Importance and utilization of agricultural weather information in Minnesota: A survey

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ABSTRACT

Both increasing economic pressures to optimize farm enterprise inputs and environmental concerns related to the stewardship of our land, water, and air resources are motivating those involved in agricultural production to be more sensitive to the impact of weather and climate variability. Delivery of timely and high quality agricultural weather information has become an important function of many state extension services. In Minnesota, these services, along with daily agricultural weather forecasts have been provided since 1979 through the Cooperative Agricultural Weather Advisory Program (CAWAP), a joint effort of the National Weather Service (NWS) and the Minnesota Extension Service (MES). This survey was conducted to evaluate these services. Five hundred and thirty-five farm owners, managers, and operators responded to the agricultural weather survey conducted MES, which included producers of all major agricultural commodities. Awareness and utilization of agricultural weather information were found to be relatively high, with a strong preference for receiving this information over commercial radio and television. Forty-eight-hour forecasts and 3- to 5-day outlooks were rated very important by respondents. Precipitation probabilities, frost/freeze warnings, and soil moisture reports were the most highly rated information. Fifty-four percent of the respondents rated current information services as adequate, while 44% wanted more frequently updated information. It is perceived that the partnership of NWS and MES in agricultural weather services should continue and that improvements in agricultural weather information services can be made by responding to the survey results.

RECORDS of the Minnesota Agricultural Statistics Service for 1987 show that over $7 billion worth of agricultural products are marketed annually by Minnesota producers. Agriculture is by far the states largest industry. However, each year substantial losses in production and profitability (defined as return on investment per unit quantity produced) occur due to unfavorable weather conditions and poor management decisions brought about by imprecise or incomplete weather forecasts. The recently depressed farm economy and widespread financial crisis in rural counties have prompted even greater attention to the need for agricultural weather information in making operational decisions, many of which directly govern profitability and production. Examples of such decisions include scheduling plantings, fertilizer applications, selection of herbicides or insecticides and rates of application, managing air flow through stored grain facilities, determining timing and amount of irrigations, scheduling fungicide applications in a disease management program, and determining harvesting schedules.

Section D-40 of the National Weather Service Regional Operations Manual establishes policy and procedures regarding agricultural weather services within the organization. With some exceptions, most state Weather Service Forecast Offices (WSFO) provide some type of limited agricultural weather services to the public. For example, in most of the 14 north central states, agriculture is the number one industry. Each of these states has either full or limited agricultural weather services provided by the respective WSFO. However, because of competing interests and responsibilities within the organization, leadership at the local level in these programs is usually handled by a staff meteorologist assigned as an agricultural focal point. This individual, in addition to working rotating shifts, may also share other focal point responsibilities (e.g., severe weather educational programs, computer systems, fire weather, etc.), such that total time available to work on planning and promoting agricultural weather services at the local level may be limited to one work shift per month or less. Because of this situation, some state extension services have formally or informally established partnerships with local WFSOs to assist in providing and promoting agricultural weather services suited to local county needs.

The Minnesota Extension Service (MES), in cooperation with the National Weather Service (NWS), the Minnesota State Climatology Office of the Department of Natural Resources, the Minnesota Agricultural Statistics Service, and the Minnesota Department of Agriculture established a Cooperative Agricultural Weather Advisory Program (CAWAP) for the state in 1979. The CAWAP provides and promotes the use of weekly agricultural advisories (released each Tuesday morning) and daily agricultural weather zone forecasts. This program was most recently described by Spoden and Seeley (1985).

In 1983, the MES conducted an informal survey (by phone and letter) of news broadcasters across the state to determine how many were using the agricultural forecasts and advisories. This survey showed that over 70% of those radio stations carrying regularly scheduled farm news used the daily agricultural weather zone forecasts in their programming [usually shortly after the 0600 h CDT release time over the National Oceanic and Atmospheric Administration (NOAA) Weather Wire], and fur-

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ther that 60% used the weekly agricultural advisories in their farm news broadcasts on Tuesday or Wednesday. These results suggest that forecast and advisory information was being carried by the media. Uncertainty remained however, about how many agricultural producers were actually using the forecasts and advisories in decision making or planning, and which information was found most useful.

Surveys have historically been used a great deal by the USDA Cooperative Extension Service to assess the needs of various clientele. In recent years, Hesterman et al. (1986), Jackson and Taylor (1983), and Schmitt (1988) have conducted grower and fertilizer dealer surveys to determine their information needs and to tailor extension programming to those needs. In other cases, evaluations of existing extension programs have been conducted using surveys. Ragland et al. (1982) surveyed 200 Kentucky farmers who used the Green Thumb videotext system to access agronomic weather, market, and production information. They found that the videotext system worked particularly well in getting highly perishable market and weather information to farmers, but 95 to 100% reliability was required as system failures were, understandably, poorly tolerated.

Murphy and Brown (1983) suggested that surveys to assess public understanding, interpretation, and use of weather forecasts are needed in order to improve forecast terminology and the usefulness of the information. More recently, Lehman (1987), Changnon et al. (1987), and Easterling (1986) have used surveys to evaluate the use of near real-time climate information and climate outlooks. They conclude that such surveys are valuable in designing and selecting information products and prioritizing further developments in forecasting technologies.

This survey was initiated to determine some characteristics of the *end-users* (primary producers and managers) of forecasts and advisories provided by CAWAP in Minnesota; their relative rating of the importance of agricultural weather forecasts and advisories; where they obtain this information; and the frequency of use from among selected forecast and advisory products. Somewhat similar surveys in other states, e.g., Getz (1978), Johnson and Perry (1983), Vining et al. (1984), and Weiss and Robb (1986), have been oriented to specific agricultural commodities and to he means of information distribution. Features of these studies were incorporated into this survey and used in conjunction with questions related specifically to Minnesota agricultural commodities and CAWAP forecast and advisory services.

MATERIALS AND METHODS

Seventy-one of the 87 counties in Minnesota were included in the survey. Those counties left out of the survey were primarily not agriculturally based. The survey was conducted by using a mailed questionnaire and a follow-up postcard to encourage a response. One thousand producers were randomly selected from a list provided by Farmer Data Bank, an affiliate of Webb Publishing and the *Minnesota Farmer Magazine*. Thus, the audience sampled represented active full-time or part-time operators and managers who subscribe to farm magazines, journals, marketing newsletters, and other sources of information.

Of the 1000 questionnaires mailed, 56 were returned unmarked due to change of address, retirement, sale of the farm or operation, death of the owner, etc. Of the balance of the 944 questionnaires, 535 were filled out and returned (57%). In the context of other published surveys, this was considered to be a relatively high rate of response, particularly for the fall of 1986, which proved to be a difficult harvest season in many counties and thus competed for respondents time.

The questionnaire was divided into five parts, totaling 36 individual questions (see Appendix). Part 1 requested general information about years of operation and commodities produced. Part 2 asked users to rate the importance of weather forecast content. Part 3 addressed the distribution of information and what the preferences were for receiving forecasts and advisories. Part 4 was intended to determine what percentage of the sampled audience used the forecast and advisory information products, and how often they used them. Part 5 provided for general comments about agricultural weather information benefits or shortcomings as viewed by the individual respondent.

RESULTS AND DISCUSSION

Responses to Part 1 of the questionnaire revealed that the average number of years in farming operations among the 535 respondents was 28, ranging from 3 to 80 yr. The average farm size in this survey was 241 ha, ranging from 32 to 10 000 ha. The crop commodities produced included field corn (*Zea mays* L.), soybean [*Glycine max* (L.) Merr.], spring wheat (*Triticum aestivum* L.), and alfalfa has (*Medicago sativa* L.). Sugarbeet (*Beta vulgaris* L.), barley (*Hordeum vulgare* L.), and oat (*Avena sativa* L.) were most often cited as other important crops produced by the respondents. The reported cropland in irrigation was 85080 ha, representing about 5% of the total cropland in the state during 1986. Beef and dairy cattle (*Bos taurus*), along with hogs (*Sus domesticus*), sheep (*Ovis aries*), poultry (*Gallus domesticus* and *Meleagris gallopavo*), and goats (*Capra hicus*) were the major livestock commodities reported in this survey. Table 1 summarizes the totals reported for each commodity and the percentage of overall state production represented in the survey.

Part 2 of the survey asked respondents to rate the importance of agricultural weather information to their decision making and planning process (see Appendix). Content of forecast and advisory products was broken down into two categories; (i) synopsis-type reports that usually accompany forecast and advisory products and present a brief analysis of soil moisture, crop development, or crop pest conditions; and (ii) specific weather elements that are addressed in the 48-h forecast, such as precipitation probabilities, wind speed and direction,

Table 1. Commodity types, totals, and the percentage of 1986 state production represented in the survey.

Crop type	Total land, ha	Percentage of state production
Field corn	44 288	1.9
Soybean	33 965	1.8
Wheat	19 040	1.8
Alfalfa	7 791	1.0
Sugarbeet	1 732	1.4
Oat	1 940	0.6
Barley	2 019	0.5
Livestock type	**Total no.**	**Percentage of state production**
Beef cattle	20 212	5.0
Dairy cattle	10 182	1.2
Hogs	124 618	3.0
Sheep	7 186	3.4
Goats	167	1.5
Poultry	381 222	3.0

temperature, humidity, and hours of sunshine. Additionally, respondents were asked to rate the importance of outlooks based on the period covered, ranging from 3 to 5 d to 90 d. The summary for Part 2 of the survey is shown in Table 2. The Waller-Duncan *T* test was used to evaluate the means for the least significant difference (LSD).

The synopsis reports on soil moisture, soil temperature, insect development, crop development, and plant diseases were all rated relatively high, with soil moisture at the top of the list significantly different from all of the others except insect development reports. Though the mean rating on animal stress reports was the lowest, this included all 535 respondents. When just those who reported significant numbers of livestock (317 respondents with at least several dozen livestock animals) were summarized, the mean rating for this information category was 4.6.

Mean ratings of forecast elements in this survey were similar, though slightly higher overall than those reported by Vining et al. (1984). Precipitation was clearly rated the most important forecast parameter, with freeze/frost warnings rated second and air temperature forecasts third. Wind, relative humidity, and hours of sunshine were not as important to respondents, but all rated equally. Of the outlooks, the 3- to 5-d period was rated the most important. Then in descending order of importance were 6- to 10-d, 30-d, and 90-d outlooks, with mean ratings that were all significantly different from one another. This is not surprising since the relative accuracy of these outlooks conforms to the same descending order.

Part 3 of the survey was designed to evaluate the importance of the sources of information (see Appendix). Based on the LSD criteria, all sources of agricultural weather and climate information listed in Table 3 were rated significantly different from each other. Results showed that most producers have a strong preference to receive forecasts and advisory information over their local commercial radio or television station, rated 4.67 and 4.44, respectively. This was encouraging since a relatively high percentage of Minnesota radio and television stations incorporate agricultural forecasts and advisories in

Table 2. Importance of weather information to decision making and planning using a rating scale, where 1 = not important and 5 = very important.

Category	Mean rating
Synopsis-type reports	
Soil moisture reports	3.96
Insect development reports	3.86
Soil temperature reports	3.83
Crop development reports	3.80
Plant disease reports	3.80
Crop yield projections	3.41
Climatic summaries	3.34
Animal stress reports	3.23
LSD (0.01)	0.12
Specific 48-h forecast elements	
Precipitation probabilities	4.62
Freeze/frost warnings	4.16
Air temperature	4.01
Wind speed and direction	3.61
Relative humidity	3.58
Hours of sunshine	3.55
LSD (0.01)	0.11
Outlook period	
3-5 d	4.57
6-10	3.83
30 d	3.00
90 d	2.72
LSD (0.01)	0.12

their news programming. Respondents rated the value of their own weather observations quite highly as well. A number of Minnesota growers belong to various weather observation networks in the state, including the National Weather Service cooperative observer network, the Soil and Water Conservation District networks, and various commercial radio and television networks.

The statistical summary on the utilization of NOAA weather radio showed a bimodal distribution (many ratings of 4 or greater and 2 or less), with an overall mean rating of 3.00. Because NOAA weather radio in Minnesota is limited to nine transmitter sites covering only about 50% of the state, the ratings for this source of information indicate that those within range of state transmitters strongly preferred to receive weather information by this means. Approximately half of the counties surveyed have NOAA weather radio available to their area. Those beyond reach of the NOAA weather band naturally rated it very low as a distributor of information.

The mean rating for newspaper sources of weather information was lowest at 2.49. This was assumed to be at least parially attributable to the fact that weather information is so perishable in the context of newspaper delivery. The printed media do provide a good method to educate the agricultural public on weather-related issues, but time scales appropriate to daily decision making prevent newspapers from fulfilling the same role as radio and television. The MES CAWAP had a mean rating of 3.49 in the survey. The CAWAP distributes newsletters, advisories, zone forecasts, and data summaries statewide via taped phone messages and the county extension computer-based bulletin board services. Regarding the use of home computer systems, Weiss and Robb (1986) reported that among top Nebraska wheat

Table 3. Mean ratings for sources of agricultural weather and climate information, where 1 = not important and 5 = important.

Source of information	Mean rating
Radio	4.67
Television	4.44
Own observations	4.12
Cooperative weather advisory (through county extension)	3.49
NOAA weather radio (limited areal coverage)	3.00
Newspaper	2.49
LSD (0.01)	0.12

Table 4. Mean ratings for the importance of various components of the weekly agricultual weather advisory, where 1 = not important and 5 = very important (240 respondents).

Component	Mean rating
5-d outlook	4.22
Timing of advisory information	3.91
Soil temperatures	3.69
Crop growth reports	3.67
Pest management	3.65
Livestock stress	3.39
Climate summaries	3.28
LSD (0.01)	0.19

farmers, 24% (34 of 142) has small or personal computers and another 18% (25 of 142) indicated that they were considering purchasing a computer. Since CAWAP distributes information via electronic bulletin boards accessible by home computers, a similar question was included in Part 1 of this survey. Thirteen and one-half percent (72 of 535) of the Minnesota respondents reported that they owned a computer, while an additional 32% indicated that they were considering the purchase of one. Both this survey and the Nebraska Survey indicate a significant and growing audience with the capability of accessing agricultural weather information from electronic bulletin board services.

Statistics for Part 4 summarize what percentage of the sampled audience used agricultural weather zone forecasts and weekly agricultural advisories. Fifty-six percent (298) of the total respondents (535) had used agricultural weather zone forecasts at least occasionally, and 199 of those were regular users of these forecasts (categories c and d of Question 2 shown in the Appendix). Nine percent of those samples were not even aware that the National Weather Service released an agricultural weather zone forecast each day at 0600 h CDT, indicating that some statewide promotional and educational programs on this service may be useful. Forty-five percen (240) of the total respondents had used the weekly agricultural advisory at least occasionally. Sixty-nine percent (165) of those who indicated that they had used the advisory responded that they were regular users of this information (again categories c and d in Question 4). Those who responded to No. 4 in Part 4 of the survey were also asked to respond to No. 5, indicating how they rate the importance of various components of the weekly agricultural weather advisory. Table 4 summarizes their responses.

Incorporation of the 5-d outlook with other advisory information was rated very highly. Relating pest management, livestock stress, and soil temperature information to the 5-d outlook would appear to be an appropriate response to these user preferences. This agrees with the results reported by Weiss and Robb (1986).

The timing of advisory information was rated to be very important. Weekly advisories that address current field situations and problems are only possible through cooperation with county extension offices and National Weather Service personnel. Proper timing of advisory information can be achieved if these two groups routinely communicate. The CAWAP facilitates this type of communication and it is perhaps its most important function.

Fifty-four percent of the total respondents to Question 6 in Part 4 (see Appendix) rated CAWAP information services as adequate, while 44% wanted more frequently updated agricultural zone forecasts and advisories.

SUMMARY AND CONCLUSIONS

Five hundred and thirty-five Minnesota farm managers, owners, and operators responded to the survey (57% of those mailed). All major agricultural commodities in the state were represented. The sampled group averaged 28 yr of experience. Awareness and utilization of the daily agricultural weather zone forecasts and weekly agricultural advisories was relatively high, with a strong preference for receiving this information from commercial radio and television. In areas of the state covered by NOAA Weather Radio, this means of dissemination was highly preferred. This survey indicates that expansion of the NOAA Weather Radio service to larger geographic areas would be well received.

Respondents rated the importance and utilization of the MES CAWAP information relatively high, in the context of decision making and planning. A significant percentage of respondents either currently utilize home computers or are considering the purchase of one. The growing widespread use of this technology provides, through computer-based bulletin boards and electronic mail, a direct and timely channel through which agricultural weather information can be disseminated.

The most frequently utilized information was available from the 48-h forecast, or the 3- to 5- and 6- to 10-d outlooks. specific content that was highly rated in importance included precipitation probability, freeze/frost warnings, temperature forecasts, soil moisture reports, soil temperature reports, predictions of crop and insect development, and plant disease reports. For those significantly invested in livestock industries, animal stress reports were rated as very important information.

As A result of this survey, improvements in agricultural weather information format, content, timeliness, and quality should be pursued jointly by the MES and NWS. Surveys such as this one and others indicate a great deal of public interest in agricultural weather and climate information, perhaps heightened by the rural economic crisis. It is anticipated that the NWS Forecast Offices will continue to have limited resources, and thus be unable to provide improved services to the agricultural community on their own. The state extension services, through

their linkages with county extension personnel, state agricultural specialists, and the media are ideally equipped to assist the NWS in this area. Working with NWS regional managers and local agricultural focal point meteorologists, extension staff could play key roles in promoting greater utilization of agricultural weather information, educating the public on interpretation of data and forecasts, conducting user future surveys, and providing valuable feedback to NWS personnel so that local needs could be better met.

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APPENDIX

Minnesota Agricultural Weather Survey
University of Minnesota Cooperative
Agricultural Weather Advisory Program.

The Minnesota Agricultural Extension Service appreciates your effort to help us serve you better.

Department of Soil Science
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St. Paul, MN 55108

PART ONE—GENERAL INFORMATION

1. County: _____
2. Years of operation: _____
3. Acres in production: _____
4. Irrigated crop areas: _____
5. Normal annual number of acres planted to:
   a. Corn: _____
   b. Soybeans: _____
   c. Wheat: _____
   d. Alfalfa: _____
   e. Other (please specify): _____
6. Normal annual number of head raised:
   a. Beef cattle: _____
   b. Dairy cattle: _____
   c. Hogs: _____
   d. Sheep: _____
   e. Goats: _____
   f. Poultry: _____
7. Do you own a small computer? (circle one) yes no
8. If you answered no to Question no. 7, have you considered purchasing a small computer for your farm? yes no

PART TWO

In this section we are interested in knowing what types of agricultural weather information you consider important as you make decisions. For *each* category listed below, rate its importance to you on a scale of 1 to 5, where a value of 1 is not important and 5 is very important.

	Not imp.				Very imp.
1. Soil temperature:	1	2	3	4	5
2. Soil moisture:	1	2	3	4	5
3. Crop development:	1	2	3	4	5
4. Yield projections:	1	2	3	4	5
5. Climate summaries:	1	2	3	4	5
6. Extended weather outlooks (no. of days in advance):					
a. 3-5 days:	1	2	3	4	5
b. 6-10 days:	1	2	3	4	5
c. 30 days:	1	2	3	4	5
d. Seasonal (90 days):	1	2	3	4	5
7. Precipitation probabilities (immediate through next 48 hours):	1	2	3	4	5
8. Air temperature (immediate through next 48 hours):	1	2	3	4	5
9. Relative humidity (immediate through next 48 hours):	1	2	3	4	5
10. Wind speed and direction (immediate through next 48 hours):	1	2	3	4	5
11. No. of hours of sunshine:	1	2	3	4	5
12. Animal stress reports:	1	2	3	4	5
13. Plant disease reports:	1	2	3	4	5
14. Insect development reports:	1	2	3	4	5
15. Freeze/frost warnings:	1	2	3	4	5

PART THREE

Here we would like to know the importance of various media in providing you with weather information. For *each* category listed below, rate its importance to you on a scale of 1 to 5, where a value of 1 is not important and 5 is very important.

	Not imp.				Very imp.
1. Newspaper:	1	2	3	4	5
2. Radio:	1	2	3	4	5
3. Television:	1	2	3	4	5
4. NOAA Weather Radio:	1	2	3	4	5
5. Minnesota Cooperative Weather Advisory (issued by the Minnesota Extension Service in cooperation with the National Weather Service):	1	2	3	4	5
6. Using the same scale, how important do you consider your own observations?	1	2	3	4	5

PART FOUR

The following questions refer to the Minnesota Cooperative Weather Advisory Program and Daily Agricultural Weather Forecasts.

1. Are you aware of the National Weather Service's daily agricultural weather forecasts?
   Yes _____ No _____ Don't know _____
2. If you answered yet to Question no. 1, how often do you use the agricultural weather forecast? (check one of the following):
   a. Seldom if ever _____
   b. At least a few times _____
   c. A number of times _____
   d. Frequently _____

3. Are you aware of the joint National Weather Service–Minnesota Extension Service weekly agricultural weather advisory?
   Yes _____ No _____ Don't know _____
4. If you answered yes to Question no. 3, how often do you use the weekly agricultural weather forecast? (check one of the following):
   a. Seldom if ever _____
   b. At least a few times _____
   c. A number of times _____
   d. Frequently _____
5. For those who use the weekly agricultural weather advisory, please indicate the importance of its components listed below. For each component rate its importance to you on a scale of 1 to 5, where value of 1 is not important and 5 is very important.

	Not imp.				Very imp.
a. Climate summaries:	1	2	3	4	5
b. Soil temperatures:	1	2	3	4	5
c. Crop growth reports:	1	2	3	4	5
d. Livestock stress:	1	2	3	4	5
e. Pest management:	1	2	3	4	5
f. 5-day outlook:	1	2	3	4	5
g. Timing of advisory information:	1	2	3	4	5

6. If the frequency of either the agricultural weather forecasts or the weekly weather advisory were to increase, would you use these products (check one):
   a. More often _____
   b. Less often _____
   c. Just as often _____

PART FIVE—COMMENTS

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