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report on
PLANT DISEASE

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THE WEATHER AND PLANT DISEASES

The common plant diseases that have attacked field crops, vegetables, fruits, turf, and ornamental plants in Illinois in past years are likely to be present this year. The extent of disease development, however, depends on the combination of weather conditions during the growing season. Weather is a term used for the aerial environment. It includes light, temperature, snow, rain, humidity, dew, cloudiness, sunshine, wind, air currents, evaporation, and atmospheric pressure. Any one or some combination of these elements may affect disease occurrence. For example, in an apple orchard air movements that are either wind or eddy currents may lift scab fungus spores from old leaves on the ground up to succulent leaves and fruit on the trees.

Temperature and moisture limit many diseases. Fire blight of apples and pears, for example, is most severe in a warm, wet spring and early summer (Tables 1 and 2). The buildup of nematode populations, on the other hand, are favored by a long, warm-to-hot, growing season.

HOT TERRITORY CLIMATES

We know that many diseases flourish best in certain climates. Just like the plants they attack, some pathogens prefer cool regions; others, warmer areas. Practically all fungi and bacteria require free moisture on susceptible plant surfaces in order to multiply, spread, and infect plants. Other pathogens need less. We know also that the weather of any one area or region generally fluctuates within rather definite limits and averages, as part of a characteristic pattern. The general prevalence of plant diseases and the occurrence of particular diseases are influenced to a great extent by these characteristics.

Variations from the "normal" conditions are often responsible for sporadic outbreaks of certain diseases that otherwise do not occur normally. The climate of a region is a major factor both in terms of what crops can be grown profitably and in the prevalence of diseases to which those crops are susceptible. Whether a plant disease causes significant losses often depends on how local or seasonal climatic conditions match the requirements for development, dispersion, and infection by the pathogen. Some plant diseases occur wherever the host plant is grown. Others are restricted to certain areas of this "host territory." The presence of a disease may be either inconsequential or very destructive during some seasons–all as a result of the weather.

FUNGICIDES AND WEATHER

Because many of these patterns have been identified, outbreaks of certain diseases can be successfully predicted one to three weeks or more in advance–for example, epidemics (or epiphytotics) of potato and tomato late blight; apple and pear scab; downy mildews of lima beans, vine crops, and grapes; leaf and stem rusts of small grains; Cercospora leaf spot of sugarbeet; and sycamore anthracnose. Such predictions are used as a basis for deciding whether to apply or withhold fungicides.

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Table 1. Potential damage from some common plant diseases in Illinois, depending on the rainfall during the spring and summer.

Crop	Disease	Wet spring and/or summer	Normal spring and/or summer	Dry spring and/or summer
All plants	Crown and root rots, leaf spots and blights, seed rot, damping-off	Heavy	Light to moderate	Doubtful
Small grains	Foliage diseases, rusts, scab, glume blotch	Heavy	Light to heavy	Doubtful
Small grains	Yellow dwarf (virus)	Doubtful to heavy	Light to heavy	Light to heavy
Corn	Common smut	Doubtful	Light	Light to heavy
Corn	Foliage, diseases, stalk rots, ear rots	Moderate	Light	Doubtful
Corn and soybeans	Charcoal root rot	Doubtful	Moderate	Heavy
Soybeans	Foliage diseases, Phytophthora root and stem rot, pod and stem blight	Heavy	Light	Doubtful
Alfalfa	Foliar diseases, root and crown rots, anthracnose, spring and summer black stem	Moderate to heavy	Moderate	Light
Beans (garden)	Foliage diseases (bacterial blights, rust), *Sclerotinia*, *Pythium*	Heavy	Moderate	Light
Potato, tomato, vine crops	Leaf blights and spots, anthracnoses, fruit (tuber) rots, Sclerotinia white mold	Heavy	Light	Doubtful
Apple, pear	Scab, fire blight, cedar rusts, leaf spots, fruit spots and rots	Heavy	Moderate to heavy	Light to moderate
Grape	Black rot, downy mildew, fruit rots	Heavy	Light to heavy	Light to moderate
Strawberry	Foliage diseases, fruit rots, root rots	Heavy	Light to moderate	Light
Raspberry	Anthracnose, cane blights, fruit rots, foliage diseases	Heavy	Light to moderate	Light
Trees, shrubs	Leaf spots and blights, anthracnoses, rusts	Heavy	Light to moderate	Doubtful
Evergreens	Needle blights, Diplodia tip blight	Heavy	Moderate	Light
Evergreens	Browning, needle drop	Heavy	Light	Moderate to heavy
Lawns	Leaf spots, melting-out, slime molds, dollar spot	Heavy	Light to moderate	Light
Lawns	Rusts, summer patch, necrotic ring spot, powdery mildew, anthracnose	Doubtful	Light to moderate	Moderate to heavy

To some extent, the common or endemic diseases of a particular crop can be expected every year. Since the organisms that cause plant diseases generally cannot be eliminated once they are inside a plant, disease control must necessarily involve measures designed to prevent infection. The critical nature of these measures increases when weather conditions favor infection and disease development.

If inoculum of a fungal pathogen is present and viable in large numbers, and if the weather is ideal for infection in a susceptible host, a protective fungicide is more effective than when weather conditions are not as favorable. In other words, fungicide efficiency in providing crop protection also depends on the weather.

DISEASE PROSPECTS

Table 1 indicates the prospect of disease losses under several generalized weather conditions. In these examples, the weather (particularly rainfall) has a more or less direct effect on the pathogen itself.

Sometimes the effect can be direct, say on an insect or mite vector or other carrier responsible for spreading the pathogen from plant to plant. The incidence of bacterial wilt of corn can often be directly correlated with the prevailing temperatures during the preceding winter. A warm winter furnishes ideal conditions to sustain life for the adult corn flea beetles, in whose bodies the causal bacterium overwinters. The incidence of bacterial wilt can be forecast on the basis of the sum of the monthly mean temperatures for December, January, and February. When the sum of the mean Fahrenheit temperatures for these months is less than 90, bacterial wilt will be mild or absent the following season; when the sum is over 100, the disease is likely to be severe. (See Report on Plant Diseases No. 201, Stewart's Leaf Blight of Corn, for additional information).

FIRE BLIGHT OF APPLE AND PEAR

The blossom blight phase of fire blight disease on apples, pears, and related plants is usually erratic in Illinois. The temperatures and moisture conditions as well as the prebloom freezing temperatures largely determine whether or not blossom blight infection will occur. The inoculum (bacterial cells) that causes blossom blight comes from bacterial ooze on the surface of fire blight cankers. A sudden freeze during the prebloom period destroys a high percentage of these bacteria, greatly reducing the likelihood of blossom infection.

After a freeze, the number of degree-days required for the bacterial population to again reach a potentially dangerous level is computed from 65°F, the minimum temperature for the growth of the organism. In counting the number of degree-days, a maximum temperature of 65°F on a given day is considered as zero. Each degree above 65 is counted as another degree-day. For example, a maximum temperature of 70°F is counted as 5 degree-days. Observations indicate that 30 degree-days are needed before the bacteria can multiply sufficiently to cause infection. For example, 2 days with a maximum temperature of 80°F, 3 days at 75°F or 6 days at 70°F following a prebloom freeze would supply the necessary 30 degree-days.

Table 2 shows when fire blight blossom and twig infections are likely to occur, and thus when streptomycin applications would be needed to provide protection. (For more details, see Report on Plant Diseases No. 801, Fire Blight).

Table 2. Temperature and Moisture Conditions Necessary for Blossom and Twig Blight Infections, Fire Blight Disease of Apple and Pear

Infection or not	Temperature	Moisture
Blossom blight infection likely to occur:	a. At least 30 degree-days between latest freeze and early bloom, and b. Maximum temperature of 70° to 80°F (21° to 27°C) during early bloom.	a. Adequate rainfall during prebloom period, and b. Very light rain and high humidity during early bloom
No blossom infection likely to occur:	a. A freeze close to bloom and fewer than 30 degree-days between the latest freeze and early bloom, or b. A maximum temperature below 65°F (17°C) or above 86°F (30°C) during early bloom.	a. Drought preceding and during bloom, or b. Excessive moisture during early bloom.
Twig blight infection likely to occur:	a. A temperature range between 70° and 80°F (21° and 27°C).	a. Sufficient rain for succulent growth, and b. Periods of 100% humidity for at least 24 hours.

Note: All of the conditions listed under the Temperature and Moisture columns must be present in order to produce the effect specified in the first column.

LATE BLIGHT OF TOMATO AND POTATO

Under conditions that favor disease development, late blight can destroy entire fields of potatoes and tomatoes in 10 to 14 days. It can occur any time during the growing season from seeding through harvest. Spraying regularly with fungicides will control the disease, but is expensive. When conditions that favor production, dissemination, and infection by the late blight fungus are understood, the number of spray applications can be reduced sharply.

The sporangia, or spores, of the fungus are formed when the relative humidity is greater than 90 percent for more than 10 to 15 hours. Optimum spore formation occurs at a relative humidity of essentially 100 percent. The temperature and the length of a period of favorable humidity determine the rate of spore production. Sporangia are formed over a temperature range of 45° to 86°F (7° to 30°C), the optimum being 65° to 70°F (18° to 21°C). Sporangia produced under cool conditions (45° to 70°F; 7° to 21°C) produce 8 to 12 or more motile secondary spores (zoospores), that swim in moisture films; and, thus, cause multiple infections. Sporangia produced under warmer conditions (70° to 86°F or 21° to 30°C) germinate by a germ tube, each producing only one infection. The optimal temperature for infection is 77°F (25°C) and takes 8 to 48 hours. Therefore, cool, moist nights are required to provide a buildup of inoculum, and slightly warmer days with high relative humidity over a 4- to 5-day period for infection and disease development.

Because of our knowledge about the rather precise conditions required for inoculum production and infection, it is possible to forecast disease occurrence. Forecasts depend on "infection periods," when the fungus produces spores and is able to cause infection. Fungicide applications should be timed to provide maximum chemical protection before the infection periods occur.

Two methods have been developed for forecasting late blight. Both are based on measurements of temperature and moisture. These are the hygrothermograph and rainfall-temperature methods. The methods can be used alone or to supplement each other.

Hygrothermograph Method of Forecasting. By correlating the average temperature with the time when the relative humidity is 90 percent or above on a hygrothermograph located in a field, a "blight severity" number can be obtained. Blight forecasts are not made until the severity number is 20. The need for fungicide application is indicated in Table 3, which shows how the number is assigned. The example below explains the method.

Table 3. Late Blight Severity Number

Average temperature range[a]	Severity number				
	0	1 (trace)	2 (slight)	3 (moderate)	4 (severe)
	hours of 90-percent relative humidity or above				
45°-53°F (7°-12°C)	15	16 to 18	19 to 21	22 to 24	25+
54° to 59°F (12°-15°C)	12	13 to 15	16 to 18	19 to 21	22+
60°-80°F (15.5°-27°C)	9	10 to 12	13 to 15	16 to 18	19+

[a]Average temperature during period when relative humidity is 90 percent or more.

Example: If the average was 54° to 59°F (12° to 15°C) and the relative humidity was 90 percent or more for 16 to 18 hours, the blight severity number would be 2. If the temperature averages 60° to 80°F (15.5° to 27°C) for 16 to 18 hours, an index number of 3 would be recorded. The need for spraying is indicated by the weekly severity numbers, after a total of 20 is accumulated. When the severity number is 3 per week, spray; 1 to 2 per week, spray not needed; 1 per week, fungus is alive; 0 for three consecutive weeks, the fungus is dead.

The rainfall-temperature method of forecasting. The equipment needed for this method consists of a maximum-minimum thermometer and a rain gauge. Rainfall and temperature readings are then correlated to calculate periods "favorable for blight." For such a period to exist, the temperature and the rainfall must be favorable at the same time.

The temperature is considered favorable when the average of the maximum and minimum temperatures for 5 days is less than 78°F (25.5°C). Since low temperatures slow down disease development, skip days when the temperature is less than 45° (7°C). Rainfall is favorable if the 10-day total is 1.20 inches or more. Always measure rainfall for 10 consecutive days. When favorable temperatures and rainfall occur for 10 days, and the immediate weather forecast is for cool and wet conditions, late blight can be expected in 1 to 2 weeks. (For more details, see Report on Plant Diseases No. 936, Late Blight of Potato and 913, Late Blight and Buckeye Rot of Tomato).

PLANT, VECTOR, PATHOGEN AND WEATHER

Forecasting uses all of the techniques for determining when weather conditions are favorable for certain diseases. Commercial growers are notified when such conditions exist by newsletters, radio and TV.

With most plant diseases, there is a highly complicated interaction between at least two kinds of living organisms–the host plant and pathogen.

Sometimes, especially with viral, mycoplasmal and spiroplasmal diseases, another living organism is also involved–the vector (aphid, leafhopper, thrips, mite, nematode, and so on). Any one or all of these organisms may be highly sensitive to weather conditions, and each factor may have a profound influence on the incidence or severity of the disease. Thus, the effect of climatic conditions on disease can be much more complicated than in the examples given in Table 1. These relationships have to be established through laboratory, greenhouse, and field research applied to each disease separately.

Mosaics are viral diseases that attack many crop and garden plants. The great majority of mosaics are transmitted from plant to plant by the feeding of various species of aphids. Winds from the south and west may blow tremendous numbers of virus-carrying aphids into Illinois during the spring and early summer. If the weather remains warm and dry, large aphid populations build up, causing the spread of mosaics. Rainy weather, on the other hand, is conducive to high aphid mortality; hence, there is little spread of mosaic viruses.

It is not possible to predict the behavior of one disease from what is known about another. Since the relationships of weather and pathogens are still unknown for many plant diseases, this area of research remains a fertile one. The plant pathologist, the farmer, and the grower can learn to cope with the weather through the use of resistant varieties, biological or other cultural controls, and pesticides. In this way, they can do much to reduce the losses caused by disease.