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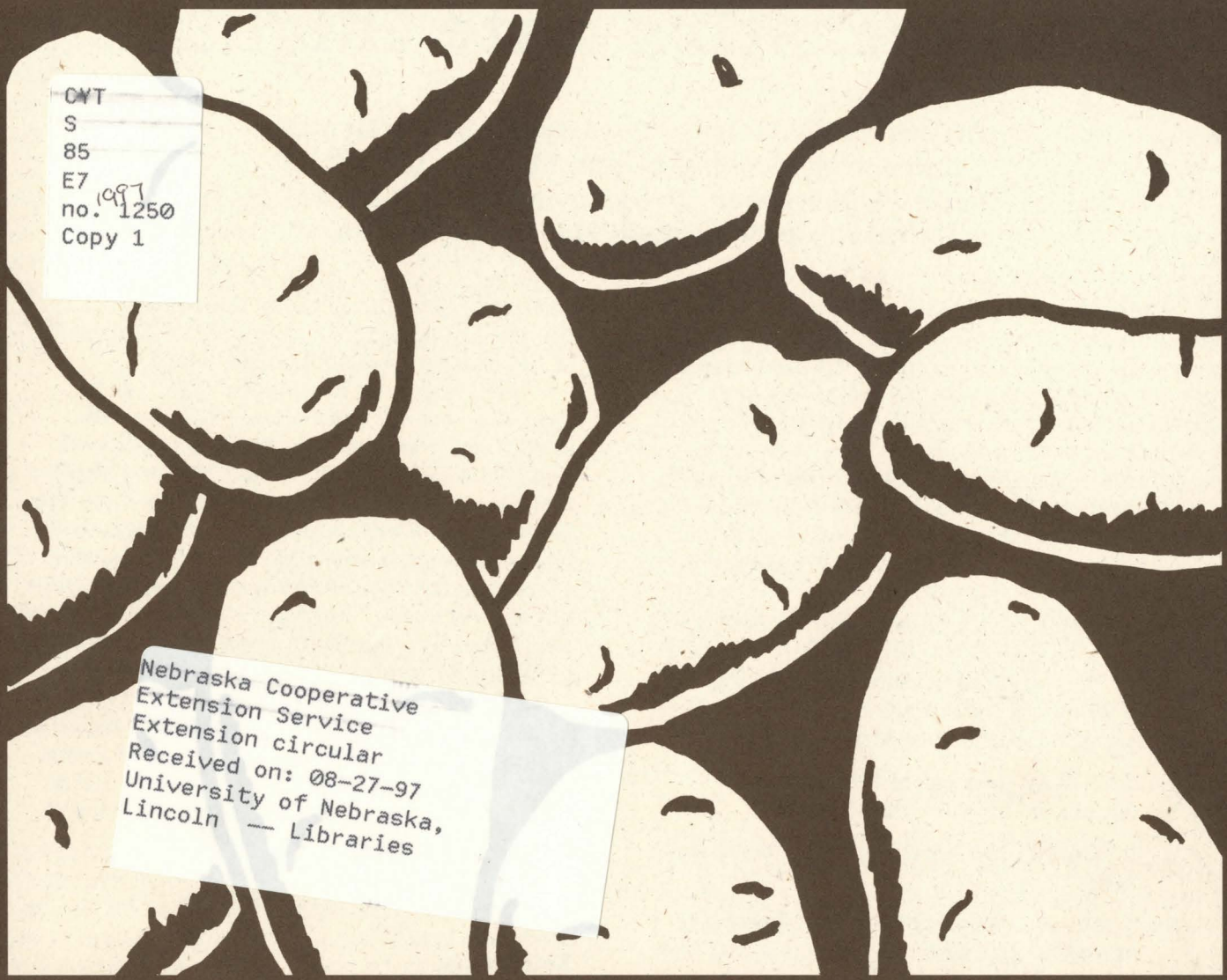

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Forecasting Late Blight

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Forecasting Late Blight

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Objective: A method for forecasting environmental conditions favorable to the development of late blight is described. How is weather data obtained from hygrothermographs and weather stations? How are the data used to calculate severity values? How is late blight forecasted and fungicide applications scheduling recommended? These questions will be answered here. The intended audience is potato growers; tomato growers would also benefit.

The most accurate method for forecasting late blight is to collect the data directly from a particular field and determine whether conditions are favorable for disease development. The data needed to forecast late blight are:

1. date of **50 percent emergence** of a variety/field [*not planting date*]
2. maximum and minimum **daily temperature**
3. duration in **hours of relative humidity above 90 percent**
4. **rainfall and irrigation**: daily water exposure in inches

Late blight forecasting basically warns growers of the potential for the development of the disease and then suggests the rates and scheduling of fungicides. If late blight inoculum is present, it predicts the occurrence of symptoms. This disease develops when there has been an extended period of favorably low average temperatures (below 80°F) and high relative humidity (above 90 percent) after emergence. Forecasting is based on the field reaching a **severity value threshold.**

Once a potato variety's date of emergence is observed in a field, there are two techniques for obtaining the data needed to calculate severity values. The more accurate technique is for a grower to place a hygrothermograph in the field and collect the temperature and humidity information every week and more often when the threshold is approached or reached. The other, less accurate but easier technique is obtaining the information from a weather station. This weather information can be downloaded through a computer hook-up to the University of Nebraska's weather bulletin board.

After a grower has obtained the needed data, the severity values can either be calculated directly by a grower using a pencil and paper or can be typed into the "Potato Crop Management" (PCM) program developed by the University of Wisconsin. The PCM program is highly recommended since it has functions other than late blight forecasting, such as early blight forecasting, emergence prediction, irrigation scheduling, growing degree day calculations and Colorado potato beetle predictions.

Most of the information presented is from the PCM manual. The PCM program is based on the "Blitecast" system developed by the Pennsylvania State University (Krause et al, 1975) and data from studies conducted in western Nebraska (Wallin and Schuster, 1960).

Severity Values

Emergence —

Late blight forecasting starts with the emergence date of a particular variety in a field. The determination of whether the threshold of severity values is reached is based on the accumulation of daily severity values **from the date of emergence.** The date of emergence has been defined as the date when at least 50 percent of the plants have emerged from the ground. A thin green row on top of the hill should be visible at this time. From this date, the daily temperature and relative humidity needs to be recorded on an hourly chart for severity value calculations.

Assigning Values —

The severity value is a measure of the interaction between temperature and relative humidity in the presence of the late blight fungus. Table 1 shows how severity values are assigned to specific conditions.

If there is no late blight observed in the field nor in a nearby field, then a cumulative

severity value total of **18** predicts late blight symptoms are to appear in 7 to 14 days if the inoculum is present and no fungicides are applied.

Example: Let's use Figure 1 as an example. This is a hypothetical hygrothermograph and gives the temperature and relative humidity changes for four days in a field. The vertical bars represent 2-hour intervals. Let us also say that 50% emergence occurred on Sunday so that this hygrothermograph starts from the emergence date. The top part is the temperature chart in Fahrenheit and the bottom part is the relative humidity chart in percent.

When using a hygrothermograph placed in a field, 90 percent relative humidity (RH) is the threshold for severity value calculations. In determining the length of time above 90 percent RH disregard chronological time, i.e., midnight is not a cut-off. Now, let's look at the sequence and scenarios.

DAY 1, Monday: Scenario A — The RH did not reach 90 percent and, therefore, no severity value is assigned.

[Note. When using weather station data, a threshold of 80-85 percent is suggested by researchers in North Dakota.]

DAY 2, Tuesday: Scenario B — The RH reached 90 percent at 10 pm, Monday, and lasted for just over 10 hours to 8 am, Tuesday. [This is represented by the diagonal markings.] The temperature during that 10-hour period ranged from a minimum of 42°F to a maximum of 56°F. The average temperature for that period is

(42+56)/2 = **49°F**.

From Table 1, we see the severity value assigned to this period is zero (0).

[Note. Had the temperature averaged 69°F, the assigned value would have been one (1).]

At 8 pm, the relative humidity again rose to 90 percent.

DAY 3, Wednesday: Scenario C — The RH reached 90 percent at 8 pm on Tuesday and has not dropped below 90 percent since. So, continue to Thursday.

DAY 4, Thursday: Scenario C — The relative humidity has been at or above 90 percent since 8 pm, Tuesday, and finally dropped below 90 percent just after 10 am on Thursday. The duration of this period is 38 to 39 hours. The minimum temperature for this period is 38°F and the maximum temperature is 78°F. Therefore, the average is 58°F. Again looking at Table 1, we see that 38 hours is not listed, so we use Formula 2.

(38 hours - 1) / 3 = 12.33
12 - 3 = 9 severity values

Keep a severity value table for each field. [PCM will do that for you.] Let's say this variety was planted in this field on May 1 and emerged on May 22 (Monday). Therefore, Day 1 (Monday, date of emergence) starts the forecasting.

Table 1. Severity values assigned to different temperatures and durations of high relative humidity (90 percent or greater). (adapted from PCM manual)

Assigned Severity Value	*Average Temperature Range during Period of High Relative Humidity, 90% or Greater*		
	45-53°F [1]	*54-59°F [2]*	*60-80°F [3]*
	*Number of Continuous, Uninterrupted Hours at 90+% RH **		
0	< 16 hr	< 13 hr	< 10 hr
1	16-18 hr	13-15 hr	10-12 hr
2	19-21 hr	16-18 hr	13-15 hr
3	22-24 hr	19-21 hr	16-18 hr
4	25-27 hr	22-24 hr	19-21 hr
5	28-30 hr	25-27 hr	22-24 hr
6	31-33 hr	28-30 hr	25-27 hr

Formulas:
[1] — (hours minus one) divided by 3 then reduced by **4**.
[2] — (hours minus one) divided by 3 then reduced by **3**.
[3] — (hours minus one) divided by 3 then reduced by **2**.
Round-off to lowest whole number.

* An interruption is a two hour break when the RH drops below 90 percent.

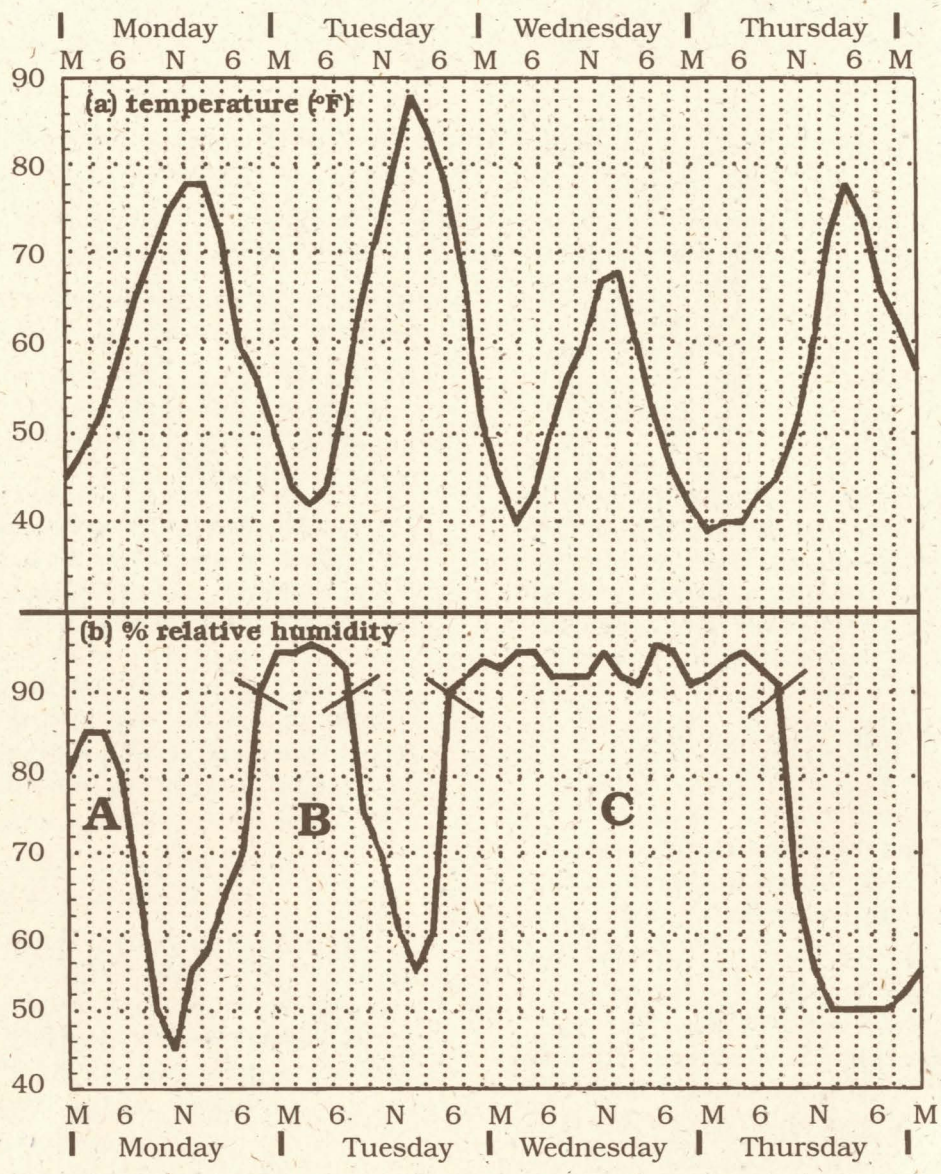

Figure 1. (a) Temperature record; (b) Relative Humidity record.

Late Blight Forecast: *field:* Scottsbluff *variety:* Norgold Russet *planted:* MAY 1 *emerged:* MAY 22
Has late blight been observed in field or nearby? NO **
Dates: May 22 to May 25.

	5/22	5/23	5/24	5/25	5/26	5/27	5/28
Severity Value	0	9	0	0			

Severity values are given to the date at the start of a high humidity period.

[Since the 38-hour long period started on Tuesday, the nine severity values are recorded for Tuesday, not at the end of the period.]

** If the answer to this question is YES, then fungicide treatment is recommended regardless of the severity values!

Forecasting Late Blight from the Severity Values —

In the above example, the total severity value after four days following emergence is NINE (9). When the cumulative total reaches EIGHTEEN (18), then symptoms of late blight are forecasted to occur in SEVEN (7) to FOURTEEN (14) days assuming late blight inoculum is present from sources such as infected seed pieces or cull piles.

Continuing the example, let's say that the relative humidity stayed below 90 percent for

the next three weeks and no severity values are assigned. Then, a storm front approaches and raises the humidity and lowers the temperature. You get the hygrothermograph chart for the week of June 12 and determine the severity values.

Late Blight Forecast: *field:* Scottsbluff *variety:* Norgold Russet
planted: MAY 1 *emerged:* MAY 22
Has late blight been observed in field or nearby? NO **
Dates: May 22 to June 18
Accumulated Severity Values: **9**

	6/12	6/13	6/14	6/15	6/16	6/17	6/18
Severity Value	0	0	0	6	0	5	0

Severity values are given to the date at the start of a high humidity period.

** If the answer to this question is YES, then fungicide treatment is recommended regardless of the severity values!

In that week, ELEVEN (11) severity value points occurred. When added to the NINE (9) already accumulated, the total is TWENTY (20), above 18. In fact, 18 had been reached on June 17. The forecasting model predicts late blight symptoms will occur after seven to 14 days or between June 24-30 in the example if inoculum is present (e.g., cull piles or seed) and if fungicides are not applied. The recommendation is to spray that variety in that field within FIVE (5) days after reaching a severity value of 18 to prevent and control infestation.

Fungicide Recommendations Based on Severity Values —

Once 18 severity values have accumulated from the date of emergence, tracking temperature and relative humidity and assigning severity values should be continued. From this information, appropriate intervals for fungicide applications can be determined. However, one more piece of information needs to be monitored and added now. Recommendations are also based on the amount of water received by the field through rainfall or irrigation. That is:

Inches of rain fallen during the past 10 days
PLUS
Inches of irrigation water applied during the past 10 days

Continuing the example above, let's say that no severity values accrued for the following two weeks. On July 1, 0.6 inches of water was applied through irrigation. Then, on July 4, a low front comes in; one-half (0.5) inch of rain falls on the field and the temperature drops. You get the hygrothermograph chart for the week of July 3 and determine the severity values.

Late Blight Forecast: *field:* Scottsbluff *variety:* Norgold Russet
planted: MAY 1 *emerged:* MAY 22
Has late blight been observed in field or nearby? NO **
Dates: May 22 to July 9
Accumulated Severity Values: **20**

	7/3	7/4	7/5	7/6	7/7	7/8	7/9
Severity Value	0	1	0	0	0	4	0

Severity values are given to the date at the start of a high humidity period.

** If the answer to this question is YES, then fungicide treatment is recommended regardless of the severity values!

In this scenario, 1.1 inches (0.6 irrigation + 0.5 rain) of water had been received by the field during the 10 days prior to July 8. During the week of 7/3, five (5) severity values accumulated. With these data, according to the Table 2, a 7-day fungicide spray interval is recommended.

The three intervals recommended for fungicide application are:

5-day == Conditions have been ideal for late blight development.
7-day == Conditions favor late blight development; normal spraying recommended.
10-day == Conditions are not favorable for late blight. Less frequent spraying will provide short-term protection in case conditions change rapidly.

Hygrothermographs: Maintenance and Use

Instrument —

A recording hygrothermograph basically keeps track of hourly changes in air temperature and relative humidity. Most use a week-long chart so the data can be collected weekly. The upper part of the chart gives the tempera-

Table 2. Fungicide spray interval recommendations based on severity values calculated from the last 7 days and water received during the last 10 days.

*Total rain + irrigation received in previous **10** days*	*---Total severity values during the previous **7** days ---*					
	< 3	*3*	*4*	*5*	*6*	*> 6*
	--- Spray Interval for Late Blight Control in Days ---					
< 1.2 in.	10-14	10-14	10	7	7	5
> 1.2 in.	10-14	10	7	5	5	5

ture record; the bottom relative humidity. They can be either spring-wound or battery driven; the former seems to be more reliable in the field. Hygrothermographs cost $500 and up and are available from forestry and greenhouse nursery suppliers. Their calibration needs to be checked every spring before use; periodical checking during the season is also recommended. Hygrothermographs need to be placed inside a shelter in a field to protect the instrument from rain, hail, wind, etc. A rain gauge, accurate to 0.05 inches, will be needed, once late blight is forecasted, for fungicide scheduling recommendations.

Calibrations —

The following are a few suggested methods for calibrating a hygrothermograph. Since the primary interest in temperature is the low end of the scale, the temperature probe (smooth) may be placed in ice water and the pen checked for a reading at 32°F. If the probe cannot be separated from the instrument, then it needs to be calibrated against an accurate thermometer, for instance placed in a refrigerator. The critical range in relative humidity (RH) is about 90 percent. The RH probe (hair element) needs to be placed in a highly humid environment. If the hygrothermograph's RH probe cannot be detached from the instrument, place a block in the center of a pan filled with hot water and place the hygrothermograph on the block. Put the water-filled pan with the hygrothermograph inside a plastic bag and seal the bag. After two hours the RH inside the bag will be above 90 percent. The hygrothermograph should indicate the correct RH; if not, adjust the hygrothermograph accordingly. If you also place an accurate thermometer inside the bag, both temperature and relative humidity may be calibrated at the same time. (A more precise determination of RH can be accomplished using either a sling psychrometer or a wet bulb/dry bulb. The hygrothermograph can be then compared to the readings from these instruments.)

Housing —

The hygrothermograph needs to be placed in a weather shelter to protect the instrument from adverse weather. A shelter consists of a double-walled roof and perforated or slatted walls to allow free air movement. Lining the inside of the shelter with window screening will keep bees and wasps from nesting inside and keep mice from entering and chewing on the hairs of the RH probe. The construction of a shelter takes about four hours and costs $25-50. Plans are available (Van Arsdel, 1963). If you wish to buy a shelter instead of making one, they are available through forestry-supply companies.

Field Placement —

For the most accurate readings, a hygrothermograph and its shelter needs to be placed in a part of a field where the likelihood of late blight is the greatest, i.e., the wettest part. It needs to be in place by the date of emergence. Some suggested locations are:

1. Within the potato canopy, preferably in a low spot of the field.
2. Near the center of a pivot system where irrigation keeps the vines wet.
3. Close to a body of water, e.g., stream, ditch or pond.
4. Near a fence row or woods where air movement is restricted.
5. On the leeward side of windbreaks, e.g., trees, barn.

The point is: place the hygrothermograph where dew appears first in the evening and dries last in the morning.

Rain gauges should be placed near the shelter but not so that it is affected by the shelter in the distribution of rain or irrigation.

Technically, a hygrothermograph should be placed in every field. Since this is not common, however, strategic placement of a hygrothermograph is required. Often, this means locating the instrument in a center-pivot within a cluster of center-pivots or by a stream or ditch between fields. Another, less accurate, method is not to use hygrothermographs and use information from the nearest weather station.

Recording Notes —

The temperatures of interest for late blight forecasting are the maximum and minimum temperatures during a period of high relative humidity, at or greater than 90 percent. If the high humidity period extends past midnight, record the duration and severity value on the date the period **began**. Record zero (0) for the subsequent days until a new period begins. The high humidity period is considered broken when the RH drops below 90 percent for at least two hours. Collect rainfall and irrigation data daily.

Common Problems —

To maintain a constant flow of ink from the pens to the chart, check the following items:

1. Is the pen touching the chart? If not, keep the hygrothermograph tilted slightly backwards to insure constant pressure of the tip against the chart.
2. Is the pen empty? Fill the pen every week when changing charts. Felt-tipped pens come with their own ink supply, which should last a growing season (4-6 months).
3. Is the pen clogged? Clean the pen tip whenever you see dust or debris in or on it. The easiest way to do this is to run the edge of a paper sheet through the split of the pen tip. If this is not checked and the debris builds up, the tip may have to be removed and soaked in water. This isn't applicable to felt-tipped pens.
4. Are there ink blots on the chart? Do not overfill pens. Ink expands when the relative humidity is high. Also, check if the clock stopped.
5. Did the clock stop? Batteries usually last six months and should be changed at the beginning of the season. If a spring wound instrument is used, it should be fully wound every week when the charts are changed. The clock may be cleaned annually before use; this usually is done by a jeweler.

Storage — A hygrothermograph should be cleaned at the end of the season and inspected for broken hairs (RH probe) which should be replaced. Release the tension on the hairs of the probe with a counter weight. Store the instrument away from rodents and insects.

Getting Data from Weather Stations

Although field-placed hygrothermographs are the most accurate method for collecting data, data collected from weather stations are being widely used due to convenience. The weakness of these data is that weather stations are located in flat areas surrounded by low cut grasses. There are no obstructions nearby so wind is free to influence the readings and the station is away from wet or irrigated areas. In short, it does not read the microclimate existing in a field of potatoes but the macroclimate of the general area. During the past few years, weather station data have been monitored and compared with hygrothermograph data and late blight appearance. The relative humidity (% RH) threshold for weather station data which has correlated well with field data is **80% RH** (not 90% used with hygrothermographs). This has been confirmed throughout Nebraska in 1995 and 1996. A late blight forecasting service for Nebraska using these data is currently available during the season from the UN-L Panhandle Research and Extension Center at Scottsbluff by the senior author (call 308-632-1240).

For those who want to use these data directly, the following is the procedure for obtaining the information from the University of Nebraska's High Plains Climate Center.

"High Plains Climate Center"

The High Plains Climate Center (HPCC) has developed an interactive computer system for disseminating climate data and near-real time data. This service can be accessed through the Internet using a Telnet application. To connect to the HPCC On-Line System, you need to establish an account. The initial fee is $100 that includes a $25 start-up cost and $75 for a minimum 300 minute usage. There is an "autopilot" feature which, when used, saves connect time and repetitive entering of requested information.

Daily and hourly weather data (air temperature, relative humidity, soil temperature, wind speed and direction, irradiance, and precipitation) for a particular weather station is available. Summaries that may be obtained

include the National Weather Service Reports, 90-Day Forecasts, HPCC Monthly Impact Statements, Growth Degree Days (GDD) Updates, and Evapotranspiration (ET) Updates.

To get the subscription form and to learn whether you may be eligible for a grant to cover the fees, call (402) 472-6706. A "User's Guide" and account information will be sent to you upon receipt of the initial fee or a grant request.

When you get an account, you log-in

at host address type	*hpccsun.unl.edu*
at General User ID type	*weather*
at General Password	*hpcc*bbs*
at Personal ID	<your account name>
at Personal Password	<your account password>

This and more information can be accessed by the HPCC's web site whose address is " *http://hpccsun.unl.edu/online* ".

Nebraska stations currently (1997) available are Ainsworth, Alliance-North, Alliance-West, Arapahoe Prairie, Arthur, Beatrice, Cedar Point, Central City, Champion, Clay Center, Curtis, Dickens, Elgin, Gordon, Grand Island, Gudmundsen Ranch, Halsey, Holdrege (2 stations), Kearney, Lexington, Havelock, Lincoln (7 stations), McCook, Mead (2 stations), Minden, Mitchell, Monroe, Concord, North Platte, O'Neill, Ord, Red Cloud, Scottsbluff, Shelton, Sidney, Smithfield, West Point, and York. In Wyoming, only Torrington is connected to the system; in Colorado, Akron, Sterling, Stratton, and Walsh are connected. States with stations also connected to the system are Iowa (7 stations), Kansas (16), Minnesota (6), Missouri (2), Montana (2), North Dakota (42), and South Dakota (10).

Potato Crop Management Software (PCM)

The University of Wisconsin has put together a software package called "The Integrated Systems Approach to Potato Crop Management" or PCM. It runs on IBM-compatible computers in DOS. A newer version, WISDOM, is available for running in WINDOWS. The price for PCM is about $250 and WISDOM is about $500. With this software, data — emergence date, duration (hours) of high humidity period, minimum and maximum temperature during that period, and rainfall or irrigation — are entered into the "Disease Management" module which does the calculations, forecasting and recommendations for you. This module will also forecast early blight based on the P-Days concept. This software program also contains "Emergence Prediction," "Insect Management" and "Irrigation Scheduling" modules. PCM is available from the Wisconsin IPM Program at (608) 262-8332 or 0170.

References

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