CLIMATIC RESEARCH IN THE DEPARTMENT OF SOIL SCIENCE

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North Dakotans appreciate the impact weather and climate have on the state's agriculture and general economy. The likelihood of success in any climatically affected activity can be enhanced by an awareness, knowledge, and application of climatic information. To assist in this goal, various climatic studies are conducted by the Department of Soil Science.

MICROCLIMATIC RESEARCH STATION

The Microclimatic Research Station (MRS), located on the Main Experiment Station at Fargo, was established in 1979 and has been continuously upgraded. The MRS consists of a 4-acre square with an acre of sod in the northwest corner devoted to meteorological instruments. The southwest corner houses four weighing lysimeters used for evaporation and water use studies. A winter wheat survival experiment is in place on the remaining 2 acres.

Meteorological Measurements

A 12X16 foot building near the center of the area houses a programmable data acquisition system (PDAS) and other meteorological and field equipment. The PDAS records the following meteorological variables every hour throughout the year: air temperature at 5 feet in the instrument shelter; air temperature profile from 2 inches to 6 feet; soil temperatures under various cover and tillage conditions to depths as great as 40 feet; wind speed and direction; relative humidity and incoming and reflected solar radiation.

During the growing season, daily observations are made of the following: current, maximum and minimum temperature in instrument shelter; pan evaporation including maximum and minimum water temperatures and daily wind movement over the pan; maximum and minimum temperature at 5 feet and 2 inches using exposed thermometers; precipitation from three different types of gauges; dry and wet-bulb temperatures; maximum and minimum relative humidity and other significant weather phenomena considered important at particular times. Periodic soil moisture measurements are also made throughout the growing season.

These data have been stored on a computer tape system and tabulated and analyzed for specific purposes by researchers in other departments as well as our own. Some of the uses for these data include: availability of solar radiation as an energy source, availability of wind as an energy source, soil as a source or sink for energy, plant water use for irrigation scheduling, plant growth and development, insect and disease development, heating and cooling requirements, and relation of temperature inversions to crop spraying.

One example of the use of soil temperature data is illustrated in Figure 1. The soil temperature with depth on January 20, 1982 is shown for two different tillage treatments, disked and no-till. The temperature throughout the profile is warmer for the no-till treatment because of the additional snow cover trapped by the standing stubble. In addition, the frost depth is only 18 inches on the no-till compared to 38 inches for the disked treatment.

Lysimeters

Four precision-weighing lysimeters hve been installed in the southwest corner of the MRS. A weighing lysimeter is a device that measures the water loss (evapotranspiration) from soil and vegetation by measuring the weight loss from a volume of soil. Each lysimeter consists of an inner tank, with dimensions 5 ft X 5 ft X 5 ft, filled with soil and resting on a scale. This apparatus is placed inside a buried tank so that the top is even with the soil surface. A cross section of a weighing lysimeter is shown in Figure 2. Water loss is measured by the scale as a weight loss. The scale can detest weight changes equivalent to 0.0077 inch of rainfall or evapotranspiration. The weight from each lysimeter is recorded hourly by the PDAS.

The lysimeters are being used to evaluate evapotranspiration with the various management systems. Because of their sensitivity, changes in water content can be determined over very short time periods (a few hours, for example). Figure 3 shows the effect tilling bare soil has on evaporation. The tilled lysimeter had 0.12 inches evaporation in 24 hours while the untilled lysimeter lost

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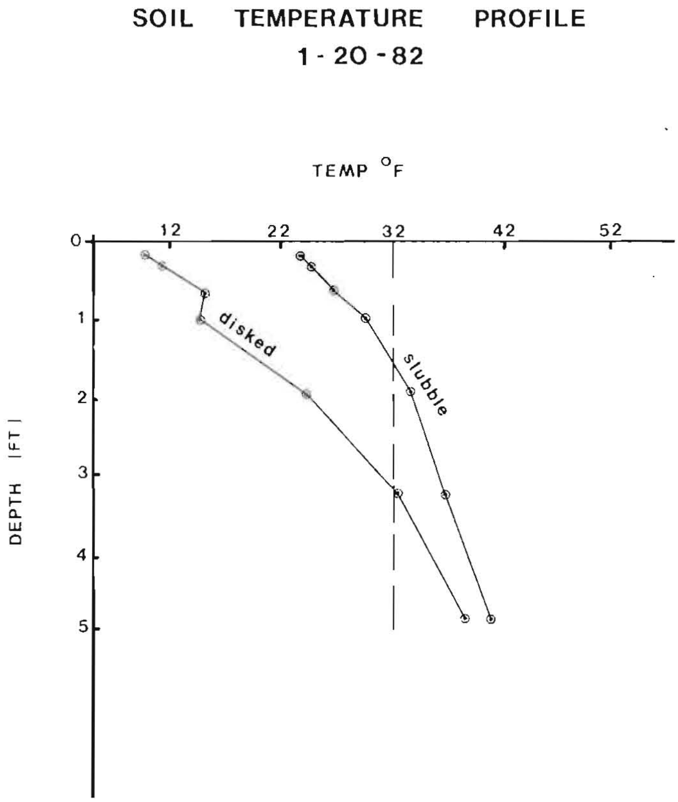

Figure 1. Soil Temperature profile under stubble and disked treatments on January 20, 1982.

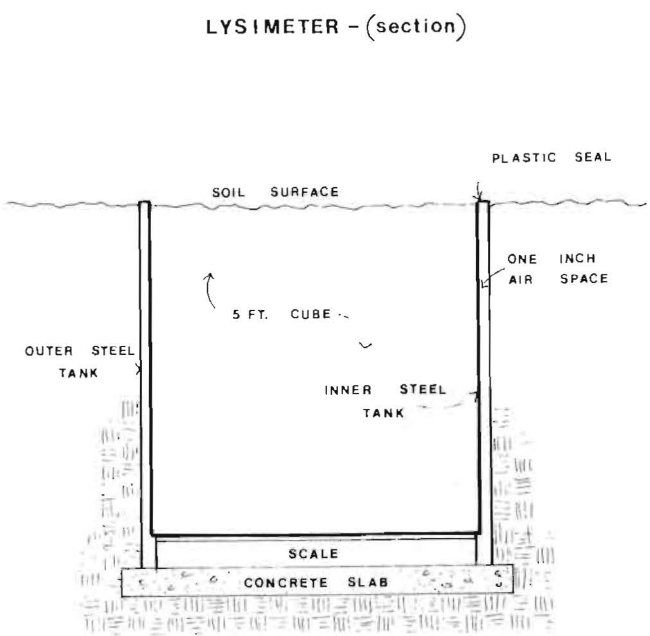

Figure 2. Cross-sectional view of weighing lysimeter.

only 0.02 inches. The inset figure shows the water content when the soil was tilled. In another experiment, no-till soybeans had 0.39 inches less evaporation loss than conventional-till soybeans from May 1 to June 12, 1982 (Brun, 1982).

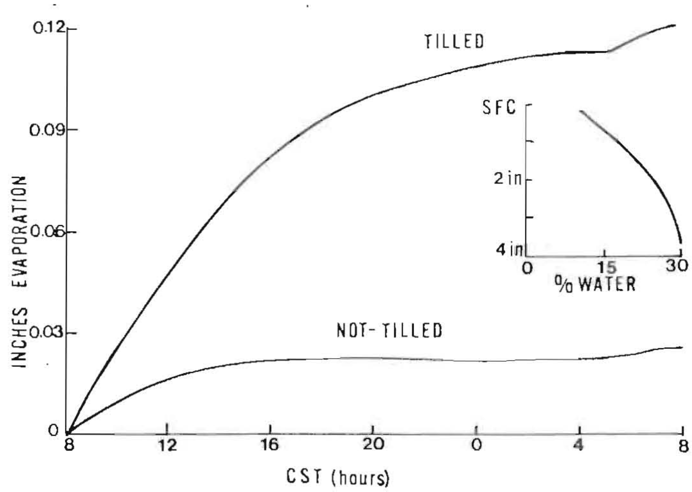

Figure 3. Evaporation from tilled and untilled bare soil. Inset indicates water content prior to tillage.

The data in Table 1 show growing season water use obtained with lysimeters. These data show the importance of stored soil water for total crop water use (evapotranspiration); 28 to 55 percent of the total crop water use was from stored soil water.

Table 1. Growing season water use measured with weighing lysimeters at Fargo.

Year	Crop	Precipitation	Evapotranspiration	Soil Water Used	Percent from Soil Water
		inches			
1981	Sunflower	12.16	18.72	6.56	35
1981	Sunflower	12.19	16.92	4.73	28
1981	Wheat	9.15	13.19	4.04	31
1981	Wheat	8.92	13.55	4.63	34
1982	Soybean	7.36	13.04	5.68	44
1982	Soybean	7.06	15.56	8.50	55
1982	Wheat	7.12	11.08	3.96	36
1982	Wheat	7.39	10.61	3.22	30

Winter Wheat Survival

Currently, a winter wheat management study is being conducted on the 2 acres located on the east side of the MRS. Two varieties of winter wheat are being grown under three management or tillage systems; conventional (plow, disk, and harrow), reduced (disked), and no-till (seeding into standing stubble). These systems result in differing amounts of stubble residue which traps differing amounts of snow. Soil temperatures at the 1-inch depth, representing the temperature of the plant crown, are recorded hourly by the PDAS. Snow depths are recorded regularly in each plot.

During the winter of 1981-82, tillage treatments had a major effect on snow depth. Through most of the winter, snow depths varied from 0-2 inches on the conventional, 2-4 inches on the disked, and 6-8 inches on the no-till treatments. Snow depth had a major influence on the soil temperatures in each plot. Figure 4 shows the average daily air and soil temperatures for the conventional and no-till treatments from November 25, 1981 to February 4, 1982. The soil temperatures were less variables and generally warmer than air temperatures. The snow on the surface almost always led to warmer soil temperatures.

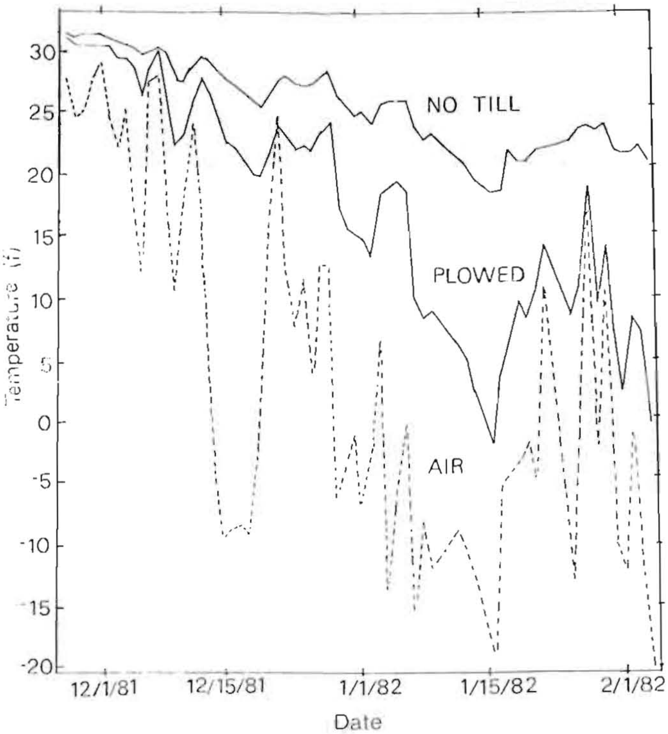

Figure 4. Average daily air and one inch soil temperatures for plowed and no-till winter wheat plots from 11/14/81-2/4/82 at MRS, Fargo (Adopted from Brun et al., 1982).

Figure 5 shows a series of lines and associated equations that predict the minimum soil temperature based on minimum air temperature and snow depth (Larsen et al., 1983). During the very cold 1981-82 winter, 3-4 inches of snow was found to be adequate insulation to protect Roughrider and Centurk-78 winter wheat from otherwise lethal soil temperatures.

CLIMATE AND STREAMFLOW

Records show that streamflows have been increasing with time in eastern North Dakota, but are decreasing with time on some western North Dakota rivers. A preliminary study (Brun et al., 1981) demonstrated that there was no apparent climatic change causing these streamflow changes in the east. It also indicated that land drainage was related to these changes.

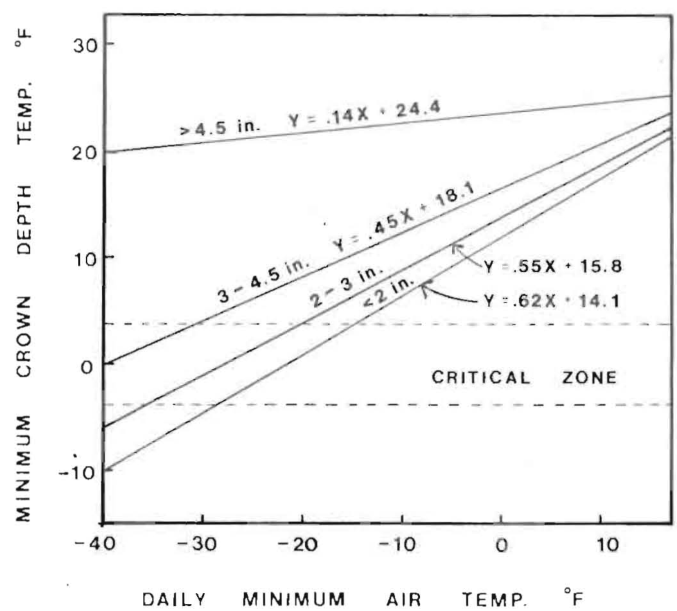

Figure 5. Relationship of daily minimum crown depth (one inch) temperature to daily minimum air temperature as affected by snow depth.

Current research is centered on further analysis of precipitation patterns and runoff in the east and west. Also, cultural practices such as land drainage and stock dam construction will be compared to the streamflow changes.

CLIMATOLOGY OF SOLAR ENERGY

Solar radiation was measured at Bismarck by the National Weather Service from 1952 through 1975. These data have been analyzed to determine the availability and dependability of solar radiation as an energy source throughout the year. Results will be useful for evaluating and sizing solar collectors and their storage systems. The data will also be useful for long range planning purposes.

ADDED RAINFALL EFFECTS

The objective of this study is to predict the effect a well-managed cloud seeding program would have on precipitation in North Dakota and, further, to assess the economic benefits of this added precipitation. The study does not attempt to assess the effectiveness of the past 25 years of cloud seeding activities in North Dakota. It was assumed that seeding can increase precipitation and that this increase occurs in a very specific way consistent with past observations.

Monthly precipitation totals were averaged over the 50-year period 1931-1980 for 40 locations in the state. The April-September monthly averages were published in map form (Enz et al., 1982). In addition, the number of days per month with rainfall of varying amounts was calculated (Table 2).

Results also indicate that cloud seeding would increase June, July, and August total precipitation about

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53. Zubriski, J. C. and E. B. Norum. 1955. **What effect do fertilizers have on soil moisture utilization by wheat?** North Dakota Agric. Sta. Bimonthly Bull. 17:126-127.

54. Zubriski, J. C., E. B. Norum and D. Q. Posin. 1953. **Comparison of phosphorus "A" values with chemical tests for soil phosphorus on 40 North Dakota soil samples.** p. 102-104. IN "Compilation of experimental work reported at the Fifth Annual Phosphorus Conference of the North Central Region, Dec. 2-3, 1953".

55. Zubriski, J. C., E. H. Vasey and E. B. Norum. 1970. **Influence of nitrogen and potassium fertilizers and dates of seeding on yield and quality of malting barley.** Agron. J. 62:216-219.

56. Zubriski, J. C. and D. C. Zimmerman. 1974. **Effects of nitrogen, phosphorus and plant density on sunflower.** Agron. J. 66:798-801.

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12 percent in eastern North Dakota and about 18 percent in the west. Department of Agricultural Economics personnel are now evaluating the economic benefits.

Table 2. Average number of days with selected amounts of daily precipitation, 1931-1980 (after Enz et al., 1982).

Daily Precip.	Dickinson	Mandan	Pettibone	Fargo
	Days in June, July, and August with indicated precipitation			
	number of days			
0.01-0.10	16.1	13.5	11.5	15.5
0.11-0.50	11.1	9.7	9.7	10.3
0.51-1.00	3.3	3.3	3.2	3.3
1.00	1.3	1.4	1.7	1.8
Total days	31.8	27.9	26.1	31.0

CLIMATOLOGY OF HAIL IN NORTH DAKOTA

In an effort to quantify hailfall throughout North Dakota, we have identified all the National Weather Service hail occurrences and stored this information on computer tape. Unfortunately, many cooperative observers have apparently ignored hail events so an evaluation of these data is most difficult. A scheme is being developed to identify the poorer records. When this is completed, these data will be analyzed in order to determine the frequency of hail.

Additional detailed hail data collected by cooperative observers for the North Dakota Weather Modification Board will also be analyzed. Since these data include hail amounts, times of occurrence, and severity in addition to dates, they will improve the hail information. Eventually the economic impact of hail will be investigated in cooperation with the Department of Agricultural Economics.

LITERATURE CITED

1. Brun, L. J. 1982. **No-till saves water two ways.** p. 289-290 IN 1983 Crop Production Guide, (North Dakota Agr. Assoc., Fargo).

2. Brun, L. J., J. K. Larsen and G. W. Johnson. 1982. **Overwinter crown depth temperature, the key to winter wheat survival.** p. 290-293 IN 1983 Crop Production Guide, (North Dakota Agr. Assoc., Fargo).

3. Brun, L. J., J. L. Richardson, J. W. Enz, and J. K. Larsen, 1981. **Streamflow changes in the southern Red River Valley of North Dakota.** ND Farm Research 38(5):11-14.

4. Enz, J. W., H. G. Vreugdenhil, J. E. Johnson and L. W. Schaffner. 1982. **Cloud seeding for rainfall increase — what can we expect in North Dakota.** Soil Science Research Report 1, ND State Univ., Fargo.

5. Larsen, J. K., L. J. Brun and J. W. Enz. 1983. **The effect of snow depth on winter wheat survival.** Agricultural Experiment Station, Research Report No. 96. North Dakota State University.