Screening of sainfoin cultivars and lines for yield, winter hardiness and resistance to fusarium crown and root rot in east central Alberta

S.F. Hwang[1], B.P. Berg[2], R.J. Howard[3] and D.W. McAndrew[4]

A field trial was conducted to evaluate ten cultivars and six breeding lines of sainfoin for dry matter yields, winter survival and resistance to fusarium crown and root rot. Significant differences were observed in dry matter weights of each cut taken in 1989 and 1990. Winter survival of all cultivars and lines was less than 30% three years after seeding, and all suffered from fusarium crown and root rot. With the exception of Nova having the lowest disease severity rating, no significant differences in crown and root rot severity occurred among the cultivars and lines evaluated.

Can. Plant Dis. Surv. 72:2, 107–111, 1992.

Un essai au champs a été mené pour evaluer dix cultivars et six lignees généalogiques de sainfoin pour leurs rendements en matiere seche, leur resistance hivernale et leur resistance a la pourriiture fusarienne de la couronne et de la racine. Des differences significatives ont ete observees dans les poids de la matiere seche de chaque coupe prise en 1989 et en 1990. La survie hivernale de tous les cultivars et lignees a ete 30 % moindre trois années apres l'ensemencement, et tous ont souffert de pourriture fusarienne de la couronne et de la racine. A part une exception ayant eu le taux de severite pathologique le plus bas (ie, Nova), aucune difference significative de severite pour la pourriture de la couronne et de la racine ne s'est produite parmis les cultivars et les lignees evaluees.

Introduction

Sainfoin (Onobrychis viciifolia Scop.) is a perennial legume that has been cultivated as a forage crop in Europe and Asia for several centuries (2,4). Despite having considerable merit as a forage crop, sainfoin is not widely grown in Canada (4). Crown and root rot was identified as one of the most important factors affecting the longevity of sainfoin stands in the United States (9). A survey of sainfoin fields in 1983 revealed that this disease also was prevalent and destructive in southern Alberta (6). Crown and root rot is an important disease of other forage legumes including alfalfa (3,5,7), clover (3)and birdsfoot trefoil (1).

Crown and root deterioration in forage legumes can be caused by biotic and abiotic factors. Previous studies have demonstrated that bacterial and fungal species are major components of the disease complex (1,3,5,6,7,10,13,14). *Fusarium* solani (Mart.) Sacc. and species of Pseudomonas and *Erwinia* were found to be the most important crown and root rot pathogens of sainfoin in Montana (13). In Alberta, Pseudomonas fluorescens Migula, P. syringae van Hall, Erwinia carotovora subsp. carotovora Bergey et al., and Enterobacter agglomerans (Beij.) Ewing & Fife were shown to be part of the crown and root rot complex on sainfoin (6). The high frequency of isolation of *F.* solani from diseased roots suggested that sainfoin is a host for this pathogen. Other *Fusarium* spp. also have been implicated in crown and root rot of alfalfa (3,5,7), clover (3)and birdsfoot trefoil (1)in Alberta.

Crown and root rot infection can affect the habit of plant growth and in temperate regions the level of tolerance to low temperatures. Infected buds often become necrotic and, in both alfalfa and sainfoin plants, may become asymmetrical (13,14). Alfalfa plants affected by crown and root rot disease may be severely injured by low temperature (5,8,12). It has been suggested that infected roots accumulate low levels of reserve foods which affects the maximum level of plant tolerance to low temperature (8,11). The development of more resistant, winterhardy cultivars may reduce the adverse economic impact of crown and root rot in alfalfa (8,11) and sainfoin (9). This study was undertaken to evaluate cultivars and lines of sainfoin for their disease resistance and to compare their yield and winter survival under field conditions.

Materials and methods

A field experiment was established near Bonnyville, Alberta in the spring of 1988. A preemergence herbicide, Eptam 8-E (EPTC 80% EC) at a rate of 4.5 L/ha, and 90 kg/ha of monoammonium phosphate (11-51-0), 20 kg/ha of potash

1 Alberta Environmental Centre, Vegreville, Alberta, Canada T9C 1T4.
2 Alberta Agriculture, Vermilion, Alberta, Canada TOB 4M0.
3 Alberta Special Crops and Horticultural Research Center, Brooks, Alberta, Canada T1R 1E6.
4 Agriculture Canada, Research Branch, Vegreville Experimental Farm, Vegreville, Alberta, Canada T9C 1S6.
Accepted for publication March 5, 1992.

(0-0-60) and 19 kg/ha of elemental sulphur (0-0-0-90) were incorporated into the soil prior to planting. Sainfoin seeds of 16 cultivars and lines were surface-sterilized in 70% ethanol for two min, followed by two min in 0.6% sodium hypochlorite, then rinsed three times in sterilized distilled water. The surface-disinfested seeds were sown in vermiculite in root-trainers (Spencer-LaMaire Industries, Edmonton, Alberta) and grown in the greenhouse at 20±5°C under 12 to 17 h natural light. After emergence, seedlings were thinned to one per root-trainer cell. One-month-old seedlings of each cultivar and line were transplanted to the field with six plants per meter in a randomized complete block design with four replications. There were four 1-m-rows spaced 20 cm apart in each plot.

Three single-spored isolates of *F. solani* (S-25, S-19, and S-20) were obtained from symptomatic roots of sainfoin seedlings and maintained on potato dextrose agar slants at 5°C. During the summer of 1989, each isolate was grown on a sterile oat-rye kernel medium (1:1, v/v), mixed, and sprinkled on the plot at a rate of 25 g/plot. Each plot was cut twice each year at the 20% bloom stage and the sainfoin clippings were oven dried at 70°C for 24 h to determine dry matter yield per plot. Prior to the first cut during the springs of 1989, 1990 and 1991, winter survival was determined by counting the number of plants with new shoot growth in each plot. The percentage of plants surviving out of the total planted was calculated. In 1991, the surviving plants from each plot were dug up and the roots were bisected longitudinally to visually assess the severity of crown and root rot. Disease severity ratings were determined using the scale: 0 = clean, no disease; 1 = slight, 1-20% of the crown and root discoloured; 2 = moderate, 21-50% of the crown and root discoloured; 3 = severe, 51-100% of the crown and root discoloured; and 4 = dead.

An analysis of variance and Duncan's multiple range test were used to determine whether differences in data on dry matter yield, percent winter survival and disease severity of crown and root rot among cultivars and lines were statistically significant.

Table 1. Average yields from sainfoin plants clipped twice in 1989 and in 1990.

	Dry weight (g)/plant[1]					
	1989			1990		
Cultivar or line	1st cut	2nd cut	Average	1st cut	2nd cut	Average
Eski	41.5 ab[2]	48.8 ab	90.3 abc	12.4 bc	10.1 b	22.5 de
Fakir	15.7 fg	22.6 b	38.3 f	21.5 ab	10.1 b	31.6 c
Hampshire Common	27.1 bcdef	29.7 b	56.8 def	13.2 bc	10.1 b	23.3 cde
Krasnodar	32.2 abcde	59.8 ab	92.0 ab	16.2 bc	8.9 b	25.1 cde
Melrose	40.5 abc	48.4 ab	88.9 abc	11.1 bc	8.9 b	20.0 e
Nova	42.9 a	46.8 ab	89.7 abc	35.7 a	23.2 a	58.9 a
Octo	24.6 defg	32.2 b	56.8 def	15.9 bc	11.7 b	27.6 cd
Remont	25.8 cdefg	48.0 ab	73.8 bcde	7.9 bc	9.3 b	17.2 e
Sparta	36.1 abcde	58.9 ab	95.0 ab	10.8 bc	11.6 b	22.4 de
Viva	26.6 bcdef	53.3 ab	79.9 bcd	3.1 c	2.3 b	5.4 f
L2082 (Russian selection)	39.0 abcd	48.3 ab	87.3 abc	13.6 bc	5.2 b	18.8 e
L2086 (Polish selection)	24.6 defg	41.8 defg	66.4 cde	21.4 ab	21.8 a	43.2 b
L2092 (Russian selection)	31.3 abcde	43.1 ab	74.4 bcde	11.3 bc	7.4 b	18.7 e
L2110 (American selection)	22.8 efg	31.5 b	54.3 ef	12.6 bc	5.2 b	17.8 e
L2209 (Romanian selection)	36.7 abcde	74.0 a	110.7 a	12.1 bc	11.3 b	23.4 cde
L2334 (Great Britian selection)	11.3 g	28.0 b	39.3 f	9.5 bc	12.1 b	21.6 de

1 Dry weight per plant was estimated by dividing the total dry weight of the clippings harvested from each plot by the number of plants that survived in each plot.

2 Values in a column followed by the same letter are not significantly different using Duncan's multiple range test ($P = 0.05$).

Results and discussion

Significant differences ($P = 0.05$) were observed in dry matter weights between cultivars and lines for each cut of sainfoin taken in 1989 and in 1990, (Table 1). The average dry matter weight for the first cut of cultivar Fakir was lower in 1989 than the weight for the first cut in 1990. For all of the other cultivars and lines the first and second cut dry weights were higher in 1989 than in 1990. The sum of the average dry matter weights for the two cuts in 1989 for cultivars Eski, Krasnodar, Melrose, Nova and Sparta, and breeding lines L2082 and L2209 varied between 87.3 to 110.7 g/plant and were significantly greater than the yield values for the remaining cultivars Fakir, Hampshire Common and Octo, and breeding lines L2110 and L2334 (38.3 to 56.8 g/plant). In 1990, the sum of the average dry matter weights for Nova (58.9 g/plant) and L2086 (43.2 g/plant) were significantly greater than all of the remaining cultivars and lines (5.4 to 31.6 g/plant).

The 1989 winter survival values among the six lines and ten cultivars tested were not significantly different, except for Fakir and L2334 which had significantly lower survival (69 to 71%) (Fig. 1). In 1990, Eski, Krasnodar, Melrose, Nova, L2082, and L2209 had significantly greater winter survival (71 to 79%) than did Viva, Fakir, Hampshire Common and L2334 (15 to 29%). The remaining six cultivars and lines were intermediate (43 to 68%). The 1991 values for survival among all of the cultivars and lines tested were less than 30%, but Nova had the highest winter survival value (28%), while the values for L2082, L2092, Sparta and Melrose varied between 12 and 16%.

All cultivars suffered from fusarium crown and root rot. With the exception of Nova having the lowest disease severity rating, no significant differences in disease severity ratings occurred among the cultivars and lines evaluated (Fig. 2).

Results of this study have demonstrated that the experimental cultivars and breeding lines evaluated herein, as well as the registered cultivars Melrose and Nova, have commercially unacceptable susceptibilities to crown and root rot. The mean disease severities in all cases were high. Winter survival of all genotypes evaluated was less than 30% three years after seeding. In long-term forage systems, stand persistence is an important attribute in cultivar selection. Winter survival of all sainfoin cultivars and lines evaluated in this study was quite high the first year after seeding, but thereafter the severity of winterkill increased rapidly so that by the third year after seeding all cultivars were almost completely winterkilled. Although Nova had the least disease severity and greatest survival, the yield was below the level of economic benefit. To realize the full potential of sainfoin as a forage crop in western Canada, further research should be directed toward the development of cultivars that are cold hardy and disease resistant.

Acknowledgements

We gratefully acknowledge Dr. L. Dosdall for his comments on the manuscript, Dr. M.R. Hanna and Mr. A. Sherman for providing the seeds, and Lakeland Agricultural Research Association for providing technical assistance.

Literature cited

1. Berkenkamp, B., L. Folkins and J. Meeres. **1972.** Crown and root rot of birdsfoot trefoil in Alberta. Can. Plant Dis. Surv. 52:1-3.

2. Cooper, C.S., J.A. Duke, M.B. Forde, C.F. Reed and J.K.P. Weder. **1983.** *Onobrychis viciifolia* Scop. Pages 177-180 *in* Duke, J.A., (Ed.). Handbook of legumes of world economic importance. Plenum Press, New York.

3. Cormack, M.W. **1937.** *Fusarium* spp. as root parasites of alfalfa and sweet clover in Alberta. Can. J. Res. 15:493-510.

4. Hanna, M.R., D.A. Cooke, S. Smoliak, B.P. Goplen and D.B. Wilson. **1977.** Sainfoin for Western Canada. Agric. Can. Publ. 1470/E. 18 pp.

5. Hwang, S.F. and G. Flores. **1987.** Effects of *Cylindrocladium gracile, Fusarium roseum* and *Plenodomus meliloti* on crown and root rot, forage yield, and winterkill of alfalfa in northeastern Alberta. Can. Plant Dis. Surv. 67:31-33.

6. Hwang, S.F., R.J. Howard and L. Goatcher. **1989.** Bacteria associated with crown and root rot of sainfoin in southern Alberta. Can. Plant Dis. Surv. 69:5-8.

7. Hwang, S.F., R.J. Howard and E.R. Moskaluk. **1989.** Crown and root rot of alfalfa in southern Alberta. Can. Plant Dis. Surv. 69:9-11.

8. McKenzie, J.S. and G.E. McLean. **1984.** A field test for assessing the winter hardiness of alfalfa in northwestern Canada. Can. J. Plant Sci. 64:917-924.

9. Meyer, D.W. **1975.** Yield, regrowth, and persistence of sainfoin under fertilization. Agron. J. 67:439-441.

10. Pegg, G.F. and D.W. Parry. **1983.** Infection of lucerne *(Medicago sativa)* by Fusarium species. Ann. Appl. Biol. 103:45-55.

11. Richard, C., R. Michaud, A. Freve and C. Gagnon. **1980.** Selection for root and crown rot resistance in alfalfa. Crop Sci. 20:691-695.

12. Richard, C., C. Willemot, R. Michaud, M. Bernier-Cardou and C. Gagnon. **1985.** Low-temperature interactions in fusarium wilt and root rot of alfalfa. Phytopathology 72:293-297.

13. Sears, R.G., R.L. Ditterline and D.E. Mathre. **1975.** Crown and root rotting organisms affecting sainfoin *(Onobrychis viciifolia)* in Montana. Plant Dis. Reptr. 59:423-426.

14. Stuteville, D.L. and D.C. Erwin (Eds.). 1990. Compendium of alfalfa diseases, 2nd ed. APS Press, St. Paul, MN. 84 pp.

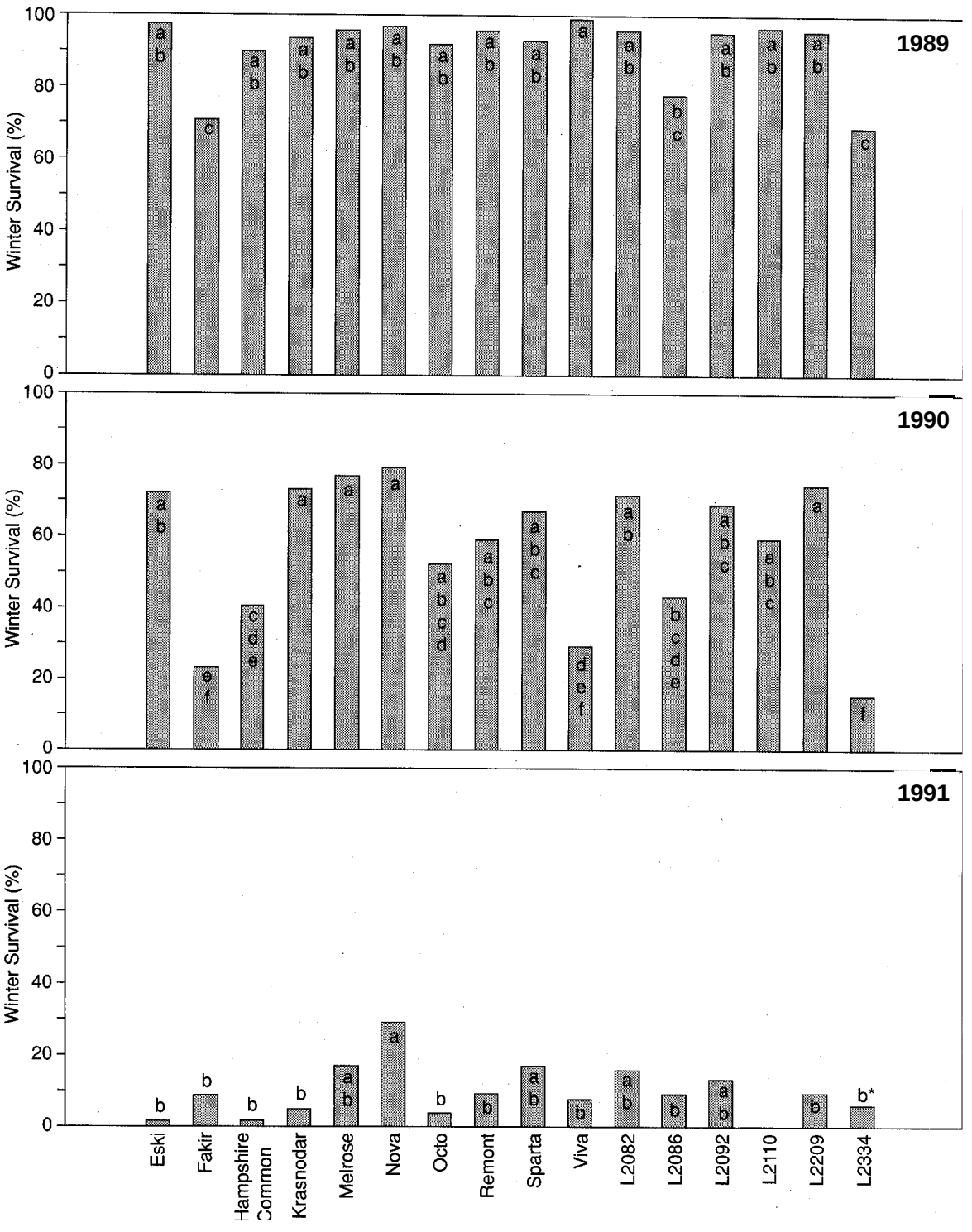

Fig. Percent winter survival of ten cultivars and six breeding lines of sainfoin from 1989 to 1991. *Means within each year followed by the same letter are not significantly different using Duncan's multiple range test.

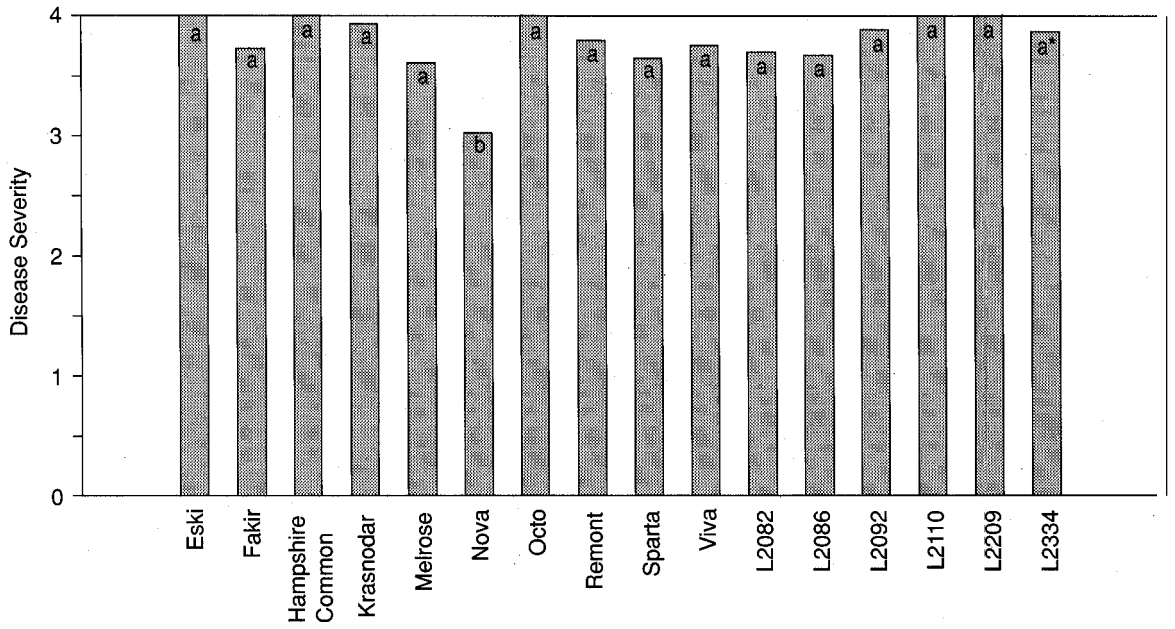

Fig. 2. Disease severity ratings of ten cultivars and six breeding lines of sainfoin to fusarium crown and root rot on a scale of 0-4, where 0 = clean, no disease; 1 = slight, 1-20% of the crown and root discoloured; **2** = moderate, **21-50%** of the crown and root discoloured; 3 = severe, **51**-100% of the crown and root discoloured; and **4** = dead. *Means followed by the same letter are not significantly different using Duncan's multiple range test.