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Source of Late Blight Epidemics

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The late blight pathogen, *Phytophthora infestans*, survives in infected potato tubers, which potentially represents an inoculum source the following season (19,23). However, infected tubers frequently rot during winter months and cease being a threat as an inoculum source when decomposed. Contemporary strains of *P. infestans* are highly aggressive and rapidly rot tubers, limiting the availability of viable host tissue (16). Epidemics of late blight characteristically start from low levels of initial inoculum originally arising from infected seed tubers, volunteer potato plants developing from infected tubers in the field, or from infected tuber refuse (13,16,24). The relative importance of the three types of late-blight-infected tubers as inoculum sources varies and depends in part on microclimates, local conditions, and the extent of infection the previous fall (7,24).

Epidemics in the Columbia Basin have been traced to infected seed tubers, refuse tubers and volunteers (13). Observations in commercial fields and surrounding areas early in the course of epidemics revealed that volunteers are especially likely to pose a threat when potato plants in the field were infected the previous season, moreover, infected volunteers have been found in a field two years after an infected potato crop. Cull piles formed in late winter or early spring from tubers taken from storages can be a serious threat because infected tubers in storage are protected from external environmental variations in temperature and moisture, which may increase rot. Infected tubers may survive in cold storage at temperatures used to store seed tubers with little to no rot or symptom development (14). Latent infections in seed tubers are a particular threat in generating new epidemics.

Transmission of *P. infestans* from infected tubers to plant tissues the next season may occur during seed-tuber handling, cutting and planting (18) or in the field (9,19). For secondary infection to occur during seed tuber handling and cutting, the pathogen must survive in intact tubers during the winter, sporulate, be dispersed, and infect additional tubers or foliage. Temperature and humidity within piles of cut seed tubers often favor sporulation, and sporangia have been observed on infected seed pieces within 19 hours of cutting (21). Sporangia are readily transmitted by direct contact from infected tubers or seed pieces to non-infected seed pieces (5). Tubers infected prior to planting may be more likely to produce viable shoots than those infected in the field near harvest because of less time for rot to develop before shoot emergence. Under experimental conditions, transmission occurred from tubers to shoots when tubers were inoculated in the spring before planting, but not when tubers were inoculated in the fall (7). Infection during seed-tuber cutting and handling increases the threat of late-blight outbreaks on foliage in the field. Fungicide seed piece treatments potentially reduce transmission from infected seed tubers (11,22).

The exact pathway by which *P. infestans* progresses from planted, infected seed tubers to plant foliage has been disputed (1,3,19). De Bary (4) originally proposed that the pathogen spread by mycelial growth within infected seed tubers and advanced contiguously or followed growing shoots to produce lesions and sporangia on above-ground stems. However, the validity of De Bary's work on vegetation of the pathogen was questioned when not duplicated by other researchers as described by Melhus (19). A moist environment plays an important role in the expression of transmission of the pathogen from infected seed pieces to shoots (12,15) (Fig. 1), and many of the studies contradicting De Bary's observations were done in relatively dry seasons or environments.

Figure 1. Sporulation (white downy growth) on stem above soil surface resulting from transmission of *Phytophthora infestans* from an infected seed piece.

Additionally, continuous lesions are not always observed on the below-ground stem between the infected seed piece and the resultant lesion on the above-ground stem (12,17) and mislead some of the previous researchers. No necrotic tissue or only slight streaking of reddish brown discolored tissue may be observed on below-ground stems when *P. infestans* is transmitted by mycelia growth within internal tissues (Fig. 2). De Bary's proposed pathway has been validated (19,23) and was recently confirmed when *P. infestans* was detected in asymptomatic shoots emerging from infected tubers with the aid of the polymerase chain reaction (2,10) and when sporangia and lesions developed on asymptomatic shoots placed in a moist environment (12,15).

Emergence of infected shoots from infected seed pieces is often low and infected seed tubers frequently result in a reduced stand due to tuber rot and pre-emergence blighting of shoots (3,19). For example, over five consecutive years only 21 of 3260 (0.64%) infected seed tubers planted produced infected above ground shoots capable of sporulating (9). In experiments in Oregon and Washington (20**)**, transmission from artificially infected seed pieces to emerging shoots was 1.9 to 3.8% of the inoculated seed piece depending on the cultivar. In western Washington, tuber-to-sprout transmission was as high as 25% on plants held at 60 to 90% relative humidity in the greenhouse and transmission was greater with a US-8 than US-11 isolate (7). Transmission is promoted in a moist environment (12). In a field experiment, transmission to emerged shoots did not occur from inoculated seed pieces until shortly after a rainy period following row closure. Eighty inoculated cut seed pieces were planted and late blight lesions developed almost simultaneously above the soil level on two separate main stems (Fig 3). One of the two lesions occurred about 8 cm above the soil level. Sporangia formed with the developing lesions.

The transmission rate from an infected seed tuber to foliage does not need to be very high for a late blight epidemic to develop given the explosive polycyclic capabilities of *P. infestans* and the large amount of potato seed tubers planted in major production regions (9,23). For example, in the Columbia Basin in 2010 the number of seed pieces that was planted was over 2.625×10^9 with a total weight of 156,300 metric tons. Only a few infected tubers are needed to initiate an epidemic (9,23) and a few infected shoots arising from infected seed pieces in a commercial field is below the perception threshold and will not likely be noticed during the early stages of epidemics. Inoculum originating from infected seed tubers in commercial fields can be especially devastating because of the potential earliness of the initial inoculum, the rapidity with which it can be produced, and the proximity of inoculum to the crop. In addition, the moist conditions favoring emergence of infected shoots also favor sporulation and repeated infections in the field (8,12). As many as 300,000 sporangia can be produced from a single lesion demonstrating the explosive reproductive capabilities of the pathogen (6). In addition, weather conditions in the Columbia Basin are usually the least stable in May and June, with greater likelihood of rain events, further encouraging the development of primary inoculum, spore movement and new infection.

Figure 2. Streaking of reddish brown tissue on the below-ground stem where *Phytophthora infestans* moved internally in the below-ground stem from an infected seed piece to near the soil line and then formed a symptomatic lesion during a moist period.

Management of late blight in the early growing season

Management tactics that restrict transmission from infected seed tubers to shoots and the initial development of late blight epidemics include the following:

1. Plant certified, late blight free seed tubers
2. Eliminate culls and tuber refuse
3. Manage volunteer potato plants
4. Treat seed with a fungicide containing mancozeb or Curzate
5. Plant seed tubers within 24 hours of cutting

Epidemics of late blight characteristically arise from a very low level of infected seed tubers, a few infected volunteer plants, or from infected tuber refuse. Certified seed lots should be selected from seed areas where late blight did not occur or from farms where the disease was successfully managed. Seed health certificates and visits to the seed farm during the growing season can be helpful in selecting satisfactory seed lots. Volunteers in fields that had late blight the previous year are especially likely to be infected and pose a threat the current year. Refuse tubers pose a serious threat as a source of late blight inoculum and should not be tolerated.

Spores of the late blight organism can form on infected seed tubers and spread to and infect other seed pieces during cutting and handling. Sporulation can occur on infected seed within 24 hours after cutting because of favorable temperature and humidity within a pile of cut seed tubers. Spread to other seed pieces occurs as air currents disperse spores and as seed pieces are mixed during handling. Fungicide seed treatments that contain mancozeb or Curzate reduce this spread (11,22). Planting seed tubers within 24 hours of cutting will also help reduce tuber to tuber infections. The use of fungicides on potato seed will not negate the importance of using certified seed tubers free of late blight. Soil temperatures should be 55 F and increasing at planting.

Figure 3. Late blight lesion on an above-ground stem arisen from an infected seed piece planted in the field.

6. In the first 80 ft of the pivot center, either make more fungicide applications or do not grown potatoes. This is usually the wettest area of the circle and most conducive environment for late blight infection on foliage and tubers. Late blight often begins in fields near the pivot center, and recent research demonstrated that large proportions of infected tubers originate in this area. Rot in storage can move throughout the storage from concentrated sources of infected tubers. Lost production area is about 0.4 acre or 0.3% of a 125-acre field. This is with a 25 ft radius subtracted for pivot turn around road. Yield and tuber quality are often lower in this area so lost tuber yield would be less than the lost production area. Benefits can be a reduction in number of fungicide applications, better late blight control and fewer infected tubers going into storage.

7. Irrigate sparingly until just before tuber initiation. This reduces the risk of early season late blight, infection by *Verticillium dahliae* (cause of early die disease), and infection of seed pieces by soft rot bacteria.

8. Avoid pivot overlaps, over watering and watering during rainy periods or when dew is occurring. Try to irrigate when leaf wetness periods will be less than eight hours. Moisture for sporulation and infection mostly come from sprinkler irrigation in the Columbia Basin. Watering during late evening and at night will usually extend the leaf wetness period in semiarid environments. This is because temperatures are

cooler and wind speed is lower and the foliage will dry less rapidly than during the day. Potato fields infected with late blight should be irrigated during the daylight hours to minimize continued late blight development. Reduce irrigation when the crop canopy begins to open and towards the end of the growing season.

9. Plant seed pieces relatively deep and form an adequate hill to provide a soil cover over tubers. Tubers become infected when spores of the late blight pathogen come in contact with tubers in the field. Soil cracking and hill erosion expose tubers in the field and make them especially vulnerable to infection from spores that are washed from infected foliage by irrigation water or rain. Spores are not washed more than an inch through intact soil. In a study at WSU where spores were applied over the surface of silt loam, medium sand and fine sand, tuber infection decreases with increasing soil depth. Most infected tubers were found at the soil surface, and infection was rare on tubers at 2 inches and deeper. In consequence, planting depth, hilling practices, and other cultural practices should be exercised to promote an adequate covering of soil over tubers and to reduce soil cracking.

10. Use good fertilization practices. Massive vine growth creates a microclimate favorable for late blight.

11. Monitor fields for late blight, especially near the center of pivots, along wheel tracks, and low areas in fields.

12. Apply effective fungicides before prolong wet periods after row closure (15).

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Up-Coming Field Days

Oregon

Oregon State University, Hermiston
Potato Field Day, June 24, 8 am – lunch time.

Washington

Washington State University, Othello
Potato Field Day, June 25, 8:30 am – lunch time.

Have you other field days or events you'd like announced? Send me an email: ajensen@potatoes.com.