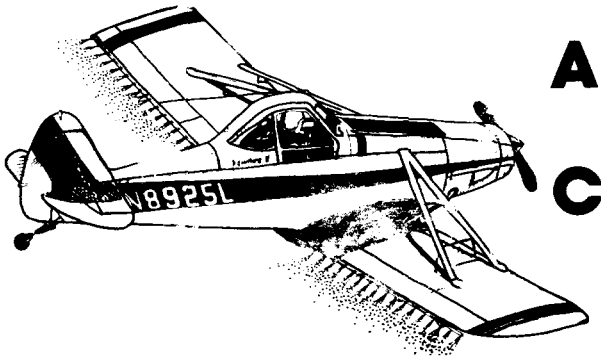

AERIAL APPLICATION OF FUNGICIDES FOR CROP DISEASE CONTROL

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Many common crop diseases can be controlled by proper and timely application of fungicides. This circular attempts to provide useful information for both growers and aerial applicators.

Small grains, North Dakota's leading crops, are often relatively disease-free, but disease may be serious when moisture is plentiful. Yield reductions when leafspot diseases are severe may range from 10 to 35 percent for wheat and barley.

Dry beans are an important crop in North Dakota, and diseases are an annual problem. They cause crop losses in individual fields ranging up to 50 percent for white mold and total crop failure for rust. Dry beans are a high management crop requiring weekly or twice weekly monitoring for diseases.

Potatoes and sugarbeets are important row crops in North Dakota. Potatoes are sprayed most years to control early blight, which may cause early loss of foliage and tuber decay. In cool, wet years late blight may be a problem. Late blight is capable of rapid spread and complete crop destruction. It also may infect tubers and cause tuber breakdown in storage. Sugarbeet tonnage and sucrose yields may be severely reduced by Cercospora leafspot, particularly on highly susceptible varieties.

SMALL GRAINS

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Several small grain leafspot diseases are important in reducing yields. Tan spot is the most serious leafspot of spring wheat and durum. Both tan spot and leaf rust may be severe on winter wheat. Septoria leaf blotch is important in some years. Tan spot and Septoria survive on stubble and straw in the field. Tan spot attacks throughout the growing season, but it often attacks earlier and with greater severity in fields where wheat is planted into wheat stubble or straw. Septoria attacks following the boot stage of wheat development on most cultivars. Leaf rust survives primarily in the main winter wheat growing regions of the United States, and its spores blow north in the spring. In some years leaf rust arrives too late to cause serious damage, but it is always a threat to susceptible wheats grown in eastern North Dakota. All winter wheats commonly grown in North Dakota are susceptible. All but a few spring wheats are resistant to leaf rust, and most durums are moderately resistant.

Spot blotch is the most serious barley leafspot, although net blotch is also important in northeastern counties.

When is a Fungicide Needed? Fungicides may pay for themselves in years with good yield potentials. There is no economic return in spraying a crop with a poor yield potential or one that is severely attacked by virus or bacterial diseases that reduce yield potentials and cannot be controlled with fungicides.

Mancozeb fungicide (Dithane M-45, Manzate 200, or Penncozeb) can be used on barley, wheat or oats for control of leafspot. Leaf rust can be controlled with Dithane M-45 or Manzate 200 (wheat only). Two applications are required to protect the flag leaf from infection. The flag leaf manufactures much of the food that is stored in the grain, so the greatest economic return from the use of fungicides is by protecting the flag leaf. Mancozeb fungicides are protectant fungicides. They act on the surface of the leaf to prevent infection but cannot cure infections that are already established. After infection, it takes four to six days for spots to appear; spraying fungicide during this period will **not** prevent the leaf spots from developing. The first application of fungicide should be made as soon as the flag leaf is fully expanded, when the head is still in the boot. A second application should be made in seven to 10 days. A single application to the flag leaf may not provide adequate disease control and is **not** recommended. When severe disease develops early in the season, spraying the crop in the jointing stage may reduce disease but generally may not be economically feasible. Early season spotting is less frequent and data on losses has not been obtained. Spraying small grains in the seedling stage is not considered to be economic.

A new class of fungicides called sterol inhibitors have some therapeutic ("curative") properties as well as acting as protectants. For example, triadimefon (Bayleton) has therapeutic activity on rusts and powdery mildew up to four days after infection. If infection occurred more than four days before the triadimefon was applied, disease will develop, but the number of viable spores (spores capable of starting new infections) will be diminished. A single application of triadimefon to the flag leaf will give about 21 days protection against rusts and powdery mildew but will not protect against tan spot. Other sterol inhibitors with a

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broader spectrum of activity may be registered in the next several years. The sterol inhibitors are systemic - once applied and dried on the plant (at least four hours), they cannot be washed off by rain or dew.

Key factors in determining whether a fungicide will pay are given in Table 1.

Table 1. Factors which favor an economic return from use of fungicides on small grain.

Factor	Remarks
1. High yield potential.	1. At least 50 bu/A for wheat and 65 bu/A for barley (varies with cost of application and market value of the grain).
2. Planting into stubble or straw of same crop.	2. Wheat on wheat (all classes) or barley on barley.
3. Susceptible variety.	3. See variety recommendations for information on leaf spot and leaf rust susceptibility.
4. Plants frequently wet for extended periods.	4. Wet to at least midmorning.
5. Wet weather in forecast.	5. Major front moving in - spray before the rain.
6. Disease already present.	6. Usually on lower leaves.

Growers who haven't sprayed before may wish to leave an unsprayed check strip to see how much benefit is received from the fungicide. The check strip should be representative of the whole field. The sprayed area must be a minimum of three airplane swaths, preferably more, to allow for proper overlap of the spray deposit. Growers who leave a check strip should be sure to harvest the strip and make a yield comparison with the sprayed part of the field. Simply observing the field without taking yields may not define profitability or nonprofitability. The unsprayed plot may have to be harvested earlier than the sprayed; the unsprayed plot may mature earlier because of disease.

Irrigated small grains, small grains grown under intensive management, small grains no-tilled into stubble of the same crop, and two-row barleys or winter wheat grown in the eastern part of the state are all prime candidates for fungicide sprays.

DRY BEANS

Yield losses from three major bean diseases can be reduced by foliar sprays of fungicides. These diseases are rust, white mold, and halo blight.

Rust builds up rapidly when temperatures are 60-80°F and dew or rain keeps plants wet for eight hours or more. Varieties differ in susceptibility. Many races of rust occur in North Dakota, and no variety of pinto or navy is resistant to all races present in the state. Fields should be monitored for rust; the first spray should be applied when an average of two rust pustules are present per leaf. Maneb and chlorothalonil provide excellent control but are protectant fungicides; they must be applied before extensive infection has occurred. Periodic fungicide applications may be required if the weather remains favorable for disease development. It does not pay to use a fungicide once the lower pods of pinto beans begin striping. Sometimes navy beans may also need to be sprayed with a fungicide for rust control until the pod fill stage. Good coverage of the entire plant is essential for rust control.

White Mold infections begin on the dead blossoms and dead lower leaves. These infections are started by airborne spores that can come from any white mold-contaminated field in the area. The soil in contaminated fields must be wet for several days for spores to be produced. The lower parts of plants must remain wet for four to six hours for the spores to infect. Three factors can be considered in deciding if it will pay to spray for white mold.

The first factor is the presence of white mold in the field. If white mold is present, the second factor to consider is yield potential. Spray if potential yields are 2,000 pounds per acre or more. The third factor to consider is weather. Spray only if there is rain at blossom time or the crop is being sprinkler irrigated. All three factors must be present for fungicides to be economically warranted.

White mold can be controlled with benomyl (Benlate), thiophanate methyl (Topsin M), or thiabendazole (Mertect). These are systemic fungicides, but they go up the sapstream of the plant not down. COMPLETE coverage of the entire plant (especially the lower parts) is **essential** for white mold control. Canopy penetration is essential for control. Apply the first spray at early bloom. Make a second application at full bloom.

Halo blight is a bacterial disease that is most obvious in cool, wet weather. Halo blight bacteria produce a toxin at temperatures below 70°F. The toxin causes large light green to yellow halos on leaves. Occasionally the bacteria and toxin become systemically distributed throughout the plant, and then the entire upper portion of the plant turns yellow.

Copper fungicides can reduce the spread of halo blight. Halo blight spreads rapidly in cool, wet weather. If even a small amount of halo blight is present and prolonged cool, wet weather is forecast, apply a copper fungicide (eg. Kocide, Oxy Cop, Top Cop, Copper Count, Champion, etc.) before it rains. No fungicide is needed if hot, dry, windy weather is expected.

Copper fungicides do not restrict the spread of common blight. If common blight is the problem, there is no benefit in using a fungicide.

POTATOES

Early blight and late blight of potato can be controlled by foliar fungicides. Early blight is common most years and is favored by warm, humid weather. It can be controlled by various fungicides including chlorothalonil (Bravo), captafol (Difolatan), triphenyl tin hydroxide (Du-Ter, Super Tin), maneb, and mancozeb. Triphenyl tin hydroxide is a restricted use pesticide.

Late blight occasionally develops in cool, wet years. Weather favors late blight when at least 1.2 inches of rain has fallen in the past 10 days and the average temperature has been 78°F or lower for the past five days. Fungicides for control of early blight are also effective for late blight control. Copper fungicides are also effective for late blight

control but give only moderate control of early blight. Metalaxyl (Ridomil) gives excellent late blight control; unlike most fungicides, metalaxyl has therapeutic (curative) action in addition to protectant action. If late blight is severe, vine killing is extremely important and should be done **at least** two weeks before harvest to prevent tuber infections. Hilling up around the vines will help prevent spores of the late blight fungus from washing down onto the tubers. This will reduce tuber infection which results in storage decay.

SUGARBEETS

Cercospora leafspot of sugarbeets develops in warm, humid weather. Usually it appears after the row middles have filled in and a canopy forms. It can completely destroy foliage on susceptible varieties. This causes losses in both tonnage and sucrose because new leaves are produced from stored reserves in the root.

The systemic fungicides benomyl (Benlate), thiabendazole (Mertect), and thiophanate methyl (Topsin M) are no longer recommended because the Cercospora fungus has developed resistance to these fungicides. Resistance is widespread in the Red River Valley and southern Minnesota and is likely to persist for some time.

Triphenyl tin hydroxide (Supertin, Du-Ter) gives excellent control. Although it is not systemic, it is very resistant to rain once it has dried on the leaf. Triphenyl tin hydroxide is a restricted use pesticide; workers should not enter the field during the first 24 hours after spraying. Copper, maneb, and mancozeb are protectant fungicides that also give good control of Cercospora leaf spot.

Since the fungicides for Cercospora control act as protectants to protect against infection, timely application is essential. The first application should be made when Cercospora is first observed in a field. If the field is being monitored by professional crop scouts, the first application may be delayed slightly.

AERIAL APPLICATION OF FUNGICIDES

Aerial application can give excellent coverage and canopy penetration. Factors influencing coverage and penetration include the method of application, weather, and equipment.

Spraying Height. Most spraying should be done with the boom 6-10 feet above the crop. Flying higher reduces downwash, canopy penetration and the percent of fine droplets reaching the crop. Applicators cannot expect to get good coverage and canopy penetration when spraying over the tops of center pivot irrigation systems. Downwash and canopy penetration are increased by flying at the recommended height and at slightly reduced speeds. In contrast, flying too low may result in undesirable streaking. Growers who want to see part of the crop on the spray plane wheels may unintentionally invite streaking rather than getting the best possible application.

Nozzle Placement. Nozzles should be pointing back or 15° down from horizontal. The equipment should be calibrated before spraying to deliver 5 gallons of water per acre at approximately 20-30 psi, depending on the recommended pressure for the nozzles. Increasing the pressure above 30 psi to compensate for nozzles with inadequate delivery may result in droplets that are too fine. Pressures below 20 psi may result in "dribbling." Nozzles should be arranged to provide an even spray distribution. Clustering nozzles on the right side of the fuselage compensates for prop wash. Spray delivered too near the wing tips is picked up by the wing tip vortices and tends to drift. For this reason, the outermost nozzles should be located inboard ¼ to ⅓ of the total wing length (semispan).

Swath Width. The effective swath for spraying fungicides and getting canopy penetration is approximately the wingspan of the aircraft being used, or slightly more than the wingspan (not over 10 percent). Tight swaths are essential for good fungicide coverage. The swath width used for fungicides should be the same as is used for a desiccant-type herbicide. The pattern of spray deposition and swath width can be checked at spray pattern analysis clinics provided annually at selected locations by the North Dakota Cooperative Extension Service.

Droplet Size and Drift. Medium sized droplets (200-400 microns or 1/64-1/128 inch) are ideal for fungicide application. These droplets are small enough to provide a good spray pattern on the leaf yet large enough to fall to the crop without evaporating. Droplets that are less than 150 microns tend to evaporate before they reach the crop, especially when spraying during hot weather. These smaller droplets may be carried downwind as illustrated in Fig. 1. Once a droplet evaporates it can remain suspended in the air for long periods and drift away from the target crop. Applicators whose equipment produces many fine droplets may lose significant amounts of fungicide to drift, resulting in reduced amounts actually landing on the crop. This can lead to reduced control. Coarse droplets produce a poor pattern of coverage.

Controlling Droplet Size. Droplet size is affected by pressure, nozzle design, air speed, surface tension, density of the spray, and angle of the nozzle in relation to the air stream. Pressures should be about 20-30 psi. If the nozzles are not capable of delivering 5 gallons per acre, increasing pressure will do little to compensate. To double the gallonage, you must quadruple (4 ×) the pressure - this will result in droplets that are too fine. Use larger orifice discs and/or cores to increase gallonage. A drift control agent helps reduce excessively fine droplets but may result in undesirably large droplets, especially at low pressures. The angle of the nozzle is very important in controlling droplet size. The more the nozzles are turned into the airstream the finer the droplets and the greater the drift. Nozzles should be directed straight back to down 15°. Only hollow cone nozzles are recommended for fungicides. Usually D-6 to D-10 or D-12 orifices with 45, 46, or 56 cores will give the volume needed. A spreader-sticker should be applied to the spray tank to improve coverage and retention of wettable powders; it is not needed for flowable fungicides.

When to Spray. Fungi infect during wet periods caused by rain or dew. Sometimes growers prefer to wait and spray **after** a rain for fear the rain will wash off the fungicide. This is usually too late, as infection has already occurred and leafspots will continue to develop in spite of the fungicide application. Protectant fungicides only **protect** against infection. They do not "cure" infection! Waiting to spray

after a rain often results in claims that the fungicide didn't work or that the application was faulty when actually the application was too late. It is preferable to spray **before** the rain. If the fungicide dries on the leaf before it rains and if a spreader-sticker was used, it will take a lot of rain to wash the fungicide off. It may be necessary to spray again after a long rainy period in order to get full protection during high humidity and long dew periods following the rains, but the application **before** the rain is essential to control (Fig. 2).

Some growers do not want their crop sprayed when it is wet with dew. There is no data to indicate whether this is necessary or not, but experience suggests that satisfactory results can be obtained by spraying when the crop is covered with dew.

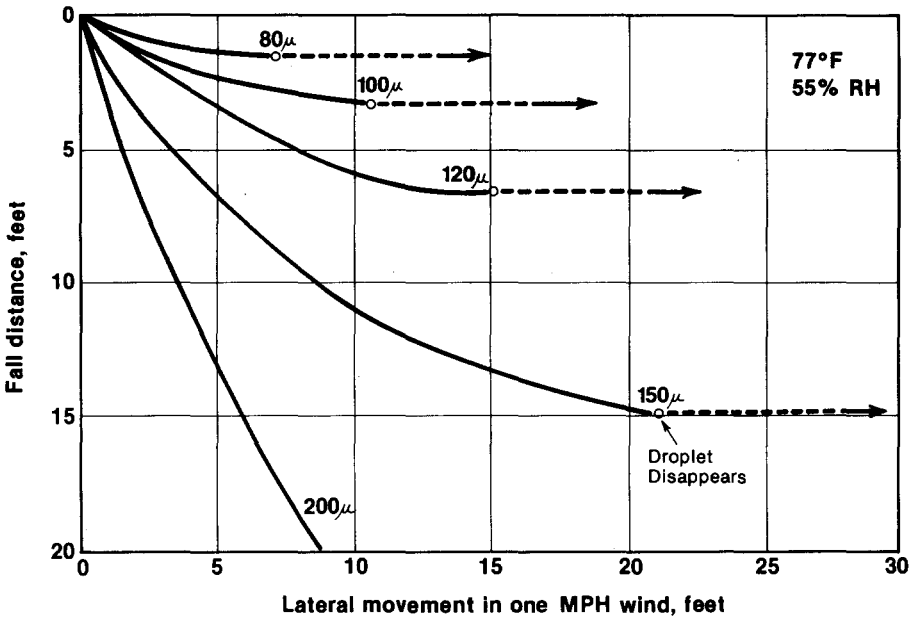

Figure 1. Evaporation rate of water droplets. μ = droplet diameter in microns (from Extension Publication AE-73 Revised 1986).

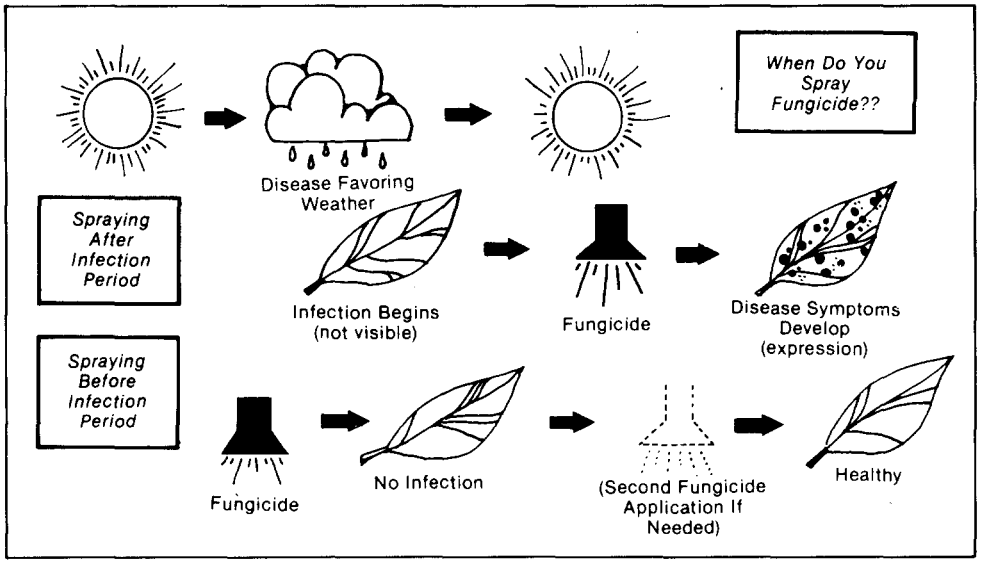

Figure 2. Protectant fungicides must be sprayed before an infection period (disease-favoring weather). Spraying done after an infection period, even though symptoms are not yet evident, will not prevent disease development. Spraying before an infection period protects against infection.

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