Diseases of flue-cured tobacco in Ontario and estimates of disease losses, 1972-73[1]

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In Ontario the major diseases of flue-cured tobacco *(Nicotiana tabacum)* are brown root rot caused by the root lesion nematodes *Pratylenchus* spp; pole rot caused by *Rhizopus arrhizus;* weather fleck induced by air pollution; and sore-shin caused by *Rhizoctonia solani.* In 1972 and 1973 the average annual yield loss from these and other tobacco diseases was estimated at 3.5%, representing a farm value of $5.5 million. Annual losses from pole rot and weather fleck were estimated at 1.3% and 0.73%, respectively. Brown root rot is controlled on most farms by soil fumigation at a cost of approximately $2.2 million per annum; despite these control measures losses averaged 0.4%. Blue mold caused by *Peronospora tabacina* has not been noticed in Ontario since 1966. Stalk rot (rattle box) caused by *Sclerotinia sclerotiorum* was recorded for the first time in Canada in 1970 but has not become a problem; and *Myrothecium verrucaria* is reported for the first time from tobacco seedlings. A comparison between the tobacco disease patterns in Canada and North Carolina is also discussed.

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En Ontario, les principales maladies du tabac jaune *(Nicotiana tabacum)* sont le pourridie brun cause par les nematodes radicicoles *(Pratylenchus* spp.), le chauffage a la pente attribuable a *Rhizopus arrhizus,* la moucheture causee par la pollution de l'air et la tige noire attribuable a *Rhizoctonia solani.* En 1972 et 1973, la baisse moyenne des rendements annuels attribuable aux troubles susmentionnes et a d'autres maladies du tabac ont ete evalues a 3.5% de la production, soit une valeur a la ferme de 5.5 millions de dollars. Les pertes annuelles dues au chauffage a la pente et a la moucheture ont ete estfmees respectivement a 1.3 et 0.73% de la production. La plupart des producteurs de tabac luttent contre le pourridie brun par la fumigation du sol a un coût d'environ 2.2 millions de dollars par année; malgre ces mesures de lutte, les pertes ont atteint en moyenne 0.4% de la production. La moisissure bleue causee par *Peronospora tabacina* n'a pas ete signalee en Ontario depuis 1966. La pourriture sclerotique attribuable a *Sclerotinia sclerotiorum* a ete signalee pour la premiere fois au Canada en 1970, mais n'est pas devenue un probleme; enfin, *Myrothecium verrucaria* a ete signalé pour la premiere fois sur des plants de tabac. Le present article etablit egalement une comparaison entre les caracteristiques des maladies du tabac au Canada et en Caroline du Nord.

Flue-cured tobacco *(Nicotiana tabacum* L.) is a major crop in Ontario. About 85% of the crop is grown in Norfolk, Elgin, Brant, and Oxford counties, with the remainder in Essex, Middlesex, Kent, Simcoe, Bruce, Durham, and Northumberland counties. In 1971, 1972, and 1973 the acreage of flue-cured tobacco was 81,214, 86,633, and 104,679, respectively , with corresponding farm values of over $131 million, $130 million, and $180 million. This paper discusses observations on tobacco diseases during these three seasons, reports two new fungal records on tobacco in Canada, and compares disease patterns in Canada with those in North Carolina, which is the major flue-cured producing state in the U.S.A. This comparison is based on disease loss estimates for North Carolina (10) and Ontario.

Disease incidence and crop losses

Information on disease incidence and severity, and on crop losses incurred in the field and during curing, was collected mainly from about 350 farms in Norfolk, Elgin, Brant, and Oxford counties and from 50 farms in Middlesex, Essex, Kent, Simcoe, Bruce, Durham, and Northumberland counties. For seedbed diseases, about 150 greenhouses distributed throughout those counties were visited each season. Additional information on disease incidence and severity was collected through contacts with growers during office visits and telephone calls.

Diagnosis of damping-off, black root rot, and sore-shin was based in most cases on the microscopic examination of diseased tissue to confirm the presence of the causal fungus. Nematodes from diseased roots and soil samples were identified at the Agriculture Canada Research Station, Vineland, Ontario. Virus diseases were identified by their typical symptoms, otherwise samples were sent to the Research Station, Vineland, for precise identification through host. range studies, electron microscopy, and serological tests. Weather fleck and pole rot were identified through their visible symptoms.

The spread of disease in the seedbed, field or kiln, the frequency of disease in the tobacco farms, and the losses in tobacco weight and quality due to disease were considered in estimating disease losses.

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Greenhouse diseases

Blue mold *[Peronospora tabacina* Adam] has not been noticed in Ontario since 1966.

Damping-off *[Rhizoctonia solani* Kuhn and *Pythium* spp.] caused losses to tobacco seedlings estimated at 5-10% in 1972 and at 3-5% in 1973. No crop losses were incurred since growers had an excess of seedlings for planting,their fields.

Black root rot *[Thielaviopsis basicola* (Berk. & Br.) Ferr.] caused slight infection in seedbeds that had not been properly sterilized. Black root rot infection did not affect the seedling supply for the field.

Root knot *[Meloidogyne hapla* Chitwood] caused damage in only a few greenhouses during 1971-73 due to improper sterilization of the seedbeds, but losses have been insignificant.

Field diseases

Black root rot *[Thielaviopsis basicola]* caused severe losses prior to 1969. Since then losses have been considerably lower due to the propagation of the cultivars Delhi 34 and 'Virginia 115', which are highly tolerant to black root rot. Losses were estimated at $300,000 and $504,000 in 1972 and 1973.

Brown root rot *[Pratylenchus penetrans* (Cobb), *P. neglectus* (Rensch.) Filipjev and *P. crenatus* Loof]. A recent survey indicated that these three species of the root lesion nematode are causing stunting to tobacco (8). Losses due to brown root rot were estimated at $500,000 and $738,000 in 1972 and 1973. About 90% of the growers fumigate their fields against nematodes. Cost of fumigation was estimated at $2 million and $2.5 million those 2 years, respectively.

Root knot *[Meloidogyne* Goeldi] and root cyst [*Heterodera* Schmidt] nematodes. Although root knot (2,8) and root cyst nematodes (7) are present in tobacco soil, their damage to tobacco is almost negligible. Apparently soil fumigation and the tobacco-rye rotation practiced by the vast majority of growers has been effective in suppressing the population of these nematodes.

Sore-shin *[Rhizoctonia solani* Kuhn in 1972, caused losses of about $500,000 and replanting costs of about $500,000. Due to the relatively dry conditions that prevailed in 1973, losses were reduced to $396,000 and very little replanting was necessary. It should be emphasized here when comparing losses in 1972 and 1973, that the acreage of the 1973 crop was 15% higher than that of 1972.

Virus diseases. A few cases of tobacco mosaic virus, tobacco etch virus, tobacco ring spot virus, cucumber mosaic virus, and streak virus have been noticed during the last three seasons but their spread has been very limited. In 1972 a virus disease identified by host range and serological tests as having as the causal agent tobacco veinal necrosis virus (TVNV), which is a strain of potato virus Y, was reported on one farm in the La Salette area of Norfolk County; however the following season there was no trace of the disease on that farm or on the neighboring farms. In 1973 another case identified by host range and electron microscopy as potato virus Y (probably TVNV) was found on a farm in the Langton area, Norfolk Co., but the spread of the disease was very limited. Losses due to virus diseases were estimated at $400,000 in 1972 and at $144,000 in 1973 crops. Drier conditions which prevailed in the 1973 season might explain the relatively low losses in 1973.

Weather fleck [air pollution] *is* a physiological disorder and is mainly induced on mature leaves by high levels of ozone in the atmosphere. The present tobacco cultivars Virginia 115 and Delhi 34 are more tolerant to weather fleck than previously grown cultivars such as Hicks Broadleaf. Damage from weather fleck has been higher on farms close to Lake Erie. Losses were estimated at $1 million in 1972 and $1.35 million in 1973. In making loss estimates, decrease in weight and quality of flecked leaf, as well as depreciation of leaf quality as a result of harvesting immature leaves to avoid the disease, were considered.

Curing diseases

Pole rot *[Rhizopus arrhizus* Fischer] has caused the highest disease losses in recent years. Losses were estimated at $3.0 million, $2.0 million and $2.16 million in 1971, 1972, and 1973. In estimating disease losses, loss in weight of the cured leaf and the labor costs involved in discarding diseased areas in order to make the tobacco shipment acceptable to buyers were considered. The factors that have contributed to the pole rot problem will be discussed later.

Two new records of fungi on tobacco in Canada

Stalk rot or "rattle box" caused by *Sclerotinia sclerotiorum* (Lib.) de Bary was noticed for the first time on a tobacco farm in the Alllston area in 1970. The diseased field was isolated from the rest of the farm and was surrounded with high trees, which induced a higher relative humidity in that particular field. According to the grower, the disease had been noticed in that field for several seasons before 1970 but infection never extended to tobacco on the same or neighboring farms.

The disease on mature plants during August was characterized by the formation of a canker which extended close to the leaf base for more than 10 cm in length and spread in an oval pattern (Fig. 1). The brown margin of the canker enclosed light-colored, dead tissue with some dark grayish areas. When the diseased tissue was split longitudinally the stem was found to be hollow due to the breakdown of the pith tissue by the fungus, and white mycelium with loosely attached sclerotia were scattered in the pith cavity. Sclerotia were black in color and hard in texture and varied considerably in shape and size (Fig. 1). Large sclerotia were about 25 x 5 mm. When intact diseased plants were shaken the sclerotia rattled in the hollow stem and hence the name "rattle

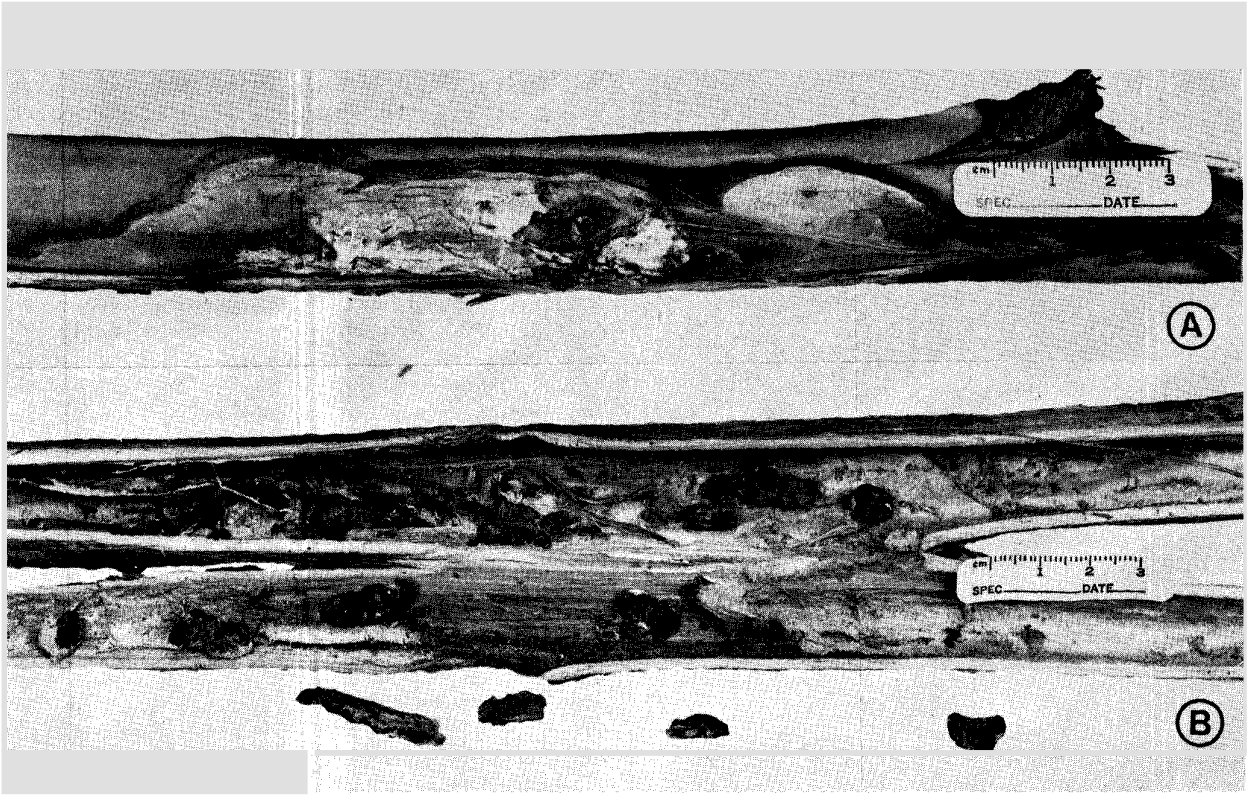

Figure 1. Stalk rot or "rattle box" of tobacco caused by *Sclerotinia sclerotiorum*, a) a canker formed on the stem of a tobacco plant, b) an infected stem split longitudinally showing the hollow pith with white patches of mycelium and loose sclerotia.

box". The fungus was isolated and its identification was confirmed by Miss Mary **E.** Elliott. Stalk rot caused by S. *sclerotiorurn* has been previously recorded in several other tobacco growing countries including the U.S.A. (Connecticut), Germany, India, Japan, Taiwan, Indonesia, and New Zealand (12).

Myrotheciurn verrucaria has been isolated from leaves of tobacco seedlings cv. Hicks Broadleaf and Delhi 34 grown on steam-sterilized muck soil in flats under greenhouse conditions during the winter months. Water-soaked areas appeared on 16-20 mm diam leaves that were close to or touching the soil surface. The water-soaked areas turned gray in color then brownish. Later, dark, cushion-like sporodochia emerged on the surface **of** infected areas (Fig. 2). The fungus was isolated on PDA and identified by Dr. S. J. Hughes as *Myrotheciurn verrucaria* (Alb. and Schw.) Ditmar ex Fr. Several trials have been made *to* reinfect injured and uninjured leaves of young tobacco seedlings with the isolated strain of *M. verrucaria* under different moisture conditions, but all trials to reproduce disease symptoms have been unsuccessful. *M. verrucaria* is a common saprophyte and might have colonized the young tobacco leaves under unidentified predisposing conditions. Apparently this is the first record of *M. verrucaria* being isolated from leaves of tobacco seedlings.

Discussion

The most serious diseases of flue-cured tobacco in Ontario, as manifested by disease loss estimates, were pole rot, weather fleck, and nematode induced injury. This pattern of disease severity differs slightly in the case of flue-cured tobacco grown in Quebec and in the Maritime Provinces, as well as of burley tobacco grown in Ontario and cigar tobacco grown in Quebec. In Quebec nematodes, black root rot, and gray tobacco (physiological disorder, are the common problems of flue-cured tobacco, whereas pole rot and black root rot are the main problems in cigar tobacco (personal communication, P.P. Lucosevicius, L'Assomption, Que., 1974). In the Maritimes, black root rot, sore-shin, nematodes, and pole rot are causing moderate losses to the flue-cured crop (personal communication, **K.** E. Lelacheur, Charlottetown, **P.E.I.,** 1974). Virus diseases and pole rot are the main problems on burley tobacco in Ontario (personal communication **W.** A. Scott, Harrow, Ont., 1974). Pole rot of air-cured tobacco (cigar and

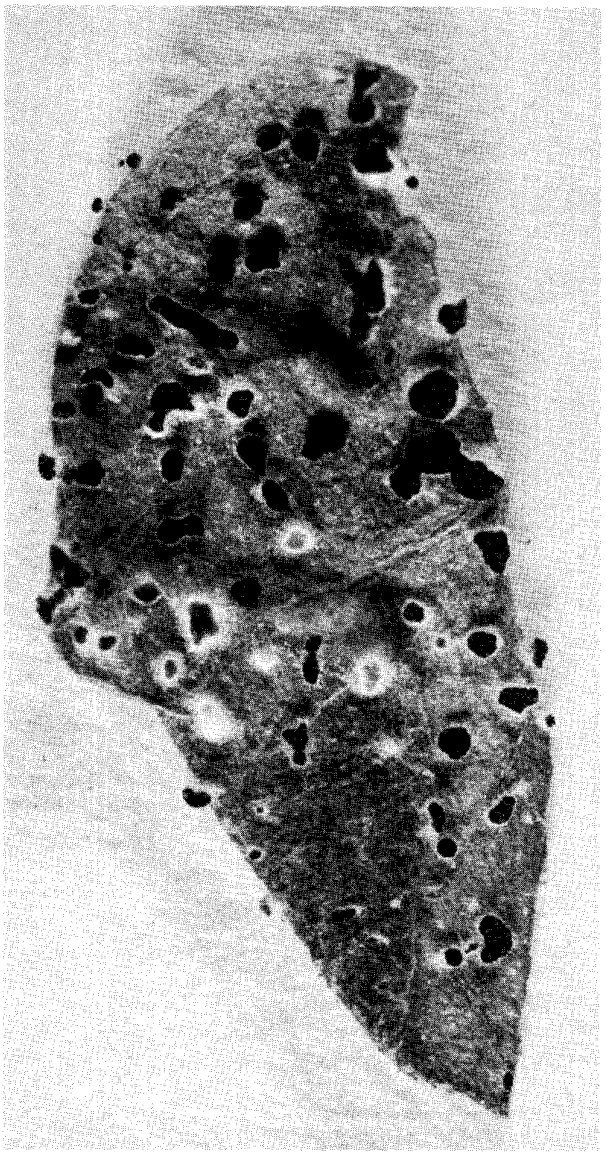

Figure 2. Surface view of a leaf of tobacco seedling showing sporodochia of *Myrothecium verrucaria.*

burley) is caused by different organisms and *R. arrhizus,* the main cause of pole rot of flue-cured tobacco, does not contribute to pole rot of air-cured tobacco, presumably due to the thermophylic tendencies of this fungus (3).

Disease patterns on flue-cured tobacco in Ontario (Ont.) and in North Carolina (N.C.) differ considerably. In N.C. losses due to pole rot in 1972 and 1973 (Table 1) were too low to specify and probably were included under "Miscellaneous leaf losses" (10). Similarly, losses due to weather fleck in N.C. were lower than in Ont. and might be attributed to differences in varietal susceptibility or in the ozone levels in the atmosphere at maturation or both. The main disease problems in N.C. are black shank, tobacco mosaic, and nematodes (10). The nematode problem in Ont. is almost totally due to the root lesion nematode, whereas in N.C. it is mainly due to root knot and partly due to the root lesion nematode. Black shank caused by *Phytophthora parasitica* has not been recorded in Ont. and losses due to viruses are relatively low compared to N.C. This might be due to a longer winter season in Ont. and a lower population of perennial weeds on which viruses might overwinter. Bacterial (Granville) wilt *[Pseudomonas solanacearum*]; fusarium wilt [*Fusarium oxysporum* f. sp. *nicotianae]* and brown leaf spot *[Alternaria alternata]* induce appreciable losses in N.C., but in Ont. bacterial wilt has not been recorded and losses due to fusarium wilt, brown leaf spot, and other pathogenic leaf spots are negligible. Losses due to black root rot are higher in Ont. than in N.C. (Table 1) presumably due to the relatively lower soil temperatures in the spring. Low soil temperature is known to increase severity of black root rot (5,7). Sore-shin caused appreciable losses in Ont. but its losses were negligible in N.C. during 1971-1973.

It is evident from this survey of tobacco diseases that disease patterns differ not only between widely separated tobacco growing areas, such as Ont. and N.C. which are about 720 km (450 miles) apart, but also differ within the same area at different periods of time. It is therefore essential from the economic point of view and in the scientific interest, as well, to follow such changes in disease pattern by carrying out regular qualitative and quantitative surveys. Blue mold and pole rot are good examples in this respect.

Blue mold was first reported in Ontario in 1938 and occurred sporadically until 1945; between 1945 and 1947 it was epidemic (1). At that time, infection was attributed to spore showers carried by favorable winds from exposed tobacco seedbeds in Kentucky and Ohio (4). Following the epidemic in 1947, the disease declined and has not been recorded during the past 7 seasons. Apparently the disease failed to get established in Ontario, most probably due to unfavorable winter conditions; moreover the source of inoculum has been checked due to effective control measures against the disease in both states.

Pole rot was not listed among diseases of Canadian tobacco in 1950 (6). However annual losses from pole rot in the 1970's were between 2 and 3 million dollars. During the past 23 years tobacco yield per acre has almost doubled, and it is possible that the introduction of vigorously growing cultivars, improved cultural practices, and the use of tying machines have led to heavier kiln loading, thus increasing humidity during curing. In addition, the utilization of mechanized tying has resulted in more injury of tobacco leaf butts. High relative humidity (3,11) and leaf butt injury (4) have been reported to enhance *R. arrhizus* spread and pole rot severity.

Table 1. Average disease losses expressed as percentage loss in yield and corresponding loss in dollars, of 1972 and 1973 crops of flue-cured tobacco in Ontario and North Carolina

Disease	Ontario			North Carolina*	
	Loss %	Loss ($'000)	Cost of Control ($'000)	Loss %	Loss ($'000)
Plant bed					
Damping-off and others	0.1		83	0.09	555
Field					
Black shank	0	0		0.76	4,883
Brown root rot	0.40	619	2,250	0.86	5,259
Black root rot	0.26	402		0.1 5	902
Granville wilt	0	0	0	0.14	864
Blue mold	0	0	0	0.04	184
Fusarium wilt	0.1			0.02	90
Brown spot	0.1			0.30	1,879
Miscellaneous leaf diseases	0.1			0.1 0	583
Sore-shin	0.29	448	250 (replanting)		
Miscellaneous root diseases	0	0	0	0.07	426
Mosaic				0.51	3,129
Other viruses	0.19	272	0	0.05	274
Weather fleck	0.73	1.175	0	0.05	257
Kiln					
Pole rot	1.30	2,080	0		
Miscellaneous losses and wastage	0.31	492	0		
TOTAL	3.48	5,488	2,583	3.14	19,285

* Estimates of disease losses in North Carolina are based on data published by F. A. Todd (10).

While pole rot is the major disease problem in Ontario, losses due the disease are limited or negligible in North Carolina. This might be attributed to different factors: a) In N.C. the tobacco growing season is longer than in Ont., therefore harvesting mature leaves is much more common in N.C. Mature leaves need a shorter yellowing period and the yellowing process provides optimal conditions for development of the disease. b) Kilns in Ont. are generally more air-tight than those in N.C. and hence operate at a higher relative humidity during curing which favors pole rot.

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Literature cited

1. Conners, I. L. 1967. An annotated index of plant diseases in Canada. Research Branch, Can. Dep. Agr. Publ. 1251.
2. Elliot, J. M., and C. F. Marks. 1972. Control of nematodes in flue-cured tobacco in Ontario. Can. Dep. Agr. Publ. 1465.
3. Gayed, S. K. 1972. *Rhizopus arrhizus* causing pole rot of flue-cured tobacco in Ontario. Can. J. Plant Sci. 52:142-144.
4. Gayed, S. K. 1972. Relation between midrib injury and tobacco leaf infection by *Rhizopus arrhizus* causing pole rot. The Lighter 42 (3): 29-31,
5. Johnson, J., and R. H. Hartman. 1919. The influence of soil environment on the root rot of tobacco. J. Agr. Res. 17:41-86.
6. Koch, L. W., and G. H. Berkeley. 1950. Diseases of tobacco in Canada. Can. Dep. Agr. Publ. 667.
7. Lucas, G. B. 1965. Diseases of tobacco. The Scarecrow Press Inc., New York. 778 p.
8. Olthof, Th. H. A., and B. E. Hopper. 1973. Distribution of *Pratylenchus* spp. and other stylet-bearing nematode genera in soils in the flue-cured tobacco area of southern Ontario. Can, Plant Dis. Surv. 53:31-33.
9. Patrick, Z. A., and L. W. Koch. 1956. Tobacco: a special report on tobacco diseases. Can. Plant Dis. Surv. 36:86-88.
10. Todd, F.A. 1973. Flue-cured tobacco extension research on wheels annual report Agr. Extension Serv., North Carolina State Univ. p. 159-161.
11. Walker, E. K., and L. S. Vickery. 1969. Curing flue-cured tobacco. Can. Dep. Agr. Publ. 1312.
12. Wolf, F. A. 1957. Tobacco diseases and decays. Duke Univ. Press, Durham, North Carolina. 386 p.