IMPACT OF CROP MANAGEMENT ON PLANT DISEASES

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Introduction

Crop management systems on the Canadian prairies are changing rapidly, with major trends towards reduced tillage, increased continuous cropping, and increased crop diversity. These factors will all have an effect on the level of crop loss caused by plant disease. Plant pathologists have some specific information on the interaction of crop management, diseases, and environment. However, most of this information is based on relatively small studies that examine only a few variables at a time. We need to understand the "big picture" in order to anticipate and prepare for problems instead of simply reacting to them after they appear. To do this we must combine theory, research results, and practical experience to provide growers with a reliable basis for assessing the potential impact of various management options on their own operations.

We don't have all the answers, but in this presentation we intend to present our ideas on how changes in crop management will affect diseases, with special focus on potential problem areas, and some suggestions on areas where more research is needed.

What do (or don't) we know about crop management on plant disease?

Farming and gambling are similar in that success or failure largely depends on forces outside of an individual's control. The risk can be managed by choosing to play the right game and by using a good betting system. On the prairies, crop loss caused by diseases is a risk that is affected by weather. This portion of the risk is beyond a producer's control. Most diseases are difficult to control after they have got a strong start requiring a curative treatment, i.e. foliar fungicide applications. More often, diseases can be reduced by careful attention to factors such as location, tillage management, cropping sequence, cultivar resistance, and soil fertility before the crop is even planted. We will be discussing only the first three factors in this presentation.

Location

Generally, foliar disease problems are greater as you move from the brown to the dark brown to the black soil zones on the prairies. The use of rotations and tillage to control foliar diseases of cereals may not be important in the brown soil zone but would be in the black soil zone. For most diseases, the probability of a disease outbreak is greatest in areas where rainfall is higher, providing that inoculum is present. Therefore, the risks associated with inadequate crop rotation are highest on average in the black soil zone. An example of this was noted in a lentil trial where seed infested with ascochyta was planted at several locations in the brown and black soil zones in 1987. At sites in the brown soil zone, ascochyta blight developed slowly and caused minimal crop damage, whereas at sites in the black soil zone, blight developed rapidly and crop losses were severe (Morrall, pers. comm.).

Location also influences which soil-borne root pathogens may be present on a regional basis. For example, in the Pacific Northwest of the United States, continuous wheat crops grown under zero tillage developed severe yield limiting root disease problems with fusarium, take-all, and pythium root rots. Yet, in the brown and dark brown soil zones of Saskatchewan, these problems have not developed because the location and climate restrict the pathogens' survival.

While assessing the level of risk, producers should also identify potential disease problems for the local area. Diseases present in fields in past years can cause future problems. Mycosphaerella blight is one of the major diseases of pea on the prairies. Survival of the pathogen is reduced when pea haulm is buried (Sheridan 1973), but it can survive for long periods as a saprophyte in soil. In fact, *A. pinodes* has been isolated from soil as long as 20 years after the last pea crop (wallen et al. 1967). Disease problems of a neighbour can also influence the degree of risk. This pathogen produces an air-borne spore that can easily move to adjacent fields, so growers in areas where pea production is common can expect to encounter this disease in their field every year, irrespective of crop rotation or tillage choices.

Tillage

Tillage practice affects diseases that are either primarily soil-borne or residue-borne. For some diseases there is a predictable pattern of disease development under reduced tillage but for others, there is no way to predict the effect that reduced tillage will have on disease losses. Based on evidence in other regions, reduced tillage was expected to increase the root disease of cereals. Contrarily in southern Saskatchewan, reduced tillage lowered disease levels of common root rot and the amount of inoculum compared to conventional tillage (Bailey et al. 1992). Grain yields were 6% higher under zero tillage than under conventional tillage.

Sclerotinia is a soil-borne disease of oilseed and pulse crops. Merriman et al. (1979) recommended a single deep ploughing to bury some crop residue and the fungus because survival of the sclerotia was greater at the soil surface and when protected by crop residue. Survival of the sclerotia declined when buried in the soil at 4 cm deep. Secondary tillage was not recommended because this action returned sclerotia back to the surface and increased survival. On the other hand, there is some evidence that the incidence of sclerotinia stem rot infection declines under zero tillage as compared to conventional tillage if there are high levels of organic matter at the soil surface (Boland, pers. comm.).

Reduced tillage systems can increase the risk of serious disease epidemics in areas where foliar diseases are a problem because of increased levels of initial inoculum when crop residues are left on the soil surface. When inoculum is reduced, epidemics develop more slowly because they start at a point further down on the sigmoid disease progress curve, and therefore take longer to reach the exponential growth phase. Reductions in inoculum are probably more important in areas where environmental conditions suitable for infection occur relatively infrequently (like in Saskatchewan) than in regions where the frequency of conditions conducive to infection (frequent rainfall and high humidity) are common. Once disease is established, local weather determines how quickly it progresses to the exponential phase. Intermittent wet/dry periods encountered in the prairies often limits the progress of these diseases.

In Saskatchewan, studies have shown that reduced tillage increases foliar disease severity on cereals, but not always to economically important levels (Bailey et al. 1992). In the brown soil zone, foliar diseases did not significantly reduce grain yields from 1986 to 1991 but did reduce yield from 1992 to 1994. The greatest losses were encountered in zero tillage plots with continuous wheat (28%) but the losses under zero tillage were only 6% higher than under conventional tillage. In 1994 in the black soil zone, fungicide treatment increased yields by 11% in wheat and 29% in barley, but did not show an interaction with tillage method. Since the weather cannot be predicted, one would not be able to tell if conditions would or would not be favourable for yield limiting disease development in any given year.

For lentil, the most important diseases on the prairies are ascochyta and anthracnose. These diseases are mainly stubble-borne (Gossen & Morrall 1986, Buchwaldt & Bernier 1993). *Ascochyta fabae* f.sp. *lentis* survives for up to three years at the soil surface, but for only a few months when buried at 16 cm (Kaiser & Hannan 1986). Therefore, tillage can be used to reduce ascochyta inoculum in lentil crops. *Colletotrichum truncatum the* cause of anthracnose, can survive burial for extended periods (Buchwaldt & Bernier 1993), so tillage may not have as large an impact on control for this pathogen as for ascochyta.

The impact of reduced tillage practices on blackleg of canola is currently unknown but it could be positive. The reasons are that most of the crown remains below the soil and this is the tissue from which most of the spores originate. Relatively few spores are produced from leaves and stems, which break down rapidly. Spores from infected canola stubble are produced primarily on 2-4 year old plant crowns left on the soil surface where the crowns break down more slowly, and so act as an inoculum source for a long time. Under zero tillage, canola crowns would remain undisturbed and be covered by the soil. The dead tissue would be exposed to wetting and drying cycles that could assist in the decomposition of the residue. The combined effects of physical coverage by soil and faster breakdown should reduce inoculum production more quickly than under conventional tillage where each tillage pass brings some crowns back to the surface resulting in increased sporulation. Also, glyphosate (Roundup) is known to reduce sporulation of the fungus, so the use of this herbicide to control weeds in reduced tillage situations may also reduce inoculum levels of blackleg. Nevertheless, if these theories are substantiated, primary inoculum levels are only reduced and nothing will prevent spores arriving from neighboring fields to provide enough inoculum to get the disease cycle started.

Crop Selection and Rotation Planning

For most soil borne and residue borne diseases, a long time period between susceptible crops would be the best solution, but it is neither easy nor practical for most growers. For some diseases, rotation is critical, but for others its is less important. The level of risk depends on the shortest interval in the rotation between crops with similar disease problems. Diverse crop rotations reduce the risk of catastrophic losses caused by pests, but a rigid crop rotation plan reduces the grower's ability to win big if other factors, e.g. markets, make other cropping options preferable.

Crop selection should be thought of as long term investing. Crops of similar types usually have similar disease problems and should not be grown in consecutive years. Losses due to foliar diseases of cereals are variable each year but can be up to 40% under severe disease outbreaks. Reduced tillage and continuous cropping of wheat and/or barley will likely lead to more problems because these pathogens survive on residues left on the soil surface. Sometimes a rotation of wheat following barley will not be effective in foliar disease control because *Septoria nodorum,* which is one of the fungi causing septoria leaf blotch, reproduces abundantly on barley residues even though it does not become a major pathogen problem on barley (Duczek & Bailey 1994). Sometimes a short break of one or two years can provide adequate management of a disease. Under conventional tillage, a rotation of one year between wheat crops was sufficient to lower disease levels for septoria leaf blotch when conditions were unfavourable for disease development, but under favourable conditions for disease development, two years between wheat crops was better than one year (Pedersen & Hughes 1992).

In other cases, rotation alone is not sufficient to give control. Common root rot is ubiquitous where cereals are grown because the fungus produces a lot of inoculum which survives for a long time in soil. It grows on cereal residues but can also sporulate to a lesser degree on canola, sunflower, flax, and alfalfa (Duczek et al. 1994). Low levels of spores in the soil can cause high levels of disease in the crop, resulting in average annual losses of 510%. Rotation alone is not practical for control and it should be used in conjunction with other sustainable strategies.

For some diseases, crop rotation is a critical factor for the long term success in disease management of crops. Virulent blackleg is widespread in Saskatchewan. There is fair to good resistance in *Brassica napus cultivars,* but only poor resistance in *Brassica rapa. In* susceptible cultivars, losses of up to 56% occur in severely infected crops (Petrie 1985). Crop rotation is recommended for control of blackleg, but it may not always succeed because spores can move at least up to 8 km. Inoculum produced from one year old residue is of minor importance in starting the disease cycle, but large numbers of spores are produced on two year or older residues (Petrie 1994) This means the residue from the crop in 1994 will produce a large number of spores in 1996, so blackleg may be high in 1996. Therefore it would not be practical to grow canola in 1996 or 1997 in those fields when the risk of the disease is at its peak.

Sclerotinia affects many plant species and there is no resistance. Crop rotation and the use of fungicides are the methods of control. The introduction of sunola into areas where canola is grown may increase the importance of sclerotinia because more inoculum, that is, sclerotia, are produced in infected sunola than in infected canola (Pearse 1994). Similarly, pea production increases the risk of this disease because sclerotinia is difficult to detect in a pea crop and yield is not always reduced in infected plants, but upon harvest, high numbers of sclerotia are released to the soil or mixed with harvested seed (Davies 1991). A planned rotation is needed to keep inoculum potential down for blackleg and sclerotinia or the susceptible crops may lose their value.

What problems remain and what future research is needed to solve them?

1. Short term research is being used to provide answers to problems that require long term studies. This is especially true for plant pathology research in farming systems where diseases may not be present initially but develop over time. The short term response may not reflect what is occurs in the long term. Basic research on the biology of pathogens and on their interactions with the environment are required to build the foundation for integration of disease management strategies under numerous crop management variables. The petal testing kit for sclerotinia stem rot is an application developed from fundamental epidemiology research. Practical applications of basic principles are rarely understood until a critical volume of knowledge is available for interpretation. Without the basic research, problem solving is like building a jigsaw puzzle without a picture to follow.

2. Technological changes may occur faster than research can be conducted. In essence, the discipline of pathology is responding to changes in technology instead of directing the technology. Without a knowledge base, predictions cannot be easily made on how the various technological changes will affect disease epidemics. An example of where we need to be proactive is in studies on the role of landscape architecture in disease development leading to variable rate applications of fertilizers and fungicides within a field by using the Geographical Information Service mapping systems.

3. Information on risk assessment and appropriate educational tools to assist producers in farm management planning for disease control are lacking. Inadequate literature exists on estimates of losses for many diseases. Loss estimates are often based on speculation and not statistically conducted research. It is necessary to develop economic thresholds for plant diseases similar to those frequently prepared for insects. Research should be done to determine realistic economic losses, disease thresholds, prediction and risk assessment variables. This information is essential for the development of computer based decision support modelling systems. Disease forecasting models have been developed for other crop/disease situations (i.e. late blight forecasting in potatoe) in the United States and in Europe but have been neglected in the lower input, lower valued, and weather dependent cropping systems encountered on the prairies.

4. Research should focus on the effects of rotation and tillage on diseases of oilseeds and pulses. More research has been done in the past on cereal diseases in different environments around the world. We have learned from these studies that extrapolation of results from one environment to another are not usually possible. This leads to apparent conflicts in literature. In order to solve problems at the farm gate, we need to have an understanding of all components in the system that we are using.

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