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M. Hudon, G. Bourgeois, G. Boivin and D. Chez

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Article abstract

The impact of European corn borer (*Ostrinia nubilalis*) [Lepidoptera: Pyralidae] infestation and stalk rot infection caused by *Gibberella zeae* on yield of eight grain maize (*Zea mays*) inbreds, two commercial and six experimental hybrids was evaluated from 1975 to 1980. Three criteria were used: leaf feeding, total plant damage at harvest and tunnel length/plant height ratio. For most criteria, the cultivars were significantly different and the artificial European corn borer infestation had an effect almost every year. Although *G. zeae* can have a signifiant effect on plant damage at harvest and yield of grain maize, no consistent link was found between stalk rot and European corn borer.

Yield reductions in grain maize associated with the presence of European corn borer and *Gibberella* stalk rot in Québec

Marcel Hudon[1], Gaétan Bourgeois[1], Guy Boivin[1], and Daniel Chez[2]

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The impact of European corn borer (*Ostrinia nubilalis*) [Lepidoptera: Pyralidae] infestation and stalk rot infection caused by *Gibberella zeae* on yield of eight grain maize (*Zea mays*) inbreds, two commercial and six experimental hybrids was evaluated from 1975 to 1980. Three criteria were used: leaf feeding, total plant damage at harvest and tunnel length/plant height ratio. For most criteria, the cultivars were significantly different and the artificial European corn borer infestation had an effect almost every year. Although *G. zeae* can have a significant effect on plant damage at harvest and yield of grain maize, no consistent link was found between stalk rot and European corn borer.

Hudon, M., G. Bourgeois, G. Boivin et D. Chez. 1992. Réductions des rendements du maïs-grain associées à la présence de la pyrale du maïs et de la fusariose des tiges au Québec. PHYTOPROTECTION 73: 101-110.

L'effet d'une infestation de la pyrale du maïs (*Ostrinia nubilalis*) [Lepidoptera: Pyralidae] et d'une infection de la fusariose des tiges causée par *Gibberella zeae* sur le rendement de huit lignées de maïs grain (*Zea mays*), de deux hybrides commerciaux et de six hybrides expérimentaux a été évalué de 1975 à 1980. Trois critères ont été utilisés: la criblure du feuillage, les dégâts totaux des plantes à la récolte et le rapport de la longueur des galeries creusées par les chenilles de pyrale dans les tiges sur la hauteur totale du plant. Pour la plupart des critères, les cultivars étaient significativement différents et l'infestation artificielle de pyrale du maïs a eu un effet presqu'à chaque année. Bien que *le G. zeae* ait eu un effet significatif sur les dégâts totaux à la récolte et le rendement en grain du maïs, aucune relation n'a pu être établie entre la maladie et la pyrale du maïs.

INTRODUCTION

Stalk-boring insects and stalk rot organisms are among the most important causes limiting maize (*Zea mays* L.) production in the world (Dicke and Guthrie 1988; Shurtleff 1980). These organisms become major factors in determining the quality, yield and harvestability of the crop, and their impact varies with geographical area and climate. Stalk rots are caused by several pathogens, particularly the fungi *Fusarium* spp. (*Gibberella*). *Gibberella* stalk rot induced by *Gibberella zeae* (Schw.) Petch (perfect stage of *Fusarium graminearum* Schw.) is the main pathogen in Ontario (McKeen 1951) and Québec (Chiang *et al.* 1987). Yield reduction may vary with the hybrid (Wilcoxson 1962) and the inbred lines (Smith and Madsen 1949), the pathogenicity of fun-

1. Research Station, Agriculture Canada, 430, boul. Gouin, Saint-Jean-sur-Richelieu, Québec, Canada J3B 3E6. Contribution No. 335/92.08.01R
2. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, 2700, rue Einstein, Sainte-Foy, Québec, Canada G1P 3W8

gus, the intensity of infection per plant and the season (Michaelson and Christensen 1953). Many organisms are vectors of *Gibberella* stalk rot, particularly the European corn borer (ECB), *Ostrinia nubilalis* (Hübner) [Lepidoptera: Pyralidae], which remains among the most destructive insects of maize in Canada (Hudon and LeRoux 1986).

Christensen and Schneider (1950) and Taylor (1952) were the first to report an association between ECB infestation and infection by ear and stalk rots. Incidence and severity of stalk rots increase with the presence of *O. nubilalis* (Bergstrom *et al.* 1983; Christensen and Schneider 1950; Keller *et al.* 1986). In Minnesota, Christensen and Schneider (1950) investigated organisms that developed in maize plants after ECB infestation. They found that *Fusarium* spp. were the most common pathogens isolated from injured plants and also from internal parts of living and dead borers (Dicke and Guthrie 1988). Maize inbred lines and hybrids normally resistant to stalk rots caused by *Diplodia* and *Fusarium* spp. (*Gibberella*) were readily infected when attacked by *O. nubilalis* (Jarvis *et al.* 1984; Krueger and Weiler 1977). Jarvis *et al.* (1982) reported that *Diplodia* stalk rot damage was highest under high levels of O. nubilalis infestation. Interactive effects of ECB and the common stalk rot species have been reported by several authors (Bergstrom *et al.* 1983; Chez *et al.* 1977; Krueger and Weiler 1977) and this evidence suggests that this insect-disease complex is so intimately linked that any yield reduction studies, breeding programs, or other control strategies focusing on a single fungus or insect are incomplete without detailed consideration of the concomitant role of other pests (Keller *et al.* 1986). More recently, Nyhus *et al.* (1988) reported that the level of resistance to ECB and *Diplodia* stalk rot in the population crosses of two maize synthetics (BSAA and BSBB) suggested that the genes governing this resistance are acting in an additive manner. Selection for resistance to both traits was associated with increased physical stalk strength as well as for resistance to stalk-rotting organisms.

The following study was undertaken to determine the interactive effects of *Gibberella* stalk rot and the ECB on yield reduction and plant damage of inbred

Table 1. Inbred lines, experimental and commercial hybrids evaluated during the period 1975-1980, L'Acadie, Québec

Maize cultivars	Leaf feeding rating[a]	Years					
		1975	1976	1977	1978	1979	1980
Inbred lines							
CO 239	R	X	X				
Q 191	R	X		X			
T 341	R		X				
CH 591-36	R			X			
Bc 23	S				X	X	X
Bc 9A	I				X	X	X
Bc 14	S					X	X
Bc 6635	R					X	X
Hybrid lines							
Stewart 2606	R	X					
Stewart 2704	S	X					
MR21 X ZPR2077	I-S		X				
R588 X T146	I-R		X				
Bc 9A X Bc 23	I-S				X	X	X
Bc 14 X Bc 23	S					X	X
Bc 6635 X Bc 23	R-S					X	X
Bc 9A X Bc 6635	I-R					X	X

[a] R = resistant, I = Intermediate, S = susceptible.

lines, experimental, and commercial hybrids of maize.

MATERIALS AND METHODS

Grain maize plots were established on a Macdonald clay loam soil at the experimental farm of Agriculture Canada at L'Acadie. The study was conducted for 6 yr (1975-1980), using a randomized complete block design with four replications each year. The treatments were arranged as a factorial experiment with three factors: maize lines or hybrids, ECB infestation, and *G. zeae* infection. The number of levels in the maize lines or hybrids factor as well as the lines or hybrids themselves were not the same from one year to the other (Table 1). For these reasons, a statistical analysis was done for each year, with a general linear model procedure (SAS Institute Inc. 1985). The factors ECB infestation and *G. zeae* infection had two levels each. Levels of the ECB infestation were either an insecticide-treated or an artificial infestation, and levels of *G. zeae* infection were natural infection and artificial inoculation with *G. zeae*.

Most cultivars evaluated in this study are considered of the early type in their flowering and harvest maturity, but varied in their resistance or tolerance to the ECB from very resistant, to resistant, intermediate and susceptible. Some years, certain cultivars had to be replaced due to a shortage of seeds, particularly for the hybrids, but for the last 2 yr, all materials remained the same (Table 1).

Each genotype was submitted to the four combinations of treatments mentioned previously. The insecticide-treated plants, including plants with natural infection of *G. zeae*, received two applications of granular carbofuran (Furadan 10G) at 1.1 kg a.i. ha^{-1}, made at maximum natural egg laying of the univoltine strain of the borer that occur normally during the 2nd and 3rd week of July. The artificial ECB infestation consisted in the deposition of 4 egg masses $plant^{-1}$ (100 eggs in total) for the inbreds and 6 egg masses $plant^{-1}$ (150 eggs in total) for the hybrids into the whorl of each plant in two or three lots of two masses each, at 2-d intervals, during the middle of the natural egg laying period of the borer (normally mid-July). ECB egg masses were obtained according to the rearing technique of Guthrie (1971).

Plants were artificially inoculated with *G. zeae* during or after pollination, at the second internode of the plants using the toothpick method (Young 1943). The inoculum preparation and technique were similar to that described by Chiang *et al.* (1987).

Except for 1976, where two rows of plants were used, each plot consisted of a single row of 8 m long, hand-planted about mid-May at a rate of 61 775 seeds ha^{-1}. All plots were spaced 90 cm apart. The number of plants sampled in each plot varied from 10 (1979) to 30 (1978) depending on the number of inbreds and hybrids evaluated during that year. An herbicide combination of atrazine at 1.35 kg a.i. ha^{-1} (2-chloro-4-ethylamino-6-isopropylamino-*s* -triazine) with alachlor at 2.64 kg a.i. ha^{-1} (2-chloro-2'-6'-diethyl-*N*-(methoxymethyl)-acetamilide) was applied to the whole field before planting. Plots were fertilized according to recommendations.

Plants were rated for ECB leaf feeding approximately 4 wk after the last egg mass deposition using a 9-class visual rating system (1 = no feeding, 9 = extensive feeding) (Guthrie *et al.* 1960), and for total plant damage and breakage at harvest, using a 10-class visual rating system (1 = uninfested plant, 10 = plant broken below the ear) (Hudon *et al.* 1979). Plant height was recorded at tasselling in July. The criterion, «tunnel length over plant height ratio» (TPHR) is the total length of tunnels in cm in a plant divided by its height. It is considered a reliable criterion for evaluating univoltine ECB damage and maize resistance or tolerance to *O. nubilalis* (Hudon and Chiang 1991). All plots were hand-harvested each year by mid-October and yield data consisted of the kernel weight (g $plant^{-1}$) of the ear of each plant dried at 60°C for 3 d and shelled.

RESULTS AND DISCUSSION

The *F* values for the comparison of leaf feeding, plant damage, TPHR and yield between the treatments and their degree

Table 2. *F* values for the effects of cultivars, stalk rot and ECB infestation on leaf feeding, plant damage, tunnel length over plant height ratio (TPHR) and grain maize yield at L'Acadie, Québec from 1975 to 1980

Year	Source	Degree of freedom	*F* values			
			Leaf feeding	Plant damage	TPHR[c]	Yield
1975	Blocks	3	2.98*[a]	2.16	2.63	0.81
	Cultivars(C)	3	1.71	22.29***	7.03***	533.85***
	Stalk rot(Sr)	1	0.42	0.02	14.42***	3.57
	ECB	1	270.02***	345.24***	1366.73***	495.90***
	C X Sr	3	0.26	0.75	0.31	2.12
	C X ECB	3	1.71	8.98***	3.41*	0.96
	Sr X ECB	1	0.42	6.02*	27.23***	7.00**
	C X Sr X ECB	3	0.26	0.48	0.77	1.56
	Error	45				
	Total	63				
1976	Blocks	3	-[b]	-	3.15*	0.66
	Cultivars	3	-	-	10.53***	27.92***
	Stalk rot	1	-	-	13.23***	0.18
	ECB	1	-	-	367.06***	8.30**
	C X Sr	3	-	-	7.36***	0.14
	C X ECB	3	-	-	12.67***	0.96
	Sr X ECB	1	-	-	13.23***	0.12
	C X Sr X ECB	3	-	-	7.36***	0.38
	Error	45				
	Total	63				
1977	Blocks	3	0.69	0.61	0.40	1.18
	Cultivars	1	20.35***	1.36	15.73***	24.96***
	Stalk rot	1	3.83	0.26	0.13	0.31
	ECB	1	1.85	7.23**	32.16***	2.05
	C X Sr	1	0.18	2.47	0.07	0.31
	C X ECB	1	8.37**	0.16	12.75**	3.47
	Sr X ECB	1	0.46	0.06	0.06	1.31
	C X Sr X ECB	1	1.04	0	0.13	1.34
	Error	21				
	Total	31				
1978	Blocks	3	0.34	1.24	2.24	8.98***
	Cultivars	2	7.72**	32.13***	10.36***	268.68***
	Stalk rot	1	0.01	4.42*	0.85	3.30
	ECB	1	635.72***	11.80**	34.97***	0.57
	C X Sr	2	0.07	1.13	1.98	0.44
	C X ECB	2	9.05***	2.12	11.00***	0.48
	Sr X ECB	1	0.06	0.18	0.67	0.04
	C X Sr X ECB	2	0.20	0.34	2.14	0.36
	Error	33				
	Total	47				
1979	Blocks	3	0.61	2.07	1.14	1.24
	Cultivars	7	12.87***	3.88**	13.00***	88.04***
	Stalk rot	1	0.28	23.52***	1.66	8.74**
	ECB	1	763.23***	1.28	318.59***	8.96**
	C X Sr	7	1.46	1.46	1.18	0.80
	C X ECB	7	11.56***	5.03***	11.10***	1.34
	Sr X ECB	1	0.08	12.51***	8.55**	0
	C X Sr X ECB	7	1.13	2.02	1.81	0.73
	Error	93				
	Total	127				

Table 2. (suite)

Year	Source	Degree of freedom	*F* values			
			Leaf feeding	Plant damage	TPHR[c]	Yield
1980	Blocks	3	-	2.13	0.20	0.94
	Cultivars	7	-	3.85**	13.87***	168.36***
	Stalk rot	1	-	25.84***	0.82	1.17
	ECB	1	-	31.37***	200.58***	9.68**
	C X Sr	7	-	0.86	2.11*	0.99
	C X ECB	7	-	0.96	9.65***	2.21*
	Sr X ECB	1	-	0.63	0.01	0.02
	C X Sr X ECB	7	-	0.88	1.65	0.53
	Error	93				
	Total	127				

[a] *, **, ***: significant at the 0.05, 0.01, and 0.001 levels, respectively.
[b] Data not available.
[c] TPHR is the total lengthof tunnels in cm in a plant divided by its height.

of significance are presented in Table 2. The effect of ECB factor on leaf feeding was significant ($P \leq 0.001$) except in 1977. This result indicates that the manual infestation of plants using egg masses yielded young larvae and that the insecticide treatments used were able to keep the population of ECB at a low level in the treated plots. The absence of effect in 1977 might be due to the cultivars Q191 and CH591-36 used that year, both of which are partially resistant to leaf feeding by *O. nubilalis* (Hudon *et al.* 1979). The effect of cultivar was significant ($P \leq 0.01$) except in 1975 largely because the hybrids (susceptible) and inbreds (resistant) reacted differently to ECB attack. The interactions between cultivar and ECB were also significant ($P \leq 0.01$) except in 1975 (Table 2). Stalk rot had no significant effect on leaf feeding by ECB and there was no significant interactions between stalk rot, ECB and cultivar (Table 2).

ECB presence increased significantly the leaf feeding on most cultivars and years. However, only one out of 17 tests showed a significant increase in leaf feeding due to the presence of stalk rot (Table 3). This observation indicates that infection by stalk rot does not modify the palatability of maize plant parts to young ECB larvae.

Plant damage at harvest reflected injury done during the season by both ECB larvae and stalk rot. The cultivars were significantly different ($P \leq 0.01$) except in 1977. The manual infestation by ECB also had an effect every year except 1979 (Table 2). In 1978, 1979 and 1980, stalk rot was a significant factor ($P \leq 0.05$) indicating that infection by this pathogen weakens plants and increases breakage near harvest time. This phenomenon has been observed previously in Québec by Chez *et al.* (1977). Significant interactions were found between cultivar and ECB and between stalk rot and ECB in 1975 and 1979.

A different picture arose when the results for plant damage at harvest are analyzed for each cultivar (Table 4). Plant damage was related to artificial ECB infestations in some years but results were not consistent. The four hybrids tested in 1979 showed no significant effects while three of the same cultivars showed an effect in 1980. Some significant effects were also observed for the presence of stalk rot. However, five out the seven significant effects indicated that the presence of stalk rot decreased plant damage at harvest. Perhaps infected plants become less suitable for ECB larval development and that decreased survival or slower development of larvae result in lower stalk damage.

The TPHR is more indicative of the acceptance of a plant by ECB larvae and their subsequent survival. Using this criteria, again cultivar and artifical infestation of ECB had a highly significant effect ($P \leq 0.001$) every year. In 1975 and 1976, the artifical infection of stalk rot had a significant effect ($P \leq 0.001$) indicating that an infected plant is less acceptable for ECB development. For these 2 yr, the interaction between stalk rot and ECB was also significant ($P \leq 0.001$) (Table 2).

Table 3. Mean value of leaf feeding for plots with and without European corn borer and stalk rot

Year	Cultivars	Mean leaf feeding rating[a]			
		European corn borer		Stalk rot	
		With	Without	With	Without
1975	CO 239	2.69 ***[b]	1.00	1.82	1.86
	Q 191	3.25 ***	1.00	2.22	2.04
	Stewart 2606	2.74 ***	1.00	1.95	1.79
	Stewart 2704	2.61 ***	1.00	1.80	1.81
1977	Q 191	2.47 *	1.84	2.27	2.04
	CH 591-36	1.38	1.60	1.66 *	1.31
1978	Bc 23	4.42 ***	1.08	2.77	2.71
	Bc 9A	4.52 ***	1.02	2.76	2.79
	Bc 9A X Bc 23	5.80 ***	1.00	3.36	3.44
1979	Bc 23	5.90 ***	1.46	4.15	3.21
	Bc 9A	6.29 ***	1.69	3.84	4.14
	Bc 14	8.18 ***	1.72	5.21	4.70
	Bc 6635	3.52 ***	1.50	2.34	2.69
	Bc 9A X Bc 23	4.61 ***	1.72	3.10	3.24
	Bc 14 X Bc 23	5.84 ***	1.50	3.60	3.74
	Bc 6635 X Bc 23	5.13 ***	1.79	3.28	3.62
	Bc 9A X Bc 6635	4.71 ***	1.55	3.33	2.92

[a] Leaf feeding rating: 1 = no feeding, 9 = extensive feeding.
[b] *, ***: significant at the 0.05 and 0.001 levels, respectively.

Table 4. Mean value of plant damage for plots with and without European corn borer and stalk rot

Year	Cultivars	Mean plant damage rating[a]			
		European corn borer		Stalk rot	
		With	Without	With	Without
1975	CO 239	5.29 ***[b]	2.15	4.23	3.89
	Q 191	6.44 ***	2.22	4.14	4.52
	Stewart 2606	5.16 ***	1.81	3.46	3.51
	Stewart 2704	3.33 ***	1.54	2.43	2.44
1977	Q 191	2.05 *	1.29	1.41	1.92
	CH 591-36	1.66	1.10	1.51	1.25
1978	Bc 23	1.85 **	1.14	1.62	1.38
	Bc 9A	2.80 **	2.40	2.84 **	2.36
	Bc 9A X Bc 23	2.42	2.31	2.39	2.35
1979	Bc 23	1.40	1.72	1.82	1.30
	Bc 9A	2.28	1.84	2.41	1.70
	Bc 14	1.46 ***	4.10	3.71 **	1.85
	Bc 6635	1.08	1.58	1.37	1.29
	Bc 9A X Bc 23	2.17	1.85	2.59	1.44
	Bc 14 X Bc 23	2.90	1.94	2.99	1.85
	Bc 6635 X Bc 23	1.93	1.72	2.33	1.32
	Bc 9A X Bc 6635	1.60	1.62	1.70	1.52
1980	Bc 23	2.35	1.75	1.84	2.26
	Bc 9A	3.67	3.02	2.52	4.19
	Bc 14	2.81 **	1.52	1.67 *	2.68
	Bc 6635	2.73	2.12	2.25	2.61
	Bc 9A X Bc 23	2.84	2.46	2.15 *	3.15
	Bc 14 X Bc 23	3.58 **	1.79	2.01 *	3.25
	Bc 6635 X Bc 23	2.42 ***	1.26	1.45 **	2.24
	Bc 9A X Bc 6635	3.19 ***	2.09	2.40 *	2.88

[a] Plant damage rating: 1 = clean plant, 10 = plant broken below the ear.
[b] *, **, ***: significant at the 0.05, 0.01, and 0.001 levels, respectively.

Table 5. Mean value of tunnel length over plant height ratio (TPHR) for plots with and without European corn borer and stalk rot

		Mean TPHR[a]			
		European corn borer		Stalk rot	
Year	Cultivars	With	Without	With	Without
1975	CO 239	0.349 ***[b]	0.016	0.155 ***	0.209
	Q 191	0.436 ***	0.038	0.221	0.253
	Stewart 2606	0.456 ***	0.031	0.221	0.266
	Stewart 2704	0.422 ***	0.031	0.212	0.241
1976	CO 239	0.153 ***	0.008	0.087	0.072
	T 341	0.197 ***	0	0.140 **	0.058
	MR21 X ZPR2077	0.139 ***	0.008	0.079	0.068
	R588 X T146	0.080 ***	0.006	0.041	0.046
1977	Q 191	0.100 **	0.006	0.053	0.054
	CH 591-36	0.023 ***	0.002	0.010	0.016
1978	Bc 23	0.017 **	0.002	0.004 *	0.014
	Bc 9A	0.101 ***	0	0.065	0.036
	Bc 9A X Bc 23	0.029 ***	0.001	0.017	0.013
1979	Bc 23	0.043 ***	0.001	0.030	0.015
	Bc 9A	0.086 *	0.016	0.042	0.060
	Bc 14	0.123 ***	0.006	0.063	0.065
	Bc 6635	0.164 ***	0.006	0.086	0.084
	Bc 9A X Bc 23	0.040 ***	0.001	0.023	0.019
	Bc 14 X Bc 23	0.101 ***	0.001	0.042 *	0.060
	Bc 6635 X Bc 23	0.051 **	0.002	0.014 *	0.040
	Bc 9A X Bc 6635	0.063 ***	0.002	0.031	0.035
1980	Bc 23	0.054 ***	0.005	0.039 *	0.020
	Bc 9A	0.059 ***	0.011	0.021 *	0.049
	Bc 14	0.165 ***	0.086	0.046	0.048
	Bc 6635	0.146 ***	0.015	0.070	0.092
	Bc 9A X Bc 23	0.028 **	0.001	0.016	0.013
	Bc 14 X Bc 23	0.046 ***	0.007	0.035 *	0.019
	Bc 6635 X Bc 23	0.021 **	0.002	0.012	0.012
	Bc 9A X Bc 6635	0.079 ***	0.001	0.032	0.048

[a] TPHR is the total length of tunnels in cm in a plant divided by its height.
[b] *, **, ***: significant at the 0.05, 0.01, and 0.001 levels, respectively.

All cultivars in all years showed a significant effect of ECB artificial infestation on TPHR (Table 5). In all occasions, the presence of ECB increased TPHR as expected. In eight cases, a significant effect of stalk rot was found. In five instances, the presence of stalk rot decreased the TPHR confirming the observations from harvest damage. However, for the other three cases, the presence of stalk rot increased the TPHR. The impact of the presence of stalk rot on the feeding of ECB larvae thus remains unclear.

Yield was highly affected by the cultivar used and significant effects were found for ECB presence in 1975, 1976, 1979 and 1980. The presence of stalk rot had a significant effect ($P \leq 0.01$) on yield only in 1979 (Table 2).

Significant effects of ECB artificial infestation on yield were found in less than half the cultivars and years evaluated. In all instances, however, the presence of ECB decreased yield significantly (Table 6). The presence of stalk rot was associated with significant decrease in the yield on five occasions but with an increase on another occasion.

The strong impact of ECB artificial infestation on leaf feeding and TPHR was expected. Leaf feeding reflects the establishment of the young larvae within the plant and as such the significance of this factor indicates that the artificial infestations were successful. TPHR is a measure of the development of the larvae within the plants and indicates that plants in ECB treatment plots had larvae within their

stalks. For both these measures, the presence of stalk rot had no consistent effect. The feeding of young ECB larvae or their establishment in the stalk was not influenced by the presence of stalk rot. In New York State, interactions between ECB infestation and stalk rot caused by *Colletotrichum graminicola* (Ces.) Wils. varied between years and according to the stage at which the artificial infestation was made (Keller *et al.* 1986).

Differences in damage at harvest or yield between cultivars or years should reflect how individual cultivars react to ECB attack. As such, the results obtained for plant damage at harvest and yield are easier to explain. Years like 1975 and 1976 showed a large impact of the presence of ECB on both plant damage and yield for most cultivars. Three yugoslavian hybrids, Bc14XBc23, Bc6635XBc23 and Bc9AXBc6635, showed no significant effect on plant damage or yield following artificial infestation from ECB in 1979 but these effects appeared in 1980. Again, for these indices, the presence of stalk rot had no consistent effect.

From these results, it appears that although stalk rot can have a significant effect on plant damage and yield of maize, no consistent link exists between this infection and the presence of ECB. These results agree in general with those of Carson and Hooker (1981) and Foott and Timmins (1983) who found no association between severity of stalk rot and ECB infestations, and so disagree with those of Christensen and Schneider (1950), Chiang

Table 6. Mean value of maize yield for plots with and without European corn borer and stalk rot

		Mean yield (g plant^{-1})			
		European corn borer		Stalk rot	
Year	Cultivars	With	Without	With	Without
1975	CO 239	40.4 ***[a]	90.9	59.6	71.7
	Q 191	0 ***	53.7	26.7	27.1
	Stewart 2606	96.8 ***	158.8	129.4	126.2
	Stewart 2704	125.4 ***	181.8	148.8 *	158.5
1976	CO 239	77.2 **	92.2	85.7	83.7
	T 341	42.6 *	50.8	46.6	46.7
	MR21 X ZPR2077	83.6 ***	112.6	95.9	100.2
	R588 X T146	105.4 **	112.4	105.7 **	112.1
1977	Q 191	25.3	36.8	30.6	31.5
	CH 591-36	14.4	12.9	12.2	15.2
1978	Bc 23	42.5	41.4	36.4 *	47.5
	Bc 9A	55.1	57.5	54.9	57.6
	Bc 9A X Bc 23	140.1	148.9	141.1	147.9
1979	Bc 23	16.6	17.2	10.1 *	23.7
	Bc 9A	27.2	32.9	29.1	31.0
	Bc 14	22.0	34.3	24.5	31.7
	Bc 6635	14.9 ***	37.3	21.9 *	30.3
	Bc 9A X Bc 23	79.4	92.7	80.4	91.8
	Bc 14 X Bc 23	97.4	113.7	95.6	115.5
	Bc 6635 X Bc 23	96.9	95.4	97.7	94.7
	Bc 9A X Bc 6635	84.2	81.8	80.0	86.0
1980	Bc 23	31.1	36.2	30.0	37.3
	Bc 9A	42.4	38.4	40.8	40.0
	Bc 14	29.3 **	43.7	37.3	35.8
	Bc 6635	32.0	32.1	34.8 *	29.3
	Bc 9A X Bc 23	104.4	101.1	103.3	102.1
	Bc 14 X Bc 23	103.7 **	125.1	109.2	119.6
	Bc 6635 X Bc 23	113.0	120.8	111.9	121.9
	Bc 9A X Bc 6635	91.0 **	102.6	97.0	96.6

[a] *, **, ***: significant at the 0.05, 0.01, and 0.001 levels, respectively.

and Wilcoxson (1961) and Jarvis *et al.* (1982). Those observations were made on the bivoltine strain of *O. nubilalis* and the present results are based on observations of the univoltine strain that is dominant in Québec.

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