Virus infection of potato seed stocks in Ontario under commercial insect-control practices

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Seed stocks in Canada's Elite Seed Potato Program are in the field for 5 consecutive years before reaching the table-stock grower. This may be too long a period to prevent considerable reinfection of virus-free stocks by contact viruses such as virus X and, in an area like southern Ontario, by potato leaf roll virus. To test this hypothesis, clones of Sebago that were free from virus X and clones of Sebago and Kennebec free from visible symptoms of virus infection were grown in the field in southern Ontario. Plants showing symptoms of tuber-borne diseases in the field and in greenhouse tests were removed from the program. The Kennebec clones were eliminated within 3 years; the X-free Sebago clones were reduced to 17% and the other Sebago clones to 27% of their original populations in 5 years. Replicated yield trials of all clones were carried out, with virus-free Sebago included for the last 2 years; no differences in yield were observed among clones or among classes of seed.

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Dans le cadre du Programme canadien d'amelioration de la pomme de terre de semence Elite, les stocks de semences sont évalués en plein champ pendant 5 annees consecutives avant d'atteindre les producteurs de pommes de terre de consommation. Il est possible que cette periode soit trop longue pour prevenir une forte reinfection des stocks indemnes par les virus de contact comme le virus X et, dans une region comme celle du sud de l'Ontario, par le virus de l'enroulement des feuilles. Pour verifier cette hypothese, certains clones de Sebago exempts du virus X et d'autres de Sebago et de Kennebec exempts de symptômes visibles de virose, ont ete cultivés en plein champ dans le sud de l'Ontario. Les plants qui ont manifesté des symptômes de maladies transmises par les tubercules, dans les essais de terrain et de serre, ont ete rètires du Programme. Les clones de Kennebec ont ete éliminés en moins de 3 ans; ceux de Sebago exempts du virus X ont ete réduits a 17% et les autres clones de Sebago, a 27% de leur peuplement original en 5 ans. On a effectue des essais de rendements a repetitions de tous les clones, la variete Sebago indemne pour les 2 dernieres annees; on n'a constaté aucune difference de rendement entre les clones ni entre les classes de semences

The introduction of the Elite Seed Potato Program in Canada has raised several questions concerning the possibility of maintaining the required standards in the seed throughout the many stages of production.

There are four stages before the seed reaches the commercial seed grower and two more from the seed grower to the producer of table stock as follows:

Pre-elite	Foundation
Elite I	Certified
Elite II	Table stock
Elite III	

Pre-elite stocks, originally selected from the best commercial seed available, are tested for bacterial ring rot and indexed in the greenhouse for visible virus symptoms. Those which pass inspection are planted the following season to produce Elite I. This is done either on Elite Seed Farms or, as in Ontario, by Elite Seed Growers under contract and is continued to the production of the Elite III, the seed dropping one grade each year. Elite III seed is sold to commercial seed growers who increase it through the Foundation and Certified stages to sell to the producer of tablestock and processing potatoes.

The introduction of virus-free pre-elite seed has improved the quality of seed entering the program but has not altered the fact that the seed has a long and hazardous road to follow before it reaches the tablestock grower. The quality of the seed at this latter stage is governed by several factors: the quality of the seed entering the program, which we have dealt with; the calibre of the seed growers throughout the program; the quality of the inspection service; last and perhaps the most important is the disease environment in which it is grown.

Southern Ontario, where most of the seed potatoes are produced in the province, has long been believed to be a poorer environment for seed production than northern Ontario, because of the higher population of the green peach aphid (*Myzus persicae).* This has recently been confirmed by McEwen (F.L. McEwen, personal communications). Prevailing winds bring swarms of winged aphids into southern Ontario from Michigan, Ohio, and western New York; these aphids; together with our overwintering population, make leaf-roll virus a major problem to all seed growers. It was decided, therefore, to investigate the rate of infection of a "clean" population under conditions which were typical of the major seed-growing areas of the province.

Materials and methods

This experiment was conducted at the Horticultural Research Station, Cambridge (formerly Preston) in a Fox sandy loam which is typical of many of the potato-growing areas of Ontario.

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In 1966, when the investigation began, no virus-free seed was available. We were fortunate, however, to obtain 103 tubers of virus X-free Sebago from Dr. N. S. Wright, Agriculture Canada, Vancouver, B. C., and 3 from Dr. N. R. Thompson, Michigan State University, East Lansing, Michigan. So that we could compare yields among these clones and also between them and commercial seed, we also selected one tuber from each of 15 superior-looking Sebago clones and from 14 Kennebec clones in Foundation (old system) seed blocks at Cambridge.

To increase each clone to the point where we had enough seed for a yield trial, they were planted in tuber units in the field and rogued for visible virus diseases, blackleg, and rhizoctonia. The X-free and Foundation potatoes were planted in separate blocks at this stage to avoid premature contamination. The plants were hilled soon after emergence and sprayed with a herbicide; irrigation pipes were installed and left in place and a fungicide/insecticide program was applied by air-blast sprayer from an adjacent roadway, so that there was no unnatural spread of virus. Great care was taken not to touch the surrounding plants while roguing.

The vines were killed each year when most of the tubers had reached "A" size (4-12 oz: 113-340 g). Each unit was harvested individually and two small tubers from each were split and grown in the greenhouse in the winter of 1966-67 to check for visible virus symptoms and, in the case of the X-free clones, for virus X using *Gomphrena globosa* as the indicator plant. Those clones which became reinfected with virus X, but were free from visible symptoms of virus and other diseases, were retained and increased separately. One clone of Elite I from the Ontario seed program was added to those surviving the roguing and indexing and all were planted in the field in 1967 in the same manner. The program was repeated in 1968 so that there was enough 6-8 oz (170-227 g) seed produced of each clone to give sufficient 1.5-2.0 oz (42-56 g) seed pieces to plant 3 replicates of randomized single 20 ft (6.1 m) rows in 1969. Virus X-free and X-infected plots were separated by X-free guard rows of the same cultivar.

In 1969 we also obtained a few tubers from a single clone of virus-free Sebago from Dr. Wright and these were planted separately for increase.

The experiment was repeated in 1970 and 1971 with 4 replicates and including the virus-free clone. The same precautions were taken as before, with the addition of virus-free guard rows for the virus-free plots. When the yield trial began diseased plants were not rogued but were staked and in 1969, which corresponded to the Elite III-to-Foundation stage, were harvested separately. If the remaining plants produced enough seed, the clone was replanted the following year, providing that it met the standards for the class.

The insect-control program until 1969 was DDT weekly in the early part of the season and thiodan weekly from early July until the tops were killed. The green peach aphid appears in late July in this area. Systemic insecticides applied in granular form at planting time have been found to be of little value against aphids in this area because the effectiveness has worn off by the time the aphids appear.

Following the withdrawal of DDT, thiodan was used weekly from crop emergence until early July at which time it was alternated with meta-systox. In 1970, the agricultural oil "Corntrol" was added to the spray material on the recommendation of Bradley (1) to help in the control of aphid-transmitted viruses.

Results

Disease incidence

It was necessary to rogue 24 of the British Columbia X-free Sebago clones in the field in 1966, 16 for leaf roll, 4 mosaic, 2 blackleg, and 2 rhizoctonia. No Ontario clones were removed from the field, but 1 Kennebec, 5 Sebago, and 1 Michigan X-free clone were discarded in the greenhouse because of leaf roll (Fig. 1).

In the 1967 growing season only 3 B.C. Sebago clones were rogued in the field but in the greenhouse 24 were rejected for mosaic, together with 3 Foundation Kennebec and 3 Foundation Sebago for mosaic and 1 of each for leaf roll.

The numbers were further reduced in 1968. Two Foundation Sebago clones were rogued for leaf roll; 3 Foundation Kennebec and 2 X-free B.C. Sebago clones had mosaic. In the greenhouse 1 B.C. X-free and the remaining Kennebec clones were discarded for leaf roll and 1 Michigan and 3 B.C. clones were found to be infected with virus X and were transferred to the Foundation group.

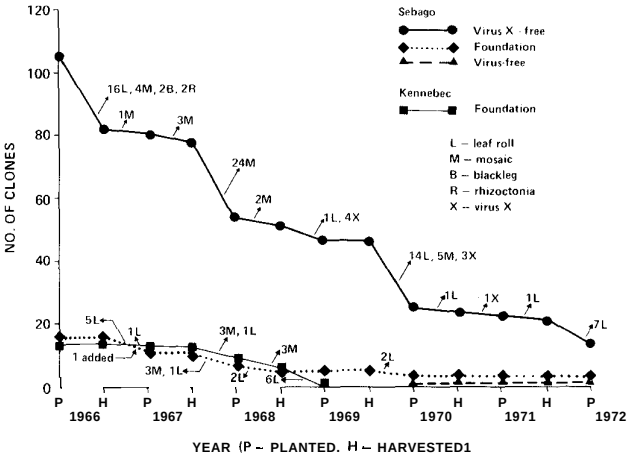

Figure 1. Disease status of potato clones grown in the field in southern Ontario 1966-72; numbers and letters indicate the number of clones discarded because of disease during screening in the field and greenhouse.

Table 1. Yields of Foundation, virus-free, and virus X-free Sebago potatoes, 1969-71

Year	Seed planted	Yield in cwt/acre and (t/ha) Total	Ont. No. 1
1969	X-free	284.1 (31.8)	260.6 (29.2)
	Foundation	292.7 (32.8)	266.9 (29.9)
		N.S.	N.S.
1970	X-free	238.9 (26.8)	221.8 (24.8)
	Foundation	260.2 (29.1)	243.1 (27.2)
	Virus-free	212.4 (23.8)	197.2 (22.1)
		N.S.	N.S.
1971	X-free	204.2 (22.9)	178.2 (20.0)
	Foundation	200.3 (22.4)	175.8 (19.7)
	Virus-free	200.7 (22.5)	175.0 (19.6)
		N.S.	N.S.

As described above, no plants were removed from the field in 1969, but diseased units were staked and harvested separately for inclusion in yield data. In the greenhouse, however, 14 B.C. X-free and 2 Ontario Foundation Sebago clones were rejected for leaf roll. Five B.C. clones were discarded for mosaic and 3 were relegated to the X-infected (Foundation) class. Similar patterns were repeated in 1970 and 1971, so that following the 1971 field and greenhouse screening there remained only 14 B.C. X-free, 1 virus-free, and 12 X-infected clones. Of the last, 9 were originally X-free, 2 were Foundation (old system), and 1 was from the Elite program. All of these clones were Sebago, the last of the Kennebec having been eliminated in 1969.

Yields

Table 1 shows that there were no differences in total yield or in yield of Ontario No. 1 tubers among classes in any year. The analysis of variance also showed that there were no differences among the clones within the classes.

Discussion

The standards used in inspecting and roguing these plots were those of the Elite Seed Program (2). No visible disease is allowed in Elite I and II seed, but there is unlimited roguing. In the third inspection for Elite III there is a tolerance of 0.1% for all viruses and 0.25% for all diseases. For the final (2nd) inspection of the Foundation grade these figures are the same as for Elite III but for the Certified grade they are 1.0% and 2.0% respectively.

Because unlimited roguing is allowed in the Elite I - III stages (1967-69) a clone was removed if, after roguing, there was not enough seed left to plant the necessary plots the following year. In the Foundation and Certified stages (1970-71) a clone was removed if the percentage infection exceeded that permitted under the regulations.

It can be argued that this experiment is no longer relevant because eventually we shall be using virus-free seed and therefore there will be no spread of tuber-borne viruses in a crop. Within limits this is true for the so-called contact diseases which are spread by mechanical means, but it is most certainly not true for the leaf roll virus, which is spread by aphids. However, in view of the freedom from virus X within the bulk of the population studied and the care taken to avoid its spread by other than natural means, it would seem that a valid comparison can be made between this and the spread of similar viruses in an allegedly virus-free population.

A proven method of preventing leaf roll is killing the vines before the aphid vector appears. This was not done because we were following regular Ontario practice, which is to kill the vines when the plants have produced a marketable yield. In most areas this would not occur by the time the aphids appear, thus emphasizing the fact that if seed growers are to produce seed free from leaf roll, they must receive a price that is high enough to compensate for the low yields caused by early vine killing.

If we ignore the 24 B.C. clones rogued in the field in 1966 and count the program from 1967, the period from then until 1971 corresponds to the time taken for a seed-lot to pass through the Elite program from Elite I to tablestock. Thus out of the original 82 Sebago clones only 14 were left to plant as Certified seed and harvest as tablestock in 1971. This is a reduction of about 83% in 5 years, or, on average, 17% of the original population per year, in spite of an above-average insect-control program. It will be noted that the amount of infection did not increase in 1969, 1970, and 1971, even though diseased plants were left in the field until harvest.

These findings support the view of McEwen (3) that southern Ontario is a poor location for increasing virus-free potato stocks, but if such a program is to be carried out successfully a very high level of care will be needed by both growers and professionals.

The yield results differ from many of those quoted by Wright (5), who reported that an increase usually is obtained when potatoes are freed from virus X. However this is not always so (4) and Wright himself failed to obtain an increase at one location, thus indicating that other, environmental, factors are involved.

The lack of yield differences among the clones was to be expected. Clones of a vegetatively reproduced cultivar are genetically identical and under the same growing

conditions all yields should be the same. Differences in yield would only be induced by disease or mutation, and in the latter case, of course, we are dealing with a new cultivar. In 25 years of selecting and testing clones in the Scottish seed program, Hardie (J. L. Hardie, personal communication) has found that all plants which remained true-to-type maintained their yield potential and that no mutants equalled the nuclear stocks in performance.

If clonal selection is to be a factor in improving the yield of potatoes, widespread testing of disease-free stocks would seem to be necessary to ensure that real differences are obtained.

Literature cited

1. Bradley, R.H. 1971. In Annu. Rep. Natl. Work Plan. Comm. Potato Breeding. Fredericton, N.B.
2. Canada. 1969. Destructive Insect and Pest Act. The Canada Gazette. Pt. 11, Vol. 103.
3. McEwen, F.L. 1972 In Annu. Rep. Ont. Regional Potato Committee.
4. Murphy, H.J., M.J. Goven, and D.C. Merriam. 1966. Effect of three viruses on yield, specific gravity and chip color of potatoes in Maine. Amer. Potato J. 43:393-396.
5. Wright, N.S. 1970. Combined effects of potato viruses X and S on yield of Netted Gem and White Rose potatoes. Amer. Potato J. 47:475-478.