EXTENSION AGENT AWARENESS OF CLIMATE AND NEW DIRECTIONS FOR RESEARCH IN NORTH CAROLINA

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Abstract

Each state in the United States of America has an institution known as the Cooperative Extension Service. These institutions, almost always associated with the Land Grant University's tripartite mission of research, education, and extension, are in essence providers of adult education. In the case of climate science, they have been called a boundary organization which serves as a two-way intermediary between climate researchers and end-users. In order to better collaborate with the Extension Service, this investigation explored their attitudes toward, knowledge of, and willingness to use climate information and seasonal climate forecasts. A survey instrument was developed and distributed to North Carolina extension personnel in March 2009. A total of 109 responses were retrieved and analyzed. A principal finding is that extension agents need and desire to gain a better understanding of climate science and its application to agricultural practices. The respondents find seasonal climate forecasts to be useful and understand the economic value of forecast guidance. However, requested accuracy of seasonal climate forecasts is beyond the skill of current climate models. The survey results are discussed as well as their implication for future work in climate assessment programs regarding information to reduce risk in agriculture and natural resource management. In general, extension will continue to be a valued partner for the dissemination of climate tools and products by serving as an intermediary

between climate scientists and end-users. This feedback loop can tailor and improve formats, content, presentation, access, and credibility of climate risk reduction decision support systems.

1. Introduction

An evident link exists between weather/ climate phenomena and the industry of agriculture (Reichelderfer et al., 1941; Hewitt and Ibarra, 1999; Fraisse et al., 2006). Global oceanic and atmospheric circulations interact to produce the phenomenon called El Niño Southern Oscillation (ENSO), which originates in the tropical Pacific Ocean and can influence weather and climate patterns in North Carolina (NC) (Trenberth 1997; Roswintiarti 1998, Baigorria et al., 2008). The warm phase of this phenomenon, or El Niño, occurs when sea surface temperatures are above normal in the eastern equatorial Pacific Ocean. El Niño is often associated with wet conditions in eastern North Carolina during the cool season of October through March. Contrarily, the cool phase of ENSO is known as La Niña and is associated with below normal sea surface temperatures in the eastern equatorial Pacific Ocean. Eastern North Carolina experiences drier conditions more frequently in the cool season during La Niña. Less confidence exists in the influence of ENSO on climatic conditions of eastern North Carolina during summer months. ENSO impacts are also less prevalent in western NC during all seasons. However, ENSO has an overall strong influence on climate variability, which can have major impacts on agricultural production.

North Carolina State University (NCSU) is an affiliate of the Southeast Climate Consortium (SECC, http://seclimate.org) which is a partnership of universities aimed at integrating climate information with agricultural, water resources, and coastal needs. The SECC provides a climate information and decision support system, AgroClimate, which is accessible at http://agroclimate.org/ (Fraisse et al., 2006; Breuer et al., 2008). This website was created to present information on the impacts of climate variability on agriculture to Cooperative Extension Service personnel, consultants, farmers, and other agricultural decision makers in Florida, Georgia, and Alabama, and to provide county-level risk management decision aids. The site includes climate forecasts based on ENSO phase, drought index forecasts for use by forest managers (KBDI), forecast shifts in freeze probabilities, and crop-specific information on yields and management options to reduce risk. In addition, periodic climate and commodity-specific agricultural outlooks are available. The site has been developed in close cooperation with the Cooperative Extension Service in each of the three states.

The authors are working to adapt and develop AgroClimate decision support tools and information for North Carolina. The goal is to implement the current tools available on the Internet (www.agroclimate.org) as well as incorporate new products and services that are targeted and tailored to the needs of NC growers and extension personnel to better serve their clientele. A survey instrument was chosen as the appropriate research tool to facilitate the process of incorporating North Carolina into AgroClimate. The baseline survey was conducted before any educational workshops on climate forecasts or AgroClimate training sessions. The objectives of this study were:

- To examine awareness and understanding of climate forecasts
- To identify levels of certainty needed, and interest in, climate forecasts
- To elicit preferences with regard to presentation and formats of climate forecast information, and
- To determine priority areas for further research and development of climate risk tools in conjunction with target extension and producer communities

2. Methodology

We developed a baseline survey instrument for North Carolina extension agents based on a survey conducted in Florida in 2004 (Cabrera et al., 2006). The goal of this survey was to quantify knowledge, perceptions, attitudes and potential use of seasonal climate forecasts among the agents, and by extension, to their clientele. The survey was Internet-based and consisted of 55 questions. To maximize the number of responses in the sample population, the Cooperative Extension Service's Associate Director and State Program Leader for Agriculture and Natural Resources sent an email message to the target audience urging participation, following Dillman's tailored design method (Dillman et al., 2008). The survey was voluntary, anonymous, and approved by the institutional review board (IRB) at North Carolina State University.

For this study, western NC is defined as extension districts of West, West Central, North Central, and South Central while eastern NC is defined as districts of Northeast and Southeast (Figure 1).

Purposive sampling is a well-established method in qualitative research (Patton 1990; Bernard 2006). In a purposive, criterion-based sample, respondents are selected based on specific criteria rather than by random sampling. Our criteria were to identify extension personnel in North Carolina who work in agriculture and natural resource management.

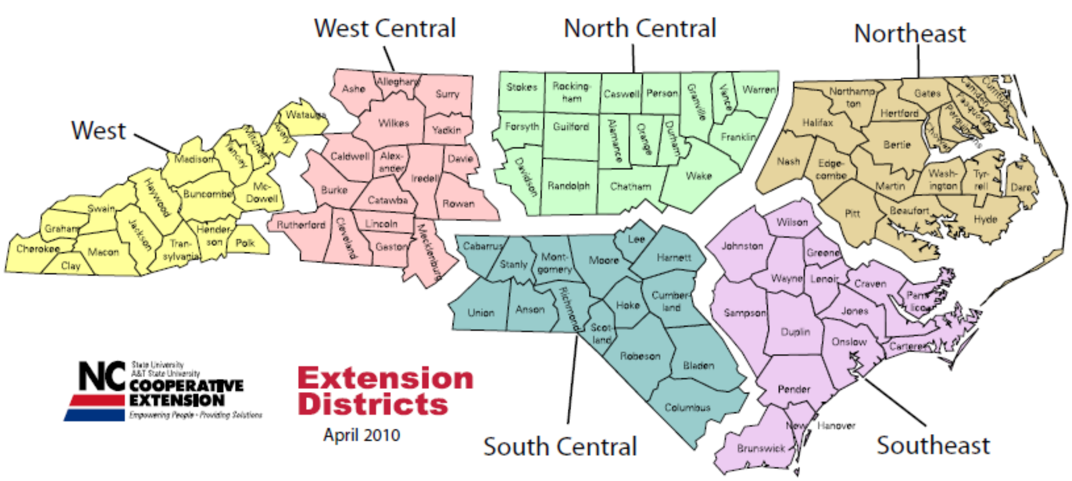

Figure 1. Extension districts of North Carolina, adapted from North Carolina Cooperative Extension Service (2010).

3. Results

We received a total of 109 responses during the inclusive period of March 6, 2009 through April 3, 2009. Single selection questions are presented in the text as percentages while multiple answer questions ("Check all that apply") are displayed as proportions. Also, please note that "Check all that apply" responses in the tables do not add to 100%.

a. Demographics of Target Audience

Characteristics of the survey population are described in Table 1. Most extension agents are males between the ages of 46 to 55 years old and have worked in extension for over six years. Across all extension districts of NC, which are shown in Figure 1, there appears to be an even spread in the number of respondents per district. About 76% of agents' clientele have a farm between 11 and 1000 acres in size. While about half of the extension agents did not respond with regard to the size of their farm, the majority of those that did respond manage less than 500 acres of land. This makes the agents both members of the boundary organization and end-user groups. As such, they are considered stakeholders.

Agent responsibilities cover a wide range of commodities, including field crop, fruit, and vegetable production, as well as greenhouse or nursery production, poultry, swine, livestock, turf grass, aquaculture, timber, and forage production. Out of a total of 109 respondents, 50 agents also have duties relevant to water quality. Other responses included water quantity, waste management, horses, agritourism, natural resources, youth gardens, local foods, home gardening, and honeybees.

b. Basic knowledge and use of weather and climate information

Table 2 depicts extension agent knowledge of, and current usage of, weather and climate information. While only 16.5% of the survey respondents have any training in meteorology or climate related subjects, most extension agents recognize the temporal differences between weather and climate forecasts. About 62% of extension agents utilize weather forecasts on at least a weekly basis to advise their clientele. In answer to a separate question, approximately 76% of respondents stated that they rely on weather forecasts on at least a weekly basis to do their work.

Approximately 52% of agents agree that climate forecasts for a specific crop/activity are more useful than general ones, while about 39% neither agree nor disagree with this statement, which shows uncertainty among the target audience.

Extension agent knowledge of ENSO events is shown in Table 3. While 82% agree their work is influenced by ENSO climate events, extension agents have a vague knowledge of climate impacts of ENSO events. With regard to the phases of El Niño and La Niña, most respondents were unsure of the climatic effects and/or could not distinguish whether temperature and/or precipitation patterns were higher or lower than normal conditions during a particular phase. Of the 52 agents who were unsure about the effects of El Niño (N=109), 25 respondents are located in eastern NC extension districts while 27 agents represent western NC districts. Out of 62 respondents who were uncertain of the effects of La Niña (N=109), 28 agents are from eastern NC districts and 34 agents are located in western NC districts. Thus, extension agents in eastern NC, which has a stronger ENSO signal than western NC, do not appear to be more knowledgeable about La Niña and El Niño impacts. For neutral phase, most agents understand that temperature and/or precipitation patterns are not affected, although 34 out of 109 respondents are unsure about the climatic effects during this phase. Of these 34 agents, 15 respondents are from eastern NC extension districts and 19 respondents represent western NC extension districts. Overall, these results reveal an educational opportunity exists with regard to NC extension agent knowledge of climate information.

Table 1. Extension agent demographic information (N=109)

Gender	N	%
Male	83	76.1
Female	24	22
No response	2	1.8

Age	N	%
Less than 25	5	4.6
25 to 35	19	17.4
36 to 45	22	20.2
46 to 55	42	38.5
56 to 65	17	15.6
Greater than 65	1	0.9
No response	3	2.8

Work District	N	%
North Central	14	12.8
Northeast	21	19.3
South Central	19	17.4
Southeast	24	22
West	15	13.8
West Central	16	14.7

Years Working in Extension	N	%
Less than 1	7	6.4
1 to 3	9	8.3
4 to 6	15	13.8
More than 6	78	71.6

Clientele Average Farm Size (acres)	N	%
Less than 2	6	5.5
2 to 10	10	9.2
11 to 80	29	26.6
81 to 200	23	21.1
201 to 500	11	10.1
501 to 1,000	20	18.3
More than 1,000	6	5.5
No response	4	3.7

Extension Agent Farm Size (acres)	N	%
Less than 2	8	7.3
2 to 10	9	8.3
11 to 80	14	12.8
81 to 200	7	6.4
201 to 500	11	10.1
501 to 1,000	3	2.8
More than 1,000	1	0.9
No response	56	51.4

Activities Relevant to Agents' Work (Check all that apply)	N	%
Field crop production	60	55.0
Vegetable production	47	43.1
Beef cattle	36	33.0
Dairy cattle	14	12.8
Hogs	22	20.2
Poultry	18	16.5
Greenhouse or nursery production	44	40.4
Forage production	42	38.5
Annual fruit production	29	26.6
Aquaculture	15	13.8
Perennial fruit or nut production	33	30.3
Timber/Christmas tree production	27	24.8
Turf grass/Landscape	40	36.7
Water quality	50	45.9
Other	9	8.3

Table 2. Basic climate information/current usage of this data (N=109).

Training in Meteorology or Climate?	**N**	**%**
Yes	18	16.5
No	91	83.5

Perception of a Weather Forecast (Check all that apply)	**N**	**%**
What will happen today	71	65.1
What will happen tomorrow or the day after	83	76.1
What will happen during the next two weeks	69	63.3
What will happen this month	14	12.8
What will happen next month	9	8.3
What will happen this season	9	8.3
What will happen in six months	5	4.6
Don't know	3	2.8

Perception of a Climate Forecast (Check all that apply)	**N**	**%**
What will happen today	5	4.6
What will happen tomorrow or the day after	3	2.8
What will happen during the next two weeks	8	7.3
What will happen this month	26	23.9
What will happen next month	12	11.0
What will happen this season	39	35.8
What will happen in six months	11	10.1
Don't know	5	4.6

Frequency of using Weather Forecasts to Advise Clientele	**N**	**%**
At least daily	17	15.6
At least weekly	50	45.9
At least monthly	13	11.9
Seasonally	19	17.4
When extreme events are forecast	6	5.5
Rarely or never	4	3.7

Reliance on weather forecasts to do their work	**N**	**%**
At least daily	28	25.7
At least weekly	55	50.5
At least monthly	11	10.1
Seasonally	10	9.2
When extreme events are forecast	3	2.8
Rarely or never	2	1.8

Climate forecasts for a specific crop/activity are more useful than general ones.	**N**	**%**
Strongly Agree	11	10.1
Agree	46	42.2
Neither agree nor disagree	43	39.4
Disagree	8	7.3
Strongly Disagree	0	0.0
No response	1	0.9

Table 3. Knowledge of ENSO events (N=109).

Work Affected by El Niño or La Niña Climate Events

	N	%
Strongly Agree	34	31.2
Agree	55	50.5
Neither agree nor disagree	16	14.7
Disagree	2	1.8
Strongly Disagree	1	0.9
No response	1	0.9

Climate Impacts of El Niño Phase (Check All That Apply)

	N	%
More rain than usual	28	25.7
Less rain than usual	25	22.9
Same amount of rain as usual	1	0.9
Higher temperature than usual	25	22.9
Lower temperature than usual	9	8.3
No change in temperature than usual	4	3.7
Don't know what effects there are	52	47.7
No response	2	1.8

Climate Impacts of Neutral Phase (Check All That Apply)

	N	%
More rain than usual	3	2.8
Less rain than usual	6	5.5
Same amount of rain as usual	62	56.9
Higher temperature than usual	1	0.9
Lower temperature than usual	2	1.8
No change in temperature than usual	47	43.1
Don't know what effects there are	34	31.2

Climate Impacts of La Niña Phase (Check All That Apply)

	N	%
More rain than usual	17	15.6
Less rain than usual	29	26.6
Same amount of rain as usual	1	0.9
Higher temperature than usual	14	12.8
Lower temperature than usual	12	11.0
No change in temperature than usual	3	2.8
Don't know what effects there are	62	56.9

c. Willingness to Provide and Utilize Climate Forecasts

Over 70% of extension agents are willing to provide climate forecasts and forecast advice to their clientele as shown in Table 4. However, approximately 80% of respondents want the climate forecast to be correct at least 75% of the time in order to use or recommend that farmers change their practices based on the forecast as depicted in Table 4. In other words, agents want it to be a La Niña season at least 75% of the time that it is forecasted to be La Niña and vice versa.

In a comparison of extension agent willingness to provide climate forecast advice, female agents between the ages of 36 to 55 have the least average willingness to provide this information, as shown in Figure 2. An ANOVA was performed to explore statistical significance of the aforementioned least average willingness. The null hypothesis of equal means has been rejected at the 95% confidence level using the

ANOVA F-test. Therefore, a pairwise comparison of the means is performed using Fisher's Least Significant Difference (LSD) as a subsequent test for statistical difference between the groups. The mean response of 36 to 55 year-

Table 4. Willingness to provide forecasts and forecast accuracy preference (N=109).

Willingness to Provide Climate Forecasts to Clientele	**N**	**%**
Strongly Agree	26	23.9
Agree	55	50.5
Neither agree nor disagree	26	23.9
Disagree	2	1.8
Strongly Disagree	0	0.0
Willingness to Provide Climate Forecast Advice to Clientele	**N**	**%**
Strongly Agree	18	16.5
Agree	67	61.5
Neither agree nor disagree	21	19.3
Disagree	3	2.8
Strongly Disagree	0	0.0
Requested Accuracy of Climate Forecasts	**N**	**%**
80 percent of the time	32	29.4
75 percent of the time	54	49.5
60 percent of the time	12	11.0
50 percent of the time	5	4.6
40 percent of the time	0	0.0
25 percent of the time	1	0.9
No response	5	4.6
Requested Accuracy of Forecasts to Recommend Changes to Clientele	**N**	**%**
80 percent of the time	49	45.0
75 percent of the time	44	40.4
60 percent of the time	7	6.4
50 percent of the time	4	3.7
40 percent of the time	0	0.0
25 percent of the time	0	0.0
No response	5	4.6

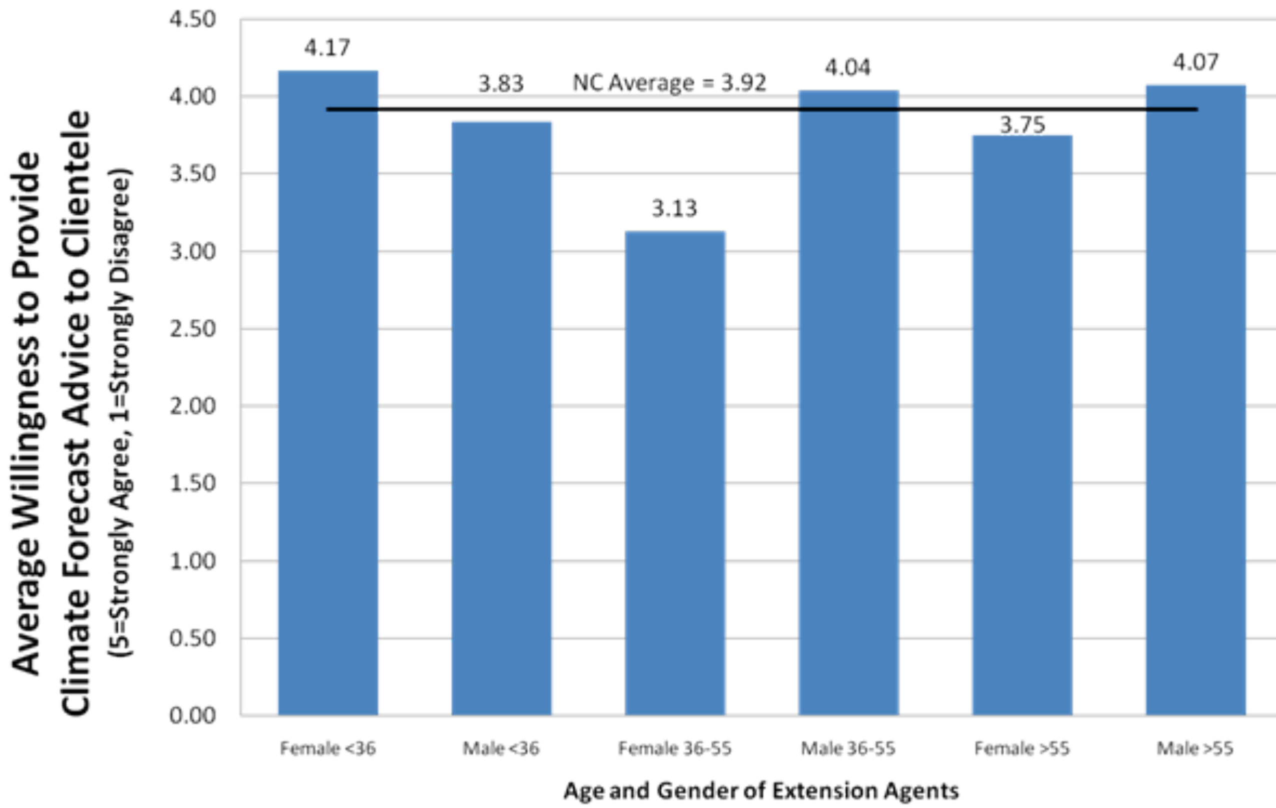

Figure 2. Average willingness to provide climate forecast advice to clients based on age and gender of extension agent.

old females is shown to be significantly different from the other category means.

Figure 3 shows that agents in northeastern NC, a region with a relatively strong ENSO signal, are most willing to provide climate forecast advice to clientele. However, an ANOVA F-test fails to reject the null hypothesis of equal means at the 95% confidence level.

With respect to clientele farm size, agents with responsibilities for clientele with smaller farms of less than 2 acres are least willing to provide this advice. However, an ANOVA F-test fails to reject the null hypothesis of equal means at the 95% confidence level. Most farm size categories are more amenable than the NC average willingness, as shown in Figure 4.

Over 50% of extension agents feel that growers, producers, and decision makers in their region are interested in using climate forecasts as shown in Table 5. However, approximately 35% of respondents are unsure about this statement.

d. Who Should Interpret the Climate Forecasts?

Table 6 illustrates extension agent preference for interpretation of seasonal climate forecasts. Approximately 60% of agents neither agree nor disagree about a desire to make their own interpretation of the impact of climate forecasts in their area. About 25% of respondents do not prefer to make their own interpretation of the impact of these forecasts while only about 12% prefer to make their own interpretation.

In order for producers to use climate forecasts, about 36% of respondents believe the producers will need some help in interpretation from the agents and approximately 34% feel that the forecasts will need to be delivered in lay

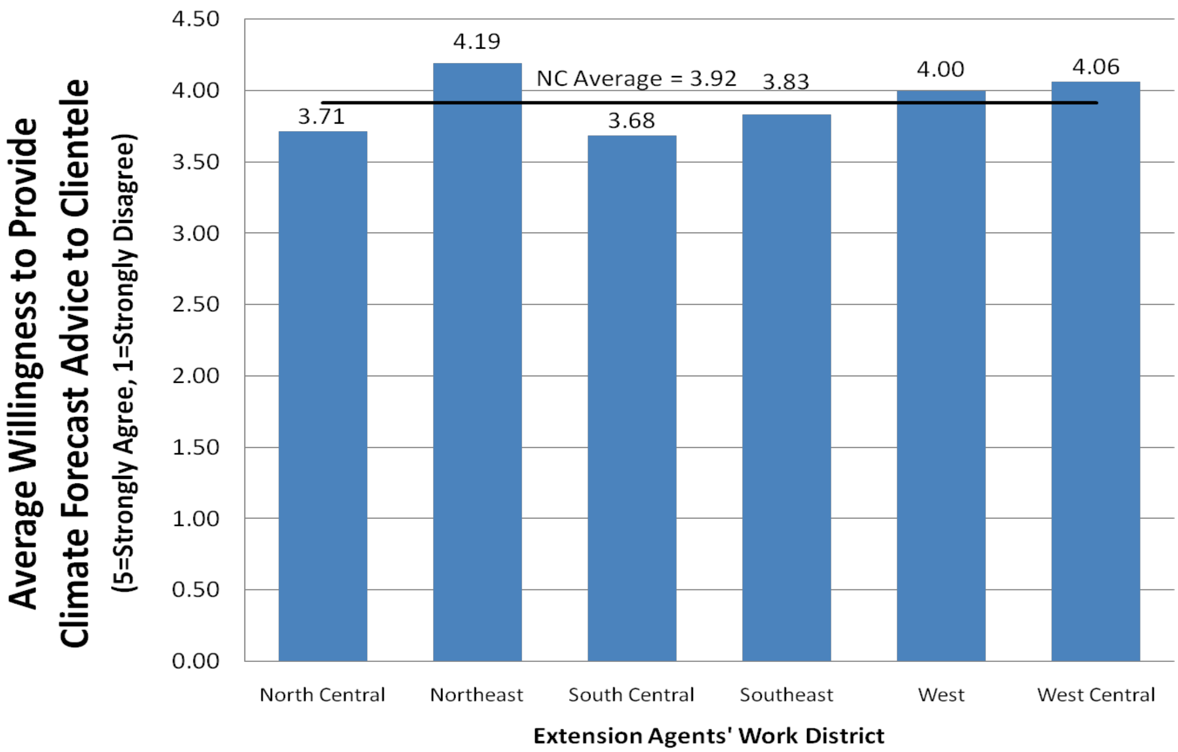

Figure 3. Average willingness to provide climate forecast advice to clients based on work district of extension agent.

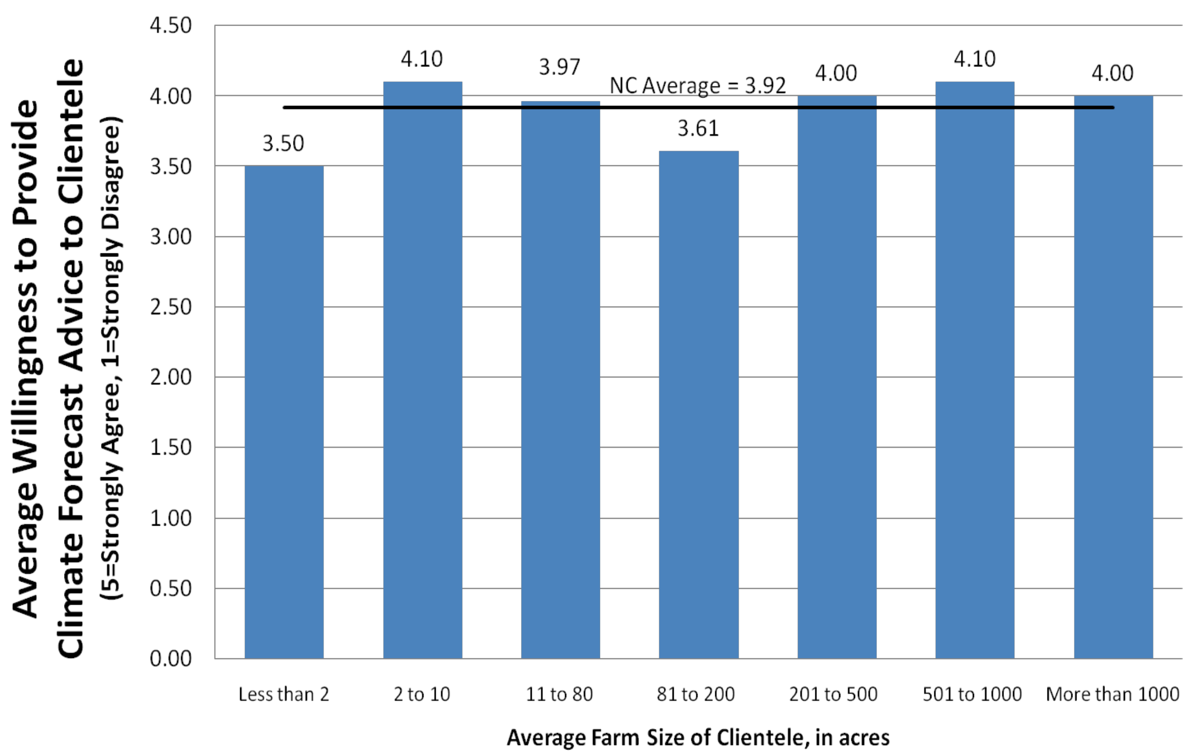

Figure 4. Average willingness to provide climate forecast advice to clients based on average farm size of clientele.

Table 5. Interest Level of Clientele in my Region (N=109).

Growers and Producers are Interested in Using Climate Forecasts	N	%
Strongly Agree	8	7.3
Agree	50	45.9
Neither agree nor disagree	42	38.5
Disagree	7	6.4
Strongly Disagree	2	1.8
Agricultural Producers are Interested in Using Climate Forecasts	**N**	**%**
Strongly Agree	14	12.8
Agree	57	52.3
Neither agree nor disagree	34	31.2
Disagree	2	1.8
Strongly Disagree	1	0.9
No response	1	0.9
Decision Makers in my Region are Interested in Using Climate Forecasts	**N**	**%**
Strongly Agree	14	12.8
Agree	51	46.8
Neither agree nor disagree	42	38.5
Disagree	2	1.8
Strongly Disagree	0	0.0

Table 6. Preference for accuracy and interpretation (N=109).

I Prefer to Make my Own Interpretation of the Impact of Climate Forecasts in my Area	N	%
Strongly Agree	0	0.0
Agree	13	11.9
Neither agree nor disagree	65	59.6
Disagree	27	24.8
Strongly Disagree	3	2.8
No response	1	0.9
For producers to be able to use forecasts in my work area they will need…	**N**	**%**
Significant help including training	10	9.2
Some help in interpretation from me	39	35.8
Little to no help in interpretation from me	8	7.3
They are unlikely to use forecasts	2	1.8
The forecasts to be delivered in layman's terms	37	33.9
The information to be distributed as management recommendations rather than climate forecasts	12	11.0
No response	1	0.9

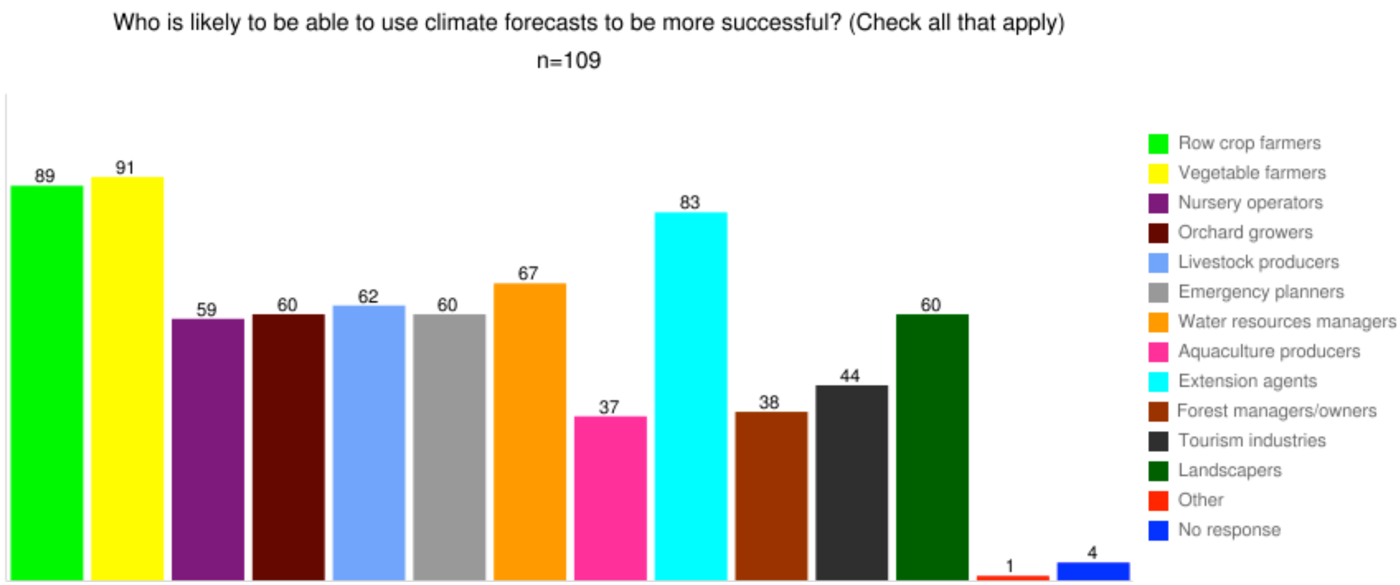

Figure 5. Clientele likely to be able to use climate forecasts to be more successful.

terms. About 11% of respondents think that this information needs to be distributed as management recommendations rather than as climate forecasts. Approximately 9% of the survey population believes that producers will require significant help, including training, which reiterates the need for climate education.

e. Who Can Use Climate Forecasts?

With regard to an audience that could use climate forecasts to be more economically successful, over 80 extension agents out of a total of 109 respondents feel that vegetable farmers, row crop farmers, and agents themselves could fill this role (Figure 5). Over 50 out of a total of 109 respondents agreed that categories of water resources managers, livestock producers, landscapers, emergency planners, orchard growers, and nursery operators could also benefit from climate forecasts. One respondent felt climate forecasts would not be advantageous to any audience since, “forecasts are not that good”.

f. Knowledge of climate information with respect to anomalous events

As shown in Table 7, approximately one third of respondents believe anomalous events, such as extreme dry events, freeze events, and crop failure or low yields, can be predicted reliably using climate forecasts which suggests the need for climate education. About 50% of agents neither agree nor disagree with this statement which reiterates the opportunity for education. A two-tailed Student’s t-test reveals that responses to the three questions about anomalous events are not significantly different between eastern NC and western NC districts at the 95% confidence level.

Most extension agents are confident that it is useful to know if the coming growing season will be different than normal conditions, since approximately 95% of respondents agree with this statement, as depicted in Table 7.

Table 7. Predictability of Anomalous Events (N=109).

Extreme Dry Events can be Predicted Reliably Using Climate Forecasts	**N**	**%**
Strongly Agree	3	2.8
Agree	37	33.9
Neither agree nor disagree	55	50.5
Disagree	12	11.0
Strongly Disagree	1	0.9
No response	1	0.9
Freeze Events can be Predicted Reliably Using Climate Forecasts	**N**	**%**
Strongly Agree	3	2.8
Agree	38	34.9
Neither agree nor disagree	54	49.5
Disagree	11	10.1
Strongly Disagree	2	1.8
No response	1	0.9
Crop Failure/Low Yields can be Predicted Reliably Using Climate Forecasts	**N**	**%**
Strongly Agree	2	1.8
Agree	33	30.3
Neither agree nor disagree	54	49.5
Disagree	16	14.7
Strongly Disagree	2	1.8
No response	2	1.8
It is Helpful to Know the Coming Growing Season Climate will Differ from Normal	**N**	**%**
Strongly Agree	60	55.0
Agree	44	40.4
Neither agree nor disagree	5	4.6
Disagree	0	0.0
Strongly Disagree	0	0.0
It is Helpful to Know the Coming Growing Season Climate will Differ from Typical	**N**	**%**
Strongly Agree	50	45.9
Agree	56	51.4
Neither agree nor disagree	3	2.8
Disagree	0	0.0
Strongly Disagree	0	0.0

g. Format Preference of Weather and Climate Forecasts

Out of 109 respondents, 97 extension agents feel freeze alert forecasts would be useful, as shown in Table 8. Over 50 agents agreed that certain other forecast categories would be useful, including disease risk, growing degree days, plant moisture stress, climate risk, El Niño/La Niña phase, and cooling/heating degree days. Over 35 respondents consider forecasts of yield risk, livestock heat stress index, wildfire risk, lawn and garden moisture index, and chill hour accumulation to be valuable. Three of the respondents suggested other forecasts which would be helpful, such as drought, flood, wind, moisture patterns, and weather forecasts.

Table 8. Preference for Climate Forecasts (N=109).

Useful Forecasts to Clientele (Check All That Apply)

		N	%
Freeze alert		97	89.0
Wildfire risk		40	36.7
Climate risk		64	58.7
Disease risk		77	70.6
El Niño/La Niña phase		52	47.7
Growing degree days		75	68.8
Cooling/heating degree days		51	46.8
Lawn and garden moisture index		39	35.8
Yield risk		43	39.4
Chill hours accumulation		38	34.9
Plant moisture stress	65	59.6	
Livestock heat stress index		42	38.5
Other		4	3.7

Format Preference for Receiving Forecasts (Check All That Apply)

		N	%
Telephone	4	3.7	
Fax		4	3.7
E-mail		102	93.6
World wide web		49	45.0
Text messages		7	6.4
Extension bulletins		22	20.2
Mail		7	6.4
Television	13	11.9	
Radio		6	5.5
Podcast		3	2.8

Format Preference in Providing Forecasts to Clientele (Check All That Apply)

		N	%
Telephone	54	49.5	
Fax		9	8.3
E-mail		80	73.4
World wide web		32	29.4
Text messages		1	0.9
Radio		12	11.0
Mailed newsletter		77	70.6
Meetings		64	58.7
Site visits		59	54.1
Podcast		1	0.9
Other		1	0.9

Which of the following would be most useful? (assume you normally receive 5 inches of rain)

		N	%
During January there is a 70% probability that precipitation will be greater than average		34	31.2
During January there is a 70% probability that precipitation will be greater than 8 inches	27	24.8	
During January there is an 85% probability that precipitation will exceed 2 inches	13	11.9	
During January there is a 30% probability that precipitation will exceed 5 inches	6	5.5	
During January there is an 80% probability that precipitation will be less than last year		9	8.3
No preference		9	17.4
No response	1	0.9	

Most agents would like to receive forecasts and provide forecasts to clientele by email as shown in Table 8. Out of a total of 109 respondents, 49 extension agents also prefer to receive forecasts through the World Wide Web. More than half of respondents wish to provide forecasts to their clientele through mailed newsletters, meetings, site visits, and telephone contact. In addition, most extension agents prefer forecasts that can predict abnormal conditions with a high probability. Approximately 17% of respondents have no preferred climate forecast format.

h. Impact of Using Climate Forecast Advice

Out of a total of 109 respondents, 93 extension agents feel that their clientele can use climate forecasts to improve planting schedules as shown in Table 9. Over 50 agents out of a total of 109 respondents conclude that their clientele can utilize climate forecasts to enhance other areas including harvest planning, variety or crop selection, irrigation management, nutrient management, allocation of land to crops or activities, and integrated pest management. Over 30 out of a total of 109 respondents also believe that clientele can use climate forecasts to improve waste management, spacing or stand density, labor management, and marketing. One respondent suggested another area that could be improved is municipal water management and/or water restrictions. Another agent felt none of these areas could be advanced since, "forecasts are not that good".

As shown in Table 9, most extension agents felt clientele would be able to use climate forecasts to improve their economic status by a reduction in risk of economic losses and/or by an increase in profitability. With better climate forecasts, 90 out of a total of 109 respondents believe crop growers could improve planting dates. Over 50 out of a total of 109 agents also felt improvements could be made to variety selection, irrigation planning, and land allocation. With enhanced climate forecast information, over 50 out of a total of 109 extension agents agree that livestock producers could better manage their stocking rate, herd size, and feed purchases.

i. Economic Impacts

In order to quantify extension agents' knowledge of economic impacts and explore new areas for climate applications research, three multi-part questions were included in this survey. Agents responded about the average number of sprays for weed, disease, and insect control during the growing season in their particular region with regard to crops of corn, cotton, peanuts, soybeans, and fruit. Most extension agents were either unsure how to respond to these questions or provided no response.

With respect to corn, about 50% of extension agents felt their clientele sprayed twice for weed control during the growing season. Approximately 27% and 29% of respondents agreed that growers in their region sprayed once for disease and insect control, respectively. None of the agents felt their clientele sprayed corn for weed, disease, or insect control more than three times during the growing season.

About 34% of respondents felt that clientele on average sprayed cotton for weed control between two to four times. About 17% of agents agreed that clientele only sprayed cotton once or twice for disease control, and approximately 32% of respondents believed growers in their region sprayed cotton one to three times for insect control.

With regard to peanuts, approximately 28% of respondents agreed that clientele typically spray between two to four times for weed control during the growing season. About 29% of agents felt that growers spray peanuts on average two to six times for disease control, and one to three times for insect control during the growing season.

The majority of extension agents, about 40%, agreed that their clientele spray soybeans on average two times for weed control during the growing season, while about 10% of respondents felt growers spray either one or three times. Approximately 27% of agents agree that clientele spray soybeans once for disease control during the growing season, and 33% of

Table 9. Impacts of Utilizing Climate Forecasts (N=109).

People I Work with Can Use Climate Forecasts to Improve… (Check All That Apply)	N	%
Planting schedules	93	85.3
Allocation of land to crops or activities	62	56.9
Labor management	33	30.3
Harvest planning	72	66.1
Waste management	35	32.1
Nutrient management	66	60.6
Irrigation management	67	61.5
Marketing	33	30.3
Variety or crop selection	68	62.4
Spacing or stand density	34	31.2
Integrated pest management	54	49.5
Other	2	1.8
No response	4	3.7

People I Work with would be able to Use Climate Forecasts to… (Check All That Apply)	N	%
Increase their profitability	60	55.0
Reduce the risk of economic losses	89	81.7
Reduce expenditures	45	41.3
Modify insurance coverage	51	46.8
Gain an edge over competing producers	35	32.1
Purchase the correct insurance products	49	45.0
Take greater advantage of market changes	41	37.6
Climate forecasts will not impact their decisions	9	8.3
No response	8	7.3

If they had better climate forecasts, crop growers could improve… (Check All That Apply)	N	%
Planting dates	90	82.6
Land allocation	60	55.0
Variety selection	73	67.0
Irrigation planning	70	64.2
Storage planning	43	39.4
Purchases	46	42.2
Product marketing	43	39.4
Labor costs	36	33.0
Climate forecasts would not improve management	7	6.4
No response	6	5.5

With better climate forecasts, livestock producers could better manage… (Check All That Apply)	N	%
Storage planning	29	26.6
Field rotation	47	43.1
Stocking rate	60	55.0
Feed purchases	57	52.3
Herd size	59	54.1
Marketing	38	34.9
Labor costs	27	24.8
Climate forecasts are not useful	7	6.4
No response	28	25.7

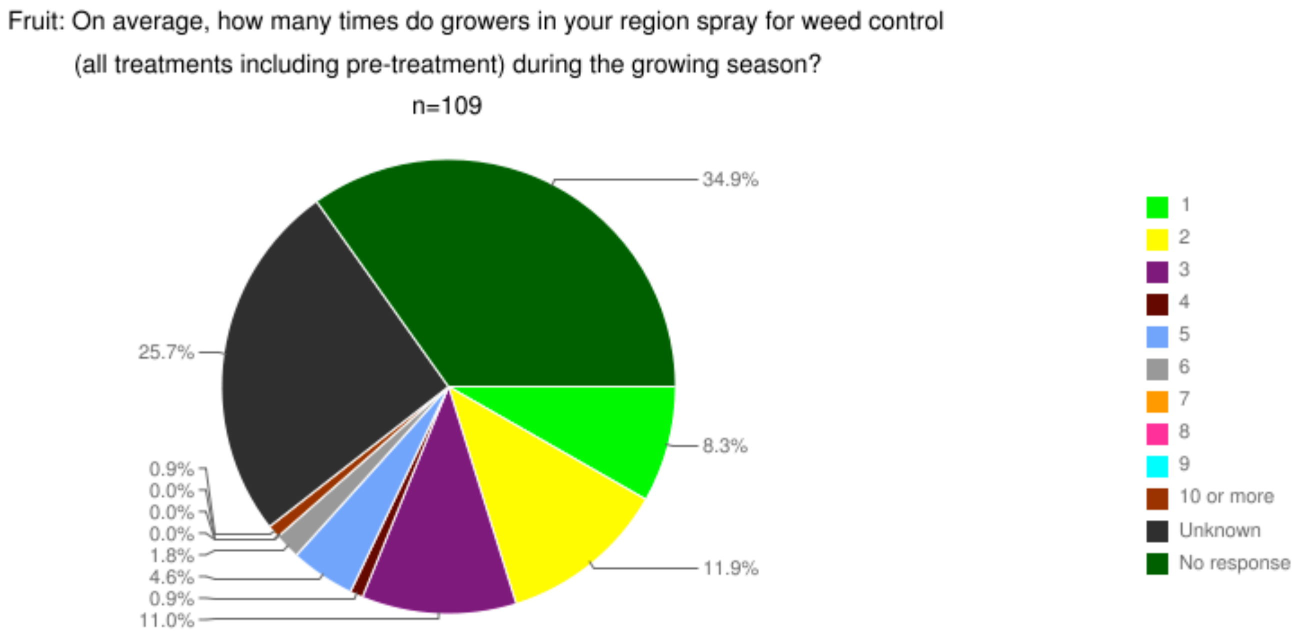

Figure 6. Average number of times clientele spray fruit for weed control (including pre-treatment) during growing season.

respondents agree with this statement with respect to insect control.

As shown in Figures 6 to 8, about 31% of extension agents understood that clientele spray fruit between one to three times for weed control during the growing season. With regard to how often clientele spray fruit for disease and insect control, agent responses demonstrated a wide range, yet fairly even distribution, varying from two to ten or more sprays.

Climate and weather applications have shown promise as decision support tools for optimizing the amount and number of pesticide applications in crops (Pavan et al., 2009). The potential benefits of climate and weather-based pesticide spraying are that growers will be able to apply pesticides only when conditions are favorable for disease development, thus reducing the number of applications and production costs without compromising disease control. This will also benefit the consumer population and other stakeholders.

Graphical representations of the 55 survey questions are accessible at: http://www.nc-climate.ncsu.edu/ ag_survey_stats.php. To display the results, dynamically generated pie charts were created using PHP scripts and Google charts technology. Please note that question 35 was omitted due to data collection issues.

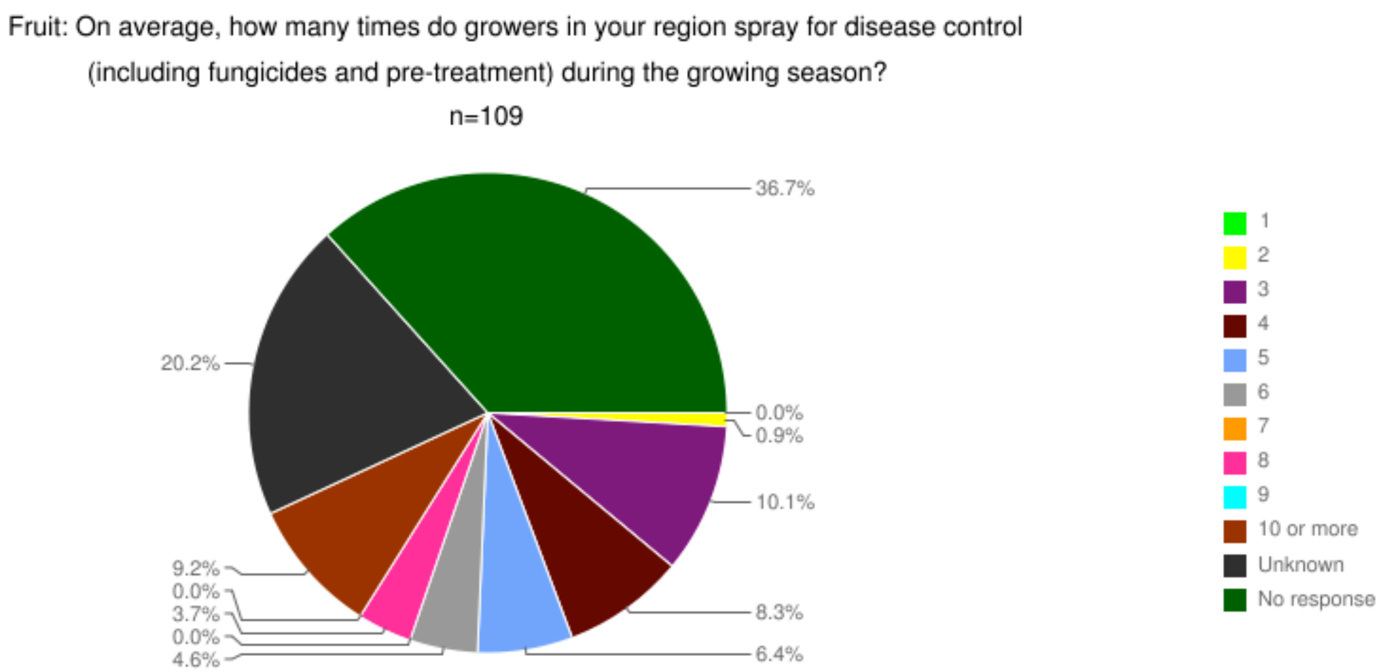

Figure 7. Average number of times clientele spray fruit for disease control (including fungicides and pre-treatment) during growing season.

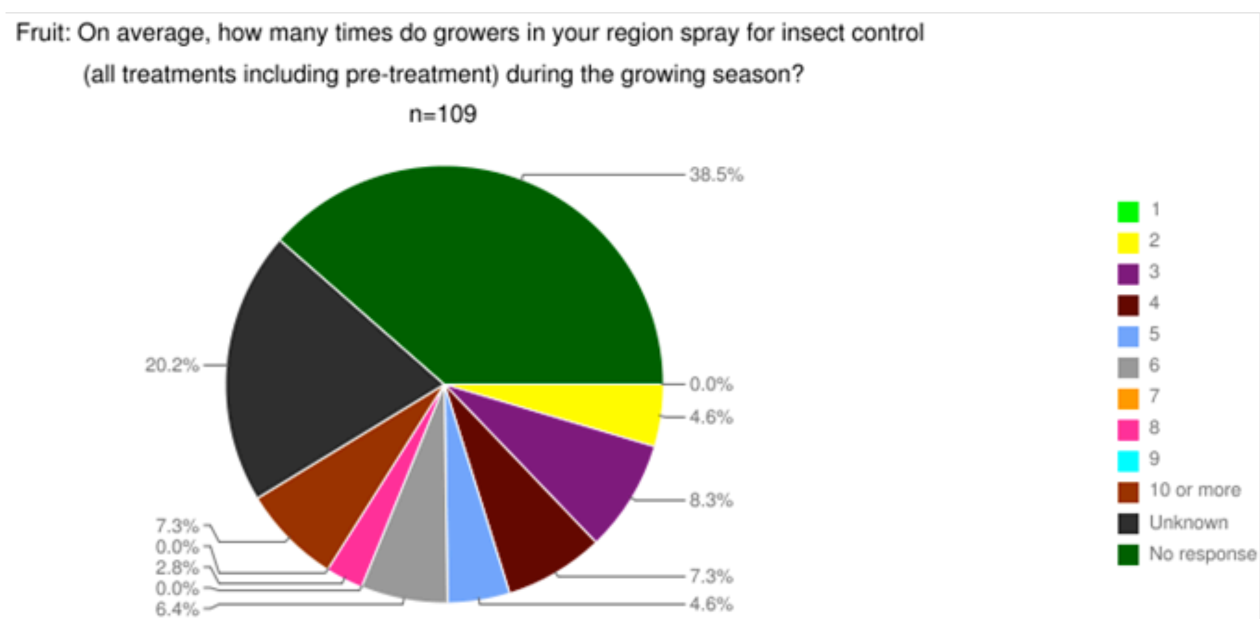

Figure 8. Average number of times clientele spray fruit for insect control (including pre-treatment) during growing season.

4. Conclusions

Baseline surveys are fundamental sources of data on perspectives, attitudes, suggestions, and opinions of climate information and decision support system projects. They allow more focused attention, direction, and funding to be placed on specific demographic or geographical areas where positive opportunities for results exist. Baseline surveys also allow for the study of more difficult areas and demographics where novel communications and social science methodologies may have to be developed to reach diverse and specific audiences.

A few key concepts prevail from the results of this survey, such as an interest from extension agents in climate forecasts and more importantly, a desire to provide this type of forecast to their clientele. This generally positive "willingness to use" suggests that no insurmountable barrier exists against the adoption of climate forecast and decision support tool technology. No particular tool stands out as most appealing to extension agents; instead there appears to be an overall interest for all tools. The survey points out that a principal use for climate forecasts is as an educational tool. This coincides and reinforces findings from a survey conducted among extension agents in South Florida (Breuer 2005).

Uncertainty exists among agents with regard to climate forecast reliability in prediction of certain events, such as extreme dryness, freeze, and crop failures or low yields. Most agents require over 75% accuracy in the climate forecasts, so it is important to convey the uncertainty and skill level of the current forecast technology.

Among the survey results, there exists a general theme of an educational opportunity for the agents and their clientele. As an example, about 35% of extension agents are unsure if growers, producers, and decision makers in their region are interested in using climate forecasts, which suggests a research gap and educational opportunity. NCSU has already embraced this through AgroClimate training workshops during March 2009. In this effort, collaborating with individuals in other southeastern states through the Southeast Climate Consortium has been, and will continue to be, a key aspect for the success of this research.

The results generally agree with findings of Cabrera et al. (2006) and Breuer et al. (2010). This suggests that perceptions among extension personnel regarding awareness and understanding of climate forecasts, needs and interest in climate forecasts, format preferences, and areas for further research and development of climate risk tools may be approachable at a broader, regional scale. It must be understood, though, that in spite of the general agreement among surveys from different southeastern states, meeting local needs and interests is fundamental for success.

As an example of this, objectives of this study included determining information gaps, priority areas for research, and the need for new AgroClimate climate risk tools for target extension and producer communities. Results suggest that a fruitful area of research would be in plant pathology and its connections with climate variability and change. Baseline information is needed about how, when, and why producers apply pesticides. Along with this knowledge, research in the areas of climate thresholds, crop regions.phenology, crop modeling, learning communities, and climate literacy is needed. Societal benefits from this research might include higher farm incomes, environmental health improvements, improved marketing capabilities, and increased consumer confidence in foods produced with a minimum of pesticides.

A combination of research and applications at both the regional and the local scale is the appropriate manner of moving forward with climate science in the southeastern United States. In addition, this study may present useful methods and results that may be transferred to other regions and sub-regions.

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