Ministry of Agriculture, Food and Fisheries

Late Blight of Potato and Tomato

March 2021

Late blight is the most destructive disease of potato in British Columbia (B.C.). It is caused by *Phytophthora infestans*, an oomycete (Protist). It occurs in all regions of the province, but it is more prevalent under wet weather conditions, mainly rain, high humidity and cool to moderate temperature regimes. Monitoring for timely detection of early symptoms and knowledge of weather conditions conducive to late blight are crucial for employing effective disease management strategies. Late blight monitoring services are available for growers in the Fraser Valley. In addition to potato and tomato, the pathogen can infect other solanaceous plants, including *Solanum sarachioides* (hairy nightshade).

Symptoms

On potato, early symptoms of late blight first appear on leaves as small, circular or irregularly shaped, dark necrotic lesions within 3 to 5 days of initial infection (Figure1A). Symptoms may first appear on mature lower leaves where humid/damp conditions and cooler temperature are most likely to prevail. However, early infections can also occur on other parts of the foliage under favourable weather conditions. Air currents can carry spores from nearby infected fields or volunteer potato plants. On petioles and stems, symptoms appear as dark, water-soaked lesions (Figure 1B). Lesions expand with time as the pathogen colonizes the internal plant tissues. On mature lesions, the pathogen produces glistening white spore-bearing structures called sporangia on the under side of the leaves or on stems (Figure 1C). As the disease progresses, the entire infected tissue will blight and decay (Figure 1D). Tubers become infected at any stage of their development and they start to turn brown and rot slowly from the outside (Figure 1E & 1F). Infected tubers become susceptible to secondary infections by other soft rot pathogens present in the soil or at storage.

On tomato, leaf and stem infections are very similar to those on potato (Figure 2A). If wet weather continues after the onset of disease, the fruit also becomes infected (Figure 2B). Fruit rot develops slowly but eventually destroys the fruit before it ripens. Green fruit harvested in the fall turn black and leathery before they ripen if they were infected in the field.

Spread

Numerous sporangia are produced on mature lesions when environmental conditions are favourable; leaf wetness for more than 10 to 12 hours and moderate temperatures are favourable for sporangial production. Sporangia are dispersed by rain and/or overhead irrigation and long-distance dispersal up to several miles can occur in wind currents. Upon contact with host plants, sporangia and/or small motile spores (zoospores) released from sporangia germinate and infect the plants in the presence of free moisture on plant surfaces. Disease development is favoured by moderate temperatures and wet, humid conditions. If wet weather continues, rapid development and multiple infection cycles of the pathogen can cause complete foliar blight and defoliation of plants within a few days. Tubers become infected at any stage of their development if heavy rains wash spores from leaves through the soil or if the tubers come into contact with diseased vines during harvest.

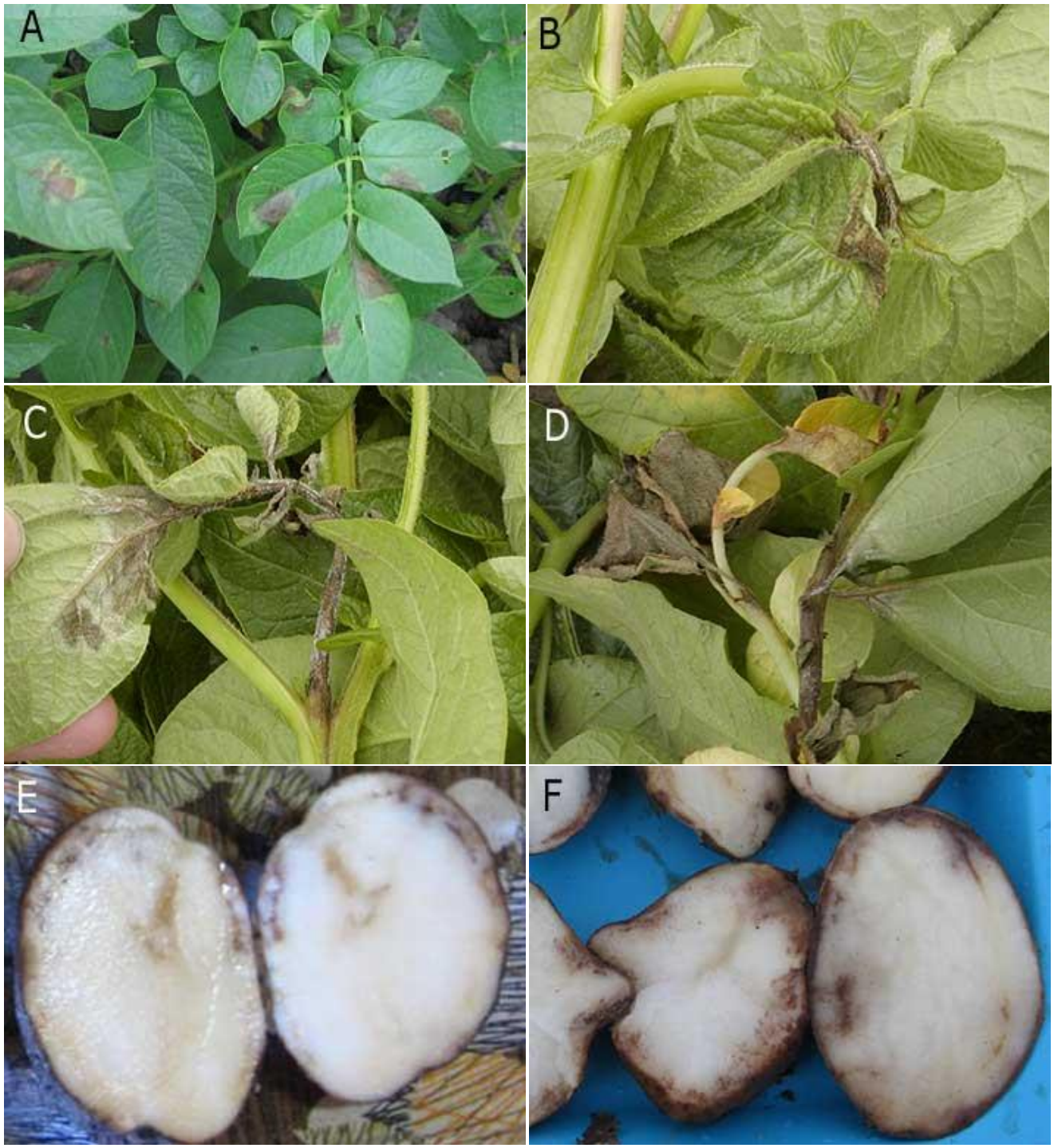

Figure 1. Symptoms of late blight on potato. Early symptoms on young leaves (A) and stems (B), appearance of white sporangia on the underside of infected leaf and on stem (C), blighting and death of infected tissues (D), and browning and rotting of tubers (E & F). Photo (1E & F) credit: Karina Sakalauskas, E.S. Cropconsult.

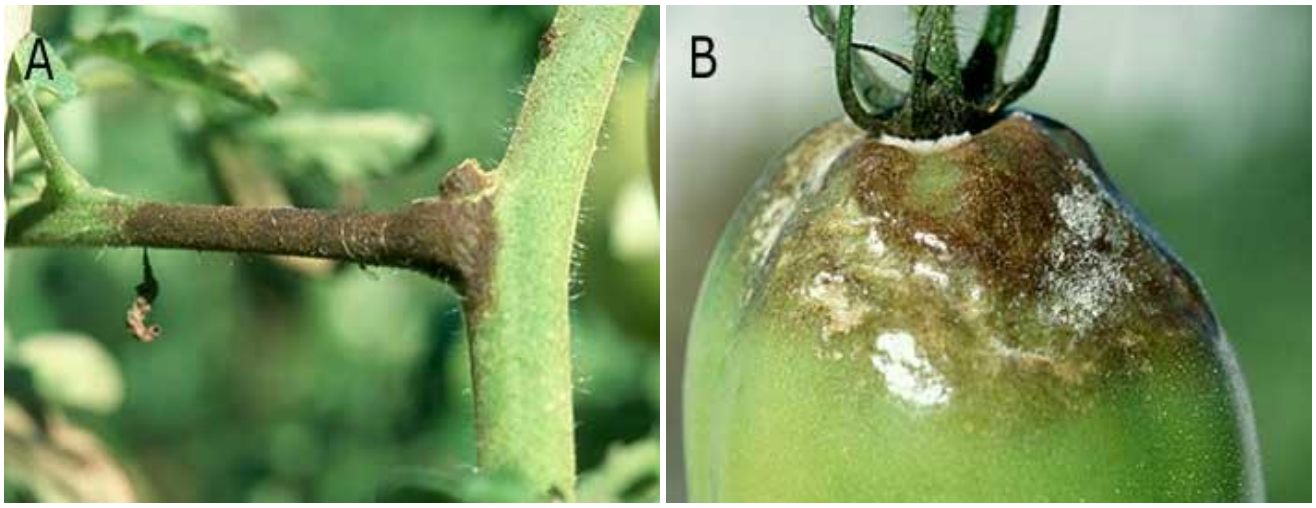

Figure 2. Symptoms of Late blight on tomato. Blighting of leaf-petiole (A) and appearance of white sporangia on infected green fruit (B).

Phytophthora infestans is an obligate pathogen and, thus, requires a host plant or plant tissue for its survival between seasons. It can survive on infected tubers in soil, cull piles or storage. Planting infected seed potatoes is one of the common pathways of introducing disease in the field. Seed-pieces with mild infection often result in the emergence of infected, symptomatic plants. Heavily infected seed-pieces rapidly decay in soil and, as a result, no plant emerges.

Nationwide, late blight has become more difficult to control. This is believed to be due to the introduction of new and aggressive genotypes (strains) of the pathogen. *Phytophthora infestans* consists of two distinct mating type populations, mating types A1 and A2, which are necessary for sexual reproduction and emergence of new and aggressive strains. Thick-walled resting spores (oospores) are produced as a result of sexual reproduction and are capable of surviving for many years in dead vines and in soil. Both A1 and A2 mating types are present in Canada. In B.C., a limited number of *P. infestans*-infected potato samples from the Fraser Valley submitted to the National Survey (from 2010 to 2018) indicates that the genotype US-23 (mating type A1), formerly the predominant strain, has now been replaced with US-8 (mating type 2).

Disease Management

Prevention

An integrated approach is essential for successful management of late blight.

Avoid replanting fields that had severe late blight incidence the previous year. Remove culls and volunteers from the field and safely destroy/deep bury them. Kill any sprouts from cull piles with herbicides. Consider crop rotation with a non-solanaceous crop.

Avoid planting highly susceptible potato varieties. Plant only clean, certified seed potatoes each year. Seed pieces should be treated with a protectant fungicide containing mancozeb to minimize spread of late blight from infected tubers. Do not plant seed pieces showing signs of decay.

Do not over-fertilize or over-water. Dense lush foliage stays wet longer and is more likely to become infected. Avoid using overhead irrigation when possible.

Use of floating mulches or row covers on early maturing potatoes encourages early succulent growth which is susceptible to late blight infection. Apply a fungicide as soon as the cover is removed.

Separate fields of early and late maturing crops as much as possible to slow down the spread of late blight from early to late crops. Early maturing crop should not be planted upwind of late maturing crop.

Solanaceous weeds such as hairy nightshade are hosts of late blight. Check adjacent crops and weedy areas in and around the field for Solanaceous weeds and implement appropriate weed control measures.

Monitor field on a regular basis for early detection of early blight symptoms. Pay close attention to the weather forecast to predict onset of late blight. Adopt an effective fungicide spray program before or soon after onset of disease and before row closure.

If blight gets out of control, top-kill the crop followed by a fungicide application when tops are about half-dead.

Harvest in dry weather after the vines have been dead for at least two weeks to ensure no or minimum tuber infection during harvest and allow grading out of tubers that were infected in the field. If infected tubers and wet soil get into storage the pathogen can sporulate and spread to other tubers.

Eradication & Management

Careful selection of chemicals and a well-managed spray program, as an integral part of an IPM program, will ensure success in the battle against late blight and, perhaps, growing of more popular potato varieties susceptible to late blight.

For best results, the first chemical spray must be applied before infection occurs. Select chemicals, both for seed/soil and foliar treatments, based on their efficacy, mode of action, chemical group, and resistance management criteria (Table 1). Do not apply chemicals belonging to the same group repeatedly; this will result in development of resistance to the chemical by the pathogen. Alternate chemicals belonging to different groups to maintain their efficacy and longevity. Chemicals must be applied at timely intervals depending on the residual effect of each chemical.

Application of chemicals can be suspended during dry weather in mid-summer but start again before the onset of fall rains. Most of the registered chemicals are non-systemic therefore residues can be washed off from foliage if a chemical spray is soon followed by a rain event or irrigation.

Table 1. A summary of registered chemicals and biological agents, and label information. Please refer to Health Canada's Pest Management Regulatory Agency website for labels for rates of application, application criteria and worker exposure safety.

Product name	Active ingredient	Chemical or biological group	Mode of Action	REI[1] hrs	PHI[2] days	Application guidelines
Copper 53W	copper sulphate	M1	protectant (non-systemic)	48	1	Apply preventatively at 7 to 10-day interval. Do not exceed 10 applications per year. Low risk of resistance development.
Copper Spray	fixed copper	M1	protectant (non-systemic)	48	1	Apply preventatively at 7 to 10-day interval. Do not exceed 10 applications per year. Low risk of resistance development.

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Cueva	copper octanoate	M1	protectant (non-systemic)	4	1	Apply preventatively at 7 to 10-day interval. Do not exceed 15 applications per year. Low risk of resistance development.
Copper Oxychloride 50, Kocide 2000, Parasol WPF	copper hydroxide	M1	protectant (non-systemic)	48	1	Apply preventatively at 7 to 10-day interval. Do not exceed 10 applications per year. Low risk of resistance development.
Dithane F45, Dithane DG Rainshield NT, Penncozeb 75DF or Penncozeb 75DF + Raincoat, Manzate DF	mancozeb	M3	protectant (non-systemic)	24	1	Apply preventatively at 7 to10-day interval. Low risk of resistance development
Polyram DF	metiram	M3	protectant (non-systemic)	NA	1	Apply preventatively at 7 to10-day intervals. Low risk of resistance development.
Maestro 80DF	captan	M4	protectant (non-systemic)	48	7	Apply preventatively at 7 to10-day intervals. Do not exceed 7 applications per year. Low risk of resistance development.
Bravo 500, ZN, 90WSP or 720	chlorothalonil	M5	Protectant (non-systemic)	48	2	Apply preventatively at 7 to10-day intervals. Low risk of resistance development.
Ridomil Gold MZ 68WP	metalaxyl & mancozeb	4 & M3	protectant (locally systemic)	24	3	Apply preventatively at 10 to 14-day interval. Do not exceed 3 applications per season. High risk of resistance development; must alternate with fungicides from different chemical groups.
Ridomil Gold / Bravo Twin-Pak	metalaxyl & chlorothalonil	4 & M5	protectant (locally systemic)	48	14	Apply preventatively at 14-day interval. Do not exceed 3 applications per year. High risk of resistance development; must alternate with fungicides from different chemical groups.
Acapela	picoxystrobin	11	protectant & curative (locally systemic)	12	3	Apply preventatively at 7 to 10-day interval. Do not exceed 3 applications per season. High risk of resistance development & must alternate with fungicides from different chemical groups. Bravo 500 or Polyram DF.
Headline EC	pyraclostrobin	11	protectant & curative	12	3	Apply preventatively at 5 to 7-day interval. Do not exceed 3

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			(locally systemic)			applications per season. High risk of resistance development & must alternate with fungicides from different chemical groups; can be tank mixed with Bravo 500 or Polyram DF.
Reason 500SC	fenamidone	11	protectant & curative (locally systemic)	Until dry	14	Apply preventatively at 7 to 10-day interval. Do not exceed 6 applications per year. High risk of resistance development & must alternate with fungicides from different chemical groups; can be tank mixed with Dithane DG or Bravo 500.
Cabrio Plus	pyraclostrobin & metiram	11 & M	protectant & curative (locally systemic)	12	3	Apply preventatively at 7 to 10-day interval. Do not exceed 3 applications per year. High risk of resistance development & must alternate with fungicides from different chemical groups.
Tanos 50DF	fenamidone & cymoxanil	11 & 27	protectant & curative (locally systemic)	24	14	Apply preventatively at 7-day interval. Do not exceed 6 applications per year. High (11) to medium (27) risk of resistance development.
Ranman 400SC, Torrent 400SC	cyazofamid	21	protectant & curative (locally systemic)	12	7 days	Apply preventatively at 7-day interval. Do not exceed 6 applications per season. Medium risk of resistance development. Use with a surfactant, Sylgard 309.
Zoxium 80W	zoxamide	22	protectant	48	3	Apply preventatively at 7-day interval. Do not exceed 6 applications per season. Medium risk of resistance development & must be tank mixed with Dithane DG.
Gavel 75DF	zoxamide & mancozeb	22 & M3	protectant	48	3	Apply preventatively at 7-day interval. Do not exceed 6 applications per season. Medium (22) to low (M3) risk of resistance development.
Curzate 60DF	cymoxanil	27	protectant (locally-systemic)	24	8	Apply preventatively at 5 to 7-day interval. Do not exceed 7 applications per season. Medium risk of resistance development. Must be tank mixed with mancozeb.

Product name	Active ingredient	Chemical or biological group	Mode of Action	REI[1] hrs	PHI[2] days	Application guidelines
Tattoo	propamocarb	28	protectant (locally-systemic)	48	14	Apply preventatively at 7 to 10-day interval. Do not exceed 7.5 L/hectare/ season. Medium risk of resistance development. Can be tank mixed with other chemicals.
Tattoo C	propamocarb & chlorothalonil	28 & M5	protectant (locally-systemic)	48	7	Apply preventatively at 7 to 14-day interval. Medium risk of resistance development. Do not exceed 3 applications per season.
Allegro 500F	fluazinam	29	protectant (locally-systemic)	24	14	Apply preventatively at 7 to 10-day interval. Do not exceed 10 applications per season. Low risk of resistance development
Confine or Rampart	phosphorous acid (mono- & di-potassium salts)	33	protectant & suppression (systemic)	NA	1	Apply as post-harvest. Low risk of resistance development.
Confine Extra	phosphorous acid (mono- & di-potassium salts)	33	protectant & suppression (systemic)	NA	1	Apply preventatively at 7 to14-day interval. Do not exceed 5 applications per season and as post-harvest. Low risk of resistance development.
Phostrol	mono- & di-sodium, potassium & ammonium phosphites	33	protectant & suppression (systemic)	NA	1	Apply preventatively at 7 to 14-day interval. Do not exceed 7 applications per season, and as post-harvest. Low risk of resistance development. May be tank mixed with other fungicides.
Acrobat 50WP or Forum	dimethomorph	40	protectant (locally systemic)	12	4	Apply preventatively at 7 to 10-day interval. Do not exceed 3 applications per season. Medium risk of resistance development. Must be tank mixed with Polyram DF, Dithane TM DG Rainshield TM or Bravo 500.
Revus	mandipro-pamid	40	protectant (locally systemic)	12	14	Apply preventatively at 7 to 10-day interval. Do not exceed 4 applications per season. Medium risk of resistance development
Zampro	ametoctradin & dimethomorph	40 & 45	protectant (locally systemic)	12	NA	Apply preventatively at 5 to 10-day interval. Do not exceed 3 applications per season. Medium risk of resistance development.
Presidio	fluopicolide	43	protectant (locally systemic)	12	NA	Apply preventatively at 7 to 10-day interval. Do not exceed 3 applications per season. Resistance development not

Product name	Active ingredient	Chemical or biological group	Mode of Action	REI[1] hrs	PHI[2] days	Application guidelines
						known.
Orondis	oxathiapiprolin	49	protectant (locally systemic)	12	0	Apply preventatively at 5 to 14-day interval. Do not exceed 4 applications per crop cycle. Resistance development not known.
Timorex Gold	tee-tree oil	biological	suppression	12	2	Apply preventatively at 7 to 14-day interval.

[1]REI - re-entry interval indicated on label

[2]PHI - pre-harvest interval

NA - information is not available (please refer product label & contact the manufacturer)

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