

Fusarium root and crown rot in alfalfa subjected to autumn harvests

L. Couture¹, C. Dhont^{1,2}, F.-P. Chalifour², R. Drapeau¹, G. Tremblay³, Y. Castonguay¹, G. Bélanger¹, and P. Nadeau¹

¹Soils and Crops Research and Development Centre, Agriculture and Agri-Food Canada, 2560 Hochelaga Boulevard, Sainte-Foy, Quebec, Canada G1V 2J3 (couturel@em.agr.ca); ²Département de Phytologie, Université Laval, Québec, Quebec, Canada G1K 7P4; ³Centre de recherche sur les grains inc. (CEROM), 335 chemin des Vingt-cinq Est, Saint-Bruno-de-Montarville, Quebec, Canada J3V 4P6.

Received 2 August 2001, accepted 7 January 2002.

Couture, L., Dhont, C., Chalifour, F.-P., Drapeau, R., Tremblay, G., Castonguay, Y., Bélanger, G. and Nadeau, P. 2002. **Fusarium root and crown rot in alfalfa subjected to autumn harvests.** Can. J. Plant Sci. **82**: 621–624. Fusarium root and crown rot in alfalfa subjected to an autumn harvest was studied in plots established in the spring of 1996 or 1997, at three sites in Quebec. Autumn harvest treatments were started the year following establishment at each site. They were made at either 400, 500 or 600 growing degree-days (GDD; 5°C) after the last summer harvest. Samples were assessed for fusarium root and crown rot severity in autumn 1998 and spring 1999. Disease severity over all sites, cultivars, and sampling periods was ranked in the following order: 400 GDD > 500 GDD > 600 GDD > control (no fall harvest).

Key words: *Fusarium*, root and crown rot, alfalfa, harvest management

Couture, L., Dhont, C., Chalifour, F.-P., Drapeau, R., Tremblay, G., Castonguay, Y., Bélanger, G. et Nadeau, P. 2002. **Pourriture fusarienne chez la luzerne soumise à une récolte d'automne.** Can. J. Plant Sci. **82**: 621–624. On a examiné le développement de la pourriture fusarienne chez la luzerne soumise à une récolte d'automne dans des parcelles implantées aux printemps de 1996 ou de 1997 à trois stations au Québec. Les traitements de récolte automnale ont débuté l'année après l'implantation à chaque station. Une récolte était faite soit 400, 500, ou 600 degrés-jours de croissance (DJC; 5°C) après la dernière coupe estivale. On a évalué l'intensité de la maladie sur des échantillons prélevés à l'automne 1998 et au printemps 1999. Sur la moyenne des stations, cultivars et temps d'échantillonnage, les symptômes se classaient dans l'ordre suivant: 400 DJC > 500 DJC > 600 DJC > témoin (pas de récolte automnale).

Mots clés: *Fusarium*, pourriture fusarienne, luzerne, régime de récolte

Fusarium root and crown rot is recognized as a significant disease in alfalfa (*Medicago sativa* L.) throughout eastern Canada (Martens et al. 1988) and elsewhere in the world (Stuteville and Erwin 1990). Infected plants do not withstand freezing as well as non-infected plants (Richard et al. 1982). Infection also reduces yield and longevity of the crop, so that stands become unproductive after a few years. Several *Fusarium* species are involved in the disease (Aubé and Deschênes 1967; Stuteville and Erwin 1990), including *F. oxysporum* Schlechtend.:Fr. and *F. solani* (Mart.) Sacc.

Harvesting alfalfa during the critical autumn rest period has been shown to reduce organic reserves in the roots (Reynolds 1971; Paquin 1985; Taesar and Yager 1985). This depletion of nutrient reserves has historically been associated with a reduction in overwinter survival. Accordingly, harvesting in autumn is discouraged in Quebec (Paquin 1985). To mitigate the negative impact of an autumn harvest on stand persistence and productivity, Bélanger et al. (1992) suggested that autumn harvest management should be based on the duration of regrowth after the last summer harvest.

Management practices such as harvesting that affect plant reserves are also likely to affect the level of infection by root pathogens. Therefore, adequate crop management practices are required to help reduce disease development.

The objective of this work was to assess and quantify the effect of timing of autumn harvest on the development of fusarium root and crown rot in alfalfa in an environment where winter survival is critical. To do this, we examined and assessed plant samples collected from plots that were originally established to study the effect of autumn harvesting management on root organic reserves in relation to spring regrowth (Dhont et al. 2001).

Experimental plots were established at three sites located in different climatic regions in Quebec. They were: Normandin (48°50 N – 72°32 W, 1333 GDD), Pintendre (46°45 N – 71°08 W, 1653 GDD), and Saint-Hyacinthe (45°37 N – 72°57 W, 2004 GDD). The GDD (base temperature of 5°C) values for these sites are based on long-term averages compiled by Environment Canada (Atmospheric

Abbreviations: GDD, growing degree-days

Environment Service 1993). The experiment was conducted in a randomized complete block design with four replicates at each site. A comparison was made between two cultivars, AC Caribou and WL 225, differing in winter hardiness (R. Michaud, personal communication, Agriculture and Agri-Food Canada, Sainte-Foy, QC).

Plots were established in 1996 at the Normandin and Pintendre sites and in 1997 at Saint-Hyacinthe. One summer harvest was taken the year of establishment at Normandin and Saint-Hyacinthe. Regular summer harvests, namely two at Normandin and Pintendre and three at Saint-Hyacinthe, were taken the following years when alfalfa was at the early flowering stage. Autumn harvest treatments started in the first year following establishment at each site. One harvest was made when 400, 500 or 600 degree-days (5°C) were accumulated after the last summer harvest, as in the experiments of Bélanger et al. (1999). Timing of the autumn harvests arrived in the period from 4 to 14 September for 400 GDD to 5 to 21 October for 600 GDD. Plots not harvested during autumn were used as controls.

Plant samples were collected for disease evaluation from each plot in late autumn 1998 (roughly 5 wk after the 600 GDD harvest date) and in the following spring (1999) before growth had resumed. No spring samples were collected at Saint-Hyacinthe, where there was no overwinter survival in 1998–1999. Each sample consisted of one quadrat 30 × 30 cm in size, containing 6 to 20 plants. Samples were taken to the laboratory and washed. Crowns and taproots were split longitudinally with a sharp knife. The severity of root and crown rot of each plant was then assessed. A visual scale from 0 to 5 was used where 0 = no visible symptoms and 5 = total necrosis. The disease data were subjected to an analysis of variance. The sites and times of sampling were considered fixed effects. Least significant difference (LSD) test was applied to compare means where appropriate.

Symptoms typical of fusarium root and crown rot were observed in plants sampled for assessment. The occurrence of *Fusarium* and the species involved were confirmed by isolations made on agar medium. To isolate the *Fusarium* species associated with diseased tissue, a few scores of surface-sterilized pieces of roots were plated on pentachloronitrobenzene agar medium as modified by Papavizas (1967). *Fusarium* type colonies were then transferred to synthetischer Nährstoffarmer agar medium (Nirenberg 1981) for identification. *Fusarium* species recovered from the samples were *F. acuminatum* Ellis & Everh., *F. avenaceum* (Fr.:Fr.) Sacc., *F. equiseti* (Corda) Sacc., *F. oxysporum* Schlechtend.:Fr., *F. sambucinum* Fuckel, *F. semitectum* Berk. & Ravenel, and *F. solani* (Mart.) Sacc.

There was no disease progress in time from late autumn 1998 to the following spring. Disease severity data for Normandin (2.80 in autumn and 2.71 in spring) and Pintendre (2.55 in autumn and 2.52 in spring) clearly show similar disease levels at both times of sampling. This is consistent with the fact that *Fusarium* spp. are not known to be active at temperatures below 0°C (Domsch et al. 1980), which occur in Quebec soils throughout the winter. No sampling was made in the spring at Saint-Hyacinthe due to lack of winter survival.

Table 1. Analysis of variance of the effect of site, cultivar, harvest treatment, and sampling time on fusarium root and crown rot of alfalfa

Source	d.f.	Mean square	P value
Sites ^z	2	28.153	<0.001
Replicates within sites	9	0.634	
Cultivars ^y	1	1.083	0.027
Harvests ^x	3	1.189	0.002
Sampling times ^w	1	0.110	NS ^v
Sites cultivars	2	0.838	0.024
Sites harvests	6	0.147	NS
Sites samplings	1	0.024	NS
Cultivars harvests	3	0.337	NS
Cultivars samplings	1	0.070	NS
Harvests samplings	3	0.121	NS
Sites cultivars harvests	6	0.241	NS
Sites cultivars samplings	1	0.018	NS
Sites harvests samplings	3	0.421	NS
Cultivars harvests samplings	3	0.070	NS
Sites cultivars harvests samplings	3	0.096	NS
Residual	111	0.216	

^zThree sites (Normandin, Pintendre, and Saint-Hyacinthe).

^yTwo cultivars (AC Caribou and WL 225).

^xFour harvest treatments (400, 500, or 600 GDD or no autumn harvest).

^wTwo sampling times (late autumn and following spring).

^vNon-significant at $P < 0.10$.

Differences in disease severity were significant for sites, cultivars, harvest treatments and the site cultivar interaction (Table 1). None of the other interactions were significant. The two cultivars did not have significantly different levels of disease severity at Saint-Hyacinthe and Normandin, but at Pintendre, there was significantly less disease on AC Caribou than on WL 225 (Fig. 1). The difference between cultivars at Pintendre is therefore the source of the overall significant difference between cultivars. Overall disease severity by site was 1.07 at Saint-Hyacinthe, 2.53 at Pintendre, and 2.75 at Normandin. Since the occurrence of *Fusarium* increases with the age of plants (Richard 1981), the lower disease level at Saint-Hyacinthe may well result from the fact that the plants there were 1 yr younger than those at the other sites.

Harvesting alfalfa in autumn increased the severity of fusarium root and crown rot over plants not harvested in autumn (Fig. 2). In the drier environment of western Canada, the progress of fusarium root and crown rot in alfalfa was not affected by harvest frequency (Gossen 1994). However, in the current study, disease severity increased with the earliness of the additional autumn harvest. Disease severity over all sites, cultivars, and sampling times was ranked in the following order: 400 GDD > 500 GDD > 600 GDD > control (no autumn harvest) (Fig. 2). In neighbouring Atlantic Canada, it has been shown that the risk of winterkill under autumn harvesting management follows a similar ranking (Bélanger et al. 1999); however, no disease assessment was made in that study.

Plants harvested at 400 GDD were consistently the most affected by fusarium root and crown rot at each site. Increases in disease severity as a result of the 400 GDD treatment, as a percentage of the value found in the correspond-

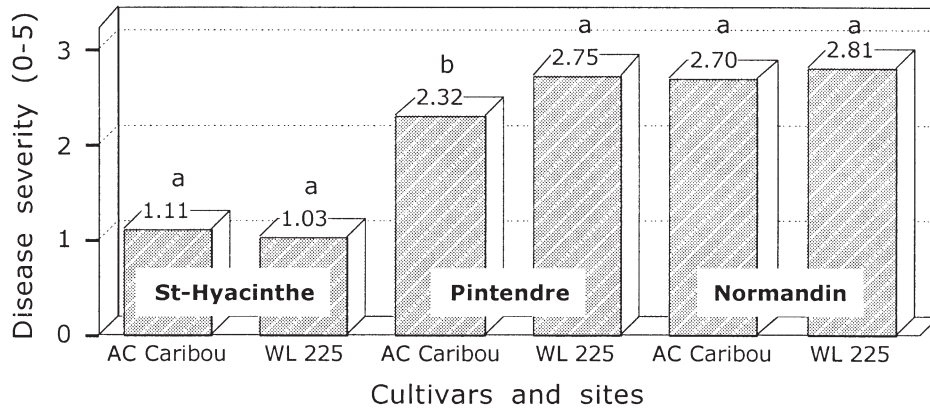


Fig. 1. Fusarium root and crown rot severity on two alfalfa cultivars at three sites in 1998–1999. LSD for cultivars = 0.15. The stand at St-Hyacinthe was a year younger than those at other two sites. Columns with the same letter within a site do not differ significantly ($P < 0.05$).

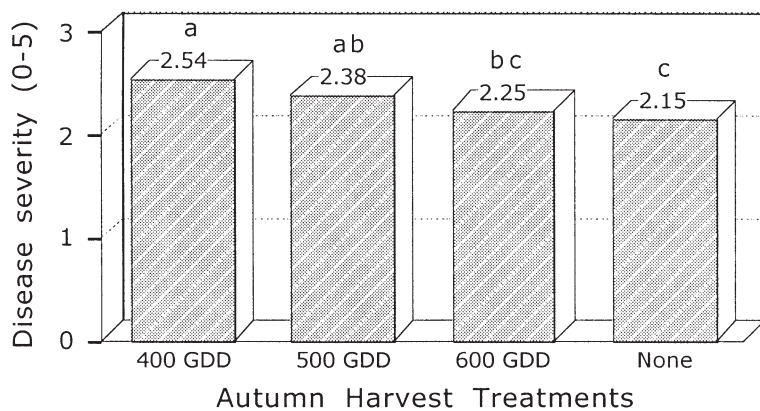


Fig. 2. Fusarium root and crown rot severity in alfalfa following harvests at three different times in autumn (LSD = 0.21) based on GDD after final summer harvest. Averages of all data at three sites in 1998–1999. Columns capped by the same letter do not differ significantly ($P < 0.05$).

ing control treatment at each site, were 16% at Pintendre, 19% at Normandin, and 38% at Saint-Hyacinthe. Increase in severity, however, was not significant at Saint-Hyacinthe where the absolute disease levels were quite low (1.25 for 400 GDD vs. 0.91 in checks). These results show that autumn harvesting of alfalfa in Quebec is untimely and undesirable since it increases the severity of fusarium crown and root rot. Cutting alfalfa late in the growing season has long been recognized as a poor management practice because it reduces stored food reserves before winter dormancy (Elliott et al. 1969). Should an autumn harvest be taken, it should be delayed as long as possible to limit the progress of fusarium root and crown rot. Since winter survival of alfalfa is dependent on the organic reserves in the roots, and *Fusarium*-infected alfalfa plants accumulate less soluble sugars (Richard and Martin 1993), the increased level of tissue damage by fusarium root and crown rot could significantly reduce persistence and spring regrowth of alfalfa.

We are grateful to Mrs. Lucie Lévesque who helped in fungal isolation and disease assessment operations. Comments by the two reviewers and the associate editor are greatly appreciated and were most useful in improving our manuscript.

Atmospheric Environment Service. 1993. Canadian climate normals, 1961–1990. Vol. 5. Quebec. Environment Canada, Ottawa, ON. 157 pp.

Aubé, C. and Deschênes, J. 1967. Crown and root rots of alfalfa and red clover and the relative prevalence of associated fungi. *Plant Dis. Rep.* **51**: 573–577.

Bélanger, G., Richards, J. E. and McQueen, R. E. 1992. Effects of harvesting systems on yield, persistence, and nutritive value of alfalfa. *Can. J. Plant Sci.* **72**: 793–799.

Bélanger, G., Kunelius, T., McKenzie, D., Papadopoulos, Y., Thomas, B., McRae, K., Fillmore, S. and Christie, B. 1999. Fall cutting management affects yield and persistence of alfalfa in Atlantic Canada. *Can. J. Plant Sci.* **79**: 57–63.

Dhont, C., Castonquay, Y., Nadeau, P., Bélanger, G. and Chalifour, F. P. 2002. Alfalfa root carbohydrates and regrowth potential in response to fall harvests. *Crop Sci.* **42**: 754–765.

Domsch, K.H., Gams, W., and Anderson, T.H. 1980. Compendium of soil fungi. Vol. 1. Academic Press, Inc., London, UK. 859 pp.

Elliott, E. S., Baldwin, R. E. and Carroll, R. B. 1969. Root rots of alfalfa and red clover. West Virginia University Agricultural Experiment Station, Bulletin 585T. 32 pp.

Gossen, B. D. 1994. Field response of alfalfa to harvest frequency, cultivar, crown pathogens, and soil fertility: II. Crown rot. *Agron. J.* **86**: 88–93.

Martens, J. W., Seaman, W. L. and Atkinson, T. G. 1988. Diseases of field crops in Canada: an illustrated compendium. 2nd ed. Canadian Phytopathological Society, Harrow, ON. 160 pp.

Nirenberg, H. I. 1981. A simplified method for identifying *Fusarium* spp. occurring on wheat. *Can. J. Bot.* **59**: 1599–1609.

- Papavizas, G. C. 1967.** Evaluation of various media and antimicrobial agents for isolation of *Fusarium* from soil. *Phytopathology* **57**: 848–852.
- Paquin, R. 1985.** Survie à l'hiver des plantes fourragères et des céréales sous les climats nordiques, en particulier au Québec: progrès et perspectives. *Phytoprotection* **66**: 105–139.
- Reynolds, J. H. 1971.** Carbohydrate trends in alfalfa (*Medicago sativa* L.) roots under several forage harvest schedules. *Crop Sci.* **11**: 103–106.
- Richard, C. 1981.** Examen de la microflore endoracinaire de la luzerne en fonction de l'âge, de l'état sanitaire et de l'emplacement dans la racine. *Phytoprotection* **62**: 67–78.
- Richard, C. and Martin, J. G. 1993.** The influence of *Fusarium oxysporum* f. sp. *medicaginis* on total soluble-sugar concentration of infected alfalfa roots. *Can. J. Plant Sci.* **73**: 647–649.
- Richard, C., Willemot, C., Michaud, R., Bernier-Cardou, M. and Gagnon, C. 1982.** Low-temperature interactions in fusarium wilt and root rot of alfalfa. *Phytopathology* **72**: 293–297.
- Stuteville, D. L. and Erwin, D. C. 1990.** Compendium of alfalfa diseases. 2nd ed. APS Press, St. Paul, MN. 84 pp.
- Taesar, M. B. and Yager, J. L. 1985.** Fall cutting of alfalfa in the North Central USA. *Agron. J.* **77**: 774–778.