POTATO WART INVESTIGATIONS IN NEWFOUNDLAND[1]

O. A. Olsen[2]

Historical

The wart disease or "canker" of potatoes, caused by Synchytrium endobioticum (Schilb.) Perc., has been known in Newfoundland for several generations and elderly gardeners in the Conception Bay area of the Avalon Peninsula have stated that canker had been present in their father's gardens. The disease was first reported officially in 1909 by Dr. H. T. Gussow, then Dominion Botanist, when wart-diseased tubers were sent to him from Red Island, Placentia Bay. Subsequently, regulations were established in 1910 prohibiting the importation of potatoes into the mainland of Canada from Newfoundland, a ban which is still in effect.

Distribution

The disease has become very widespread in Newfoundland, as shown on the accompanying map, (Fig. 1) with the heaviest infestations on the south and west shores of Conception Bay. The information presented in this map was collected during the period 1947-55 by G. C. Morgan, District Inspector, Production and Marketing Branch, by means of ground surveys, collection of wart disease samples by mail, reports of Provincial Agricultural Fieldmen, and by correspondence. The presence of the disease in Labrador was confirmed by H. Genereux when he surveyed the North Shore of the Gulf of St. Lawrence in 1957. Wart was found by the author in some other localities while travelling in the province, by receipt of diseased samples, and by correspondence, during the period 1957-1960,

Description

Potato wart is a very destructive and serious disease of potatoes in Newfoundland. The most popular potato varieties are highly susceptible and heavy losses occur, especially in gardens where potatoes are grown continuously, or perhaps only alternated with cabbage or turnips.

Wart is a proliferative disease that can attack meristematic tissues of the tuber, stolons, stem, and leaves of the potato plant, but not the roots. Development of the fungus within the tissues of the host stimulates the cells to produce warty or coral-like tumors on the affected parts. They are whitish in color on the stem bases, tubers, and stolons, and green on above-ground stems and leaves. Later all warted tissue becomes blackened and rotted,

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[1] Contribution No. 3 from the Experimental Farm, Research Branch, Canada Agriculture, St. John's West, Newfoundland.

[2] Plant Pathologist.

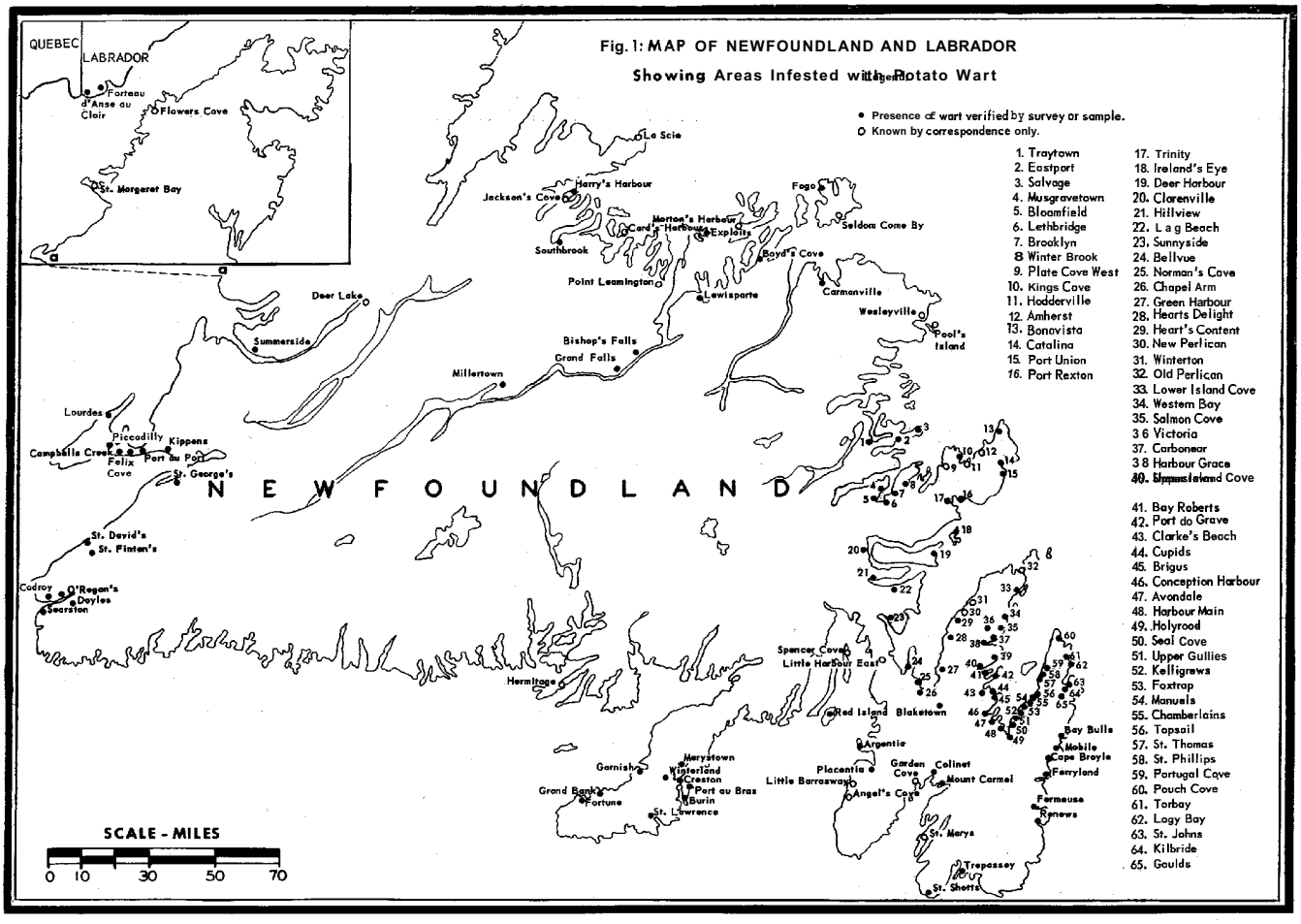
Fig. 1: MAP OF NEWFOUNDLAND AND LABRADOR
Showing Areas Infested with Potato Wart
Legend
• Presence of wart verified by survey or sample.
O Known by correspondence only.
1. Traytown
2. Eastport
3. Salvage
4. Musgravetown
5. Bloomfield
6. Lethbridge
7. Brooklyn
8 Winter Brook
9. Plate Cove West
10. Kings Cove
11. Hodderville
12. Amherst
13. Bonavista
14. Catalina
15. Port Union
16. Port Rexton
17. Trinity
18. Ireland's Eye
19. Deer Harbour
20. Clarenville
21. Hillview
22. Lag Beach
23. Sunnyside
24. Bellvue
25. Norman's Cove
26. Chapel Arm
27. Green Harbour
28. Hearts Delight
29. Heart's Content
30. New Perlican
31. Winterton
32. Old Perlican
33. Lower Island Cove
34. Western Bay
35. Salmon Cove
36 Victoria
37. Carbonear
38 Harbour Grace
40. Shearstown Cove
41. Bay Roberts
42. Port de Grave
43. Clarke's Beach
44. Cupids
45. Brigus
46. Conception Harbour
47. Avondale
48. Harbour Main
49. Holyrood
50. Seal Cove
51. Upper Gullies
52. Kelligrews
53. Foxtrap
54. Manuels
55. Chamberlains
56. Topsail
57. St. Thomas
58. St. Phillips
59. Portugal Cove
60. Pouch Cove
61. Torbay
62. Logy Bay
63. St. Johns
64. Kilbride
65. Goulds
QUEBEC
LABRADOR
Forteau
d'Anse au Clair
Flowers Cove
St. Margaret Bay
NEWFOUNDLAND
Deer Lake
Summerside
Lourdes
Piccadilly
Kippens
Campbells Creek
Felix Cove
Port au Port
St. George's
St. David's
St. Pintam's
Codroy
O'Regan's
Doyles
Searston
Millertown
Bishop's Falls
Grand Falls
Point Leamington
Lewisporte
Jackson's Cove
Harry's Harbour
Southbrook
Horton's Harbour
Card's Harbour
Exploits
Fogo
Seldom Come By
Boyd's Cove
Carmanville
Wesleyville
Pool's Island
Le Scie
Hermitage
Spencer Cove
Little Harbour East
Red Island
Blaketown
Argentia
Placentia
Little Barrasway
Garden Cove
Colinet
Mount Carmel
Angel's Cove
Garnish
Merrystown
Winterland
Creston
Port au Bras
Burin
Grand Bank
Fortune
St. Lawrence
Bay Bulls
Mobile
Cape Broyle
Ferryland
Fermeuse
Renews
St. Mary's
Trepassey
St. Shotts
SCALE - MILES
0 10 30 50 70

releasing large numbers of resting spores into the soil. These spores are very long lived, so that soils remain infested for ten to twelve years under cultivated crops and from twenty to twenty-five years under grassland,

Early Investigations

The earliest attempt to control the disease was made in the nineteen thirties, when varieties of potatoes which were immune from wart in Great Britain were imported into Newfoundland. Unfortunately, these varieties proved to be very susceptible to the local strain of wart, although one of them, Arran Victory, has become the most popular and widely grown potato in Newfoundland.

The first significant development in wart control occurred in 1948 and 1949 when H.N. Davis, a Provincial Agricultural Fieldman, made a survey of 147 potato gardens in the settlements of Seal Cove, Holyrood, Harbour Main, Avondale, and Conception Harbour and found that the Sebago variety was resistant to wart. Twenty-six plots were planted to Sebago and all were free from wart disease. Twelve varieties other than Sebago were represented in 94 gardens and all were wart infected. The susceptible varieties were also planted in the remaining 27 plots but the land was not infested by the pathogen,

Field Testing of Varieties and Seedlings

In 1960, G.C. Morgan commenced a program of testing named varieties and numbered seedlings in an effort to find other varieties with better horticultural qualities than Sebago and with possible immunity to wart. To make the tests, replicated plots were planted in wart infested soil in several areas near St. John's and around Conceptioq Bay, ' From 1950 to 1957 inclusive, 117 numbered seedlings originated by the National Potato Breeding Project at Fredericton, N. B., and 95 named varieties were thoroughly tested. The named varieties included 34,which were immune from the common strain of wart in Europe. They were obtained from the Institute of Agricultural Plant Breeding, Wageningen, Holland.

The very high resistance of Sebago was confirmed, Kennebec was found to possess high resistance, and two Dutch varieties, Ultimus and Urgenta, were found to be very highly resistant. Ultimus and Urgenta are good yielders of high quality, deep pink skinned, yellow fleshed tubers. They are late in maturity but have some resistance to late blight. The 117 seedlings were classified as 59 with very low resistapce, 25 with low resistance, 27 with moderate resistance, 3 with high resistance, and 3 were free from infection, One of the latter group was later found to be susceptible and one was discarded because of poor horticultural quality.

The varieties tested, grouped according to their resistance to wart, are listed in Table 1, The table includes 16 varieties tested by the author since 1957.

The author has continued the field testing program of varieties and also of seedlings developed at Fredericton. During the period 1958 to 1960 inclusive, 183 seedlings were tested in wart infested soil in addition to the 16 varieties mentioned above.

Table 1. Potato Varieties Tested for Wart Resistance in Newfoundland, 1950 - 1960.

Very high resistance

Less than 1% of tubers infected

Fontana
Fortuna
Kennebec
Noordeling
Norgleam
Sebago
Ultimus
Urgenta

High Resistance

One to 4% of tubers infected

Katahdin
Norland

Moderate resistance

Five to 10% of tubers infected

Antigo
Blanik
Boone
Canso
Chisago
Fram
Gineke
Huron
Irene
Plymouth
Rode Star
Rural Russet
Virgil
Voran
White Bliss
White Cloud

Low resistance

Eleven to 20% of tubers infected

Canago
Chenango
Fundy
Keswick
Merrimac
Mohawk
Ontario
Pawnee
Placid
Waseca

Very low resistance

Over 20% of tubers infected

Ackersegen
Alpha
Ari
Arran Comrade
Arran Pilot
Arran Victory
Bea
Bevelander
Bliss Triumph
Cherokee
Carnea
Chippewa
Climax
Columbia Russet
Craig's Defiance
Delus
Deodora
Dore
Dunbar Standard
Early Dewey
Early Epicure
Early Gem
Early Ida
Early Ohio
Early Rose
Empire
Essex
Frühmölle
Furore
Garnet Chili
Great Scot
Green Mountain
Home Guard
Houma
Ijsselster
Irish Cobbler
Kwinta
Libertas
Luctor
Majestic
Manchester
Manota
Meerlander
Meerster
Menominee
Netted Gem
Nova
Orion
Osage
Parnassia
Pentland Ace
Pimpernel
Pionier
Pontiac
Prinslander
Profijt
Pungo
Record
Red Kote
Red Warba
Rival
Robusta
Saco
Saskia
Satapa
Sequoia
Sharpe's Express
Sientje
Sirtema
Snowflake
Teton
Van Isle
White Rose
Wilpo
Yampa

In the first testing year, each seedling or variety was planted in two replicates of eight hills each. Seedlings showing no infection or very little in 1958 and/or 1959 were retested in six replicates of thirty or forty hills each. For estimating the severity of wart infection on varieties and seedlings at harvest time, an "infection index", involving five arbitrary infection classes, was used, made up as follows:

Class	Description	Weight
0	No infection	0
1	Light: one pustule up to 1 sq. cm.	1
2	Moderate: 1 sq. cm. to 1/4 of tuber warted	2
3	Heavy: 1/4 to 1/2 of tuber warted	3
4	Very heavy: 1/2 to all of tuber warted	4

The index was calculated by the following formula:

$$\frac{(\text{No. of tubers in class 1}) + (\text{No. of tubers in class 2x2}) + (\text{No. of tubers in class 3x3}) + (\text{No. of tubers in class 4x4})}{\text{Total No. of tubers} \times 4} \times 100$$

The wart infection indices of each seedling and variety in all replicates were then averaged to get a single value.

As result of these tests, Urgenta, Ultimus, Fontana, Fortuna, and F5318 were found to possess even greater resistance than Sebago. The resistance of Kennebec was extensively tested and appears to be equal to Sebago. Several other Fredericton seedlings and the varieties Noordeling and Norgleam were not infected in 1960, but until further testing has been done, the results must be considered inconclusive.

Effect of Weather Conditions on the Severity of Wart Infection

The observation has been made by farmers that the severity of potato wart disease is influenced by weather, being least severe in dry summers. Since test results seemed to agree with this, a comparison of weather conditions and severity of wart infection was made, The monthly precipitation and temperature records for the period April to October, 1958 to 1960 inclusive, are listed in Table 2.

Arbitrary ranges of wart infection indices were set up as follows: (1) 0; (2) 0.01 to 5.0; (3) 5.1 to 10.0; (4) 10.1 to 20.01 (5) 20.1 to 30.0; (6) 30.1 to 40.0; (7) 40.1 to 50.0, and (8) 50.1 to 60.0, The number of seedlings and varieties falling into each range annually were counted and the corresponding percentage of the total number tested for the year was calculated (Table 3).

Table 2: Average Monthly Temperature and Precipitation, April to Oct. for 1958 to 1960 inclusive, St. John's, Nfld.

Month	Rainfall in inches			Maximum Temperature			Minimum Temperature		
	1958	1959	1960	1958	1959	1960	1958	1959	1960
April	3.92	2.44	0.77	46.6	40.2	39.5	31.3	27.2	27.4
May	3.36	2.55	3.28	53.6	48.1	53.6	39.3	32.7	36.3
June	4.02	3.80	2.65	57.2	55.1	62.6	41.3	38.8	44.0
July	6.29	1.21	1.05	65.7	71.7	70.0	48.0	52.4	63.0
Aug.	3.50	3.30	2.12	69.3	64.5	70.2	53.1	51.9	61.7
Sept.	3.60	5.03	2.60	61.8	60.8	64.0	45.3	42.2	57.0
Oct.	3.79	2.41	7.11	50.6	49.5	50.9	37.3,	35.2	45.0

Table 3: Frequency Distribution of Wart Infection Indices, 1958 to 1960 inclusive

Range	1958		1959		1960	
	Number	Percentage	Number	Percentage	Number,	Percentage
0	3	3.2	7	9.8	20	26.7
0.01 - 5.0	13	14.2	26	36.6	44	58.7
5.1 - 10.0	21	22.8	22	31.0	9	12.0
10.1 - 20.0	29	31.5	14	19.8	2	2.6
20.1 - 30.0	17	18.5	1	1.4	0	0.0
30.1 - 40.0	5	5.4	0	0.0	0	0.0
40.1 - 50.0	2	2.2	1	1.4	0	0.0
50.1 - 60.0	2	2.2	0	0.0	0	0.0
Totals	92	100.0	71	100.0	75	100.0

Table 3 indicates a steady decrease in the severity of wart infection each year, because the number of varieties and seedlings falling in the lowest infection ranges has steadily increased. Also, an increasing number of varieties and seedlings have shown zero infection each year. Rainfall records for 1958-60 show that the months of June, July, August and September have become progressively drier, so much so that near drought conditions prevailed in 1960. The only consistent temperature differences in the three years were the higher minimum temperatures during the summer of 1960, June rainfall would have little effect since the potato plants in the test plots were still small and tubers had not commenced to form. The potato plant is most susceptible to wart infection in Newfoundland during July and August. Comparing the rainfall for July during the three years shows that in 1959 and 1960, it was very low. During 1959, more rainfall was received in August than in 1960. The low rainfall in July 1959, and even less rainfall in July and August 1960 can be correlated with the decreasing severity of

wart infection during 1959 and 1960. The above results could be explained by higher inherent wart resistance in the seedlings tested for the first time each year, but this is unlikely because the disease indices of those varieties and seedlings which were retested in 1959 and 1960 have decreased each year. Therefore, the apparent increased resistance of the seedlings is due to environmental conditions which are unfavorable for the development of wart infection.

Summary

1. The wart disease of potatoes may have been present in Newfoundland long before its official discovery in 1909.
2. Early attempts at control consisted of importing varieties of potatoes immune from potato wart in Europe but these were found to be susceptible in Newfoundland.
3. The very high wart resistance of Sebago was first noted in 1948. Between 1950 and 1960, the wart resistance of 111 named varieties and 300 numbered seedlings was determined. Kennebec, Sebago, Ultimus, Urgenta and F 5318 were found to have very high !resistance,
4. A correlation between rainfall and severity of wait infection was indicated from the test results of 1958, 1959 and 1960.

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EXPERIMENTAL FARM, RESEARCH BRANCH
CANADA DEPARTMENT OF AGRICULTURE
ST. JOHN'S WEST, NFLD.