Canadian Plant Disease Survey

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The *Canadian Plant Disease Survey* is a periodical of information and record on the occurrence and severity of plant diseases in Canada and on the assessment of losses from disease. Other original information such as the development of methods of investigation will also be accepted. Review papers and compilations of practical value to plant pathologists will be included from time to time.

L'Inventaire des maladies des plantes au Canada est un périodique d'information sur la fréquence des maladies des plantes au Canada, leur gravité, et les pertes qu'elles occasionnent. La rédaction accepte d'autres communications originales, notamment sur la mise au point de nouvelles méthodes d'enquête. De temps à autre, l'inventaire inclut des revues et des synthèses de rapports d'intérêt immediat pour les phytopathologistes.

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Mycoflora and condition of grains from overwintered fields in Manitoba, 1977-78[1]

J.T. Mills[2] and Ch. Frydman[3]

Cereal and oilseed crops that remained in the field over winter in an area east of the Red River in Manitoba had a high proportion of wrinkled seeds and black non-germinable embryos when sampled during 21 April to 3 May 1978. The low germination was due to late fall and winter weather conditions and molds rather than to dormancy. Corn cobs were frequently damaged by voles. Crops examined were severely weathered and were later either burnt or ploughed under rather than fed to animals. The mycoflora of cereal seeds consisted mainly of preharvest fungi, particularly *Alternaria alternata*. *Cladosporium cladosporioides* predominated on corn. The main *Fusarium* spp. isolated were *F. tricinctum, F. poae, F. sporotrichioides, F. avenaceum, F. acuminatum* and *F. sambucinum*. There was a much higher frequency of seed-borne *Fusarium* spp. isolated from overwintered crops than from crops collected from an adjacent area the previous wet fall. Thus, 12 to 52% (mean 33%) of wheat seeds from 9 fields were contaminated with *Fusarium* spp. compared to 0 to 20% (mean 2.5%) of wheat seeds from 21 swathed fields sampled in the fall. Similar high levels of *Fusarium* spp. occurred in seed samples from 16 overwintered fields of barley, oats, corn and flax.

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À l'occasion d'un échantillonnage réalisé du 21 avril au 3 mai 1978, les céréales et les oléagineux laissés sur pied tout l'hiver dans une région située à l'est de la rivière Rouge ont révélé une proportion élevée de grains ratatinés et d'embryons noircis non germables. La chute des capacités de germination s'expliquerait davantage par les conditions météorologiques survenues en fin d'automne et durant l'hiver que par des phénomènes naturels de dormance. En maintes circonstances, les épis de maïs étaient endommagés par les campagnols. La microflore des graines consistait essentiellement en champignons déjà présents avant la récolte normale, notamment *Alternaria alternata* (Fr.) Keissler. *Cladosporium cladosporioides* (Fres.) de Vries a été l'espèce prépondérante sur le maïs. Les principales espèces de *Fusarium* isolées des cultures hivernées étaient *F. tricinctum* Corda (Sacc.), *F. poae* (Peck) Wollenw., *F. sporotrichioides* Sherb., *F. avenaceum* (Fr.) Sacc., *F. acuminatum* Ell. et Ev. et *F. sambucinum* Fuckel. On a relevé une fréquence beaucoup plus forte de *Fusarium* spp. sur les grains hivernés que sur les grains prélevés sur les cultures non récoltées examinées au cours de l'automne pluvieux de 1977. Ainsi, de 12 à 52% (moyenne 33%) des grains de blé prélevés sur 9 champs étaient porteurs de *Fusarium*, contre seulement de 0 à 20% (moyenne 2,5%) pour les grains de blé obtenus de 21 champs andainés l'automne précédent. Des fréquences élevées de *Fusarium* ont été également observées chez des échantillons de grains hivernés provenant de 16 champs d'orge, d'avoine, de maïs et de lin.

It is not unusual for crops to be left in the field in Manitoba over winter due to an early snowfall. This happens in areas of up to 100 x 100 km, approximately once every 4 years and in larger areas about once every 8 years (personal communication, Hayden Tolton, Manager, Manitoba Crop Insurance Corporation). Other factors leading to unharvested overwintered crops include date of seeding, geographical location, and the soil and climatological conditions during the growing season and at harvest. The areas most likely to experience snow-covered unharvested crops are the Russell-Grandview-Roblin-Swan River and Interlake regions and the area east of the Red River (Fig. 1) although, if lasting snow comes very early, most of the crop-growing area of the province can be affected. This last happened in 1959 when all crop land 300 m above sea level west of a line through The Pas, MacGregor, and the United States border was covered with deep snow in early October.

Overwintered crops usually have a severely weathered appearance after exposure above or lying under the snow and subsequently lying in water for long periods, as might occur in the poorly drained soils of the Interlake region and east of the Red River. They are feed rather than seed material. However, farmers who feed such material to animals such as chickens, may encounter sickness in their stock if overwintering conditions are conducive to development of mycotoxigenic fungi (7). Snow-covered crops on the medium- to well-drained soils in the upland areas of northwest Manitoba including Russell, Grandview, Roblin, and Swan River usually overwinter in better condition. Cereals harvested in spring in those areas suffer only slight weight loss, show slight weathering but often grade dry and will meet commercial grade requirements.

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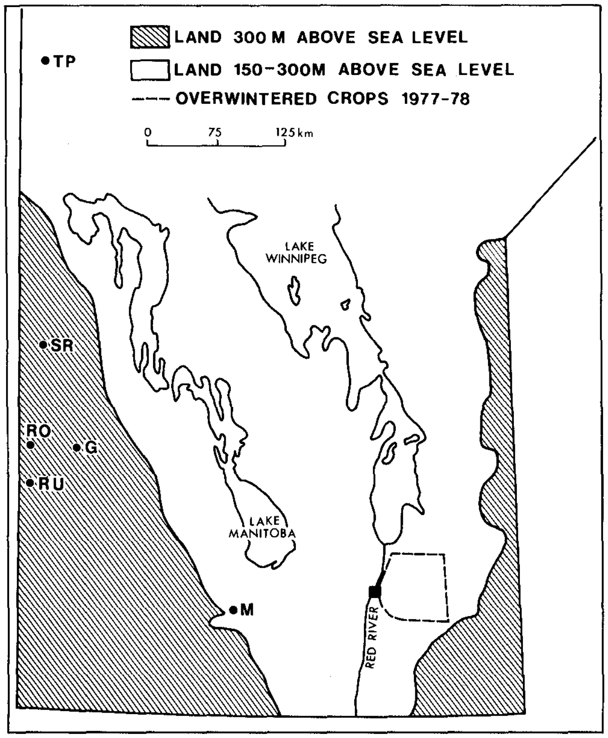

Fig. 1. Relief map of Manitoba showing locations with a history of overwintered crops. G = Grandview, M = MacGregor, Ro = Roblin, Ru = Russell, SR = Swan River, and TP = The Pas.

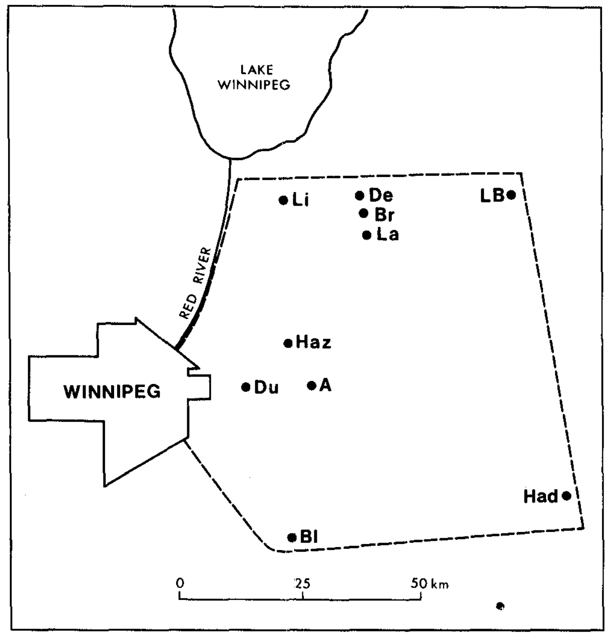

Fig. 2. Map of the east Red River region of Manitoba showing the area of overwintered crops under investigation during spring 1978. A = Anola, Bl = Blumenort, Br = Brokenhead, De = Dencross, Du = Dugald, Had = Hadashville, Haz = Hazelwood, La = Ladywood, LB = Lac du Bonnet, and Li = Libau.

The normal harvest months of August and September 1977 in Manitoba were particularly wet, delaying harvesting operations until October and November. In mid November, a heavy snowfall occurred east of the Red River in an area of poorly drained soils. Crops of wheat, oats, barley, flax, and corn were covered with snow. In view of the paucity of information on overwintered crops under Manitoba conditions, the salient characteristics of these crops were documented the following spring.

Materials and methods

Collection of samples

Samples were taken from 25 fields in a 60 x 80 km area bounded by Winnipeg, Libau, Lac du Bonnet, Hadashville, and Blumenort, Manitoba (Fig. 2), during 21 April to 3 May 1978. The fields were located through reports received from farmers by the Manitoba Crop Insurance Corporation and included nine of wheat, five of oats, two of barley, five of corn and four of flax. Approximately the same number of standing and swathed fields were sampled. About 500 cereal stems with attached heads, 100 corn cobs or several large armfuls of flax were obtained at random after walking 150 paces into the fields. The crop appearance, vole damage, soil conditions and the occurrence of snow or standing water were noted.

Processing of samples

A representative selection was made from each field sample on arrival at the laboratory and notes made on the extent of shattering of seeds and heads, brittleness of stems, visible fungi on the seed surface and on the glumes, lemmas, paleas or stems, and on the extent of vole damage, blackening of immature exposed grains on corn cobs, and splitting of bolls of flax. Samples were air dried before the seeds could be removed by threshing or hand rubbing and notes made on extent of embryo damage, seed shrinkage and wrinkling, and peeling of flax seeds. Seed samples were then examined by several physical and biological techniques to assess condition. The germinability of each sample was determined by standard seed testing methods (4); additional samples of wheat, oats, and barley were moistened with 0.2% KNO_3 solution, prechilled for 3 to 4 days at 10°C and were then germinated at 20°C. Both KNO_3 solution and prechilling are aids used for breaking seed dormancy. Further samples of each lot were examined by the tetrazolium test (1) which also permits separation into viable and non viable fractions.

Filter paper soaked in water (FP), filter paper soaked in 7.5% NaCl solution (SFP) (10), and potato dextrose agar (PDA) were used to determine types of fungi present on the seeds. One hundred seeds were placed on FP and PDA dishes and 50 on SFP dishes, with 25 cereal or flax seeds, or 10 corn seeds per dish. Five ml of solution were added per dish for corn and 4.5 ml for cereal and flax seeds. The FP, SFP and PDA dishes were incubated and the fungi identified following the methods described earlier (10).

Results

Field and crop characteristics

Snow was 0 to 20 cm deep at sampling in two corn fields at Blumenort (Fig. 3). The remainder of the fields were sampled soon after the snow had melted. The soil was often very wet, with water sometimes lying on the surface. Most uncut cereals were badly weathered and severely lodged (Fig. 4). Standing uncut corn and flax stems often remained upright. The height of the lowest corn cobs above the ground varied from 10 to 60 cm. Damage to corn cobs by meadow voles [*Microtus pennsylvanicus* (Ord)] and prairie voles [*M. ochrogaster* (Wagner)] (2), was severe in fields with cobs close to the ground. The voles were abundant under cereal swaths and their nests and runways were in all the sampled fields.

Cereal stems from overwintered fields were usually brittle. Head breakage and kernel shattering was most common in oats and barley. Dried roots, 1 to 3 cm long, were observed emerging from heads of wheat from swathed fields 4, 11, and 13. The tips of the corn cobs extending beneath the cob sheaths were often blackened, probably the result of immature kernels becoming frost damaged then invaded by fungi. The effect varied from field to field; blackening on cobs from fields 1, 16, 20, 24 and 25 extended on average 6, 12, 2.5, 2.5 and 0 cm from the tip, respectively. The extent of blackening could have been related to crop maturity. Vole damage to cobs was very severe in field 16 with many gnawed seeds, severe in fields 1 and 24, very slight in field 25 with only a few tooth marks on the cobs, and absent in field 20. The flax stem fibres varied in strength; those from fields 12 and 19 were very brittle whereas those from fields 6 and 23 were exceedingly strong.

Most wheat seeds were bleached and had gray or darkened brush ends; frequently frost wrinkles (11) were also visible. Low amounts of sprouted seeds were present in samples from fields 7 and 13 and of shrunken kernels in field 14. Most barley seeds examined had loose hulls and the dehulled seeds were dark and wrinkled. A high proportion of oat seeds had medium to heavy discoloration, especially at the apices; embryos of samples from fields 21 and 22 were black and the dorsal part of the seed including the embryo was mummified. Corn seeds were often wrinkled with wrinkling most

Fig. 3. Overwintered corn (field 24) north of Blumenort, Manitoba on 21 April 1978, showing broken plants in deep snow.

Fig. 4. Overwintered wheat (field 2) north of Anola, Manitoba on 25 April 1978, showing lodging after snow melt.

prevalent in samples from fields 1 and 16; moderate amounts of small shrivelled seeds were present in samples from fields 1 and 20, discolored seeds from fields 1 and 16, and dark embryos from fields 1, 16, 20, and 24. Most flax seeds were discolored and exhibited probable frost damage consisting of blistered, cracked and split seeds with the lining of the pods often adhering to the seeds.

Germination

Seed germination was generally low (Table 1). Normal germination varied from 1 to 47% of non-prechilled seeds from the nine sampled wheat fields. Corresponding figures for oats were 3 to 13% of seeds with normal germination, for barley 7%, for corn 3 to 24% and for flax 16 to 37% of seeds. Similar figures were obtained in the tetrazolium test with 0 to 32% of wheat seeds germinable, 4 to 14% of oat seeds, 7 to 10% of barley seeds, 4 to 25% of corn seeds and 19 to 45% of flax seeds. Dormancy, as shown by the presence of ungerminated seeds and increased normal germination after prechilling, was demonstrated only in seeds from field 18 of barley. It is likely, therefore, that the low figures obtained for normal seed germination in most other lots are the result of severe late fall and winter weather conditions and molds and are not due to dormancy.

Microflora

Preharvest fungi were visible on the surface of cereal heads particularly on the paleas and lemmas of oats. Spores of *Alternaria alternata* (Fr.) Keissler and of the imperfect state of *Cochliobolus sativus* (Ito and Kurib.) Drechsl. ex Dastur were common on cereal seeds, and spores of *Epicoccum purpurascens* Ehrenb. ex Schlecht and *Ulocladium atrum* Preuss on dehulled oat seed. *Cladosporium cladosporioides* (Fres.) de Vries commonly occurred on the stems, cob sheaths, and kernels of corn. Conidial heads of the *Aspergillus glaucus* group and of *Monilia sitophila* (Montagne) Sacc. were present between the kernels of cobs from field 24. The bolls and seeds of flax were free of obvious fungal contamination but several fungi, including *Pleospora herbarum* (Pers. ex Fr.) Rabenh., *Phoma* spp., and rust [*Melampsora lini* (Ehrenb.) Lév.] urediospores occasionally were observed on the stems.

Stem rust (*Puccinia graminis* Pers. f. sp. *avenae* Eriks. and E. Henn) urediospores and teliospores were often seen on the dehulled seeds, inside the glumes and on the stem and leaf sheaths of oats. The prevalence of this fungus reflects the widespread nature of an epidemic of the disease which resulted in loss of much of the late oat crop during 1977. Affected crops had a weathered appearance caused by premature senescence of the plants and a grey-white discoloration of the heads.

Table 1. Germinability of seeds from overwintered fields.

Crop	Field No.	Location	Standing (St) or Swathed (Sw)	Not prechilled: % Germination Normal	Not prechilled: % Germination Abnormal	Not prechilled: % Dead	Not prechilled: % Fresh ungerminated (dormant)	Prechilled: % Germination Normal	Prechilled: % Germination Abnormal	Prechilled: % Dead	Prechilled: % Fresh ungerminated (dormant)	Tetrazolium test: % Germinable	Tetrazolium test: % Abnormal	Tetrazolium test: % Non-germinable
Wheat	2	Anola	Sw	2	1	97		2	1	97		2	2	95
	4	Ladywood	Sw	24	6	69	1	13	6	80	1	13	13	74
	7	Dencross	St	17	2	81		11	3	85	1	12	8	80
	8	Brokenhead	St	29		71		21	4	75		11	13	76
	11	Libau	Sw	22	3	74	1	22	7	71		12	8	80
	13	Libau	Sw	10		90		10	1	89		3	5	92
	14	Libau	Sw	9		91		9	1	90		8	3	89
	15	Richtot	Sw	1		99		1		99			1	99
	17	Oakbank	Sw	47	8	45		48	14	38		32	30	38
Oats	3	Ladywood	St	5		95		6	1	93		5	3	92
	5	Ladywood	Sw	13	2	85		11		89		11	6	83
	9	Dencross	St	11	1	88		19	3	78		14	5	81
	21	Ladywood	Sw	3	1	96		6	2	92		4	6	90
	22	Ladywood	St	9	4	87		6	1	93		4	4	92
Barley	10	Libau	St	7		93		13	5	82		10	14	76
	18	Hazelridge	St	7	2	80	11	19	2	79		7	11	82
Corn	1	Anola	St	4		96						6	16	78
	16	Dugald	St	21	5	74						25	24	51
	20	Anola	St	3	3	94						4	63	33
	24	Blumenort	St	24	2	74						20	25	55
	25	Blumenort	St	12	5	83						18	62	20
Flax	6	Ladywood	Sw	37	4	57	2					33	25	42
	12	Libau	Sw	29	3	68						45	21	34
	19	Dugald	St	16	4	80						19	10	71
	23	Ladywood	Sw	35	8	37						43	24	33

The frequency of occurrence of seed microfloral components after plating seeds on various media is given in Table 2. Preharvest fungi predominated on wheat, oat, and barley seeds and included *Alternaria alternata*, *Cochliobolus sativus*, *Fusarium* spp., including *F. tricinctum* (Corda) Sacc., *F. poae* (Peck) Wollenw., *F. sporotrichioides* Sherb., *F. avenaceum* (Fr.) Sacc., *F. acuminatum* Ell. & Ev., *F. sambucinum* Fuckel, and *Epicoccum purpurascens*. *Alternaria, Fusarium, Cochliobolus*, and *Epicoccum* were present on an average of 87%, 35%, 12%, and 2% of the sampled cereal seeds respectively. The preharvest fungus *Cladosporium cladosporioides* and all harvest fungi, including *Gonatobotrys simplex* Corda and *Cephalosporium acremonium* Corda, occurred at low levels. Trace amounts of *Acremoniella atra* Sacc., *Papulospora* sp., and *Trichoderma viride* Pers. ex S.F. Gray also occurred. Myxomycetes and nematodes were seen occasionally. Postharvest fungi, including *Mucor, Penicillium*, and *Rhizopus*, occurred in trace amounts.

Preharvest fungi also predominated on corn but the frequency of occurrence of the species differed markedly from that on cereals. *Cladosporium cladosporioides* was the dominant fungus followed by *A. alternata, Fusarium* spp., *E. purpurascens*, and *Nigrospora oryzae* (Berk. and Br.) Petch. *Cladosporium, Alternaria, Fusarium, Epicoccum*, and *Nigrospora* were present on an average of 81%, 51%, 35%, 9%, and 7% of the sampled corn seeds, respectively. Harvest fungi, including *Cephalosporium, Gonatobotrys, Paecilomyces bacillisporus* Onions and Barron, and *Papulospora* sp. occurred in trace amounts. *Penicillium* spp. and *Mucor* sp. were commonly identified from corn but *Aspergillus* spp. were rarely isolated.

The preharvest fungi on flax seed consisted mainly of *Alternaria* and *Fusarium* together with low amounts of *Cladosporium, Cochliobolus*, and *Epicoccum*. *Alternaria* and *Fusarium* were present on an average of 78% and 34% of the flax seeds sampled, respectively. Harvest and postharvest fungi were negligible on flax seed.

Discussion

The poor condition of seeds from overwintered fields in the region east of the Red River in the spring of 1978 was determined partly by the status of the crops the previous fall and partly by the ecological factors which affected the crops during winter and early spring.

Many Manitoba crops were in swath for prolonged periods during the very wet summer and early fall of 1977 and were in contact with the moist soil, resulting in sprouting, proliferation of preharvest fungi, and even development of slime molds or myxomycetes. Myxomycetes isolated from overwintered crops were considered to be remnants of high levels the previous fall. Similarly, splitting of flax bolls occurred the previous wet fall, not

Table 2. Mycoflora of cereal and oilseeds from overwintered fields.

		% Frequency of occurrence of microfloral components+ on seeds																															
		FP (filter paper with added water)														SFP (filter paper with added NaCl solution)								PDA (potato dextrose agar)									
Crop	Field No.	Al	As ca	As fl	Ce	Cl	Co	Ep	Fu	Go	Mu	Ni	Pe	Rh	My	Al	As ca	As gl	Ce	Cl	Fu	Ni	Pe	Al	Cl	Co	Ep	Fu	Go	Mu	Ni	Pe	Rh
Wheat	2	100					4	1	16	7						62								95		6	3	4				1	
	4	100					24	2	23	8						70								100		39	13	29	3				
	7	87			9		13		39	1			1			68			2		6			82		27		2	12				4
	8	80					18	1	22	3						46								68		55	18	10	1				
	11	53			1		9		52							48								61		27	17	55					7
	13	79			2		6		45	8						62					10			100		82	29	43	7				
	14	75			2		11	1	46	4						66								100		64	17	48	14				
	15	84			1		4	3	38	6						56								100		86	6	29	13				
	17	89					26	2	12	2						34								100		87	10	18	10			2	9
Oats	3	100					5	2	19	25						90								96		20	50	46	11				
	5	100				10	8	9	7	5						94				2				100		52	39	23	8				
	9	91			2		9	6	54	4					2	72				6				100	2	49	28	41	1				
	21	94			7		1		68		7					100				12			2	100		63	48	45	37				
	22	98			9	3	16	3	58	13			3		2	100								100		92	42	25	33				
Barley	10	75				1	26		46	5						56								95		84	19	24					15
	18	87			2		11	2	20	7						100				2				90		60	12	24	21				39
Corn	1	92		1		90		11	18		1	3	2	1		6			4	86		10	4	99	100		4	88		42	2	5	10
	16	56				63		1	34	3	12	2	45	3		6				18	8	2	96	100	100		1	72		100		100	100
	20	42				90	2	10	39	2		19	1							80		6	16	100	100		15	23		32	10	1	11
	24	49				78		28	33			9	3			4		2		84	6	12	40	100	100		14	40		30	2	1	
	25	17				87		5	53	7	7		11			2	2	8	4	82	12	4	56	100	100		7	29		37	3	10	
Flax	6	89	1		1				46	4						88				10			4	100			6	4	2			6	20
	12	68			1				34	8						88							2	100		17	6	15	7	2			10
	19	62							28	29						70								92				50	65			1	
	23	92							28	7						62		2		2				100		1		10	7			6	10

+ Al = *Alternaria alternata;* As ca = *Aspergillus candidus* Link ex Fr.; As fl = *Aspergillus flavus* Link ex Fr.; As gl = *Aspergillus glaucus* group; Ce = *Cephalosporium acremonium;* Cl = *Cladosporium cladosporioides;* Co = *Cochliobolus sativus,* imperfect state; Ep = *Epicoccum purpurascens;* Fu = *Fusarium* spp. including *F. tricinctum* (Corda) Sacc.; *F. poae* (Peck) Wollenw.; *F. sporotrichioides* Sherb.; *F. avenaceum* (Fr.) Sacc.; *F. sacchari* Butler (W. Gams); *F. oxysporum* Schlecht.; *F. acuminatum* Ell. & Ev., *F. sambucinum* Fuckel and *F. sulphureum* Schlechtendahl, Go = *Gonatobotrys simplex;* Mu = *Mucor* spp.; Ni = *Nigrospora oryzae;* Pe = *Penicillium* spp., mainly *P. verrucosum* var. *cyclopium;* Rh = *Rhizopus arrhizus* Fischer and My = myxomycete spp.

during the winter or wet spring. Splitting of the bolls, which exposes the seeds to weathering, was reported during the wet harvest of 1941 (Winnipeg Free Press, September 26) and was also observed in samples of the 1977 crop obtained before the arrival of the permanent snow. The adverse weather conditions in the fall of 1977 severely affected seed weight of flax, with many Manitoba growers reporting low bushel weight (G. Platford, Manitoba Department of Agriculture, personal communication). The conditions favored development of pasmo disease, causal organism *Septoria linicola* (Speg.) Garov., which bands the stems and affects the pedicels of flax. Although the problem was widespread, we did not observe spores of this fungus on flax stems from sampled fields.

Certain features exhibited by the overwintered crops can be attributed to winter conditions. Many of the kernels showed surface wrinkling resembling frost damage (11). Whitcomb and Johnson (12), in a study of overwintered wheat in stooks under snow, also observed that kernels had a crinkled appearance. They observed more crinkled kernels in wheats which had been subjected to alternate freezing and thawing than in wheats subjected to continuous cold, the number of crinkled kernels increasing as the exposure progressed from December 18 to April 16. Also, many corn cobs were damaged by meadow voles the breeding and survival of which was favored by ample food from unharvested crops and a protective blanket of snow. Breeding of the meadow vole normally terminates in October but may continue until February under ideal conditions (2). Judging by the prevalence of voles and signs of their activity, ideal breeding conditions occurred in some of the fields in the winter of 1978.

Germination of seed samples, collected the previous fall from 21 swathed and standing wheat fields in an adjacent 60 x 60 km area west of the Red River, averaged only 10% (9). The low germination was probably due to postharvest dormancy accentuated by the cool moist conditions. In the present work, overwintered seeds were either of low germination (Table 1) or dead or ungerminable with mummified black embryos, as occurred in oats and barley. Many of the seeds probably started to germinate the previous fall but were killed by the severe cold or by preharvest fungi, e.g. *Fusarium* spp. and *Cochliobolus sativus,* which can continue to grow at seed moisture contents above 20-21% (5). Strains of these fungi are known to reduce seed germination (6). In our survey, no correlations were evident between the number of dead seeds in a sample (Table 1), the occurrence of a particular preharvest fungus (Table 2), the seed or soil moisture, or other field conditions. The microflora of overwintered cereal seeds was similar to that of seeds collected from unharvested fields in an adjacent area the previous wet fall (9) except for a much higher frequency of *Fusarium* spp., particularly *F. poae* and *F. sporotrichioides,* in overwintered samples. Thus, 12 to 52% (mean 33%) of wheat seeds from 9 fields were contaminated with *Fusarium* spp. compared to 0 to 20% (mean 2.5%) of wheat seeds from 21 swathed fields sampled in the fall. Similar high levels (mean 35%) of *Fusarium* spp. occurred in seed samples from 16 overwintered fields of barley, oats, corn and flax. *Fusarium poae* and *F. sporotrichoides* were shown by Joffe (7) to cause toxicoses in humans in Russia after ingestion of overwintered cereal grains. Joffe further showed that only grain in contact with the soil during the winter-spring period developed toxicity and that toxin formation was favored by deep snow cover and relatively high temperatures which favored repeated thawing and freezing (8). In the affected area of Manitoba, heavy snowfalls of up to 42 cm occurred during the 15th-20th November at Beausejour and other points (3), temperatures were below normal from late fall to early spring and the ground remained covered with snow until April. Presently, we do not know whether conditions in the sampled overwintered fields were conducive to production of *Fusarium* toxins. No cases of animal toxicoses were reported in Manitoba during the early summer of 1978 probably because most of the affected crops, largely insured, were either burnt or ploughed under rather than fed to animals. What we have ascertained is that more *Fusarium* species, strains of which are known to be toxigenic, developed on seed in spring than in the previous fall. Extreme caution must therefore be exercised before feeding overwintered grains to livestock and poultry.

Acknowledgements

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Assessment of severity of foliage diseases of cereals in cooperative evaluation tests[1]

Luc Couture

Percentage evaluations of foliage diseases in cereal crops are fairly accurate if a minimum of ten leaves is examined in each plot of a test, a process that takes time. Scoring each plot as a whole on a defined 0-9 scale appears more practical for cooperative tests. Examples of the reaction of oat cultivars to speckled leaf blotch caused by *Septoria avenae* in Québec are presented following the 0-9 scale.

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Les notations en pourcentage des maladies du feuillage chez les céréales sont passablement précises lorsque l'on examine un minimum de dix feuilles par parcelle dans une expérience, ce qui requiert beaucoup de temps. L'évaluation globale de chaque parcelle au moyen d'une échelle définie de 0 à 9 apparaît plus pratique dans les tests coopératifs. On présente des exemples de notations de tache septorienne causée par *Septoria avenae* chez des cultivars d'avoine au Québec, suivant l'échelle 0-9.

Introduction

In assessing the reaction of lines or cultivars of cereals to foliage diseases in evaluation tests, plant pathologists are faced with the problem of selecting the correct method to achieve their goal. The ideal method ought to be reliable, consistent and reproducible, rapid and easy to use, differential, and applicable to all diseases. Basically there are two different approaches to assessment of foliage diseases of cereals: the percentage scales and the arbitrary scales. To preclude repeated mistakes in this matter and to promote more uniformity in cooperative tests, features distinctive of each of these procedures are displayed hereunder.

Discussion

Percentage scales

The percentage procedure can be applied to indicate the proportion of diseased plants in a stand; this is appropriate for diseases which kill plants rather quickly or which cause about the same amount of damage to all the infected plants (Tarr, 1972). Examples are smut diseases. It cannot relate to diseases in which different plants or plant organs show markedly different amounts of infection, such as rusts, powdery mildews and leaf spots.

With reference to leaf diseases of cereals the percentage scale must therefore pertain to disease intensity in individual plants and preferably on a particular leaf level. The percentage figure can be assessed directly by comparing the discoloured area of single leaves with standardized charts such as Cobb's (1892) or its various modifications and James' (1971). It can also be derived by transformation of data from the 0-11 scale of Horsfall and Barratt (1945) which is outlined in Table 1. Starting at 50%, the grades in percentage are altered by a factor of two in either direction, based on diseased tissue below 50 and on healthy tissue above 50. Many users of the latter scale are not aware that one is not allowed to average scores on the 0-11 scale because each category does not correspond to an arithmetic span but rather to a logarithmic span. To average these data it is necessary to transform each individual score beforehand to its corresponding mid-percentage value as given in Table 1 and to process the transformed data. Conversion tables have been prepared to facilitate this operation with all possible combinations of up to five scores (Redman *et al.*).

Table 1. Disease categories of the Horsfall and Barratt rating system

Score	Disease percentage limits*	Disease-free percentage limits*	Disease mid-percentage value**
0	0	100	0
1	0-3	97-100	2,34
2	3-6	94-97	4,69
3	6-12	88-94	9,38
4	12-25	75-88	18,75
5	25-50	50-75	37,50
6	50-75	25-50	62,50
7	75-88	12-25	81,25
8	88-94	6-12	90,62
9	94-97	3-6	95,31
10	97-100	0-3	97,66
11	100	0	100

* In rounded numbers
**Differences between adjoining mid-percentage values unfold by a factor of two in either direction from 50% disease, with exceptions for 0 and 100%.

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In both instances, direct percentage evaluation or 0-11 scale, it is imperative to examine a minimum of ten leaves in each plot to make the survey fairly accurate. Sampling has to be representative. The same leaf level has to be used consistently as disease intensity varies greatly with leaf position. The penultimate leaf is often selected for such assessments.

Arbitrary scales

Arbitrary scales range from no symptoms (usually score 0 or 1) to very severe symptoms (score 5, 10, etc...) with intermediate categories in various numbers corresponding to scores falling between the determined limits. It is agreed that they are usually quite adequate for ranking a series of test plants or plots in order of increasing severity of symptoms when used by competent observers (Russell, 1978).

Arbitrary scales are used to assess the reaction of a whole plant or more simply of a particular leaf or set of leaves. The disease situation of a whole plot can also be integrated in one score; in this perspective we favour the 0-9 scale presented by Saari and Prescott (1975), originally designed for individual plants in wheat. In this instance the level reached by the disease on the foliage as well as the relative disease intensity on each level are taken into consideration in the grading process. Scoring the plot as a whole appears to be as accurate as more detailed methods for determining the amount of disease present (Townsend and Heuberger, 1943).

It is this latest scale that we have been following in our disease survey in evaluation tests of oat cultivars for recommendation to growers in the province of Québec. Results of surveys performed in 1978 and 1979 are presented in Table 2 to illustrate the reaction of oat cultivars to the speckled leaf blotch caused by *Septoria avenae* Frank f. sp. *avenae*. Most oat cultivars show little variation in their response to speckled leaf blotch (Couture and Pelletier, 1975) but one can still segregate the most and/or the least susceptible lines from the others with the 0-9 scale (Table 2).

The principle of the 0-9 scale is the fact that foliar diseases of cereals tend to develop as a disease pyramid, where the lower and oldest leaves are the first and most severely infected. It is particularly useful for those situations where disease is absent or very limited on the upper leaves because of the growth stage of the crop or the particular environment for a given site or a given year as is the case at Macdonald College (Table 2). By assessing those very leaves (usually the penultimate as previously mentioned) on a percentage scale one should not derive the best differential information possible from the test. But by taking into consideration the disease reaction of the whole plant with the 0-9 scale, one may still have a fair evaluation of the relative susceptibility of different lines.

The 0-9 scale has the advantage to require only one column in computer data processing which becomes more and more widespread, making it more desirable than a scale calling for two columns such as 0-10 for instance. Some workers are also tempted to use a scale similar to one often used for lodging, where 1 corresponds to no disease and 5 (or 9, etc...) to maximum disease. This is not acceptable because each assessment is distorted on account of the arithmetic value 1 standing for absence of symptoms (the lowest score). Distortion is a weakness of several assessment scales (Desaymard, 1968). In our opinion it makes it impossible to average such data.

Furthermore, another sizeable advantage of the 0-9 scale over the percentage approach is its adaptability to virus diseases such as yellow dwarf caused by BYDV that gives a disease picture completely different of the conventional rust pustules or leaf spots. Evaluation of this disease in percentage does not reflect the reaction of the plant as the balancing of disease severity on all leaf levels is not respected by a straight percentage. We stress the desirability to evaluate all leaf diseases present in a test with the same scale.

The 0-9 scale of Saari and Prescott (1975) has been adopted by CIMMYT for its international wheat and

Table 2. Disease reaction (0-9) of oat cultivars to speckled leaf blotch in evaluation plots grown at seven locations in Québec in 1978 and 1979.

	Disease severity																
Cultivars	Macdonald College		Saint-Hyacinthe		Lennoxville		Deschambault		Pintendre		La Pocatière		Normandin		Averages		
	1978 g.s.76*	1979 g.s.80	1978 g.s.77	1979 g.s.78	1978 g.s.76	1979 g.s.84	1978 g.s.73	1979 g.s.76	1978 g.s.79	1979 g.s.81	1978 g.s.77	1979 g.s.80	1978 g.s.80	1979 g.s.80	1978	1979	78-79
Ajax	1,5**	---	5,8	---	5,5	---	5,8	---	6,3	---	4,8	---	6,3	---	5,1	---	---
Garry	2,5	2,8	5,5	5,0	5,3	6,3	5,3	7,3	5,0	6,3	4,0	3,3	5,5	5,0	4,7	5,1	4,9
Dorval	3,5	2,5	4,8	5,8	6,0	5,0	6,0	6,5	6,0	6,0	5,0	3,3	5,8	5,3	5,3	4,9	5,1
Yamaska	2,8	3,0	5,0	6,3	6,3	7,8	5,8	8,0	6,8	7,3	5,8	3,3	6,8	5,8	5,6	5,9	5,8
Scott	2,0	3,0	4,8	4,5	5,3	7,8	5,3	7,5	5,0	6,8	3,5	3,0	4,8	5,0	4,4	5,4	4,9
Alma	2,3	2,8	5,3	5,0	5,8	7,8	5,3	6,8	5,8	5,3	3,8	3,8	5,5	3,8	4,8	5,0	4,9
Laurent	2,5	2,5	6,0	5,5	5,3	5,3	5,0	7,8	6,0	6,5	4,0	3,8	5,3	4,5	4,9	5,1	5,0
Oxford	1,5	2,0	5,0	5,0	4,8	5,3	4,3	6,0	5,0	4,8	3,5	3,5	5,0	4,8	4,2	4,5	4,3
Sentinel	1,5	3,3	5,3	5,3	5,5	6,5	5,3	5,5	5,5	5,0	3,8	3,0	5,3	4,8	4,6	4,8	4,7
Manic	3,5	2,3	5,5	5,8	6,0	7,0	5,0	6,0	5,5	5,3	4,3	2,8	5,3	4,5	5,0	4,8	4,9
Foothill	2,3	---	4,8	---	4,3	---	5,3	---	4,8	---	4,3	---	4,5	---	4,3	---	---
Athabasca	4,0	---	6,8	---	6,3	---	6,5	---	7,0	---	6,3	---	7,0	---	6,3	---	---
Lamar	2,3	2,0	4,3	4,0	3,3	4,0	3,3	6,3	4,8	4,3	3,3	2,8	3,8	3,5	3,6	3,8	3,7
Q.O.75.7	---	3,0	---	5,5	---	6,0	---	6,5	---	5,5	---	3,3	---	3,8	---	4,8	---
Cascade	---	4,0	---	6,0	---	7,0	---	8,0	---	7,0	---	5,3	---	6,8	---	6,3	---

* average growth stage (g.s.) of cultivars following the scale of Zadoks *et al.* (1974)
**each assessment is the average of four replicates

barley nurseries (Anonymous). Since descriptive scales are of little use to workers unless they are precisely defined (Tarr, 1972), we should like to add some more precision and modification to the outline of Saari and Prescott (1975). We summarize our considerations in Table 3. The terms free, isolated, scattered, light, moderate and severe are defined in percentage and disease severity is described on all leaf levels for each score. Furthermore, scores are not labeled with a name related to the degree of resistance or susceptibility of the plants in absolute terms such as resistant for 2, intermediate for 5 and susceptible for 8 in Saari and Prescott (1975). These names reflect the reaction prevailing under maximum disease conditions only, which is uncommon. The scale is intended to grade the relative disease severity in plants, not the absolute degree of susceptibility. It is clear that a cultivar with an average score of 6 in Table 2 is definitely susceptible while it would be declared as high intermediate following the terminology of Saari and Prescott (1975).

The use of the 0-9 scale allows one to assess each plot of each replicate of a test within a reasonable period of time to give a fair evaluation of the reaction of each entry. All the plants in a plot are considered as one unit. In the grading process, one can also resort to intermediate values between scores in cases of hesitation.

Growth stages

Whatever method is used, care should be taken to evaluate a test between the medium milk and the soft dough stages of development of the grain. A record of the crop growth stage should be taken accordingly. To determine growth stages of cereals the Feekes scale (Large, 1954) is probably the best known and most widely used but it has the definite weakness of lacking detail in the post-anthesis stages which are the important ones in many cereal disease epidemics. More recently Zadoks *et al.* (1974) developed a decimal code that is more detailed and consequently more accurate than the Feekes scale. It has now been widely recognized as the best scale available and we should recommend it to be used jointly with the 0-9 disease assessment scale. In Table 2, all but one assessments were made between stage 75 (medium milk) and stage 85 (soft dough) of the crop with reference to the scale of Zadoks *et al.* (1974).

Conclusion

In single experiments, the percentage scale is preferred because it can give high accuracy with a sufficient number of leaves. Furthermore the leaf level position can be adjusted to match the particular disease situation in the experimental plots.

But since time is limited to the one pathologist having to survey several or many sites and that all data collected in different tests and/or by different pathologists have to be comparable in cooperative tests, the answer to the initial question raised in the introduction is the extensive use of the 0-9 scale in cereal evaluation tests. It should prove especially useful for large tests with many locations and treatments.

Table 3. Adjustment of the 0-9 assessment scale to defined degrees of disease intensity on various leaf levels of cereals.

Leaf level	Intensity of symptoms* on leaves for each score									
	0	1	2	3	4	5	6	7	8	9
Upper leaves	free	free	free	free	free	free	scattered	light to moderate	moderate to severe	severe
Middle leaves	free	free	free	free	scattered to light	light to moderate	moderate	severe	severe	severe
Lower leaves	free	isolated	scattered	light	moderate to severe	severe	severe	severe	severe	severe

*Free: 0%, isolated: 1%, scattered: 5%, light: 10%, moderate: 25%, severe: 50%.

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Barley stripe mosaic in Manitoba in 1978[1]

Arthur W. Chiko

In 1978, barley stripe mosaic was detected in 36.9% and 4.0%, respectively, of the fields of two-row barley (*Hordeum distichum*) and six-row barley (*H. vulgare*) surveyed in southern Manitoba. The incidence of affected plants in these fields varied from a trace to 35%. In fields of two-row barley, the disease occurred almost as frequently in southwestern Manitoba as it did in southeastern Manitoba, a situation not previously recognized. In these respective regions, it was estimated that barley stripe mosaic virus infection reduced the total seed yield of two-row barley by 0.4% and 0.7%.

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En 1978, la mosaïque de la striure de l'orge a été constatée dans, respectivement, 36,9 et 4% des champs d'orge à deux rangs (*Hordeum distichum*) et à six rangs (*Hordeum vulgare*) inspectés dans le sud du Manitoba. La proportion de plants attaqués variait selon les champs de presque nulle à 35%. Sur l'orge à deux rangs, fait nouveau, la maladie a été observée presque aussi fréquemment dans le sud-ouest que dans le sud-est de la province, et les pertes de rendement résultantes ont été estimées respectivement à 0,4 et 0,7% dans les deux parties.

In 1975, barley stripe mosaic (BSM) was detected in 25% and none of the fields of two-row barley (*Hordeum distichum* L. emend. Lam.) examined in southeastern and southwestern Manitoba, respectively (2). However, while a considerable number of fields of this crop were examined in southeastern Manitoba, only a few fields were examined in southwestern Manitoba. The accuracy of the survey conducted in southwestern Manitoba was thus subject to considerable doubt. Consequently, in 1978 an intensive survey for BSM was conducted in both southwestern and southeastern Manitoba.

Crop Reporting Districts (CRDs) in Manitoba were revised in 1977. However, to conform to area designations used in previous surveys (2), the CRDs referred to in this report are those which existed in 1976 (4) and in previous years. The 1978 survey for BSM was conducted from June 22 to July 7. Fields of two-row barley and six-row barley (*H. vulgare* L. emend. Lam.) in the late tillering to soft dough stage were examined at intervals of about 8 and 24 km, respectively, along preselected routes passing through CRDs 3, 4, 5 and 12 in southeastern Manitoba and CRDs 2, 7, 8, 9, 10, 11, 13 and 14 in southwestern Manitoba. In each field where BSM was detected, leaf samples were collected from affected plants and the presence of barley stripe mosaic virus (BSMV) was confirmed by infectivity and serological assays (1).

Results of the 1978 survey for BSM in Manitoba are summarized in Table 1. As in previous years (1, 2), the disease was encountered much more frequently in fields of two-row barley than in fields of six-row barley. In fields of two-row barley, BSM occurred almost as frequently in southwestern Manitoba as it did in southeastern Manitoba and was detected in all but three CRDs in this province (Fig. 1). No fields of two-row barley were examined in two of these districts and only one field was examined in the other. It thus seems likely that in 1978 BSM was distributed throughout the range of two-row barley grown in Manitoba. The survey conducted in southwestern Manitoba in 1975 (2) was probably not indicative of the occurrence of BSM in two-row barley because of the small number of fields examined.

Losses due to BSMV infection in two-row barley in Manitoba were determined as described previously for

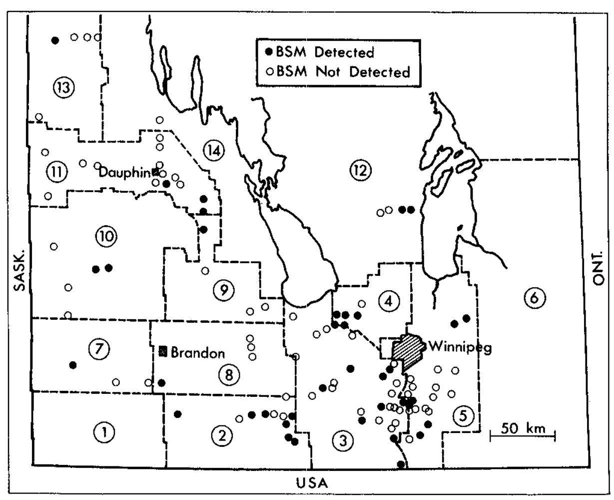

Fig. 1. Distribution of barley stripe mosaic in fields of two-row barley in southern Manitoba in 1978. Numerals designate Crop Reporting Districts in existence in 1976 (4) and in previous years.

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southeastern Manitoba (3). In 1978, it was estimated that the virus reduced the total seed yield of this crop in southwestern and southeastern Manitoba by 0.4% and 0.7%, respectively. Since BSMV occurred only sporadically in six-row barley, the virus probably had little, if any, effect on the total yield of this type of barley.

Table 1. Occurrence of barley stripe mosaic in fields of two- and six-row barley in Manitoba in 1978.

Region surveyed	Type of barley	Fields			No. fields in each infection category (% plants with BSM)				
		No. examined	No. with BSM*	% with BSM	Tr	1-5	6-10	11-20	35
Southeastern Manitoba	Two-row	56	22	39.3	14	3	3	2	-
	Six-row	52	3	5.8	3	-	-	-	-
Soutwestern Manitoba	Two-row	47	16	34.0	9	6	-	-	1
	Six-row	47	1	2.1	-	1	-	-	-

*BSMV transmitted to Black Hulless barley and reacted with BSMV antiserum.

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A deformity of apples of unknown origin

J.T.A. Proctor and E.C. Lougheed[1]

In the 1978 season, deformed apple fruits with longitudinal furrows running from the calyx to stem end were observed in eleven cultivars in the Georgian Bay district and in one cultivar in the Simcoe district of Ontario. The most severely deformed cultivars were 'Idared', 'Cortland', and 'Jonadel'. Severely deformed fruits were acceptable only for juice, causing an estimated $500,000 loss to growers in the Georgian Bay area. The cause of the deformed fruit is not known, but fluctuating temperature during cold acclimation and/or low temperature injury to seeds in developing fruit are suspected.

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Au cours de la saison de 1978, des sillons longitudinaux allant de la cavité oculaire à la cavité pédonculaire sont apparus sur les fruits de onze cultivars de pommier dans les vergers de la région de la Baie georgienne (Ontario). La région de Simcoe a été moins touchée. Les cultivars les plus gravement atteints étaient Idared, Cortland et Jonadel. Les fruits les plus fortement déformés n'étaient plus bons que pour la production de jus, occasionnant ainsi des pertes de près de $500 000 aux pomiculteurs de la région. La cause de la difformité est encore inconnue mais on soupçonne les fluctuations de température survenues au cours de la phase d'acclimatation au froid, ou encore des dégâts causés par le froid aux graines des fruits en cours de développement.

Introduction

In 1966 Davidson and Allen reported the presence of deformed apple fruits in the Georgian Bay (Collingwood) area of Ontario. Deformed fruits were fluted at the blossom end with pronounced depressions to the fruit equator, and the stem cavity was often full. Deformed fruit were observed in six cultivars with most damage occurring on 'Delicious', and 'Cox's Orange Pippin', least on 'Golden Delicious' with 'McIntosh', 'Cortland' and 'Jonadel' showing an intermediate level. Damage was confined to the Georgian Bay district of Ontario.

In the early summer of 1978, it became obvious that as apple fruits developed across Ontario many were misshapen, particularly in the Georgian Bay and Eastern Ontario districts. There were also reports of sporadic winter injury to trees in these and other parts of the Province. In addition there were misshapen apple fruits in the Champlain Valley and Western New York districts of New York State (Blanpied and McNickolas, personal communication).

Because of the extent of the injury, a survey was carried out in two apple producing districts of Ontario. Fruit of the major cultivars were collected in these districts and examined in the laboratory, weather records were analyzed, and the economic loss was estimated.

Materials and methods

Apples were collected before harvest from four orchards in two apple producing districts of Ontario - Georgian Bay (Meaford/Clarksburg), 44°32.5'N, 80°28'W; and Simcoe, 42°51'N, 80°16'W, on the north shore of Lake Erie. In each orchard a 20 kg (1 bu) composite random sample was taken from four trees of each cultivar. The cultivars, 'McIntosh', 'Delicious' and 'Northern Spy' were sampled in all orchards, and in addition, samples of 'Cortland', 'Jonadel', 'Golden Delicious', 'Spartan', and 'Idared' were collected from some orchards.

These fruit were stored in cold storage at 1°C and 90 percent relative humidity until examined. Subsequently sub-samples of 20 fruit were taken from each sample and fruit length and diameter, stem length, deformity rating on a scale of: 1 - no deformity, to 5 - severe deformation (Fig. 1B), and the number of seeds in each fruit were determined.

The experiment was analyzed as a factorial in a completely randomized design.

Results and discussion

The major characteristic of the deformed fruit was longitudinal furrowing running from the calyx to the stem end (Fig. 1A). A range of severity of this furrowing was observed within cultivars and is illustrated for 'Idared' in Fig. 1B. The furrows were often so deep that the fruit were not only unacceptable for the fresh market but unsuitable for peeling as slices and sauce. This meant that they could be sold only as juice apples and therefore brought low returns to the grower.

Economic loss

It is difficult to estimate economic loss. Insurance claims were made by some growers through the Ontario Ministry of Agriculture and Food's Crop Insurance Commission (Mr. W. Regan, personal communication). One packing-house reported an increase in cullage from

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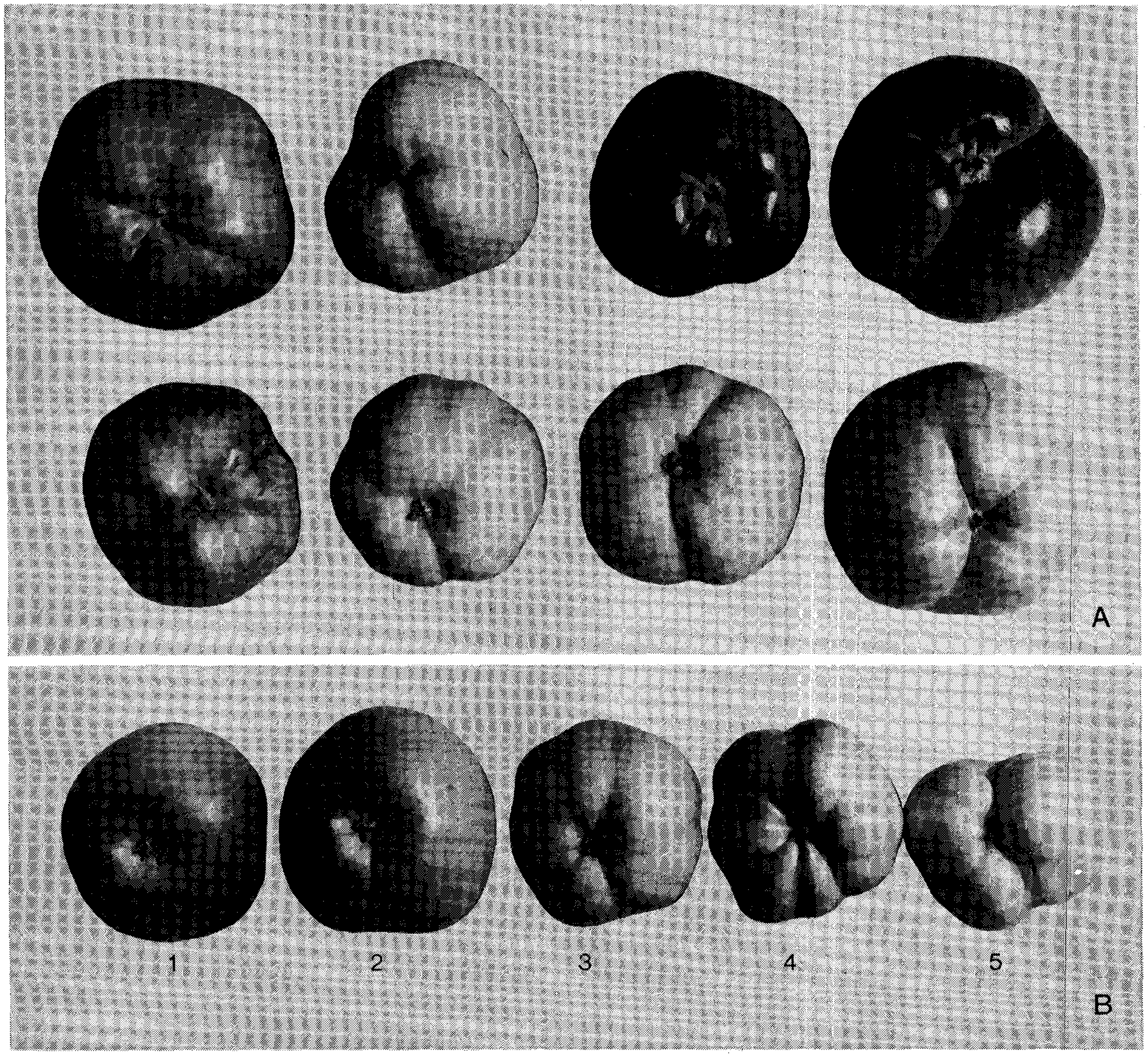

Figure 1 (A and B). (A) Misshapen apple fruits of eight cultivars from Georgian Bay, Ontario. Top row, left to right, McIntosh, Jonadel, Spartan, Cortland; bottom row, left to right, Delicious, Idared, Golden Delicious and Northern Spy. (B) Deformity rating scale using Idared as the example; 1, no deformity; to 5, extreme deformity.

the normal 20 percent to 50 percent (J. Denbok, personal communication). A conservative estimate of crop loss would be about 10 percent of the total crop in the Georgian Bay district. Translated into economic value this would be about $500,000.

Damage by districts

Fruit from Georgian Bay were more severely deformed than those from Simcoe (Table 1). Other differences in fruit occurred between districts. Fruit length and diameter were greater in Simcoe but this is only a measure of fruit size in relation to geographical location. Length-to-diameter ratios for fruit from Georgian Bay and Simcoe are essentially the same suggesting no difference in shape. Fruit pedicel length was also different in the two districts but the reason for this is not known.

Fruits from Georgian Bay had fewer seeds than fruits from Simcoe (Table 1A). Seeds are known to play a role in fruit growth and development so the relationship between seed number and deformity class was investigated. In three of the cultivars there was a significant correlation coefficient in the regression analysis of deformity class on seed number (data not presented). This would suggest some relationship between seeds and fruit deformity. Some of the deformity may be due to seed injury early in the growing season possibly inducing an imbalance in the endogenous plant hormones involved in fruit growth.

Table 1 (A). Mean values by district for deformity class, seed number, pedicel length and fruit length and diameter. All paired values for locations are significantly different at the 0.05 level of significance.

District	Deformity class*	Seed number	Pedicel length (cm)	Fruit	
				length (cm)	diameter (cm)
Georgian Bay	2.50	6.23	21.38	5.39	6.54
Simcoe	1.05	8.41	19.19	5.58	6.87

(B). Cultivar differences by deformity class* in both districts.

Delicious	McIntosh	Northern Spy	Spartan	Golden Delicious	Idared	Cortland	Jonadel
1.57[+]	1.59	1.68	1.75	2.05	2.22	2.40	3.15

*Deformity classes - 1, no deformity, 5 extreme deformity. See Fig. 1B for examples of the classes.
+Means underscored by the same line are not significantly different at the 0.05 level of significance.

The significant district x cultivar interactions for deformity class and seed number indicate more damage to the susceptible cultivars in the Georgian Bay area than in the Simcoe area.

Cultivar sensitivity

Deformed fruit were observed on 11 cultivars in the Georgian Bay district and only on 'Idared' in the Simcoe district (Fig. 1 and Table 1). Cultivars not included in Table 1 but which bore misshapen fruit were 'Lobo', 'Jerseymac' and 'Rhode Island Greening'. This extends Davidson and Allen's list of six cultivars to 12 and includes the "newer' cultivars 'Spartan' and 'Idared' (Proctor 1979). The deformity of 'Idared' in the Simcoe district has been observed there for 8 years (Proctor, unpublished data) and is particularly obvious during early fruit growth. 'Idared' was selected from the cross 'Jonathan' x 'Wagener' and since 'Wagener' fruit are sometimes misshapen (Beach 1905) 'Idared' may have inherited this characteristic from 'Wagener'. Other cultivars severely damaged were 'Cortland' and 'Jonadel' (Table 1B).

Within the Georgian Bay district fruit damage was less at 270 m elevation and remote from the lake, than at 210 m elevation and closer to the lake. This would suggest spring frost damage due to lack of drainage of cold air. Good air drainage within the affected orchards, deformed fruits at all heights within trees and temperature data at bloom time do not support the idea of damaging spring frosts.

Spontaneous sports. Einset and Pratt (1959) reviewed the histories and descriptions of sports with misshapen fruits. In general, sports are confined to a limb or limbs of a single tree and not to many whole trees within large producing areas hundreds of kilometers apart. In addition the major incidence of this deformity in 1966 (Davidson and Allen) and again in 1978, with occasional deformities occurring each year, does not support the definition of a sport which implies a new characteristic which is perpetuated. However, the susceptibility of cultivars to the conditions which cause this injury is obviously genetic in nature.

Temperature fluctuations during cold acclimation. This is another possible causal agent. During early November 1977 in Simcoe and Georgian Bay daily minimum temperatures were around 8°C rather than the normal 0°C. About the middle of the month in both locations there was a sudden drop to around -5°C. Subsequently there were above normal maximum and minimum temperatures with a pronounced fluctuating temperature regime in the Georgian Bay area which continued into December. Ketchie and Beeman (1973) have shown the importance of sustained low temperature in development of cold resistance. It could be that the temperature fluctuations during November and December injured the overwintering flower buds in the Georgian Bay area. Certainly this was the case for vegetative growth during the 1977-1978 winter.

Conclusion

The incidence of this deformity appears to be related to fluctuating fall and early winter temperatures and subsequent failure of the seeds to develop. Further investigation of this phenomenon is needed. This can be achieved by careful documentation of the incidence of misshapen or deformed fruit as done initially by Davidson and Allen (1966) and analyses of pertinent weather records. The widespread nature of this disorder suggests that it could be economically important in some years. It may be possible to avoid some of this economic loss by choice of cultivar.

Acknowledgments

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Screening Brassicas for resistance to clubroot, Plasmodiophora brassicae Wor.[1]

René Crête and Morgan S. Chiang[2]

A total of 109 Brassica accessions obtained from the Plant Introduction Station, Geneva, N.Y. were evaluated for germplasm resistance to clubroot, *Plasmodiophora brassicae* Wor. race 6, E.C.D. code number 16/02/30. All the lines were severely infected with clubroot; the least infection (about 50%) was observed in two *Brassica rapa* L. lines.

Can. Plant Dis. Surv. 60:1, 17-19, 1980.

Un total de 109 lignées de Brassica ont été évaluées pour leur résistance à la hernie, *Plasmodiophora brassicae* Wor. race 6, E.C.D. numéro 16/02/30. Toutes ces lignées ont été sévèrement infectées, excepté deux lignées de *Brassica rapa* L. où la sévérité d'infection était d'environ 50%.

Introduction

Clubroot, *Plasmodiophora brassicae* Wor., a major disease of cruciferae causes appreciable crop losses in many parts of the world.

There are few effective means of controlling this disease. Of all the chemicals tested to control clubroot, certain systemic benzimidazole derived fungicides and derivatives of dithiocarbamic acid have shown promise, Colhoun 1958, Karling 1968 and Buczacki *et al.* 1976, but these are not always reliable, practical and economical to use. Success in the control of clubroot could be best achieved by the development of disease-resistant varieties. Attempts have been made to locate possible sources of resistance (Catovic-Catani and Rich 1964; Crête and Chiang 1967 and Chiang and Crête 1972). This paper reports screening test results of Brassica lines of different origin in search of clubroot resistant germplasm which could be used in our breeding program.

Materials and methods

One hundred and nine (109) Brassica accessions were obtained from the NE-9 Regional Plant Introduction Station, Geneva, N.Y. (Table 1). The tests were conducted in a glasshouse with a temperature of 21°C ± 1°and a mean relative humidity of 50%. A combination of fluorescent and incandescent lamps were used to extend the period of illumination to 14 hours. The supplemental light had an intensity of 50 ± lux at plant level.

Resting spores of *P. brassicae* race 6, E.C.D.* code number 16/02/30 (Buczacki *et al.* 1975) were extracted from infected cabbage roots and the inoculum prepared according to Williams' 1965 method. Pasteurized organic soil, pH 5.8 was inoculated by thoroughly mixing the spore suspension to obtain 30 x 10^9 spores per 100 g of dry soil. Handi-Pot modules containing 36 pots with a volume of approximately 140 cm^3 were filled with the inoculated soil. Four seeds of each line were sown per pot and the treatments replicated 9 times. Thirty-five (35) days after inoculation all the plants were uprooted, washed and evaluated for clubroot infection. The grades of infection and the disease index were scored and calculated according to the method of Crête *et al.* 1963 with a slight modification (Crête 1975).

Results and discussion

The distribution of the plants evaluated for clubroot resistance into four grades and the disease index for each entry are presented in Table 1.

One hundred and seven (107) of the 109 Brassicas tested for resistance, against clubroot *P. brassicae* race 6, E.C.D. code number 16/02/30 showed a disease severity index ranging from 62 to 100. Two *Brassica rapa* L. lines had a disease index of 52 and 55 which is greater than our "cut-off point" of 25. However these lines will be retested and the search for germplasm resistant to *P. brassicae* should continue with other species in the Brassica family.

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[2] *Plant pathologist and plant geneticist respectively.*

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*European Clubroot Differential set

Table 1. Brassica lines tested for clubroot resistance.

Scientific name and plant introduction number	Origin	Disease grade 0	1	2	3	Disease Index
Brassica oleracea L. var. *capitata* L.						
P.I. 391555	China	1	3	1	31	91
391556	China	0	4	2	30	91
391557	China	0	1	0	35	98
Brassica campestris L.						
390962	China	0	0	0	36	100
390963	China	0	0	0	36	100
390964	China	0	0	0	36	100
391547	China	0	0	4	32	96
391548	China	0	8	7	21	79
391549	China	0	5	4	27	87
391550	China	0	0	0	36	100
391551	China	0	0	0	36	100
Brassica pekinensis Rupr.						
391558	China	0	0	0	36	100
391559	China	0	0	0	36	100
391560	China	0	0	0	36	100
Brassica rapa L.						
391561	China	3	16	5	8	52
391562	China	4	15	6	11	55
Brassica oleracea L. var. *botrytis* L.						
277273	India	0	1	0	34	98
277274	India	0	1	0	35	98
277275	India	0	0	1	33	99
277276	India	0	1	0	31	98
277277	India	0	1	6	29	93
284594	Sweden	0	0	0	36	100
284697	Sweden	2	2	0	4	58*
284698	Sweden	0	0	0	35	100
285061	Denmark	0	0	0	36	100
285062	Denmark	0	0	0	36	100
285275	Denmark	0	1	1	34	97
285276	Denmark	0	0	0	36	100
285596	Poland	0	0	0	10	100*
289693	Australia	0	0	0	36	100
289694	Australia	0	0	0	36	100
289695	Australia	0	0	0	36	100
289696	Australia	0	0	0	36	100
291565	Egypt	0	1	0	35	98
291566	Egypt	0	0	0	35	100
291567	Egypt	0	0	0	36	100
291992	Israel	0	0	2	34	98
291993	Israel	0	0	2	34	98
291995	Israel	0	0	0	36	100
291996	Israel	0	0	2	34	98
291997	Israel	0	0	1	35	99
296130	USA	0	0	1	35	99
320999	Taiwan	0	0	0	36	100
321000	Taiwan	0	1	0	35	98
321001	Taiwan	1	3	2	30	90
343474	USSR	0	1	0	35	98
343475	USSR	3	7	5	21	74
343476	USSR	0	1	0	35	98
343477	USSR	0	2	2	32	94
343478	USSR	0	3	1	32	93
343479	USSR	0	3	1	32	93
343480	USSR	0	0	0	36	100
343481	USSR	0	0	0	36	100
343482	USSR	0	0	0	36	100
343483	USSR	3	2	0	31	88
344268	Turkey	0	0	0	36	100
344269	Turkey	2	1	4	29	89
344270	Turkey	0	0	1	35	99
344271	Turkey	0	0	0	36	100
344272	Turkey	0	0	0	36	100
344273	Turkey	0	0	0	36	100
345541	USSR	0	0	0	36	100
345542	USSR	0	0	0	36	100
372585	Netherlands	0	0	5	31	95
372590	Denmark	0	0	0	36	100

*Poor germination

Table 1. (Continued)

Scientific name and plant introduction number	Origin	Disease grade				
		0	1	2	3	Disease Index
372591	Denmark	0	0	6	30	94
372592	Denmark	0	2	0	34	96
372856	Netherlands	0	0	2	34	98
372857	Netherlands	0	0	0	36	100
372858	Netherlands	0	0	0	36	100
372860	Netherlands	0	0	3	33	97
372862	Denmark	0	0	2	34	98
372863	Denmark	0	0	5	31	95
372864	Denmark	0	7	4	25	83
372865	Denmark	0	2	2	32	94
372885	Netherlands	0	1	1	34	97
372886	Netherlands	0	2	3	31	93
372887	Netherlands	2	1	0	33	93
372888	Netherlands	0	1	0	35	98
372889	Netherlands	0	0	0	36	100
372890	Netherlands	0	0	0	36	100
372897	Netherlands	0	0	1	35	99
372901	Netherlands	0	0	1	35	99
372902	Netherlands	0	0	0	36	100
373906	Netherlands	0	1	0	35	98
373907	Netherlands	0	0	0	36	100
373908	Netherlands	0	2	4	30	93
373909	Netherlands	0	0	0	36	100
373910	Netherlands	0	0	0	36	100
373919	Netherlands	0	10	10	16	72
373920	Netherlands	2	13	9	12	62
373921	Netherlands	1	18	7	12	63
373922	Netherlands	2	9	8	17	70
373923	Netherlands	1	7	3	25	78
374224	India	1	14	5	16	67
374225	India	2	5	10	19	76
374226	India	1	1	0	6	79*
374227	India	1	3	4	28	88
374228	India	2	3	10	21	80
384428	India	2	0	2	32	93
385951	Kenya	0	5	8	23	83
385952	Kenya	4	3	0	29	83
385953	Kenya	0	1	4	31	94
385954	Kenya	0	0	1	35	99
385955	Kenya	0	0	0	36	100
385956	Kenya	0	1	0	33	93
390967	Israel	0	6	5	25	84
390968	Israel	1	3	3	29	89
390969	Israel	0	4	1	31	92

*Poor germination

Acknowledgments

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ANNOUNCEMENT

Due to a recent policy change the Canadian Plant Disease Survey will no longer accept articles relating to the evaluation of new materials for disease control. Papers of this nature should be submitted either to the Pesticide Research Report, or if the research content is deemed sufficient, to a refereed journal.

THE EDITOR

Instructions to authors

Articles and brief notes are published in English or French. Manuscripts (original and one copy) and all correspondence should be addressed to the Acting Editor, Dr. H.S. Krehm, Research Program Service, Research Branch, Agriculture Canada, Ottawa, Ontario K1A 0C6.

Manuscripts should be concise and consistent in style, spelling, and use of abbreviations. They should be typed, double spaced throughout, on line-numbered paper. All pages should be numbered, including those containing abstract, tables, and legends. For general format and style, refer to recent issues of the *Survey* and to *CBE Style Manual* 3rd ed. 1972. American Institute of Biological Sciences, Washington, D.C. Whenever possible, numerical data should be in metric units (SI) or metric equivalents should be included. Square brackets may be used to enclose the scientific name of a pathogen, following the common name of a disease, to denote cause.

Titles should be concise and informative providing, with the Abstract, the key words most useful for indexing and information retrieval.

Abstracts of no more than 200 words, in both English and French, if possible, should accompany each article.

Figures should be planned to fit, after reduction, one column (maximum 84 × 241 mm) or two columns (maximum 175 × 241 mm), and should be trimmed or marked with crop marks to show only essential features. Figures grouped in a plate should be butt-mounted with no space between them. A duplicate set of unmounted photographs and line drawings is required. Figures should be identified by number, author's name, and abbreviated legend.

Tables should be numbered using arabic numerals and have a concise title; they should not contain vertical rules; footnotes should be identified by reference marks (* † § # ¶ ** ††) particularly when referring to numbers.

Literature cited should be listed alphabetically in the form appearing in current issues; either the number system or the name-and-year system may be used. For the abbreviated form of titles of periodicals, refer to the most recent issue of *Biosis List of Serials* published by Biosciences Information Service of Biological Abstracts or to the *NCPTWA Word Abbreviation List*, American National Standards Institute.

Recommandations aux auteurs

Les articles et les communiqués sont publiés en anglais ou en français. Les manuscrits (l'original et une copie) et toute la correspondance qui s'y rapporte doivent être envoyés au Rédacteur intérimaire M. H.S. Krehm Service des programmes de recherche, Direction de la recherches, ministère de l'Agriculture du Canada, Ottawa (Ontario) K1A 0C6.

Les manuscrits doivent être concis et faire preuve de suite dans le style, l'orthographe et l'emploi des abréviations. Ils doivent être dactylographiés à double interligne, de préférence sur des feuilles à lignes numérotées. Toutes les pages doivent être numérotées y compris celles portant le résumé, les tableaux et les légendes. Pour plus de renseignements sur le format des feuilles et le style, prière de consulter nos dernières publications et le *CBE Style Manual* (3e ed. 1972) de l'American Institute of Biological Sciences, Washington (DC). Dans la mesure du possible, les données numériques doivent être exprimées en unités métriques, (SI) ou être suivies de leur équivalent métrique. L'emploi de crochets est autorisé pour l'identification du nom scientifique d'un micro-organisme pathogène après le nom commun de la maladie dont il est l'agent causal.

Les titres doivent être courts et révélateurs en contenant, avec le résumé, les mots clés les plus utiles pour le classement et l'extraction de l'information.

Chaque article doit être accompagné d'un *résumé* d'au plus 200 mots en anglais et en français, si possible.

Les figures doivent pouvoir, après réduction, remplir une colonne (maximum 84 × 241 mm) ou deux colonnes (maximum 175 × 241 mm) et devraient être taillées ou montrer les parties essentielles à garder. Les figures groupées sur une même planche doivent être montées côte à côte, sans intervalle. L'article doit être accompagné d'un double des photographies non montées et des graphiques. Les figures doivent être numérotées, porter le nom de l'auteur et une légende abrégée.

Les tableaux doivent être numérotés en chiffres arabes et avoir un titre concis. Ils ne devraient pas avoir de lignes verticales. Les renvois doivent être identifiés par un signe typographique particulier (* † § # ¶ ** ††) surtout lorsqu'il s'agit de nombres.

Les références bibliographiques devraient être citées par ordre alphabétique comme dans les livraisons courantes. On peut utiliser le système de numération ou le système nom-et-année. Pour l'abrégé du titre des périodiques, on suivra l'édition la plus récente de *Biosis List of Serials* publiée par les Biosciences Information Services de Biological Abstracts ou la *NCPTWA Word Abbreviation List* et l'American National Standards Institute, Standards Committee Z39.