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Managing the ascochyta blight complex on field pea in western Canada

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Summary

Ascochyta blight, caused primarily by *Ascochyta pinodes* (sexual form *Mycosphaerella pinodes*) is an important disease of field pea in western Canada. It occurs in almost every field each year, and is capable of causing substantial loss in seed yield when epidemics develop early. There are differences in susceptibility among field pea lines, but lines also respond differently to the amount of disease that they can tolerate before substantial yield loss occurs. Studies to develop cultivars with improved resistance are on-going, and several new approaches to breeding for resistance are discussed. Foliar-applied fungicides reduce blight severity, but do not consistently increase seed yield. Cultivars with stronger stems are less susceptible to lodging, and may be more tolerant to ascochyta blight than lines with weaker stems. A low-cost option for blight management in western Canada is selection of high-yielding cultivars with strong stems and an upright growth habit for use in a diverse (e.g., four-year) cropping rotation.

Introduction

Foliar diseases are an important constraint to production of pulse crops on the Canadian prairies[1], and the impact of these diseases has increased in the region as the acreage of pulses has increased. Each of the pulse crops grown in the region (except dry bean) is associated with an ascochyta blight that can cause substantial yield and quality loss: *Ascochyta lentis* Vassilievsky on lentil, *Ascochyta rabiei* (Pass.) Labrousse on chickpea, *Ascochyta fabae* Speg. on faba bean and the ascochyta complex on field pea caused by *Mycosphaerella pinodes* (Berk. & Blox.) Vestergr. [asexual state *Ascochyta pinodes* L.K. Jones], *Phoma medicaginis* Malbr. & Roun. in Roun. var. *pinodella* (L.K. Jones) Boerema and *Ascochyta pisi* Lib. *Mycosphaerella pinodes* is the dominant pathogen in the ascochyta blight complex on the Canadian prairies, and so in recent years all of the diseases caused by the ascochyta blight complex have tended to be lumped together under the common name mycosphaerella blight.

There are numerous other foliar diseases that also attack pulses in the region, including anthracnose (*Colletotrichum truncatum* (Schwein.) Andrus & W.D. Moore) and stemphylium blight (*Stemphylium botryosum* Wallr.) on lentil, downy mildew (*Peronospora viciae* (Berk.) de Bary), powdery mildew (*Erysiphe pisi* Syd.) and bacterial blight (*Pseudomonas syringae* pv. *pisi* (Sackett) Young, Dye & Wilkie) on field pea, and white mold (*Sclerotinia sclerotiorum* (Lib.) de Bary) and grey mold (*Botrytis cinerea* Pers.:Fr.) of all pulse crops. However, the ascochyta blights are generally the most widespread and damaging diseases on each crop, and have been the focus of much of the research and resistance breeding effort in the region in the last 20 years. Substantial progress has been made in the management of *A. lentis* on lentil, based on genetic resistance and an effective program of fungicide application. There are no strong and durable sources of resistance to *A. rabiei* available in chickpea[2], but effective foliar fungicides have been identified[3] and innovations in fungicide application may help to reduce blight severity in this crop[4]. Faba bean is a small acreage crop in western Canada, and use of clean seed and diverse crop rotations are generally enough to minimize the risk of ascochyta blight on this crop at present. However, field pea is a large acreage crop and the ascochyta blight complex is present in almost every pea field each year[5,6,7]. In addition, *M. pinodes* can reduce seed yield by as much as 50%[8,9]. However, the impact of genetic resistance, fungicide application and other management approaches on seed yield and quality is not well understood. Therefore, this review will focus on recent research into the management of the ascochyta blight complex of field pea.

Symptoms

Mycosphaerella pinodes attacks the leaves, stems, flowers, and pods of field pea. Initially, small, purplish lesions with irregular margins develop on leaves. When the lesions enlarge and coalesce, they cause extensive blighting that can affect entire leaves and stipules (Figs. 1 and 2). Distinctive purplish black lesions on stems often coalesce to cause extensive blighting and foot rot. When the disease is severe, stem lesions weaken stems and increase lodging. On pods, the lesions are purplish brown and adjacent seeds within the pods may also be affected. Infected seeds from diseased pods may be small, shrunken or discoloured, but most seed lots produced in western Canada have few or no visible symptoms and less than 5% infection with *M. pinodes*. *Phoma medicaginis* causes similar symptoms on pea foliage, but lesions are most common at the stem base, where it causes a foot rot symptom. In recent years, assessment of seed samples indicates that *A. pisi* is increasing in frequency in some areas of Saskatchewan[10,11]. The symptoms are similar to those of *M. pinodes*, except that lesions are tan or brown in the centre with dark margins, and large lesions tend to be sunken.

Figure 1. Initial symptoms of ascochyta blight on field pea. Lesions can expand rapidly under cool wet conditions. Photo credit: G. Chongo.

Figure 2. Moderate symptoms of ascochyta blight at the base of the crop canopy. Photo credit: B.D. Gossen.

Development and impact

The pathogens in the ascochyta blight complex are seed-, stubble-, and soil-borne. The pathogens can survive for several years in seed, and resting spores (chlamydospores) of *M. pinodes* can survive for several years in soil. In spring, the pathogens produce conidia (asexual spores) on infested crop residue that are spread over short distances by rain splash and can infect all above-ground parts of plants. The first lesions formed quickly produce more conidia that can initiate more new lesions on healthy plant tissues. *Mycosphaerella pinodes* also produces ascospores (sexual spores) that are carried over long distances by wind[12], and are the most important source of early season inoculum in regions where the pathogen is established[13].

The frequency of transmission of *M. pinodes* from infected seeds to the above-ground tissues of seedlings is low[14,13,15]. The rapid death of pea seedlings growing from infected seed frequently traps the pathogen below the soil surface, limiting any opportunity for splash dispersal of conidia to adjacent seedlings[16]. The above-ground portions of dead seedlings may subsequently be colonized by the pathogen and produce conidia, but that process takes time and occurs infrequently[17]. Also, seed infection can reduce seedling establishment[15,16,18]. Pea crops can compensate for substantial losses in seedling density, and large reductions in stand density may not affect yield where weed invasion is not an issue[13]. However, use of seed with high germination rates and low levels of disease is always preferred over lots with low germination and high levels of disease.

Development of ascochyta blight occurs most rapidly under cool, moist conditions, and occurs more quickly as plant tissues age[19,20,21]. The relatively short latent period of this pathogen[22] allows for multiple cycles of infection and spore production to occur when conditions during the growing season are conducive for disease development. This can result in rapid increases in ascochyta blight severity in a susceptible crop. An increase in severity is often noted after canopy closure. When the canopy closes, the dense growth prevents drier air from penetrating into the canopy. Free water remains on leaf surfaces longer, which promotes infection, and the air within the canopy is cooler and more humid, which is conducive to rapid lesion development. As a result, ascochyta blight symptoms develop initially at the base of the canopy where conditions are cooler and reduced air flow results in increased humidity, and then move up into the mid and top levels of the canopy when conditions are conducive for disease increase. However, cool conditions and adequate moisture during flowering and pod set also maximize the growth and productivity of the field pea crop, so the yield potential of affected crops may remain high even though disease is severe.

A recently completed study (Hwang, unpublished) demonstrated that delaying the initiation of an epidemic of mycosphaerella blight by as little as one to two weeks can reduce subsequent blight severity and yield loss. Cultural factors such as crop rotation (to reduce primary inoculum in a field) and seeding rate and depth (to ensure that plants are as large and vigorous as possible before ascospores are available for infection) may have an influence on epidemics of ascochyta blight[23] because of their impact on the timing of infection and the growth stage of the crop when disease becomes severe.

The timing and severity of lodging affects the ability of an infected crop to achieve a substantial portion of its yield potential. In a trial where field pea lines were allowed to lodge normally or were held up with wire mesh, lodging increased blight severity and yield loss. In the same study, development of severe symptoms (e.g., large stem lesions) was associated with increased lodging and yield loss[24]. Blight severity and lodging are both influenced by stem strength[25], so breeding for improved stem strength may be a useful approach to reduce disease severity and increase yield.

Management

Management of ascochyta blight in western Canada starts long before the crop is planted, and is based on a diverse crop rotation, high quality seed, and selection of the best cultivar available. Recent recommendations for management of the ascochyta blight complex include a 4-year cropping rotation with non-host crops, selection of fields as far as possible from the previous year's pea fields, burial of infested crop residue with cultivation, and use of pathogen-free seed[26]. However, some of these recommendations are changing in response to new information and changes in field pea production systems.

Crop rotation and tillage. Pathogens in the ascochyta blight complex survive for only a few cropping seasons in infected crop residue[27,28], so a 3- to 4-year cropping rotation is sufficient to reduce or remove these pathogens from a field. Reduction in the amount of inoculum within a field can substantially reduce the level of ascochyta blight caused by *A. pisi* and *P. medicaginis*. Rotation has less impact on *M. pinodes* because ascospores from infected residue in nearby fields generally provide sufficient inoculum to initiate an epidemic in regions where field pea is a regular component of cropping rotations. As a result, blight symptoms occur in every field each year, and crop rotation has little or no impact on severity[29,30]. However, these same studies have shown that the impact of all crop diseases is generally low across all of the crops grown in a diversified rotation. Also, a diversified crop rotation is important for maintaining productive soils[31], so a diversified 3- to 4-year crop rotation is still recommended.

Although survival of *M. pinodes* is reduced by burial[27], the impact of tillage on ascochyta blight severity is much smaller than the impact of weather conditions on ascochyta blight epidemics in a 4-year crop rotation[29]. Also, burying infested crop residue with intensive tillage is becoming an increasingly unusual practice in western Canada as growers switch to reduced- or zero-tillage production systems. Most producers in the region prefer to maintain crop residues on the soil surface to protect the soil from erosion. As a consequence, the recommendation to bury infested crop residue with tillage to reduce spread of the ascochyta blight complex is no longer compatible with standard production practices. For that reason, the benefit of maintaining the residues at the soil surface outweighs the small potential benefit from burying inoculum with tillage. Similarly, although planting in fields as far as possible from the previous year's pea fields may have a small impact on levels of air-borne ascospores arriving in a field, the location of the field is unlikely to have a consistent impact on seed yield or quality, and so is not an important consideration in designing crop rotations in western Canada.

Infected seed. The level of seed infection with *M. pinodes* has little or no impact on levels of mycosphaerella blight because air-borne ascospores are a much more important source of initial inoculum in western Canada[15,13]. However, high levels of seed infection can reduce seedling emergence, which could affect the crop's yield potential. Assessment of the germination and vigour of seed lots prior to planting is strongly recommended, but routine assessment of the frequency of seed infection in seed lots is likely not warranted.

Host resistance. Differences in the reactions of field pea lines to mycosphaerella blight have been well documented[32], but the most resistant lines available are only moderately susceptible[9,33,34,35,36]. Variation in the virulence of *M. pinodes* within the pathogen population in western Canada contributes substantially to the complexity of selection for resistance[18,37]. In western Canada, breeding programs at the University of Saskatchewan and in Agriculture and Agri-Food Canada are developing field pea cultivars with improved ascochyta blight resistance. At present, the focus is on *M. pinodes*, but efforts to improve resistance to *A. pisi* may be required if the frequency of that pathogen continues to increase. One interesting new approach to selection for resistance is to assess the plant's reaction to one or more of the toxins produced by the pathogen. Toxic metabolites from *M. pinodes* and *A. pisi* have been extracted and characterized[38,39,40] and may be a useful new tool for selection of resistant germplasm in breeding programs.

In addition, two recent studies have indicated that some of the field pea cultivars in western Canada may be tolerant to *M. pinodes* [41,42]. Tolerance was also noted in a recent study in Poland[43], and may represent another new direction for field pea breeding programs. A tolerant line develops the same high level of disease as a susceptible line, but suffers less yield loss. The mechanism underlying this type of response could be a factor like stronger stems in the tolerant lines. Plants with strong stems would be less prone to lodging, and so suffer less lodging and less yield loss when stems are weakened by ascochyta blight lesions.

Foliar fungicides. The only component of the management strategy that can be implemented after the crop has been seeded is application of foliar fungicides. Field pea crops are most responsive to fungicide after the canopy closes, but at this stage the lower leaves and stems become increasingly inaccessible to fungicide application as canopy density increases. Ascochyta blight severity can be reduced with one or two applications of fungicides per season[44,41,42,45], and several effective fungicides are registered in Canada for this use. However, the impact of fungicide application on seed yield is much less consistent than its effect on disease severity, possibly because some cultivars are more tolerant to one or more components of this disease complex than other lines[41,42]. As a result, application of fungicide is often not cost-effective, and attempts to develop decision support systems to identify when fungicide application is warranted have not been successful[46]. Studies are underway to determine if factors such as nozzle type and orientation, droplet size, and spray volume (Fig. 3) have an impact on fungicide efficacy[47], but the results to date indicate that changes in application technologies will produce only modest gains in fungicide efficacy (Gossen, unpublished). In addition, some of the fungicides registered for use on field pea may have a secondary effect on plant health (e.g., improved heat and drought tolerance) of the crop. This is an interesting new approach, which may have a place in crop management in western Canada. However, these effects have not yet been substantiated by independent research groups. Also, loss of efficacy of single-mode-of-action fungicides after the development of insensitivity in pathogen populations has already been documented on the Canadian prairies[48,49]. Populations of *M. pinodes* are at a high risk to develop insensitivity, and more frequent application of fungicides increases this risk. Development of insensitivity may represent a substantial downside to this strategy, so a study of fungicide insensitivity in field pea is currently underway in Canada and the USA[50,51].

Figure 3. Application of foliar fungicide in a research trial at Saskatoon. Photo credit: AAFC.

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