"Occurrence of the orange wheat blossom midge [Diptera :Cecidomyiidae] in Quebec and its incidence on wheat grain microflora"

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Occurrence of the orange wheat blossom midge [Diptera : Cecidomyiidae] in Quebec and its incidence on wheat grain microflora

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Samples of wheat spikes (*Triticum aestivum*) were collected in the summer of 1995 from different crop districts in Quebec and the occurrence of orange wheat blossom midge (*Sitodiplosis mosellana*) and seed microflora were determined. Estimated yield loss caused by wheat midge larvae averaged 6.3%. The percentage of infested spikes was significantly correlated with total seed contamination by fungi and bacteria ($r = 0.79$). The specific occurrence of *Fusarium graminearum* in grains was also significantly correlated with number of larvae per spike ($r = 0.67$) or per spikelet ($r = 0.67$). Consequently, the wheat midge might play a role in dissemination of *F. graminearum*.

[Présence de la cécidomyie orangée du blé [Diptera : Cecidomyiidae] au Québec et son incidence sur la microflore des grains de blé]

À l'été 1995, on a prélevé des échantillons de blé (*Triticum aestivum*) dans des champs de diverses régions agricoles du Québec. La présence de larves de la cécidomyie orangée du blé (*Sitodiplosis mosellana*) fut quantifiée et une évaluation qualitative et quantitative de la microflore des grains fut réalisée. Les pertes moyennes de rendement causées par les larves de la cécidomyie du blé furent estimée à 6,3 %. Le pourcentage des épis infestés fut significativement corrélé avec la contamination bactérienne et fongique des grains ($r = 0,79$). La présence spécifique du *Fusarium graminearum* dans les grains de blé fut aussi significativement corrélée avec le nombre de larves par épi ($r = 0,67$) ou par épillet ($r = 0,67$). Il appert que la cécidomyie du blé pourrait jouer un rôle dans la dissémination du *F. graminearum*.

INTRODUCTION

The wheat midge *Sitodiplosis mosellana* (Géhin) [Diptera : Cecidomyiidae] is a well known pest in western Canada. For instance, high populations of midge occurred in Saskatchewan in 1983 and caused losses estimated to be $30 million in spring wheat (*Triticum aestivum* L.) (Olfert *et al.* 1985). This outbreak prompted studies on the biology, distribution, and behaviour of this insect in western Canada (Borkent 1989).

In Quebec, little research has been carried on the wheat midge although the presence of this insect in North America was first recorded in Quebec, in 1828 (Felt 1921). Extensive yield losses due to

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this insect brought about the phasing out of wheat production in the province (Dupont 1857). Interest in the growing of wheat in Quebec was renewed more than a century later and was expanded significantly in the 1980's. At the same time, the wheat midge was not considered to be an important pest in Québec. However, recommendations were made to keep it under a close watch (Comeau and Cloutier 1988). In 1984, 100% of the spikes were infested in the Beloeil and Saint-Hyacinthe regions (Hudon *et al.* 1984), none in 1993, and less than 50% in 1994 (Devaux and Brodeur 1994). In a set of fields at six different locations in 1994, Couture *et al.* (1995) found a range of 36-88% infested spikes.

Such surveys indicated that wheat midge populations were present in Quebec but observations on the extent of distribution of the insect was limited in scope and its incidence on wheat yields was not determined. Couture *et al.* (1995) suspected that incidence of the insect pest was involved in contamination of wheat seeds by fungi, and by *Fusarium graminearum* (Schwabe) in particular. *F. graminearum* is the most common causal agent of Fusarium head blight, a wheat disease of primary concern in Canada (Martens *et al.* 1984). The objectives of this study were to evaluate the distribution of wheat midge infestations on a wider scale in Quebec, to estimate the effect of such infestations on wheat yields, and to examine the relationships between incidence of midge larvae and seed contamination by bacteria and fungi, with special emphasis on *F. graminearum*, through correlation studies based upon a large sampling.

MATERIALS AND METHODS

Wheat spikes in 14 fields of different crop districts in Quebec (Canada) were sampled once or twice (for a total of 21 samplings) between late July to mid-August of 1995. The sampling sites were either trial plots (consisting of 18 to 41 cultivars) or single cultivar fields, including one field of winter wheat. Five of the six sites visited during the 1994 growing season (Couture *et al.* 1995) were sampled again in the present study.

Each sample consisted of a minimum of 110 spikes that were collected at random and placed in plastic sampling bags which were stored in a cooler containing crushed ice. At sites where more than one cultivar was grown, an equal number of spikes from each cultivar present was pooled into one sample. Plant growth stage (Zadoks *et al.* 1974) at the time of sampling was recorded. Upon transportation to the laboratory, all samples were transferred to a freezer (-10°C) until further use. One hundred spikes of each sample were dissected with forceps and examined for wheat midge larvae under an illuminated magnifier. Larvae and spikelets on each spike were counted. The remaining spikes were dried, threshed, and the seeds were surface-sterilized in 70% ethanol for 30 s and in 1% sodium hypochlorite for 2 min, rinsed several times with sterile water, allowed to air dry aseptically for a few minutes, then placed on two selective agar media in Petri dishes. Mannitol agar (Böhm-Shraml *et al.* 1993) was used to detect bacteria, fungi and *F. graminearum*, while pentachloro-nitrobenzene (PCNB) modified agar (Papavizas 1967) was used to detect *Fusarium* spp. The concentration of agar in both media was reduced (7 g L^{-1}) to facilitate the embedding of the seeds. A sub-sample of 100 seeds (mostly immature) was plated on each growth medium. Plates were incubated at 24°C for up to 11 d, and the number of infected seeds and colonies of each microbial group were counted. The number of *Fusarium* spp. other than *F. graminearum* was obtained by the difference between *Fusarium* spp. and *F. graminearum* counts on the respective media.

Simple correlations (*r*) were calculated between incidence of orange wheat midge larvae on spikes and seed contamination by either : bacteria, fungi, *F. graminearum*, other *Fusarium* spp., or total seed contamination that is contamination by all bacteria and fungi.

RESULTS

Larvae of the orange wheat midge were found in all samples examined (Table 1). Incidence of infested spikes ranged from 2% at Saint-Joseph-de-la-Pointe-de-Lévy (early sampling) to 98% at Lennoxville (late sampling). Half of the samples averaged more than 1.9 larvae per spike and more than 0.13 larva per spikelet. The greatest counts observed were 13.8 larvae per spike and 0.9 larva per spikelet at Lennoxville (late sampling). In fields sampled at the dough stage and above (GS ≥ 80), Normandin had the lowest infestation level (13%). The incidence of infested spikes increased with the growth stage of wheat (Fig. 1). In each of the seven fields that were sampled twice, the incidence of infested spikes and larval counts were always higher at the second sampling (Table 1). Yield loss estimated by the approach of Olfert *et al.* (1985) averaged 6.3% for all sampled fields (assuming three kernels per spikelet) and reached 21% at Lennoxville where the highest level of infestation (0.86 larva per spikelet) was observed.

Coefficients of correlation (Table 2) between the incidence of orange wheat midge in spikes and microbial contamination of seeds was highest for total seed contamination, *i.e.* contamination by all bacteria and fungi ($r = 0.79$, $P = 0.00002$). A significant correlation was observed between the presence of larvae in seed and general fungal contamination ($r = 0.72$, $P = 0.0002$). Significant correlations were also obtained between number of larvae per spike or per spikelet and presence of *F. graminearum* on grain ($r = 0.67$, $P = 0.001$, and $r = 0.67$, $P = 0.001$, respectively). *Fusarium* species other than *F. graminearum* were not correlated with incidence of midge-infested spikes or spikelets.

DISCUSSION

The orange wheat midge larvae were found in all samples examined and the level of infestation was not related to the geographical position of sites within crop districts of Quebec. For sites that were sampled in 1994 by Couture *et al.* (1995) and again in 1995, infestation levels were comparable, but larvae populations were lower in 1995 when medians reached 1.9 larvae per spike and 0.13 larva per spikelet. Normandin, the northernmost site visited, had again the lowest infestation level. Since the climate is cool in that area, wheat is usually planted late at springtime and asynchrony between times of wheat flowering and midge oviposition could account for the relatively low infestation levels observed at that site.

New cultivars of spring wheat with improved adaptation to climatic and soil conditions of Quebec will extend the wheat growing areas in the province. Since midge larvae can remain in diapause for as long as 13 yr in soil (Barnes 1956), it is anticipated that the wheat midge populations will also increase. This could have serious implications for wheat yields in view of the fact that wheat midge is now confirmed a significant wheat pest in Quebec, causing an average yield loss of 6.3%.

The high correlation ($r = 0.79$) between percentage of infested spikes by midge larvae and seed contamination by all bacteria and fungi indicates that 62% (r^2) of the variation of this contamination is related to larval infestation. Correlation coefficients between incidence of orange wheat midge and seed contamination are consistent with previous observations of heavy fungal and bacterial infection on kernels damaged by wheat midge larvae (Doeksen 1938; Miller and Halton 1961).

Although intensities of Fusarium head blight were low on wheat in Quebec in 1995 (Devaux 1996) compared to previous years, we nevertheless detected highly significant correlations between the presence of larvae in spikes or in spikelets and the presence of *F. graminearum* on grain. A positive association between wheat midge and the fungal agent of glume blotch, *Septoria nodorum* (Berk.) Berk., has previously been reported (Wellso and Freed 1982). Their study was based on the finding that larvae were more abundant on wheat heads showing symptoms of glume blotch. They suggested that either the feeding of the larvae may cause wheat heads to be more readily infected by the fungus, or that the larvae may feed on the fungus. It is known that larvae from other groups of Cecidomyiidae (especially gall midges) feed on fungi; female adults from these groups bear specialized structures to carry conidia (Borkent and Bissett 1985).

Table 1. Incidence of wheat midge and seed contaminants in wheat samples collected at different locations in Quebec in 1995

Locations[a]	Growth stage (Z)[b]	Wheat midge incidence: Infested spikes (%)	Wheat midge incidence: Number or larvae spike^{-1}	Wheat midge incidence: Number or larvae spikelet^{-1}	Contamination of seeds: Seeds infected (%)	Bacterial colonies (100 seeds)$^{-1}$	Fungal colonies (100 seeds)$^{-1}$	*Fusarium* (100 seeds)$^{-1}$ *graminearum*	*Fusarium* (100 seeds)$^{-1}$ other spp.
La Pocatière (30)	85	94	5.14	0.33	68	12	67	2	0
Lennoxville (18)	75	97	9.74	0.61	46	1	53	1	1
Lennoxville (18)	85	98	13.76	0.86	90	36	86	4	3
Lennoxville (1) (winter wheat)	91	76	2.30	0.15	63	0	65	2	8
Normandin (30)	83	13	0.30	0.02	33	3	32	0	0
Pintendre (34)	69	15	0.38	0.03	13	3	15	1	1
Pintendre (34)	85	91	6.87	0.43	92	1	101	0	2
Saint-Bruno-de-Montarville (30)	70	5	0.11	0.01	4	3	2	0	0
Saint-Bruno-de-Montarville (30)	80	39	0.75	0.05	97	5	117	2	1
Saint-Bruno-de-Montarville (1)	71	9	0.11	0.01	5	5	3	0	0
Saint-Bruno-de-Montarville (1)	84	74	1.86	0.13	73	4	88	1	2
Sainte-Anne-de-Bellevue (18)	87	90	3.57	0.22	73	20	72	0	0
Sainte-Rosalie (30)	69	34	0.80	0.05	3	0	3	0	0
Sainte-Rosalie (30)	85	75	2.45	0.16	88	9	97	1	1
Saint-Hyacinthe (1)	73	16	0.36	0.03	22	8	30	0	0
Saint-Hyacinthe (1)	85	72	2.27	0.18	59	7	63	0	0
Saint-Joseph-de-la-Pointe-de-Lévy (41)	70	2	0.04	0	3	1	3	0	0
Saint-Joseph-de-la-Pointe-de-Lévy (41)	86	94	8.07	0.49	74	10	84	2	2
Saint-Maurice (1)	75	34	0.76	0.05	28	22	6	0	0
Saint-Sévère (1)	83	89	5.32	0.39	46	17	34	1	0
Saint-Simon (41)	75	23	0.46	0.03	10	1	9	0	0

[a] The number of wheat cultivars sampled is written in parentheses.
[b] Zadoks *et al.* 1974.

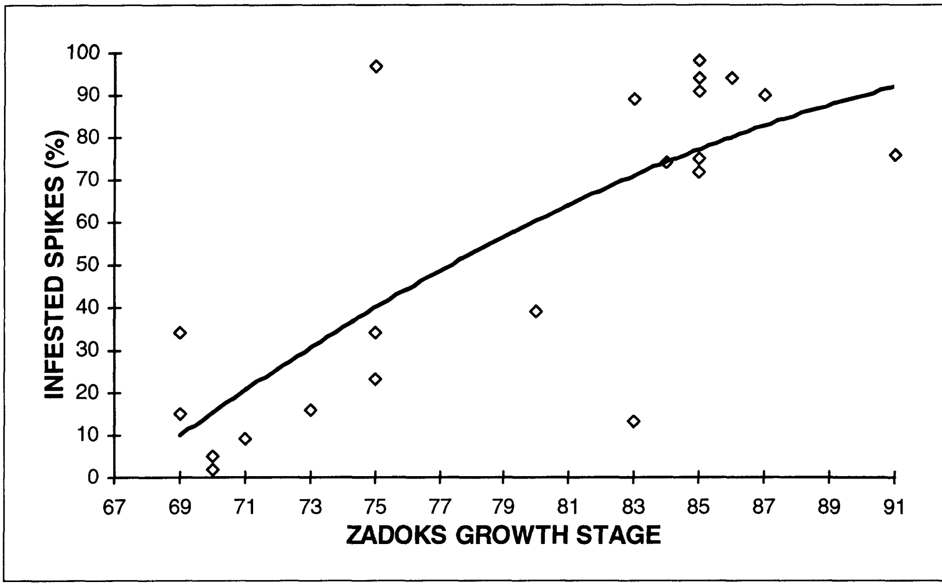

Figure 1. Relationship between spikes infested by wheat midge larvae and growth stage (Zadoks *et al.* 1974) at sampling time in Quebec wheat fields, in July and August 1995.

The two types of spores produced by *F. graminearum*, ascospores and macroconidia, can infect wheat plants and may be transported by wind. However, for infection of wheat heads, the principal reservoir of inoculum of *F. graminearum* is host debris (Sutton 1982). Since the emergence of wheat midge adult females from soil and the period of egg laying (heading and flowering) can overlap at a time when wheat is susceptible to infection by the fungus (anthesis) (Parry *et al.* 1995), it is likely that these insects may serve as efficient vectors for *F. graminearum*. From our data, insect transport may account for as much as 45% (r^2) of the total *F. graminearum* infected seeds, thereby significantly enhancing the potential damage caused by the fungal pathogen.

A second hypothesis is that adults might lay eggs preferentially on *F. graminearum* infected spikes, as suggested by Wellso and Freed (1982) for *S. nodorum*. In this case, the synergism between these pests could perhaps be less significant. Nevertheless, the prob-

Table 2. Correlation between incidence of wheat midge and contamination of seeds on wheat collected in Quebec

	Correlation (r) with seed contamination				
Wheat midge incidence	Bacteria	Fungi	*Fusarium graminearum*	Other *Fusarium* spp.	Total seed contamination
Percentage of infested spikes	0.408 *(0.067)*[a]	0.725 *(0.0002)*	0.544 *(0.011)*	0.378 *(0.091)*	0.790 *(0.00002)*
Number of larvae per spike	0.533 *(0.013)*	0.511 *(0.018)*	0.671 *(0.001)*	0.297 *(0.191)*	0.576 *(0.006)*
Number of larvae per spikelet	0.539 *(0.012)*	0.512 *(0.018)*	0.668 *(0.001)*	0.292 *(0.198)*	0.581 *(0.006)*

[a] *P* values.

ability that the midge gets contaminated by propagules of *F. graminearum* and contaminates the next wheat spike would still be significant. Further studies are therefore necessary to understand the relation between the insect and the fungus.

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REFERENCES

Barnes, H.F. 1956. Gall midges of economic importance. VII. Gall midges of cereal crops. Crosley Lockwood, London. 261 pp.

Böhm-Shraml, M., L. Niessen, S. Donhauser, G. Engelhard, and P. Wallnöfer. 1993. Medium zur selectiven Abgrenzung von *Fusarium graminearum*. Dtsch. Lebensm. Rundsch. 89 : 152-154.

Borkent, A. 1989. A review of the wheat blossom midge, *Sitodiplosis mosellana* (Géhin) (Diptera : Cecidomyiidae) in Canada. Research Branch, Agriculture Canada. Tech. Bull. 1989-5E. Ottawa. 24 pp.

Borkent, A., and J. Bissett. 1985. Gall midges (Diptera : Cecidomyiidae) are vectors for their fungal symbionts. Symbiosis 1 : 185-194.

Comeau, A., and C. Cloutier. 1988. Ravageurs – insectes, oiseaux et rongeurs. Pages 113-119 *in* Céréales de printemps – Culture. Conseil des productions végétales du Québec. AGDEX 110/20. 167 pp.

Couture, L., J.-P. Dubuc, and A. Comeau. 1995. Occurrence of contamination of wheat grain by the orange wheat midge and seed microflora in Québec. Can. Plant Dis. Surv. 75 : 128-129.

Devaux, A. 1996. Diseases of wheat in Québec in 1995. Can. Plant Dis. Surv. 76 : 90.

Devaux, A., and J. Brodeur. 1994. Enquête sur les ennemis des grandes cultures – Région agricole n° 6. Rapport du Service de phytotechnie de Saint-Hyacinthe. Ministère de l'agriculture des pêcheries et de l'alimentation du Québec. Saint-Hyacinthe (Québec), Canada. 60 pp.

Doeksen, J. 1938. De tarwegalmuggen *Contarinia tritici* Kirby en *Sitodiplosis mosellana* Géhin (Diptera : Cecidomyiidae) in Nederland. Versl. Techn. Tarwe Comm. 12 : 237-296.

Dupont, E. 1857. Essai sur les insectes et les maladies qui affectent le blé. Presses à vapeur du Canada. Montréal. 38 pp.

Felt, E.P. 1921. Wheat midge, *Thecodiplosis mosellana* (Géhin). N. Y. State Mus. Bull. 231 : 35-54.

Hudon, M., G. Boivin, P. Martel, J. Belcourt, and C. Ritchot. 1984. Insects and related pests of cereal crops – Québec. Can. Agric. Insect Pest Rev. 62 : 1.

Martens, J.W., W.L. Seaman, and T.G. Atkinson. 1984. Diseases of field crops in Canada – an illustrated compendium. The Canadian Phytopathological Society. 160 pp.

Miller, B.S., and P. Halton. 1961. The damage to wheat kernels caused by the wheat blossom midge (*Sitodiplosis mosellana*). J. Sci. Food Agric. 12 : 391-398.

Olfert, O.O., M.K. Mukerji, and J.F. Doane. 1985. Relationship between infestation levels and yield loss caused by wheat midge, *Sitodiplosis mosellana* (Géhin) (Diptera : Cecidomyiidae), in spring wheat in Saskatchewan. Can. Entomol. 117 : 593-598.

Papavizas, G.C. 1967. Evaluation of various media and antimicrobial agents for isolation of *Fusarium* from soil. Phytopathology 57 : 848-852.

Parry, D.W., P. Jenkinson, and L. McLeod. 1995. Fusarium ear blight (scab) in small grain cereals – a review. Plant Pathol. 44 : 207-238.

Sutton, J.C. 1982. Epidemiology of wheat head blight and maize ear rot caused by *Fusarium graminearum*. Can. J. Plant Pathol. 4 : 195-209.

Wellso, S.G., and R.D. Freed. 1982. Positive association of the wheat midge (Diptera : Cecidomyiidae) with glume blotch. J. Econ. Entomol. 75 : 885-887.

Zadoks, J.C., T.T. Chang, and C.F. Konzak. 1974. A decimal code for the growth stages of cereals. Weed Res. 14 : 415-421.