tests of significance guided the selection of the simplest model to adequately describe the differences between the profiles; the level of significance was taken to be ($P = 0.05$) but for the maximum number of germinants, separate spline curves were fitted at ($P = 0.07$).

RESULTS AND DISCUSSION

The accumulated ANOVA indicates a highly significant effect of temperature for D, G, GI, and CV. The effect of the ecotype was not significant for time to reach maximum number of germinants despite SK having a lower number of viable seeds than NM (Table 1). The coefficient of velocity had a significant temperature-by-seed-source interaction ($P < 0.05$) whereas GI had interaction with a probability of 0.07. Separate splines were significant for GI ($P < 0.01$).

Time to reach maximum number of germinants was similar for both ecotypes (Fig. 1a). Germination (G) profiles were distinct (Fig. 1b). Both SK and NM produced the most number of germinants between 10 and 20°C , an optimum temperature already well documented (Allen et al. 1987; Dettori et al 1984; Mohajery and Rasti 1995; Moyer and Lang 1975; Riedl et al 1964). The profiles for degree of

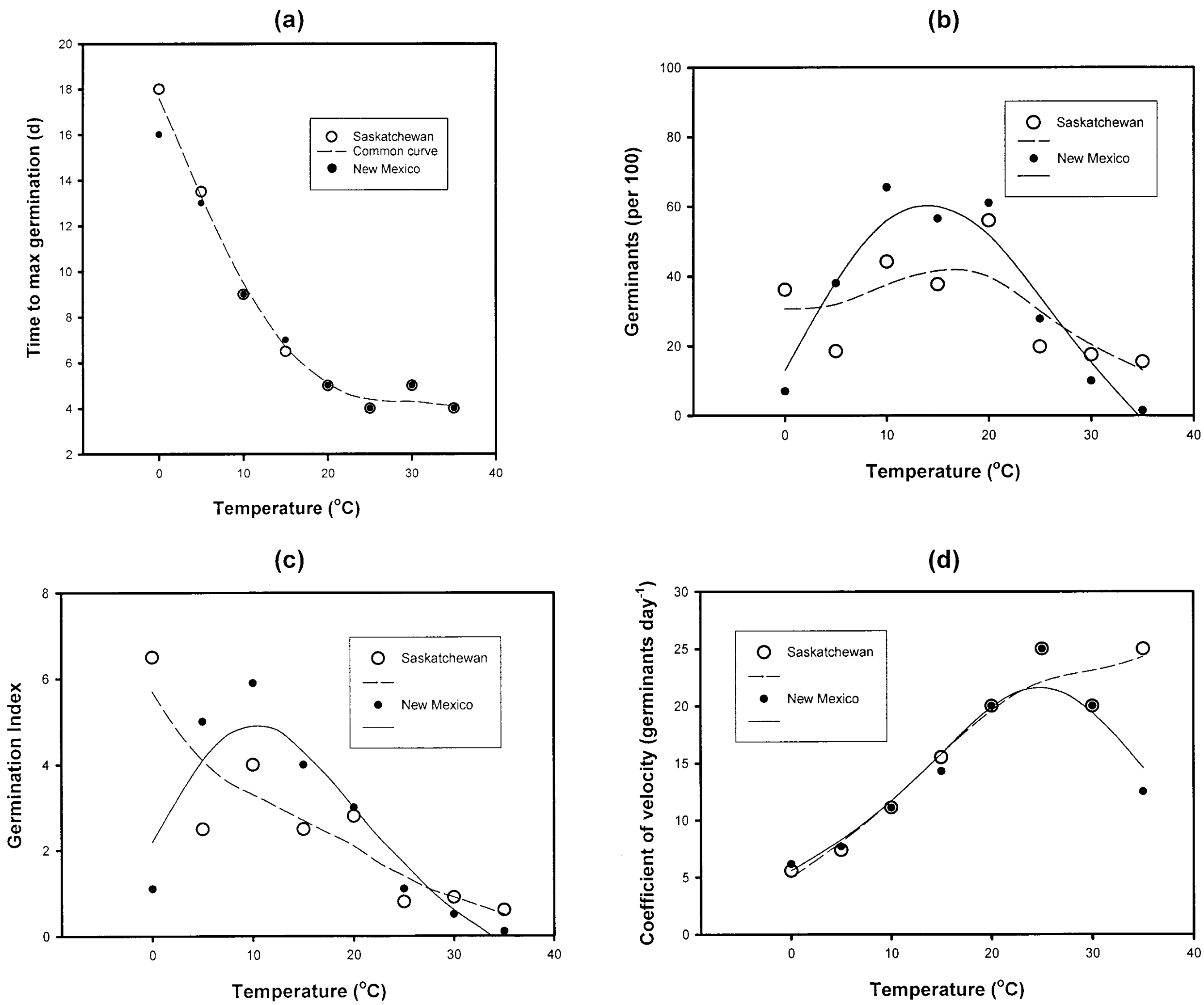

Fig. 1. Smooth curves generated from parallel curve analysis for variable vs temperature: (a) common smooth curve for time to max. germination; (b) separate smooth curves for germinants; (c) separate smooth curves for germination index; and (d) parallel smooth curves plus separate trends for coefficient of velocity.

germination differ between ecotypes; NM is more sensitive to temperature with a sharp peak between 10 and 20°C and low values at 0, 30 and 35°C. For SK, the profile was less peaked, indicating germination over a wider range of temperatures. The SK source had five, two and eight times more germinants than the NM at 0, 30 and 35°C, respectively. This result indicates that SK may have a greater genetic capacity to germinate over a greater temperature range than does NM, despite the lower viability at optimal temperatures. Saskatchewan-sourced seed has been noted to have adaptations for colder temperatures (Bai et al 1998).

The GI values (Fig. 1c) for Saskatchewan seed were lower than those of New Mexico seed, indicating a more rapid response for the former. The profiles are distinct; at 0, 30 and 35°C SK had a slower response, which may provide an advantage to insure germination occurs under more ideal conditions. Similar observations have been made in the field. The major difference for CV (Fig. 1d) was observed at 35°C, where the SK values leveled out and NM declined, indicating more germinants and a shorter germination time for the SK seed source.

CONCLUSION

The Saskatchewan DU winterfat ecovar™ and NM seed for 1997 shared the same optimum temperature range of 10 to 20°C and D but have distinct G and GI profiles. The Saskatchewan DU winterfat ecovar™ did have a greater germination response over a broader range of temperatures than NM. This response of SK should be useful for improving plant establishment of seeded winterfat in highly variable environments with wide-ranging temperatures such as those found in the Northern Great Plains.

ACKNOWLEDGMENTS

The financial support from the Saskatchewan Grazing and Pasture Technology Program and AAFC is gratefully acknowledged as well as the technical assistance of J. Bolton. I am grateful to the Associate Editor for Statistics, Dr. K. B. McRae, for the parallel curve analysis of data. I also wish to thank Associate Editor, Dr. W. Willms and two anonymous reviewers for their comments and suggestions.

Abouguendia, Z. 1998. Nutrient content and digestibility of Saskatchewan range plants: Summary Report. Grazing and Pasture Program, Regina, SK. 24 pp.

Allen, P. S., Meyer, S. E., and Davis, T. D. 1987. Determining seed quality of winterfat [*Ceratoides lanata* (Pursh) J. T. Howell]. J. Seed Technol. **11**: 7–14.

Bai, Y., Booth, D. T., and Romo, J. T. 1998. Winterfat [*Eurotia lanata* (Pursh) Moq.] seedbed ecology: Low temperature exotherms and cold hardiness in hydrated seeds as influenced by imbibition temperature. Ann. Bot. **81**: 595–602.

Clarke, S. E. and Tisdale, A. W. 1945. The chemical composition of native plants of southern Alberta and Saskatchewan in relation to grazing practices. Dominion of Canada, Department of Agriculture, Ottawa, ON. Technical Bulletin 54, Publ. No. 769.

Cody, W. J, 1996. Flora of the Yukon Territory. NRC Research Press, Ottawa, ON. 643 pp.

Dettori, M. L., Balliette, J. F., Young, J. A., and Evans, R. A. 1984. Temperature profiles for germination of two species of winterfat. J. Range Manage. **37**: 218–222.

Hastie, T. J and Tibshirani, R. J. 1990. Generalized additive models. Chapman & Hall, London, UK.

Katepa-Mupondwa, F. and Kielly, A 1997. Native plant ecovar development. [Online] Available: http://www.aginfonet.sk.ca/aglibrary/content/total_ranch_management/45.html (6 January 2003).

Mohajery, A. and Rasti, M. 1995. Germination temperature for *Bromus tomemtellus* Boiss and *Eurotia ceratoides* (L.) C.A.M. Seed Sci. Technol. **23**: 241–243.

Moyer, J. L. and Lang, R. L. 1976. Variable germination response to temperature for different sources of winterfat seed. J. Range Manage. **29**: 320–321.

Payne, R. P. (ed). 2000. The guide to GenStat®. Part 2. Statistics. VSN International Ltd., Oxford, UK.

Riedl, W. A., Asay, K. H., Nelson, J. L., and Telwar, G.M. 1964. Studies of *Eurotia lanata* (winterfat). Agricultural Experiment Station of Wyoming, Laramie, WY. Bulletin 425.

Sampson, A. W. 1924. Native American forage plants**.** John Wiley & Sons, Inc., New York, NY. 435 pp.

Scott, S. J., Jones, R A., and Williams, W. A. 1984. Review of data analysis methods for seed germination. Crop Sci. **24**: 1192–1199.

Smoliak, S. and Bezeau, L. M. 1967. Chemical composition and in vitro digestibility of range forage plants of the *Stipa-Bouteloua* prairie. Can. J. Plant Sci. **47**: 161–167.

Springfield, H. W. 1974. Eurotia lanata (Pursh) Moq. – winterfat. USDA Agriculture Handbook **450**: 398–400.

Workman, J. P. and West, N. E. 1969. Ecotypic variation of *Eurotia lanata* populations in Utah. Bot. Gaz. **130**: 26–35.