Yukon Territory Crop Pest Surveillance Project 2020
Final Results Report

Prepared by

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1.0 Introduction

Agriculture is a growing and economically important industry in the Yukon Territory and includes both crop and livestock production. Diseases, insect pests and weeds can threaten crop yields and quality. Having a knowledge of the prevalent pest risks in the Yukon will help crop producers to adopt pest management strategies that will help to minimize potential losses. The Agriculture Branch, which is part of the Yukon Government's Department of Energy, Mines and Resources, decided to undertake some exploratory disease and insect pest surveys on barley, wheat, canola and selected vegetable crops, including beets, broccoli, carrots, potatoes and turnips, on two farms in the Whitehorse area in summer, 2020. These surveys were the first of their kind to be carried out in the Territory and, hopefully, will be continued in the future as the agriculture industry expands and diversifies.

2.0 Objectives

The key objective of this survey project was to determine the identity and incidence, severity and prevalence of the major diseases and insect pests in commercial field plantings of the cereal, oilseed and vegetable crops mentioned above. This information will be used to plan potential future pest forecasting programs and to help develop or refine integrated pest management (IPM) strategies for producers. Dr. Ron Howard from RJH Ag Research Solutions Ltd. of Brooks, AB was contracted to help with the design and conduct of the surveys, to facilitate the diagnosis of disease problems and identification of insects, and in preparing reports on the results of this work.

3.0 Scope

At the outset of this project, relatively little was known about the specific types of plant health problems in field crops grown in the Territory, their distribution, and the kinds and levels of damage they're causing. This preliminary pest survey, which was carried out in summer, 2020, covered a number of crops and fields on two farms in the Whitehorse area in order to gather accurate information on the various kinds of diseases and insect pests present. The crops surveyed included cereals (barley and wheat), oilseeds (canola) and vegetables (beets, broccoli, cabbage, carrots, potatoes and turnips). Fields were visited one or more times in the mid- to late growing season (July/August) at a time when damage from most of the common pests and diseases were noticeable or abundant. Surveyors looked for infected and infested plants and collected representative samples for identification of the causal agents. If time allowed, additional information on the general abundance of the pests, e.g., low, moderate or high levels, and overall crop damage, e.g., slight, moderate or severe injury, were noted.

4.0 Key Outcomes

The key outcomes of this project were to create lists of the major and minor diseases and insect pests in the surveyed crops and to estimate the potential damage they may be causing. As the 2020 surveys were the first of their kind, the information generated will be of historical and scientific importance to the agricultural industry in the Yukon and to the scientific community in Canada. Plant disease samples collected during the preliminary surveys were sent to the Alberta Plant Health Laboratory in Edmonton, AB for definitive diagnoses. Photographs of the disease symptoms and insect and mite pests observed were sent to plant pathologists and entomologists in Western Canada for help in identifying the specific diseases and insect species

involved, respectively. This information will be used to design more in-depth systematic surveys of Yukon crops in future years, as well as for extension activities with Yukon producers.

5.0 General Disease Assessment Procedures

Disease symptoms were visually assessed on a crop-by-crop basis by determining their incidence, severity and prevalence as follows:

- Incidence – Percentage of plants, leaves, heads, kernels, etc., damaged in the target crop
- Severity – Proportion of the leaf, fruit, head, root/canopy area, etc., affected by a specific disease or insect pest feeding.
- Prevalence – The overall proportion of fields surveyed with a specific disease or insect pest.

Photographs of affected plants were taken and sent to plant pathologists and entomologists across Western Canada for their opinions on causation. Where possible, representative samples of plants with disease symptoms were packaged and sent to the Alberta Plant Health Lab (APHL) in Edmonton, AB for diagnostic analyses.

6.0 General Insect Pest Assessment Procedures

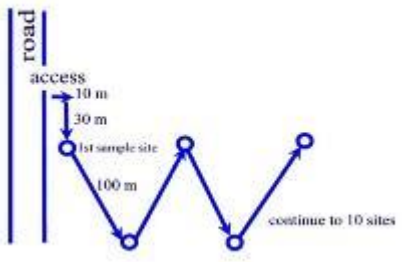
Insect population levels were determined by sampling specific areas or locations in fields and by collecting infested plants by hand or sampling the canopy with a sweep net. Sampling was done at least once or twice during the growing season. The populations of insects were visually examined, and numbers estimated, or they were collected and preliminary visual identifications and counts were made where possible. Soft-bodied insects, such as larvae and aphids, were preserved in vials of 70% alcohol pending identification.

7.0 Survey Protocols

Detailed field survey protocols were prepared for each crop included in the 2020 pest survey. These were based on the standard protocols routinely used for disease and insect pest surveys in major crop production areas in other parts of Canada. In addition, partial lists of the main diseases and pests known to occur on these crops in Western Canada and times of the season, i.e., early, mid- or late season, when these diseases and pests are normally seen, along with diagnostic information, were provided to the survey team.

<u>7.1 Cereals</u>

Single fields of barley and wheat at Farm 1 were surveyed in 2020. The barley field was planted with the cultivar ‘Maverick’ and the wheat field was seeded to an unspecified cultivar of Canada Prairie Spring (CPS) Wheat. Plant samples were taken along a W-shaped transect for a total of five sampling points for the barley field (<50 ac), as shown in the diagram and ten sampling points for the wheat field (>50 ac). The first visit, which occurred on July 30, involved visual inspection and destructive sampling wherein plants were collected and removed from the field for a detailed disease assessment at a lab space in Whitehorse. There, the roots were rinsed off and the plants were examined for disease symptoms. The second visit to these fields, which occurred on August 27, only involved visual examination of the standing crop.



7.2 Oilseeds

A single field of Polish canola (cv. Synergy) on Farm 1 was surveyed on July 27. The south half of this field was surveyed following the same protocol as for cereals, although no destructive sampling took place. Five plant samples were taken from this field on two other dates and sent to the APHL; however, one of these shipments was inadvertently detained in a warehouse in Richmond, BC for several days and did not ultimately make it to the APHL.

7.3 Vegetables

The vegetable plantings included in the survey were situated at both Farm 1 and Farm 2. For all of the vegetable fields surveyed, the first stop in each field was made near the end of the row, and several subsequent stops were made down the length of the same row. The number of stops per field varied with the crop type and field size.

- For cabbage and broccoli: three heads were assessed per stop. All leaf surfaces, top and bottom, were examined for pest presence or disease symptoms. The assessment stops were a minimum of 50 paces apart.
- For carrots, beets and turnips, a 1 m length of row was examined at each of five stops. At Farm 1, five stops were made per field down the length of one row. At Farm 2, field sizes were smaller, and three stops were made down the length of one row. The upper and lower leaf surfaces were examined at each stop.
- For potatoes, about a 1 m length of row was examined per stop. About 4-5 plants were typically found in 1 m of row. Ten leaf triplets (5 upper and 5 lower) were examined at each stop. Upper and lower leaf surfaces were examined for pests and diseases.

8.0 Survey Records

Basic background information, such as the name and location of each farm visited, the producer's name and contact information, and general cultural practices and cropping history, was obtained from the cooperating producers wherever possible. Survey data were initially recorded on paper forms and later transferred to an Excel spreadsheet or Word document to facilitate summarization and analysis. GPS coordinates were obtained for each field to enable future mapping. Sample background information and data forms for the field surveys were provided for use by the surveyors.

Digital photos and/or subsamples of the various types of diseased and insect-infested plants encountered during the field surveys were taken wherever possible. These images were reviewed by Ron Howard and several other research and extension plant pathologists and entomologists in Western Canada. Plant samples for disease diagnosis were sent to the Alberta Plant Health Laboratory in Edmonton for confirmation of the pathogen(s) involved. Some insect samples were sent to professional entomologists for examination and identification.

9.0 Scientific and Technical Support

Manpower support to assist directly or indirectly with the survey came from various sources. Agriculture Branch staff had the major responsibility for conducting the disease and insect surveys, including contacting growers for permission to survey fields, arranging the survey schedule, visiting the farms to collect data and samples, forwarding selected samples to the Alberta Plant Health Lab or to entomologists, preliminary compilation of the data for the final report, and providing a copy of the survey report to cooperating growers.

The following individuals and organizations provide technical advice and/or logistical support to the project:

- Agriculture Branch, Energy Mines and Resources, Whitehorse, YT
  Ms. Kristine Ferris, Mr. Randy Lamb, Mr. Brad Barton and Luka van Randen
  [Project funding and management, liaison with cooperators, field surveys, data collection and tabulation, shipping samples to cooperators, and assistance with preparing reports]
- Alberta Plant Health Laboratory, Alberta Agriculture and Forestry, Edmonton, AB
  Drs. Jie Feng, Qixing Zhao and Hafiz Ahmed and Messrs. Alain Starkes, Yingli Wang, Yalong Yang and Kher Zahr
  [Assistance with plant disease diagnoses]
- Agassiz Research and Development Centre, Agriculture and Agri-Food Canada, Agassiz, BC
  Dr. Wim Van Herk, Entomologist
  [Advice on wireworm identification]
- Beaverlodge Research Farm, Agriculture and Agri-Food Canada, Beaverlodge, AB
  Dr. Jennifer Otani, Entomologist
  [Advice on insect pest survey design and methodology]
- Canola Council of Canada, Lloydminster, Lloydminster, SK
  Mr. Clint Jurke, Agronomy Director
  [Advice on canola disease diagnosis]
- Lacombe Research & Development Centre, Agriculture and Agri-Food Canada, Lacombe, AB
  Dr. Kelly Turkington, Plant Pathologist
  [Advice on plant disease diagnosis]
- Mayland Consulting, Calgary, AB
  Mr. Scott Meers, Entomologist
  [Advice on insect pest identification and pest surveillance]
- Olds College, School of Life Science and Horticulture, Olds, AB
  Dr. Ken Fry, Instructor
  [Advice on horticultural crop insect pest identification]
- Pest Surveillance Unit, Alberta Agriculture and Forestry, Brooks, AB
  Dr. Mike Harding, Plant Pathologist
  [Advice on disease survey design and methodology]
- Prairie Crop Disease Monitoring Network
  https://prairiecropdisease.blogspot.com
  [General information on plant disease surveillance in Western Canada]
- Prairie Pest Monitoring Network
  https://prairiepest.ca
  [General information on insect pest surveillance in Western Canada]

10.0 Survey Results

10.1 Cereals

Barley (Farm 1)

The only barley crop surveyed in 2020 was a 27-acre field of the two-row forage cultivar ‘CDC Maverick’. This field had been planted to potatoes in 2019 and to plow-down mustard in 2018.

The seed was treated with Cruiser Vibrance Quattro prior to seeding, but no other pest control products were applied to the crop during the growing season.

No insect pests were observed in the barley crop when the field was visited on July 30 (early heading stage) and August 27 (firm dough stage) (Tables 1 and 2). Very low levels (mean = 0.2%) of loose smut (*Ustilago nuda*) (Fig. 1) were noted on the heads on the first field visit. The most prevalent diseases during the growing season were chlorotic and necrotic leaf spotting and crown and root rot (Fig. 2) . The leaf spotting was evident on both sampling dates (Table 3). Initially, the spots appeared as chlorotic flecks across the leaf blades and later as necrotic lesions; however, it was unclear as to whether this represented a progression of symptoms or reflected two distinct problems. The mean incidence of chlorotic spotting on July 30 was 68% and for the necrotic spotting on August 27, it was 75%. Crown and root rot symptoms were widespread on July 30, but no incidence or severity ratings were done. Samples submitted to the APHL revealed that *Fusarium*, *Microdochium* and *Trichocladium* species were the main root pathogens present (Table 2).

By August 27, the leaf spots had developed into necrotic lesions and the average disease incidence and severity values were 75% and 1.6, respectively (Table 3). Leaf samples submitted to the APHL tested positive for the leaf blotch pathogen *Parastagonospora avenaria* (Fig. 3; Table 4). This fungus is usually more common on wheat than barley in Canada.

Wheat (Farm 1)

The spring wheat crop surveyed was a 75-acre field of an unspecified cultivar of Canada Prairie Spring Wheat at Farm 1. This field had been planted to field peas in 2019 and to spring wheat in 2018. The seed had been treated with Cruiser Vibrance Quattro, but no other pest control products had been applied to the crop.

No insect pests were observed on the crop when the field was visited on July 30 (mid-flowering growth stage) but a few lygus bugs were seen on August 27 (soft dough stage) (Tables 5 and 6). Leaf mottling and yellowing (Fig. 4) and deformed heads were the most common symptoms seen in the crop on both sampling dates. On July 30, the mean incidence of leaf mottling was 20% and for deformed heads it was 11%. No pathogens were isolated from the mottled leaves, so it appeared that this disorder was physiological in origin. The plants also exhibited typical symptoms of crown and root rot (Fig. 5), and the pathogens *Fusarium avenaceum, F. equiseti, F. culmorum* and *Microdochium bolleyi* were isolated from a sample of affected plants sent to the APHL (Table 7). An unidentified phytoplasma was detected in some of the plants displaying deformed heads (Fig. 6). The aster yellows phytoplasma has been reported on wheat and other cereal crops in Canada where it can produce small, sterile, distorted or twisted heads. In some parts of the field, the stand was thin and very little tillering was evident in the plants. This may have been due to factors such as low soil fertility, soil compaction or a lack of moisture.

10.2 Oilseeds

Canola (Farm 1)

A 100-ac field of the Polish canola cultivar ‘Synergy’ was surveyed once on July 27 when the crop was flowering and at the early pod set growth stage. The field was fertilized prior to planting on June 1. No foliar fungicides had been applied prior to the date of the survey.

No evidence of insect pests was noted on July 27 and diseases were virtually absent as well (Table 8). One plant was found with scattered black spots on the leaves and lab tests showed that this was black spot disease caused by the fungus *Alternaria* (Fig. 7; Table 9). Another plant had a leaf with symptoms that resembled downy mildew, and another had a dark area on the stem that may have been a bacterial infection, but these diseases were not confirmed. In some parts of the field, the canola plants were stunted and chlorotic. These symptoms were characteristic of sulphur deficiency, a common disorder of canola in parts of the Prairie Provinces in which leaf yellowing and cupping tend to occur on new leaves first, then progress to other parts of the plant (Fig. 8). Purpling of leaf edges can show up when a sulphur deficiency is moderately severe. In fields short of sulphur, crops can usually find enough to get past the early rosette stage without visible symptoms. Deficiency symptoms often show up at flowering. A soil test would be required to confirm this disorder.

10.3 Vegetables

Beet (Farm 1 and Farm 2)

Damage from the beet leafminer was evident in a planting at Farm 1 that was surveyed on July 27 and August 18 (Fig. 13; Tables 10 and 11). The grower reported that this pest had been a problem in past years as well. On July 27, an average of 4.4 larvae per plant were counted and the average amount of leaf area damaged was 13%. When a second survey was conducted on August 18, the average larvae per plant had dropped to 0.6 and the average leaf area damaged to 6%. No Alternaria leaf spot (Table 12) was seen on the plants on July 27, but it began to show up by August 18 (Fig. 9), although the severity levels were very low (mean = 1%). A single root with common scab (*Streptomyces scabies*) was found (Fig. 10; Table 12).

A planting of red beets was also surveyed at Farm 2 on August 6 and 18. The beet leafminer was also found in this planting, although the infestation was lower than at Farm 1. The average number of larvae per plant was 0.25 on August 6 and 0.6 on Aug. 18, while the average leaf area damaged was 0.6% and 6.0%, respectively (Tables 13 and 14). Levels of Alternaria leaf spot were very low at this location, where the average disease incidence was 1% and the average disease severity was 0.4 on a scale of 0 to 5.

Broccoli (Farm 1)

A small planting of broccoli was surveyed only once on August 18. Extremely low levels of the cabbage root maggot and diamondback moth and their associated damage were observed in the crop and no diseases were found (Table 15).

Cabbage (Farm 1)

A cabbage planting was surveyed once on July 27. Aphids (Fig. 14), diamondback moth adults and larvae (Fig. 15) were observed, as were cabbage root maggots (Fig. 16; Table 16). About 3.2% of the leaf area was damaged by the diamondback larvae. Damage caused by the aphid was negligible. One cabbage leaf with a water-soaked patch was observed. The cause of this problem was undetermined. The grower reported that the cabbage root maggot was an ongoing pest problem, with new transplants affected and noticeable negative effects on yield.

Carrot (Farm 1)

A carrot planting was surveyed on July 27 and August 18. Both inspections revealed no disease issues (Tables 17 and 18), but an occasional wireworm (*Hypnoidus bicolor*) was found (Fig. 17).

A small amount of leaf yellowing was noted at two spots along the survey path on August 18, but no specific disease or environmental stress could be attributed to these symptoms. Low spots in the field showed some minor stunting of plant growth, which the grower reported as having been observed in most years.

Potato (Farm 2)

A potato planting was surveyed on July 30 and August 18. A 1 m length of row (4-5 plants) was examined at each of five stops. Ten leaf triplets from 5 upper and 5 lower leaves were examined at each stop. Both the upper and lower surfaces were observed for evidence of diseases and insect or mite pests. An average of 4.4 apteran (wingless) aphids were found per sampling site in July and slightly more (4.6) in August (Tables 19 and 20). Very low levels of winged aphids and possibly some spider mites were found on a few plants in July and August.

No significant disease occurrences were noted (Tables 19 and 20). Minor leaf yellowing and cupping were noted at two sampling sites on August 18, but could not be attributed to an infectious disease. One leaf with a large early blight (*Alternaria solani*) lesion (Fig. 11) was found on a plant outside of the survey area. Some cull tubers with symptoms of black scurf and soft rot (Fig. 12) collected from a potato storage grading line on October 27 were submitted to the APHL for diagnosis. The Lab confirmed Black scurf *(Rhizoctonia solani),* Soft rot (*Pectobacterium carotovorum* subsp. *carotovorum*), Blackleg (*Pectobacterium carotovorum* subsp. *atrosepticum*) and Sour rot (*Geotrichum candidum*) on the tubers (Table 21).

Turnip (Farm 2)

Turnip plants were surveyed on August 6 and 18. Winged aphids, lepidopterous caterpillars, possibly cabbage loopers, and a turnip beetle (Fig. 18) were observed Tables 22 and 23); however, only 5% of the leaf area was estimated to have been damaged on August 6 and 20% on August 18. One root with large lesion on the side accompanying subsurface discoloration was seen, along with a leaf that had a purple-colored lesion.

11.0 Summary

A summary of the diseases and pests encountered during the 2020 survey is presented in Table 24. All have previously been reported on their respective host crops in Western Canada. It's likely that most of the pathogens and pests seen in 2020 were introduced to the Territory on agricultural plants and plant products, such as seed, tubers and transplants, or on used farm equipment and machinery contaminated with infested soil and crop debris. Airborne spores and winged insects dispersed on prevailing winds and storm fronts from southern areas, including the Peace Regions of British Columbia and Alberta, are also possible means of spread.

Most of the pests and diseases encountered in the 2020 survey occurred at low levels and did not appear to be causing significant damage; however, assessing actual levels of yield and quality losses was beyond the scope of the survey. As cereal, oilseed and vegetable crop production intensifies in the Yukon, it is expected that disease and pest levels will increase over time and economic losses will occur. Some of the problems observed in 2020 that have the potential to reach this threshold in the near term include:

- Crown and root rot and leaf spot diseases on cereals
- Leaf spot and stem rot diseases on canola

- Leaf spot and leafminer on beets
- Cabbage root maggot, diamondback moth and cabbage looper on cole crop vegetables and canola
- Wireworms on carrots and potatoes
- Blackleg, soft rot and black scurf on potatoes

12.0 Future Plans

It is hoped that disease and insect surveys in the Territory can be continued in 2021 and expanded to include early as well as mid and late season sampling programs. This, of course, will depend on the availability of adequate manpower and budget resources. Some specific recommendations that should be considered include:

- Expanding the surveys to include grasses and legumes that may be used for forage and/or seed production. Some of these crops may have diseases and pests in common with some cereal and vegetable crops. In addition, it would be valuable to examine vegetable transplants being grown in local greenhouses for potential disease and pest problems that could develop and be transferred to home and market gardens.
- Adding an entomology consultant to the project team. Mr. Scott Meers of Mayland Consulting in Calgary may be available. He coordinated Alberta Agriculture and Forestry's province-wide insect pest surveillance program for many years and has considerable expertise in surveillance techniques, insect identification, pest management and agronomy.
- Contacting the cooperating producers early in the season (March/April) to arrange access to their fields and to ask them to keep records of things such as crop varieties planted, fertilizer and pesticide application records, soil test reports, and scouting records, if any, for diseases, insect pests and weeds.
- Ordering materials and supplies early in the season, especially hard-to-get items such as sweep nets, pheromone and sticky traps for insects, sampling equipment, personal protective equipment and consumables.
- Starting the surveys earlier in the season so as to pinpoint early season problems as well as those at mid and late season.
- Hiring sufficient manpower so that two surveyors are always working together while in the field for personal safety.
- Earmarking some high-profile disease and pest issues for special attention based on their potential for significant economic impacts, e.g., fusarium diseases in cereal crops, leaf spots in red beets, and cabbage root maggots in canola and cole crop vegetables. Emphasis should also be placed on finding effective control options for these problems and ultimately working towards developing practical and effective IPM programs for growers to adopt.
- Having the Territory formally join the Western Forum on Pest Management (WFPM) and for Agriculture Branch staff to actively take part in the Western Committee on Crop Pests and the Western Committee on Plant Diseases annual meetings, which are hosted by the WFPM. In addition, Branch staff should consider subscribing to the Prairie Pest Monitoring Network and the Prairie Crop Disease Monitoring Network blogs, which post current information on disease and pest occurrences, survey methods, descriptions, photos, wind forecasts and risk maps.

13.0 Tables

Table 1. Observations of insect pests and diseases on barley plants surveyed at the early heading stage at Farm 1, Whitehorse, YT on July 30, 2020.

Sample No.	Insect species observed	Estimated leaf area affected (%)	Disease symptoms Observed*	Disease incidence (%)	Disease severity (0-4)
1	0	0	Loose Smut	1	1
			Leaf flecking	80	
2	0	0	Loose Smut	0	0
			Leaf flecking	30	
3	0	0	Loose Smut	0	0
			Leaf flecking	70	
4	0	0	Loose Smut	0	0
			Leaf flecking	100	
5	0	0	Loose Smut	0	0
			Leaf flecking	60	
Mean	0	0	Loose Smut	0.2	0.2
			Leaf flecking	68	

* Chlorotic leaf flecking was common on the plants examined, but the cause was undetermined. Typical symptoms of loose smut were seen on the affected heads.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 2. A Summary of the diagnostic results for barley plant samples taken on July 30, 2020 from Farm 1, Whitehorse, YT.

Sample Number	Symptoms	Diagnosis
Barley (APHL Report #887)		
1	Root and crown rot	*Fusarium avenaceum, Microdochium bolleyi, Rhizopus/Mucor, Trichocladium, Ilyonectria* and *Ulocladium* were isolated from the affected tissues. *Fusarium*, *Microdochium* and *Trichocladium* have been reported to cause root rot in cereals. Most of the other fungi isolated were either contaminants or weak saprophytes.
2	Smutted head (loose smut)	Loose smut (*Ustilago nuda*)

Table 3. Observations of insect pests and diseases on barley plants surveyed at the late firm dough stage at Farm 1, Whitehorse, YT on August 27, 2020.

Sample No.	Insect species observed	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)*	Disease severity (0-4)**
1	0	0	Leaf spotting	75	2
2	0	0	Leaf spotting	75	2
3	0	0	Leaf spotting	75	1
4	0	0	Leaf spotting	75	1
5	0	0	Leaf spotting	75	2
Mean	0	0		75	1 .6

* DI = % plants, leaves or heads infected.
** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 4. A Summary of the diagnostic results for barley plant samples Taken on August 27, 2020 from Farm 1, Whitehorse, YT.

Sample Number	Symptoms	Diagnosis
Barley (APHL Report #951)		
1	Some leaves with dark brown lesions	Leaf blotch *(Parastagonospora avenaria*). This pathogen is more common on wheat than barley. Other fungi isolated included *Alternaria* sp., *Epicoccum* sp., *Cladosporium* sp., *Fusarium avenaceum* and *Microdochium nivale*. Most of these are either contaminants or weak saprophytes.

General Comments

- *Fusarium avenaceum* and *Microdochium nivale* are reported to cause root rot on cereal grains in Western Canada. *Fusarium* avenaceum is part of the fusarium head blight (FHB) on cereals and grasses in Western Canada as well.
- Grain samples from Farm 1 will be collected and tested for FHB infection and mycotoxins after harvest.

Table 5. Observations of insect pests and diseases on wheat plants surveyed at the flowering stage at Farm 1, Whitehorse, YT on July 30, 2020.

Sample No.	Insect species observed	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)
1	0	0	LMY	30	n/a
2	0	0	LMY	20	n/a
3	0	0	LMY	10	n/a
4	0	0	LMY	0	n/a
5	0	0	LMY/DH	10/40	n/a
6	0	0	LMY/DH	70/10	n/a
7	0	0	LMY/DH	10/10	n/a
8	0	0	LMY/DH	10/20	n/a
9	0	0	LMY/DH	20/30	n/a
10	0	0	WH	20/0	n/a
Mean	0	0		20/11	n/a

* LMY = Leaf mottling and yellowing; DH = Discolored or deformed head; WG = Weak growth; WH = White head.
** DI = % plants, leaves or heads infected.

Table 6. Observations of insect pests and diseases on wheat plants surveyed at the late milk/soft dough stage at Farm 1, Whitehorse, YT on August 27, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)
1	0	0	LMY	30	n/a
2	0	0	LMY	20	n/a
3	0	0	LMY	10	n/a
4	0	0	LMY	0	n/a
5	0	0	LMY/DH	10/40	n/a
6	0	0	LMY/DH	70/10	n/a
7	0	0	LMY/DH	10/10	n/a
8	0	0	LMY/DH	10/10	n/a
9	0	0	LMY/DH	20/30	n/a
10	0	0	LMY	20	n/a
Mean	0	0	0.4	20/10	n/a

* LMY = Leaf mottling and yellowing on ca. 75-90% of the plants examined. A nutrient deficiency was suspected, most likely nitrogen. DH = Discolored or deformed (twisted) awns.
** DI = % plants, leaves or heads infected.

Table 7. A Summary of the diagnostic results for wheat plant samples taken on July 30 and August 27, 2020 from Farm 1, Whitehorse, YT.

Sample Number	Symptoms	Diagnosis
Wheat (APHL Report #888)		
1	Small brown lesions on leaves	Possibly the early stages of a fungal leaf spot infection; however, mostly saprophytic fungi were isolated, e.g., *Alternaria*, *Cladosporium*, *Rhizopus/ Mucor*, *Cladosporium* and *Epicoccum*. This suggests that the leaf spots may have been physiological in origin and that the dead tissue was colonized by these saprophytes.
5	Brown discoloration of the lower stems and roots	Crown and root rot caused by *Fusarium avenaceum, F. equiseti, F. culmorum,* and *Microdochium bolleyi*
6	Brown discoloration of the lower stems and roots	See comments for sample #5
8	Small brown lesions on leaves Brown discoloration of the lower stems and roots Deformed spike	See comments for sample #1 See comments for sample #5 Positive for an unspecified phytoplasma
Wheat (APHL Report #952 and #953)		
1	Plants showing stunted growth, poor root systems, black mold on kernel tips and poor head development	*Fusarium avenaceum, F. equiseti, Ilyonectria, Ceratobasidium, Microdochium bolleyi, Chaetomium, Ulocladium* and an unidentified phytoplasma

General Comments

- The various pathogens isolated were similar to those reported from the Prairie Provinces. These fungi may have originally been introduced to the Yukon on contaminated seed and farm equipment. The damage levels on the affected plants were relatively low.
- *Microdochium bolleyi* is reported to cause root rot on common and durum wheat in Saskatchewan. *Fusarium* species are part of the common root rot complex on cereals and grasses in Western Canada. *Fusarium avenaceum* and *F. equiseti* can also cause fusarium head blight (FHB) in cereals and to produce mycotoxins in infected grain. Grain samples from Farm 1 will be collected and tested for FHB infection and mycotoxins.
- *Ilyonectria* consists of several pathogenic species that can infect roots. It has been reported to cause root rot on ginseng, grapevines and various tree species but not on cereals.
- *Ceratobasidium* is related to the root pathogen *Rhizoctonia*, but includes several species of beneficial mycorrhizal fungi.

Table 8. Observations of insect pests and diseases on canola plants surveyed at the mid-flower stage at Farm 1, Whitehorse, YT on July 27, 2020.

Sample No.	Insect species observed	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)***
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	1 BLS	1	1
Mean	0	0	0.2	0.2	0.2

* Scattered black leaf spots (BLS). A few scattered plants at Site #4 exhibited stunting and leaf deformity. The cause was undetermined.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 9. A Summary of the diagnostic results for canola plant samples taken on August 10, 2020 from Farm 1, Whitehorse, YT.

Sample Number	Symptoms	Diagnosis
Polish Canola (APHL Report #856)		
1	General leaf yellowing, especially on the lower leaves	Possible sulphur deficiency either due to a shortage in the soil or damage to the roots from root rot or insect pests.
	Some leaves with small brown lesions	Possible early stage fungal infection. *Fusarium avenaceum*, *Boeremia exigua*, *Cladosporium* sp. and *Alternaria* sp. were isolated from the affected tissues. The leaf spotting symptoms were consistent with those of black spot caused by *Alternaria brassicae* and related species.

General Comments

- The symptoms of sulphur deficiency, which are mainly yellowing and leaf cupping tend to occur on new leaves first. Purpling of leaf edges can show up when a deficiency is fairly severe. In fields short of sulphur, crops can usually find enough to get past the early rosette stage without visible symptoms. Deficiency symptoms often show up at flowering. A soil test is usually required to confirm this disorder.

- *Alternaria* sp., *Fusarium avenaceum*, *Boeremia exigua* and *Cladosporium* sp. were isolated from the affected tissues. *Fusarium avenaceum*, *Boeremia exigua* (syn. *Phoma exigua*) and *Cladosporium* sp. are not reported to cause leaf spotting in canola and were probably saprophytic invaders of the black spot lesions. A related species, *Phoma lingam*, is known to cause blackleg of canola in Canada.

Table 10. Observations of insect pests and diseases on mid-season red beet plants surveyed at Farm 1, Whitehorse, YT on July 27, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)**	Disease severity (0-4)***
1	2 LML	10	0	0	0
2	4 LML	10	0	0	0
3	6 LML	15	0	0	0
4	5 LML	15	0	0	0
5	5 LML	15	0	0	0
Mean	4.4	13	0	0	0

* LML = Beet leaf miner larvae.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 11. Observations of insect pests and diseases on late-season red beet plants surveyed at Farm 1, Whitehorse, YT on August 18, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)**	Disease severity (0-4)***
1	0	10	0	0	0
2	1 BLM	10	0	0	0
3	1 BLM	10	0	0	0
4	0	0	0	5 ALS	2
5	1 BLM	0	0	0	0
Mean	0.6	6.0	0	1.0	0

* BLM = Beet leaf miner larvae.
** DI = % plants infected with Alternaria leaf spot.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 12. A Summary of the Diagnostic Results for late season red beet plants taken on August 18, 2020 from Farm 1, Whitehorse, YT.

Sample Number	Symptoms	Diagnosis
Garden Beet (APHL Report #906)		
1	Leaves with purple leaf spots and general reddening	*Microdochium* spp., *Aureobasidium pullulans*, *Alternaria* sp. and *Cladosporium* sp. were isolated from the affected tissues; however, of these, only *Alternaria* species are reported to cause leaf spotting on beets.
2	Root with a lesion (scab) on one side	*Streptomyces scabies* was identified as the causal agent. This pathogen has been reported to attack beets and several other types of root crop vegetables across Canada.

General Comments

- Phoma leaf spot (*Phoma betae*) is the most prevalent leaf spot disease on red beets in most production areas of Canada; however, it appears that Alternaria leaf spot was the disease found in the beet field surveyed at Farm 1. In some areas of North America, *Alternaria alternata* and *A. brassicae* have been reported to cause leaf spotting on beets.
- *Microdochium* spp., *Aureobasidium pullulans* and *Cladosporium* sp. were also recovered from the beet leaves but none of these fungi have been reported to cause leaf spotting on this crop. Interestingly, *Microdochium bolleyi* was recovered from the roots of wheat and barley plants during this year's survey and may be associated with the root rot complex on those crops. The species of *Aureobasidium* and *Cladosporium* isolated from the beet roots in this year's survey are likely just saprophytes.
- *Streptomyces scabies* can cause common scab on potatoes and a variety of other root crop vegetables. It is widespread in North America. Several other species of *Streptomyces* have been associated with scab in potatoes in Canada and the U.S.A.

Table 13. Observations of insect pests and diseases on harvest-ready red beet plants surveyed at Farm 2, Whitehorse, YT on August 6, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)**	Disease severity (0-4)***
1	0	0	0	n/a	n/a
2	1 LML	1	0	n/a	n/a
3	0	0	0	n/a	n/a
4	0	1	0	n/a	n/a
5	0	1	0	n/a	n/a
Mean	0.25	0.6	0	n/a	n/a

* LML = Beet leaf miner larvae. Old leafminer damage was noted in samples 1 and 3-5, but no live larvae were seen.

Table 14. Observations of insect pests and diseases on harvest-ready red beet plants surveyed at Farm 1, Whitehorse, YT on August 18, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)**	Disease severity (0-4)***
1	0	10	0	0	0
2	1 BLM	10	0	0	0
3	1 BLM	10	0	0	0
4	0	0	0	5 ALS	2
5	1 BLM	0	0	0	0
Mean	0.6	6.0	0	1.0	0

* BLM = Beet leaf miner larvae; ALS = Alternaria leaf spot.
** Disease Incidence = % plants, leaves or heads infected.
*** Disease Severity = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 15. Observations of insect pests and diseases on harvest-ready broccoli plants surveyed at Farm 1, Whitehorse, YT on August 18, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)**	Disease severity (0-4)***
1	0	<1	0	0	0
2	0	0	0	0	0
3	1 CRM	<1	0	0	0
4	0	0	0	0	0
5	1 DBL	<1	0	0	0
Mean	<1	<1	0	0	0

* CRM = Cabbage root maggot pupa; DBL = Diamondback moth larva.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 16. Observations of insect pests and diseases on mid-season cabbage plants surveyed at Farm 1, Whitehorse, YT on July 27, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)**	Disease severity (0-4)***
1	0	1	0	0	0
2	3 DBL	5	0	0	0
3	1 aphid 2 DBL	0 (frass only)	0	0	0
4	5 DBL	5	water-soaked area	1	1
5	1 DBA 3 DBL 10+ CRM	5	0	0	0
Mean		3.2		0.2	0.2

* DBL = Diamondback moth larvae; DBA = Diamondback moth adult, CRM = Cabbage root maggot larvae.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 17. Observations of insect pests and diseases on mid-season carrot plants surveyed at Farm 1, Whitehorse, YT on July 27, 2020.

Sample No.	Insect species observed	Estimated leaf area affected (%)	Disease symptoms observed	Disease incidence (%)**	Disease severity (0-4)***
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
Mean	0	0	0	0	0

* Top growth was delayed and there were some missing plants at sampling sites 4 and 5.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 18. Observations of insect pests and diseases on late-season carrot plants surveyed at Farm 1, Whitehorse, YT on August 18, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)***
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	SLY	1	1
4	0	0	SLY	1	1
5	0	0	0	0	0
Mean	0	0	0.4	0.4	0.4

* SLY = A slight amount of leaf yellowing was noted on plants at sampling sites 3 and 4. The cause was undetermined.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 19. Observations of insect pests and diseases on potato plants surveyed at the early flowering stage at Farm 2, Whitehorse, YT on July 30, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)***
1	3 AA/2 MT	0	0	0	0
2	5 AA	0	0	0	0
3	3 AA	0	0	0	0
4	5 AA	0	0	0	0
5	5 AA/1 WA	0	0	0	0
Mean	4.4 AA	0	0	0	0

* AA = Apteran (non-winged) aphids, MT = Mites, and WA = Winged aphid.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 20. Observations of insect pests and diseases on potato plants surveyed at the early harvest stage at Farm 2, Whitehorse, YT on August 18, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)***
1	6 AA/1 WA	0	0	0	0
2	8 AA	0	LY	0	1
3	3 AA	0	0	1	0
4	2 AA	0	LY/LC	1	1
5	2 AA	0	0	0	0
Mean	4.6 AA	0	0.4	0.4	0.4

* AA = Apteran (non-winged) aphids, MT = Mites, and WA = Winged aphid. LY = Leaf yellowing. Minor leaf yellowing was noted at sampling sites 2 and 4 and some leaf cupping at site 4. The cause was undetermined.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 21. A Summary of the Diagnostic Results for potato tuber samples taken on October 27, 2020 from Farm 1, Whitehorse, YT.

Sample Number	Symptoms	Diagnosis
Potato (APHL Report #1016)		
1-3	Tubers (culls) with symptoms of black scurf and storage rots	Black scurf *(Rhizoctonia solani),* Soft rot (*Pectobacterium carotovorum* subsp. *carotovorum*), Blackleg (*Pectobacterium carotovorum* subsp. *atrosepticum*) and Sour rot (*Geotrichum candidum*)

Table 22. Observations of insect pests and diseases on turnip plants surveyed at the early flowering stage at the early harvest stage at Farm 2, Whitehorse, YT on August 6, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)***
1	30+ AA/ 10 CAT/ 1 TB	5	0	0	0
2	10+ CAT/ 30+ AA	5	0	0	0
3	10+ CAT/ 30+ AA	5	0	0	0
Mean		5	0	0	0

* AA = Apteran (non-winged) aphids, CAT = Lepidopterous caterpillars, TB = Turnip beetle.
** DI = % plants with symptoms.
*** DS = Proportion of the canopy or root area affected by a particular disease based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy or root system showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms,

Table 23. Observations of insect pests and diseases on turnip plants surveyed at the early flowering stage at the early harvest stage at Farm 2, Whitehorse, YT on August 18, 2020.

Sample No.	Insect species observed*	Estimated leaf area affected (%)	Disease symptoms observed*	Disease incidence (%)**	Disease severity (0-4)***
1	1 DBL/ 30+ AA	10	0	0	0
2	20+ DBL/ 9 DBP	20	0	0	0
3	20+ DBL/ 3 DBP	30	0	0	0
Mean		20	0	0	0

* AA = Apteran (non-winged) aphids, DBL = Diamondback moth larvae, DBP = Diamondback moth pupae.
** DI = % plants, leaves or heads infected.
*** DS = Proportion of the canopy affected based on a 0-4 rating scale, where: 0 = no disease symptoms, 1 = 1-10% of the crop canopy showing symptoms; 2 = 11-25% showing symptoms, 3 = 26-50% showing symptoms, and 4 = >50% showing symptoms.

Table 24. Summary of diseases and insect pests observed during surveys on cereal, oilseed and vegetable crops in the Yukon Territory in 2020.

Crops	Diseases	Insect and Mite Pests
Barley	Crown and root rot (*Fusarium avenaceum*, *Microdochium bolleyi*, *Trichocladium* sp.)	None observed
	Loose smut (*Ustilago nuda*)	
	Leaf blotch (*Parastagonspora avenaria*)	
Wheat	Crown and root rot (*Fusarium avenaceum*, *F. equiseti, F. culmorum, Microdochium bolleyi*	None observed
	Head deformity (Unidentified phytoplasma)	
	Leaf flecking & mottling (Physiological)	
Canola	Leaf spot (*Alternaria* sp.)	None observed
	Chlorosis (Possible sulphur deficiency)	
Beet	Common scab (*Streptomyces scabies*)	Beet leafminer (*Pegomya betae*)
	Leaf spot (*Alternaria* sp.)	
Broccoli	None observed	Cabbage root maggot (*Delia radicum*)
		Diamondback moth (*Plutella xylostella*)
Cabbage	None observed	Aphid (possibly *Myzus persica*e)
		Cabbage looper (*Trichoplusia ni*)
		Cabbage root maggot (*Delia radicum*)
		Diamondback moth (*Plutella xylostella*)
Carrot	None observed	Wireworm (*Hypnoidus bicolor*)
Potato	Blackleg (*Pectobacterium carotovorum* ssp. *atrosepticum*)	Aphid (possibly *Macrosiphum euphorbiae*)
	Black scurf (*Rhizoctonia solani*)	Fly (*Thaumatomyia* sp.)
	Soft rot (*P. carotovorum* ssp. *carotovorum*)	Mite (unidentified species)
	Sour rot (*Geotrichum candidum*)	
Turnip	None observed	Aphid (possibly *Myzus persica*e)
		Diamondback moth (*Plutella xylostella*)
		Lepidopterous larva (unidentified species)
		Turnip beetle (*Entomoscelis americana*)

14.0 Photographs

Figure 1. Loose smut on a barley head.

Figure 2. Crown and root rot on barley.

Figure 3. Leaf blotch on barley.

Figure 4. Yellow flecking on wheat leaves.

Figure 5. Crown and root rot on wheat.

Figure 6. Phytoplasma infection on wheat.

Figure 7. Alternaria leaf spot on canola.

Figure 8. Sulphur deficiency on canola.

Figure 9. Alternaria leaf spot on beet.

Figure 10. Common scab on beet.

Figure 11. Early blight on potato.

Figure 12. Bacterial soft rot on potato.

Figure 13. Beet leafminer.

Figure 14. Aphid from cabbage.

Figure 15. Diamondback moth larva.

Figure 16. Cabbage root maggot.

Figure 17. Wireworm on carrot.

Figure 18. Turnip beetle.