AGRICULTURE DEVELOPMENT FUND

BIOTYPING OF POTATO DISEASES
IN SASKATCHEWAN

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ABSTRACT

The potato industry in Saskatchewan has a reputation for producing vigorous, healthy seed potatoes. In order to maintain this reputation, growers need to be aware of the diseases that are present, or might become a problem, in their crops. Disease surveys of Saskatchewan grown seed and table-stock potatoes in storage in 1997/98 and 1998/99 showed that black scurf, silver scurf and dry rot are significant storage disease problems in Saskatchewan. Isolates of Fusarium species (dry rot) and Helminthosporium solani (silver scurf) were tested for their reaction to Mertect, the fungicide commonly used to control these diseases. Isolates of both species, from a number of locations, were found to be resistant to Mertect.

Powdery scab (Spongospora subterranea) was not found on seed potatoes. This disease is extremely destructive in Australia, New Zealand and Britain, and growers are alerted to the potential for spread by infected seed.

Late blight identification, and determination of mating type and sensitivity to metalaxyl (a common fungicide) have been carried out. The disease occurred in the Outlook area in 1998; the isolate was A2 mating type, metalaxyl sensitive.

The disease survey results generated by this project have been distributed to growers and industry support personnel.

EXECUTIVE SUMMARY

The potato industry in Saskatchewan has a reputation for producing vigorous, healthy seed potatoes. In order to maintain this reputation growers need to be aware of the diseases that are present, or might become a problem, in their crops. Disease problems, and the pathogens responsible, must be accurately diagnosed and identified in order for correct, control management decisions to be made. Four aspects of the potato disease situation in Saskatchewan have been studied:

1. Surveys of potatoes in storage were conducted in 1997/98 and 1998/99, to provide data on the diseases present, and to indicate problems that needed further investigation. In both years, levels of black scurf (Rhizoctonia solani), silver scurf (Helminthosporium solani) and dry rot (Fusarium species) were significant. Information about the diseases in their storages assisted producers in making management decisions, and provided the industry with a picture of the overall health status of the crop. Pathogen isolates obtained from diseased potatoes were used to test the sensitivity of the pathogens to Mertect, the fungicide commonly used to prevent disease development in stored potatoes.

2. Growers have complained of a lack of disease control when using the fungicide, Mertect, and this may be partly due to development of resistance in the pathogen to thiabendazole (the active ingredient in Mertect). Isolates of Fusarium and Helminthosporium obtained from diseased potatoes produced in the province were grown on an agar medium containing a range of concentrations of Mertect. Isolates that did not grow on agar containing 5mg/L of chemical were considered sensitive to the fungicide, and isolates that continued to grow at 100mg/L were
resistant. Resistance was found in isolates of both pathogens from a number of locations, indicating that the resistance is probably widespread. Growers need to re-evaluate the role of Mertect in disease management.

3. Powdery scab, caused by the fungus *Spongospora subterranea*, was not found in seed potatoes. The pathogen has a resting stage capable of surviving for at least five years in the soil, and can be extremely destructive. Rapid identification of the pathogen and evaluation of disease infestation of soil would be beneficial. Tests using seedlings as bait plants in soil solutions did not successfully identify contaminated soils. Greenhouse tests, when potato plants were grown in infested soil, produced diseased tubers, but this test is time- and space-consuming. Techniques using the polymerase chain reactions are being developed in other countries and will be tested in Saskatchewan. Growers have been alerted to the potential destructiveness of this disease.

4. Late blight continues to be of concern to Saskatchewan potato producers. As the potato acreage increases, with more seed being purchased from areas where blight occurs regularly, the probability of a disease outbreak occurring is increased. Late blight was not identified in 1997, but in 1998 infection was present in the Outlook area. The pathogen was isolated and determined to be mating type A2, and sensitive to metalaxyl (a chemical routinely used for disease control). The importance of scouting for disease, and early identification of the pathogen, its mating type and fungicidal sensitivity have been reported to seed growers through articles in the SSPGA newsletter, and presentations at meetings.

**TECHNICAL REPORT**

Disease problems, and the pathogens responsible, must be accurately diagnosed and identified in order for the correct management or control recommendations to be made in Saskatchewan. This information is particularly important to seed potato growers to ensure that the province maintains its reputation for healthy, clean seed. The activities covered by this project were designed to ensure that the crucial disease identification information was available to Saskatchewan growers.

1. Surveys of potatoes in storage were conducted in 1997/98 and 1998/99 to provide data on the diseases present in Saskatchewan potato seed, and to suggest problem areas that warranted further investigation.

2. Growers have complained of a lack of disease control when using the post-harvest fungicide, Mertect. This has been attributed partly to development of resistance to thiabendazole (the active ingredient in Mertect) by pathogens. Isolates of *Fusarium* species and *Helminthosporium solani* obtained from survey material were evaluated for resistance to the fungicide.

3. Powdery scab is not presently a problem in our industry. Development of the disease in Australia, Britain and New Zealand has been extremely damaging to the potato
industry in those countries. Information on the damage potential of this disease was provided to growers.

4. Management of late blight, based on reliable information regarding the status of disease in the province, is important as epidemics develop quickly, are highly destructive and costly to control. Monitoring of late blight outbreaks and typing of the late blight pathogen in the province have been carried out.

Activities, Results and Conclusions:

1. Surveys of diseases in stored potatoes:
The surveys were conducted to provide data on the diseases present in Saskatchewan potatoes, and to suggest problem areas that warranted further investigation.

a) 1997/98

Method. Thirty-five samples of tubers in storage were collected from fourteen Saskatchewan growers of seed and tablestock potatoes. The samples were collected at random from the storage bins, to obtain a representative, non-selected sample. A sub-sample of 30 tubers was taken for disease assessment from each sample. The tubers were washed and rated for presence of dry (*Fusarium* species) and soft (*Erwinia carotovora*) rots, black scurf (*Rhizoctonia solani*), common scab (*Streptomyces scabies*), and wounds, and then incubated for three weeks at room temperature and high humidity, before rating for silver scurf (*Helminthosporium solani*) infection. Each tuber was assessed for the presence of disease and the percentage of tubers infected was recorded as the disease incidence. The amount of surface area of each tuber infected was also evaluated, using standard keys for disease assessment, and the average infection level was calculated. Every grower was informed of the disease incidence and average infection level in each sample.

Results. Incidence of black scurf was high, with 50% or more of the tubers infected, in 13 out of 35 samples. An average infection level of 5% or more occurred in 10 samples. When seed lots are inspected for certification, only 5% of the sample is allowed to have 6-10% infection. The infection levels were over that limit for some of the surveyed samples. It should be noted that the survey samples were washed before assessment, but inspection of bin lots is usually done on unwashed potatoes. This suggests that inspections may be missing low levels of infection. In seed potatoes, when low infection levels are present the contaminated seed lot may perform poorly.

The incidence of common scab was less than 30% in all but one sample. Infection levels were very low, suggesting that although common scab is a widespread problem, growers are managing it effectively. Dry rot was found in 11 samples and soft rot in three. In seven of the dry rot samples, 10% or more of the sample was infected, and this would require culling out infected tubers before selling or planting.

Silver scurf was not previously thought to be a problem in Saskatchewan so the incidence of silver scurf was surprisingly high. Thirteen of the samples had 50% or more tubers infected, although the level if infection was generally low, with less than 5% of the surface infected. This disease is most easily detected after washing and
incubation, and would not be readily detected during a bin inspection. High levels on seed potatoes create problems for producers who grow succeeding generations for table and processing. There is a tendency for the infection levels to increase with each successive generation.

Isolates of *Fusarium* were collected from 14 samples of diseased tubers, both from the survey and from specimens submitted by growers for diagnosis of problems. A range of isolate types was sent to Randy Clear, Canadian Grain Commission, Winnipeg, who identified seven species of *Fusarium*. *F. sambucinum* was the predominant species, isolates of *F. equiseti*, *F. avenaceum*, *F. solani*, *F. flocciferum*, *F. acuminatum* and *F. semitectum* were also present. Evaluation of pathogenicity and fungicide resistance of these species is ongoing, and the most pathogenic will be used in future laboratory testing of disease control products.

Twenty-seven isolates of *Helminthosporium solani* were collected from ten survey samples, from seven locations. Reference samples of all isolates are being maintained.

**b) 1998/99**

**Method.** The 1998/99 survey was similar to that conducted in 1997/98. Fourteen seed and table-stock growers supplied a total of 41 samples. The initial sample size was increased to 100 tubers, which allowed assessments to be carried out three times during the storage season. The first two assessments have been carried out, the third is scheduled for April/May of 1999. Growers have been informed of the results of the first two assessments.

The disease incidence was recorded as in the previous survey, and also the percentage of tubers that fell into the disease categories used by the Agriculture and Agri-Food Inspection Agency. The permissible amounts of disease are 10% of sample with 1-5% of tuber surface infected, or 5% of sample with 6-10% surface infected.

**Results.** The incidence of black scurf was again high, 16 out of 41 samples had 50% or more of the tubers infected. Combined with infection levels, this resulted in 22 samples being above the limit set for acceptance as either seed or table potatoes. Common scab was generally at a low level, although two samples exceeded the inspection tolerances. Eight samples had unacceptable levels of dry rot, and seven samples developed soft rot after incubation for silver scurf assessment. Silver scurf incidence was high (over 50%) in seven samples, with a total of 33 samples showing some disease. This disease is widespread in occurrence and is of concern to the producers.

Thirty-nine isolates of *Fusarium* and 21 isolates of *Helminthosporium* were obtained from the second survey. The *Fusarium* isolates were predominantly *F. sambucinum*.

**Conclusions.** The surveys indicate that black scurf, silver scurf and dry rot were significant problems in stored potatoes, in many cases. These diseases can directly damage the stored crop through decay, or may adversely affect the appearance of the potatoes, reducing their market value. They may also delay or attack emerging sprouts of seed potatoes, reducing the vigour of the subsequent crop. The presence of
relatively high levels of these diseases suggests greater efforts in management and control are needed.

2. Fungicide resistance in pathogens of stored potatoes

There are reports of widespread resistance to the fungicides used to prevent decay in stored potatoes. Tubers are commonly treated with a post-harvest fungicide, Mertect (active ingredient, thiabendazole) as the crop is going into storage. The treatment is designed to protect the stored crop against attack by fungal pathogens such as *Fusarium* and *Helminthosporium* during the storage period. Growers of potatoes in Saskatchewan are rightly concerned about the efficacy of Mertect against the strains of pathogen encountered by their crops. This study evaluates the reaction of some of the isolates obtained from diseased tubers from a number of locations in the province.

**Method.** Techniques for evaluating the effect of chemicals on the growth of fungi that attack stored potatoes have not been standardized. Kawchuk, *et al.* (Resistance to Thiabendazole and Thiophanate-methyl in Canadian isolates of *Fusarium sambucinum* and *Helminthosporium solani*. 1994. American Potato Journal 71: 185-192.) dissolved the fungicides in dimethylsulfoxide before adding to autoclaved PDA, and calculated the concentration of chemical that inhibited radial growth by 50% (EC₅₀). Hanson, *et al.* (Sensitivity to Thiabendazole in *Fusarium* species associated with Dry rot of potato. 1996. Phytopathology 86:378-384.) dissolved thiabendazole (TBZ) in ethanol before adding to molten V8 agar, and considered that any isolate that grew away from the agar plug at 5mg/l of TBZ was designated resistant to the fungicide. Comparison of autoclaved and non-autoclaved amended plates reveal no deleterious effect of incorporation of the fungicide before autoclaving (Jim Holley, personal communication), and the procedure reported here involved dilution of the fungicide in water, and addition to the agar before autoclaving.

The exact amount of fungicide present on a potato tuber, that is available to act as a control agent, is likely to be extremely variable and dependant on the evenness of coverage. The recommended application rate of Mertect is 8L of fungicide in 170L of water, applied at 2L per metric tonne of tubers. Assuming an even distribution of fungicide over the surface of every potato, this translates to 1mg of fungicide on 20.8g of tuber. The average weight of a seed piece is 2oz (56.7g) so approximately 2mg of TBZ would be present on each seed piece. The agar plates contain 14 ml of agar, thus a rate of 5mg/L gives a total of .07mg TBZ per plate. If isolates are sensitive to the chemical on the plate, then it seems likely they will be sensitive to chemical on the potato, where the concentration will be higher. The validity of translating results from the laboratory testing, to the storage situation should be evaluated.

Twenty-seven *Fusarium* and 17 *Helminthosporium* isolates obtained from the 1997/98 survey, and 24 *Fusarium* isolates from the 1998/99 survey, were tested for resistance to Mertect (thiabendazole). The fungicide was incorporated into potato dextrose agar (PDA) plates at a range of concentrations- 0, 5, 10 and 100mg
thiabendazole/L agar. An agar plug taken from the edge of an actively growing fungal culture was introduced to the centre of an amended agar plate. The increase in diameter of the colony on the plates containing chemical at a range of concentrations was compared with growth on a plate containing no chemical. Different isolates grow at different rates, and to accommodate this the comparison of growth on the amended plates was made when the colony on the control (no chemical added) had reached the edge of the plate.

Three categories of reaction to Mertect were recognized: 1) no growth at the lowest level of Mertect = sensitive (S), 2) reduced growth at 5 and 10mg/L = intermediate (I), 3) growth at 100mg/L = resistant (R).

**Results.** The 27 *Fusarium* isolates obtained in 1997/98 came from 5 locations in Saskatchewan. One location had both sensitive and intermediate isolates, 2 locations had sensitive, intermediate and resistant isolates, and 2 locations had only resistant isolates. However, in the last case only one isolate was tested at one of the locations.

Of the seventeen isolates of *Helminthosporium* obtained from ten locations in 1997/98 eight were highly resistant, and nine were intermediate in reaction to Mertect. Resistant isolates were recovered from tubers grown at five of the ten locations, indicating the resistant pathogen is widespread. Isolates obtained from the 1998 crop have not yet been tested.

Testing of *Fusarium* isolates obtained from the 1998/99 survey concentrated on 25 *F.sambucimum* type isolates. Isolates from nine locations were examined and at six of these locations all isolates were resistant (total of 12). Two locations had only sensitive isolates and a mixture of sensitive and resistant isolates was found at one location.

**Conclusions.** Resistance to Mertect would appear to be widespread, and would explain why growers have been experiencing failure of the product to control disease. The fungicide has been available for a number of years, allowing time for the fungus to develop resistance to the chemical. Development of resistance has been accelerated by the fact that; a) Mertect was the only product registered for post-harvest use in potatoes. Pathogens repeatedly exposed to a single pesticide are under a selection pressure to develop resistance, and b) complete control is crucial in slowing the development of resistance. Adequate coverage of potatoes is difficult, given the adherence of soil to the surface.

Lack of an alternative chemical has been a problem for growers, but the product Dithane (mancozeb) has recently received minor use registration for post-harvest treatment of seed potatoes. The product Maxim (fludioxonil) will be registered for pre-plant treatment by spring 2000. These products will help producers combat dry rot, black scurf and silver scurf problems.

The presence of isolates that are still sensitive to thiabendazole indicates there may be a possibility of re-establishing a Mertect-sensitive population once the selection pressure for resistance has been decreased by the use of alternative chemicals. Monitoring of population changes in the pathogens will provide information about this possibility.
One variable that may affect testing for fungicide resistance is the condition of the isolates. *Fusarium* cultures are notoriously unstable. Some researchers prefer to test single spore isolates, as a way of reducing variability. However, in the storage bin isolates are not pure, and there may well be mixtures of species occurring in close proximity. Studies to compare the reaction of single spore isolates with that of the parent isolate are being undertaken.

4. **Powdery scab**

Common scab (*Streptomyces scabies*) has been considered a widespread problem in Saskatchewan. The level of damage caused by common scab varies between years, growers and cultivars. There are no chemical control methods for this disease. Cultivar resistance and proper growing practices represent the main management options. Powdery scab is caused by a fungus (*Spongospora subterranea*) that has a resting stage capable of surviving for at least ten years in the soil. There are no effective control methods for powdery scab available to growers at present. This disease has caused extensive and costly damage to the potato industries in Britain, New Zealand and Australia. Saskatchewan growers need to be prepared to combat and contain the problem.

The disease has been studied in isolation in greenhouse and laboratory experiments at the University. A bioassay technique using seedlings of tomatoes and other species for indicating the presence of the powdery scab pathogen in soil samples was not successful. Definitive symptoms did not develop in the seedling roots. A greenhouse test using potatoes grown in a variety of powdery scab infested soils was successful in producing tubers with the disease. However this test is time consuming and requires large areas of greenhouse space.

The presence of spore balls in scab pustules is the conventional method for confirming the pathogen is present. Unfortunately spore balls are produced under specific conditions, and are not always easily detected. Techniques for evaluating contamination of soil, or early infections of tubers, before spore balls are formed, would be beneficial. Use of polymerase chain reaction (PCR) primers for the identification of *Spongospora subterranea* in tubers and in soil has been studied in New Zealand (Detection of *Spongospora subterranea* in potato tuber lesions using the polymerase chain reaction (PCR). Bulman and Marshall. 1998. *Plant Pathology* 47:759-766.), and this technique should be evaluated.

5. **Late blight monitoring**

The threat of a late blight epidemic is ever present, particularly when seed planted in the province is purchased from areas known to be infected with the disease. As the potato acreage expands in Saskatchewan, the probability of diseased seed being planted and acting as a primary source of inoculum increases. Continual monitoring for disease is essential. There were no confirmed cases of late blight (*Phytophthora infestans*) in commercial or seed potato fields in Saskatchewan in 1997. At least 20 foliar specimens and five tuber specimens, from different areas of the province, were examined for infection, and the majority of the foliar symptoms were caused by early
blight (*Alternaria solani*). One sample was sent to the Agriculture and Agri-Food laboratory in Charlottetown; no late blight infection was found.

In 1998 a number of field inspections were made, and samples were examined. Late blight was confirmed in July when typical foliage symptoms, with sporulating lesions, were observed in the Outlook area. Two isolates of *Phytophthora infestans* were obtained at different times, and the mating type was determined by pairing the isolates with known A1 and A2 types provided by Dr. Bud Platt (Charlottetown). Both isolates were A2, and were found to be metalaxyl sensitive when tested by scientists in Dr. Platt’s laboratory. This information is important when growers are making decisions about fungicide applications.

A network of weather monitoring stations was established in 1998, to provide the data necessary for forecasting conditions conducive to late blight development. This network will be fully operational in 1999, and will provide information to the producers who need to be extremely vigilant in controlling late blight.

The presence of late blight in Saskatchewan in 1998 was identified quickly and appropriate management strategies were used to contain the infection. The most heavily infected area was destroyed by ploughing as soon as the disease was reported. Frequent fungicide applications prevented the spread of disease. The harvested crop was not kept for seed, and will not be available as a source of inoculum in 1999. The initial source of inoculum for the outbreak was not identified, but infected seed, produced in the States, is a possibility. The weather monitoring system did indicate conditions conducive to blight had occurred in that region. Growers are being advised to scout fields thoroughly at the beginning of the 1999 season, and to send all diseased samples to the laboratory for identification of the pathogen(s) involved.

**Further Development:**

The ongoing horticulture pathology research program will utilize the results generated in this study as a basis for the following work:

**Surveys**

Comparison of the storage pathogen data collected at the three assessment times will be made, to determine if disease levels change during the storage period. When possible, comparison with tubers stored in the producers’ bins will be made. In particular, increases in silver scurf may occur because of sporulation and spread of the fungus in storage.

Annual surveys will be made if funding is available, as changes in disease patterns and relative importance can be monitored in this way. Continuation of the surveys will help build an accurate picture of the health status of the Saskatchewan potato industry.

**Fungicide resistance**

The frequency and distribution of fungicide resistant species should be monitored, and detailed population studies conducted of the *Fusarium* species found at locations with dry rot problems. Testing and identification of isolates already obtained should be
Pathogenicity of the Fusarium species should be evaluated.
Resistence of the Helminthosporium isolates, and distribution of resistant isolates is being evaluated.

**Powdery scab**
Monitoring for the presence of powdery scab should be continued, identification techniques and control measures evaluated. It is particularly important that this pathogen does not enter the seed production system. Grower education is important.

**Late blight**
Early identification of the late blight organism is vital for controlling outbreaks of the disease. Confirmation of the presence of Phytophthora infestans, followed by determination of the mating type and metalaxyl sensitivity should be made as soon as possible. If both mating types are found in close proximity, there is a possibility that increased variability in the fungus will result, which can lead to the development of more aggressive strains. Knowledge of the sensitivity of the pathogen to specific chemicals aids the producer in making control decisions.

Evaluation of the effectiveness of the late blight forecasting system established by the Saskatchewan Seed Potato Growers Association (SSPGA) is of importance. Newer strains of the pathogen may have greater tolerance to dry conditions, and this may require changes to the parameter settings for the data collected.

**Information of benefit to producers:**

**Surveys**
Producers have used the detailed knowledge of the health of their stored crop provided by the surveys, when making management and marketing decisions. For example, if there is significant rot in the seed lot, potatoes were kept drier and cooler before planting. In some cases, test results for silver scurf levels have been requested by buyers. Surveys indicate whether problems are local or widespread, and this information influences crop management and sales decisions made by the industry.

**Fungicide resistance:**
Individual growers and their customers need to know if they are dealing with pathogens resistant to certain chemicals. When resistant isolates are present continued use of the chemical would be costly and ineffective. In these situations growers need to adopt alternative chemical and cultural controls.

**Powdery scab:**
Awareness of the potential for this disease to become a problem is of value to all producers. Efforts were made, in conjunction with the provincial pathologist, to increase grower awareness of the disease – specifically emphasizing the need to prevent entry of the disease into the seed system. Seed producers should examine all imported seed
carefully, to avoid introducing the pathogen to their soils. Recognition of the disease can be difficult, and submitting samples to a diagnostic laboratory would be advisable.

**Late blight:**

Isolation and testing of the pathogen allowed growers to make spraying decisions based on accurate knowledge of presence of the pathogen, and sensitivity of the fungus to metalaxyl, a commonly used fungicide. If the two mating types are present together then growers will need to be made aware for the potential for increased difficulty in controlling the disease.

**PROJECT DEVELOPED MATERIALS**

1. Information sheets about research projects and specific diseases have been prepared for use by extension and other industry support personnel, and for display at trade shows such as the Crop Production Show and Gardenscape (see attached).

2. Presentations outlining program results have been made at the Saskatchewan Seed Potato Growers Association meetings, and at the Prairie Potato Council Meeting, Saskatoon, December 1998.

**ACKNOWLEDGEMENT**

ADF funding has been verbally acknowledged during presentations.