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Conversing about Citrus Greening: Extension's Role in Educating about Genetic Modification Science as a Solution

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Abstract

Extension agents across the nation will need to facilitate difficult conversations with the public if genetic modification (GM) science is used to combat citrus greening disease. This study used the innovation characteristics described by Rogers to explore if using GM science as a solution to citrus greening had diffused amongst US residents. An online survey was completed by 1,051 respondents across the US. Respondents were then classified into geographic regions. Demographic differences amongst respondents from the regions were identified; however, respondents from all regions had neutral perceptions of GM science's compatibility, trialability, complexity, and observability. All regions aside from the West agreed there was a relative advantage to using GM science; the West neither agreed nor disagreed. The Midwest was the only region with half of respondents agreeing they would consume GM citrus. All diffusion characteristics aside from observability were predictors of GM citrus consumption, and when accounting for diffusion characteristics, the Midwest was less likely to consume GM products when compared to the Northeast. Recommendations are offered for how extension agents can develop educational programming tailored to the needs of their regions to aid consumers in making educated decisions about GM citrus in the future.

Keywords: diffusion of innovations, extension, citrus, citrus greening

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Introduction

Extension agents are often referred to as "change agents" and help communities adapt to a variety of issues (Peek et al., 2015). Extension is not only tasked with educating the public (Benge,

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Harder, & Carter, 2011) but engaging the public to help solve complex problems (Warner, Hinrichs, Schneyer, & Joyce, 1998). These problems are not always simple, and extension agents have been asked by university and public leaders to facilitate conversations with the public about contentious and controversial topics (Patton & Blaine, 2001; Welch & Braunworth, 2010).

One of the most complicated topics extension agents communicate about is conventional versus nonconventional agriculture (Martin, 2016) and includes discussions about genetically modified (GM) crops (U.S. Department of Agriculture [USDA], 2015). In the past, extension agents have felt unprepared to foster conversations with the public about GM science and have expressed concern about providing the public with balanced information (Brown, Kiernan, Smith, Highes, 2003). A recent meta-analysis concluded that GM crops posed no harm to human health (National Academy of Sciences, 2016; Nicolia, Manzo, Veronesi, & Rosellini, 2014), yet consumers have historically expressed suspicion of the technology (Senauer, 2013) and have been unsure about its associated risks and benefits (Ruth & Rumble, 2016). President Obama signed a law in August of 2016 that mandated food containing GM ingredients be labeled (Popken, 2016), which will likely drive more conversations amongst the public on the topic. To complicate matters, people living in different areas may hold varying agricultural values and require tailored extension education programs (Martin, 2016).

GM science may be a topic of debate, but it may also be the only way to save the citrus industry as it battles citrus greening (Allen, 2016). This disease is destroying the US citrus industry with no current solution. Citrus greening, or Huanglongbing (HLB), is caused by a bacterium spread by a small insect called the Asian citrus psyllid (UF/IFAS Citrus Extension, 2016a). The disease affects the entire tree and causes the fruit to taste bitter (UF/IFAS Citrus Extension, 2016b). There is no cure for citrus greening and no management practices that would be affordable for farmers (Singerman & Useche, 2016). Production dropped by over 100 million boxes in Florida during the 2014 season, and farmers reported 80% of their trees have been infected with HLB (Singerman & Useche, 2016). This disease could be the end of the $9 billion citrus industry in Florida (Voosen, 2014). Researchers have already used genetic science to create trees resistant to citrus canker, another major citrus disease, and have been using similar strategies to test greening resistant trees as well (Allen, 2016). Scientists are optimistic that GM science will be used to create citrus greening resistant trees in the near future (Allen, 2016). Experts in the industry expect that GM citrus trees could be the solution to the problem but only if consumers are willing to purchase and drink GM orange juice (Voosen, 2014).

Citrus production is not limited to Florida alone, with California and Texas as the two other major citrus producing states in the US (USDA, 2016b). Citrus greening had reached all three citrus producing states by 2014 (Harrell, 2014). While the disease has the potential to devastate citrus producing communities, consumers across the US will be affected if a solution is not found. Orange juice prices are expected to rise due the disease (Perez, 2017), and consumption of orange juice is expected to increase as well (USDA-Foreign Agricultural Services [FAS], 2016). However, consumers also use citrus in desserts, entrées, mixed drinks, home goods, and beauty products (Florida Department of Citrus, 2017), which could make the impact of citrus greening on consumers widespread if they are not able to find or purchase citrus products (USDA- FAS, 2016).

Extension agents are not always properly engaged with the public concerning agricultural issues (Gay, Owens, Lamm, & Rumble, 2017). With GM science as a viable solution to the disease, extension agents will need to learn how to facilitate potentially difficult conversations between researchers, growers, and consumers. Extension agents' concerns about balancing facts and values regarding GM science (Brown et al., 2002) will need to be addressed before proper educational programming can be developed.

Even though citrus is primarily grown in three states, orange juice is consumed across the nation. As a national problem, extension agents need to be able to recognize how different regions of the US view GM science as a solution to citrus greening. Differences in newspaper coverage of GM science have been identified between regional areas of the US (Crawley, 2007), which may be reflective of residents' attitude toward the technology. Variations in political ideology across the nation could also lead to differing degrees of acceptance of GM science as well. In accordance with Priority 2 of the National Research Agenda (Roberts, Harder, & Brashears, 2016), the purpose of this study was to explore the diffusion of the idea of using GM science amongst US residents as a solution to citrus greening in different regions of the US.

Theoretical Framework

Diffusion of innovations theory provided the framework for this study. Rogers (2003) described an innovation as a type of idea or practice that a group or person would consider new. The adoption of the innovation is dependent upon its perceived relative advantage, compatibility, complexity, trialability, and observability. The relative advantage of the innovation only has to be perceived by the person/group as being better than an alternative and does not have to be concrete (Rogers, 2003). How well the innovation aligns with the adopters' social norms and values is its compatibility. Complexity describes how easy or difficult it is to understand the innovation, and trialability is how easily it can be tested. The final characteristic, observability, describes how well potential adopters can view others using the innovation. Innovations high in relative advantage, compatibility, trialability, and observability but low in complexity will diffuse the quickest through a group (Rogers, 2003). Additionally, people who guide others' behaviors through social interactions, or opinion leaders, influence the rate of adoption for an innovation. After an opinion leader shares his or her experience with the innovation, the diffusion typically spreads (Rogers, 2003).

Extension has explored the diffusion of GM science amongst farmers (Perterson, Cassman, & Cantrell, 2002), but there have been few studies examining the diffusion of GM science amongst consumers. Weick and Walchi (2002) used the theory to explore diffusion of GM science with the public. The researchers concluded the relative advantage of GM crops provided benefits to farmers, but consumers viewed GM crops as having health, ethical, and environmental disadvantages compared to non-GM crops (Weick & Walchi, 2002). However, GM science was found to align more with American values when compared to Europeans, which made the innovation moderate in compatibility. Distinction between traditional, selective breeding of crops and genetic engineering has increased the complexity of understanding GM crops for the consumer (Weick & Walchi, 2002). While there are plenty of opportunities for consumers to purchase and try GM food, many of the GM products on the market do not directly benefit consumers. Consumers may have eaten GM food and not realized it, which lowered the trialability. Similarly, consumers were unable to observe the benefits of others using GM food due the lack of direct benefits, which also lowered observability (Weick & Walchi, 2002).

Klerk and Sweeney (2007) researched the effect of knowledge on perceptions of risk and adoption of GM food. The researchers concluded that for perceptions of relative advantage to increase, consumers would have to possess more positive attitudes toward the innovations than they did at the time. Rumble et al. (2016) looked specifically at the diffusion of GM science to combat citrus greening amongst undergraduate students in a citrus growing state. Relative advantage was the only diffusion characteristic viewed positively by the students; however, compatibility was the only characteristic predictive of students' likelihood of consuming GM citrus. Rumble et al. (2016) suggested research should be conducted on consumers nationwide to determine if the millennial generation differs in their attitudes toward GM science and purchasing behavior when compared to the average consumer.

The research for this manuscript explored what US consumers believe about the diffusion of GM science, specifically examining perceptions of diffusion characteristics, and determined if differences exist in different regions of the US. The U.S. Census Bureau (2015) divided the country into four main regions: Northeast, South, Midwest, and West. The southern region includes Florida, Georgia, South Carolina, North Carolina, Virginia, West Virginia, Maryland, Delaware, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas. The southern region of the US has over one-third of the farms in the nation and is known for growing high yields of cotton and fruits (USDA, 2000). In 2012, 94% of cotton fields were GM (USDA, 2016a). Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania are all considered Northeastern states. This is the most populous region of the US, but accounts for 15% of US farms and 9% of the total cropland. Midwestern states have more cropland than any other area, the largest farms, and grow mostly cash grains (USDA, 2000), which include corn and soybeans. Eighty-five percent of corn acres and 75% of soybean acres in the US have been planted with GM crops (Fernandez-Cornejo, Wechsler, Livingston, & Mitchell, 2014). North Dakota, South Dakota, Nebraska, Kansas, Montana, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio are all considered Midwestern states. Western region agriculture includes high production of fruits and more non-family farms than any other regions; however, this region has the least amount of cropland (USDA, 2000). Western states are Washington, Oregon, Idaho, Montana, Wyoming, Colorado, Utah, Arizona, New Mexico, Nevada, and California. The final US region is the Pacific region and includes Alaska and Hawaii. Alaska is not known for growing GM crops, but approximately 75% of the papaya in Hawaii were developed with GM science to stop the spread of a virus that was devastating the islands (Callis, 2013).

Purpose and Objectives

The purpose of this research was to explore the diffusion of GM science as a potential solution to citrus greening amongst different regions of the US so extension programs can be developed applicable to discussing GM science. The following research objectives guided this study:

RO1: Describe respondents in the Southern, Northeastern, Midwestern, and Western regions of the US.

RO2: Describe different regions' perceptions of GM science's diffusion characteristics.

RO3: Explore differences in regions' perceptions of GM science's diffusion characteristics.

RO4: Explore differences in regions' likelihood to consume GM citrus products.

RO5: Determine how US region, relative advantage, compatibility, complexity, observability, and trialability predict likelihood to consume GM citrus products.

Methodology

An online survey instrument was used to collect the data for this study. The population of interest was US residents, 18 years and older. Qualtrics, an online public opinion research company, distributed the instrument to a non-probability sample of an opt-in panel. The survey was distributed to 1,751 potential respondent in all 50 states in the US. To ensure responses were received from each state, quota sampling procedures were used at the beginning of the instrument. Additionally, two attention filters were used in the survey to ensure respondents were thoughtfully considering the questions. There were 1,051 respondents who met the quota requirements and passed the attention filters, which resulted in a 60% participation rate. Post-stratification weighting procedures were used to increase the generalizability of the research. The respondents' demographics were weighted on sex, race, and age to reflect the 2010 National Census. Weighting procedures can lessen the effects of non-probability sampling, such as exclusion, non-participation, and selection bias, and provide representation sometimes better than probability sampling (Baker et al., 2015).

Although this research was part of a larger study, six constructs in addition to demographic questions were analyzed to fulfill the purpose. All questions were researcher-developed. Demographic questions included age, sex, income, education, race (check all that apply), ethnicity, and political affiliation.

Semantic differential and Likert-type scales were used to collect respondents' perceptions of GM science's diffusion characteristics. Relative advantage, compatibility, and trialability were measured with Likert-type scales that included 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, and 5 = *strongly agree*. Relative advantage used eight items, which were averaged, to create the construct. Higher scores represented agreement that GM science offered a relative advantage. The items included statements like "GM science increases the amount of food a farmer can grow" and "GM science enhances the taste of food."

Compatability was measured with a six-item scale that asked repsondents how GM science aligned with their personal values and beliefs. Negatively framed statements like "Overall, GM science does more harm than good" were reverse coded so that a five indicated respondents agreed GM science was compatible. The items were averaged to make the construct.

Trialability used five statements like "food products that result from plants made with GM science are easy to try" and "if given the opportunity, I would try food products that result from plants made with GM science." Each statement was coded so that five indicated agreement that food made by GM science could be tried and one indicated disagreement. The construct was measured by averaging the five items. Real limits were created to aid in the interpretation of the results (Sheskin, 2004). Relative advantage, compatibility, and trialability used the following real limits: 1.00 – 1.49 = *strongly disagree*, 1.50 – 2.49 = *disagree*, 2.50 – 3.49 = *neither agree nor disagree*, 3.50 – 4.49 = *agree*, 4.50 – 5.00 = *strongly agree.*

Five-point, semantic differential scales measured respondents' perceptions of complexity and observability. Negative adjectives, such as "complex" and "invisible," were assigned a one and positive adjectives, like "simple" and visible" were assigned a five. The complexity construct included six pairs of adjectives and observability included six pairs too. Both constructs were created by averaging the items in each scale.

To determine if the idea of GM science had diffused amongst respondents, the final question asked their likelihood of consuming fruit or juice grown on a GM tree. A five-point Likert-type scale with the following labels was used to answer the question: 1 = *extremely unlikely*, 2 = *unlikely*, 3 = *neither likely nor unlikely*, 4 = *likely* and 5 = *extremely likely.* The question was recoded into a dichotomous vairable to use as the dependent variable in a logistic regression. Respondents were coded as likely to consume GM citrus products if they selected likley or extremely likely to consume the fruit, and were coded as not likely to consume GM citrus products if they selected the altenatives.

A panel of experts reviewed the survey prior to distribution to account for the validity of the instrument. The panel included an associate professor with expertise in survey design, an assistant professor who specializes in food production and the Associate Director for the Center for Public Issues Education at the University of Florida (UF). After receiving IRB approval from UF, a pilot test confirmed that all constructs, except one, were reliable at an alpha level of at least 0.7 (Field, 2013). Initially, trialability had a Cronbach's α of .67. After removal of one item in the construct, reliability increased to .76. In order to avoid a history effect, the survey was only open for two days (Ary, Jacobs, & Sorensen, 2010).

Regions of the US were created following the US census guide, with the Pacific region included with the Western region due to the small sample size. For objectives one and two, simple descriptive statistics were used to analyze the results. Objective three was fulfilled by using an ANOVA and a *post hoc* test. Because of unequal groups sizes in the regions, Tukey-HSD was used to determine individual differences between regions. Descriptive statistics and Chi-square analysis were used to explore obejctive four. Finally, a logistic regression was used to fulfill objective five. The regions were recoded as dummy variables, and the Northeast was treated as the control because it had the largest sample size (Field, 2013).

Results

Description of Respondents

The weighted demographics of the respondents can be seen in Table 1. The largest proportion of respondents in the South and Midwest were between the ages of 45 and 64. The largest age group in the Northeast and West was 25 to 44. The Northeast and Midwest were also the only regions where the majority of respondents were women. All four regions had similar education characteristics, but the Northeast had more respondents earning $150,000 or more annually compared to other regions. Nearly a quarter of respondents in the Northeastern and Western regions identified themselves as Hispanic. The West also had the highest proportion of respondents whose race was categorized as other and smallest proportion of white respondents. The largest political affiliations in the Midwest and West were independent, while almost half of the Northeast respondents and one-third of Southern respondents were democrats.

Table 1

Description of Respondents

	South *n* = 253 %	Northeast *n* = 317 %	Midwest *n* = 254 %	West *n* = 227 %
Age				
18-24	12	11	12	10
25-44	33	43	28	41
45-64	37	29	38	34
65+	18	18	23	16
Gender				
Female	49	57	51	46
Male	52	43	49	54
Education				
High School or less	17	14	14	20
Some College	30	22	30	26
2-year College Degree	14	11	8	13
4-year College Degree	27	35	32	27
Graduate or Professional School	12	19	16	15
Income				
$25,000 >	16	15	23	16
$25,000 -$49,999	25	18	33	28
$50,000 -$74,999	22	10	19	20
$75,000 -$149,999	34	35	20	32
$150,000 or more	4	14	6	4
Race				
White	84	80	82	69
African American	14	16	11	11
Other	3	6	8	24
Hispanic	3	24	4	26
Political Affiliation				
Republican	30	16	16	22
Democrat	36	50	33	36
Independent	32	31	41	37
Other	2	3	2	5

Regional Perceptions of Diffusion Characteristics

The South, Northeast, and Midwest respondents agreed that GM science had a relative advantage, but the West neither agreed nor disagreed about the relative advantage (see Table 2). All four regions neither agreed nor disagreed about the compatibility or trialability of GM science. Additionally, all regions indicated that GM science was average in complexity and observability.

Table 2

Description of Regions' Perceptions of GM Science Relative Advantage, Compatibility, Complexity, Observability, and Trialability

	South n = 253 M (SD)	Northeast n = 317 M (SD)	Midwest n = 254 M (SD)	West n = 227 M (SD)
Relative Advantage	3.58 (0.76)	3.62 (0.69)	3.61 (0.71)	3.49 (0.75)
Compatibility	3.22 (0.74)	3.30 (0.73)	3.26 (0.67)	3.18 (0.46)
Complexity	2.65 (0.75)	2.77 (0.79)	2.61 (0.79)	2.61 (0.74)
Observability	2.89 (1.09)	2.67 (0.95)	2.56 (0.95)	2.59 (0.91)
Trialability	3.32 (0.80)	3.47 (0.72)	3.27 (0.65)	3.25 (0.84)

Differences Regional Perceptions of Diffusion Characteristics

ANOVAs between the regions and the diffusion characteristics were not statistically significant for relative advantage and compatibility. However, statistically significant differences were identified between region and complexity (F (3, 1046) = 2.97, p = .03), observability (F (3, 1046) = 5.37, p < .01), and trialability (F (3, 1046) = 4.82, p < .01). *Post hoc* tests identified the Northeast viewing GM science as more complex compared to the Midwest, and the South viewing GM science as more observable than the Midwest and West. Additionally, the Northeast viewed trialability as greater than the Midwest or West (see Table 3). There were no other statistically significant differences between regions.

Table 3

Follow-up Tukey-HSD between Regions and Diffusion Characteristics

	I	*J*	*Mean Difference (I-J)*	*p*
Complexity	Northeast	South	.13	.21
		Midwest	.17	.05*
		West	.16	.08
Observability	South	Midwest	.31	.00**
		Northeast	.20	.07
		West	.29	.00**
Trialability	Northeast	South	.15	.08
		Midwest	.20	.01**
		West	.21	.00**

Note. *$p < .05$, ** $p < .01$

Likelihood to Consume GM Citrus by Region

The majority of respondents in each region indicated they were not likely to consume GM citrus products (see Table 4). The only exception was the Midwestern respondents were split on whether or not they would consume GM citrus products. A chi-square between region and likelihood to consume GM citrus was not statistically significant, which indicated region of origin did not impact likelihood to consume GM citrus (X^2 (3) = 6.12, p = .11).

Table 4

Respondents Likely to Consume GM Citrus Products

	n	*%*
South	253	39
Northeast	317	46
Midwest	254	50
West	227	43

Predicting Likelihood to Consume GM Citrus

The logistic regression model was statistically significant ($X^2(8) = 414.82$, $p < .00$) and could account for approximately 43.7% ($pseudo\text{-}R^2 = .437$) of the variance in likelihood of consuming GM citrus products. When accounting for the diffusion characteristics in the model, Midwest respondents were less likely to consume GM citrus products compared to Northeast respondents. Relative advantage, compatibility, complexity, and trialability were all statistically significant predictors of likelihood to consume GM citrus, but observability was not. As the relative advantage of GM science increased by one, the log odds of consumers likely to consume GM citrus products increased by 3.24. Additionally, as compatibility, complexity, and trialability increased by one, the log odds of likelihood of consuming GM citrus products increased by 1.98, 1.43, and 2.20 respectively. A full description of the results can be seen in Table 5.

Table 5

Likelihood of Consuming GM Citrus

	b	*Log Odds*	*p*
Midwest	-.53	.59	.01**
South	.21	1.24	.33
West	-.30	.74	.16
Relative Advantage	1.18	3.24	.00**
Compatibility	.70	1.98	.00**
Complexity	.36	1.43	.00**
Trialability	.79	2.20	.00**
Observability	.02	1.02	.83

Note. ** $p < .01$

Conclusions and Implications

With GM science as one of the few viable solutions to citrus greening, this research sought to examine the diffusion of the idea of GM science in different US regions to assist in developing extension programs that help producers communicate with consumers about GM science use in citrus production. Respondents in all four regions, South, Northeast, Midwest, and West, had neutral perceptions of the compatibility, complexity, trialability, and observability of GM science. This finding is reflective of consumers being unsure about the associated risks and benefits of GM science (Ruth & Rumble, 2016). Additionally, observability and trialability have been difficult for consumers to identify (Wieck & Walchi, 2002), which may explain the neutral perceptions. Similar to what was found by Rumble et al. (2016) respondents did positively perceive the relative advantage of GM science in the South, Northeast, and Midwest, but Western region respondents were neutral about the advantages. Based on Rogers (2003) description of the diffusion characteristics, the idea of GM science has likely diffused throughout the public more so in the South, Northeast, and Midwest compared to the West. However, the neutral perceptions of the diffusion characteristics aside from relative advantage indicated the technology has not yet been fully adopted by the public. While statistical associations were noted between the regions for the complexity, observability, and trialability of GM science, the large standard deviation for the scores indicated that practical differences were not present. Although these regions have varying types of agricultural production (USDA, 2000), political climates, and news coverage of GM science (Crawley, 2007), the residents shared similar views toward the technology.

Regardless of region, at least half of the respondents indicated they were not likely to consume GM citrus, which could be devastating to the citrus industry if GM science were to be used to combat citrus greening. The regions with the highest percent of respondents reporting they would not consume GM citrus were the South and West. These regions include Florida, Texas, and California – the top three citrus producing states in the country (USDA, 2016b). This evidence indicates a possible disconnect between the consumers in these areas and understanding the severity of citrus greening in their communities and on their state economy. Since GM food will be labeled in the near future (Popken, 2016), consumers will be alerted if their citrus is GM and less likely to purchase it. If producers are able to save their groves with GM science but unable to sell their product, the industry will remain in distress.

Even though the South, Northeast, Midwest, and West had similar perceptions toward GM science and likelihood to consume GM citrus products, living in the Midwest was predictive of likelihood to consume the GM fruit. Compared to the Northeast, Midwest consumers were a little more than half as likely to consume GM citrus. This finding was supported by Midwest respondents viewing GM science as more complex and harder to try compared to the Northeast respondents. Viewing the diffusion characteristics in this way indicated diffusion of the idea of GM science would be less in the Midwest compared to the Northeast, when accounting for the diffusion characteristics (Rogers, 2003), and was supported by the regression model. The Midwest produces the highest yields of GM crops, like corn and soy, in the US (USDA, 2000), so this finding counters expectations that the residents of that area would be more supportive of GM science. A possible explanation is that Midwest residents may be more exposed to controversial discussions about use of GM science due to the amount of GM crops grown in the region, which makes them less likely to consume a GM product compared to the Northeast, where GM crops are not typically grown. Alternatively, this finding could be because citrus is not grown in the Midwest, and the residents do not see the connection or need for producing GM citrus. Further research is needed to explore and understand this finding.

Positive perceptions of relative advantage, compatibility, trialability, and complexity also increased odds of the likelihood of consuming GM citrus products. This finding differed from previous studies with college students where only compatibility was predictive of consumption (Rumble et al., 2016). This difference could be due to different values between college students and the general public. In addition, regional location was included in the analysis and may be accounting for variance in the model that was not accounted for in the study conducted by Rumble et al. (2016). Positive perceptions of relative advantage increased the odds of consumption by more than three, making it the strongest predictor, which was consistent with previous literature (Klerk & Sweeney, 2007). These findings supported the diffusion of innovations theory (Rogers, 2003) related to GM science and citrus greening.

Recommendations

If GM science is used as a solution for citrus greening, extension agents will need to facilitate difficult conversations in the future to address the issue. Most of the diffusion characteristics were viewed neutrally, which means polarized attitudes have yet to form for or against the technology. However, consumers were not likely to consume citrus produced using GM science, which is concerning. Consumers likely have questions or concerns about GM science, which is why their attitudes were mostly neutral. Extension can serve the role as liaison between researchers and the public (Patton & Blaine, 2001; Welch & Braunworth, 2010) to address these concerns and provide people with relevant information about GM science to form educated opinions.

Limited differences in regional perceptions of GM science were identified, but citrus producing regions of the US had the highest proportion of respondents reporting they would not be likely to consume GM citrus products. In these areas in particular, extension agents should create educational and awareness campaigns that highlight the importance of citrus in these communities and the effect of citrus greening on local farmers. Consumers may be uninformed about citrus greening, which could create a disconnect for why their citrus would be GM in the first place. Similarly, extension agents in the Midwest could also work on educating residents about citrus greening and GM science. Specifically, educational campaigns should focus on complexity, observability, and trialability since these characteristics were viewed differently in the Midwest compared to other regions. Additionally, since Midwestern respondents were less likely to consume GM citrus products than Northeastern respondents, increasing the personal relevance of citrus greening could help consumers make educated purchasing decisions. One way to emphasize relevance would be explaining that as the disease continues to spread, orange juice prices will likely increase.

Relative advantage, compatibility, complexity, and trialability were all predictors of likelihood of consuming GM citrus. Extension programs should focus on these four areas to provide the public with appropriate information to make purchasing decisions in the future. To address relative advantage, extension agents could present information about citrus greening and potential solutions to the problem so consumers can better understand how and why GM science would be used in citrus. Inviting opinion leaders and bloggers in communities to tour orange groves affected by citrus greening is another way to demonstrate the potential need for GM science in the citrus industry. By inviting opinion leaders specifically, the information can be shared with a broad audience that the public would view credible (Rogers, 2003). Bloggers could also help spread the information received on these tours to their followers who may not have citrus groves in their communities.

Compatibility with GM science can be addressed through forum style discussions about the technology. Providing people a safe space to express their concerns about the use of GM science and have their questions answered by university researchers and local farmers would allow extension agents to discuss more than just the science. Discussing concerns based on values and beliefs would allow people to make informed decisions about the compatibility of GM science. Concerns about complexity could also be discussed at these types of events. Small, informal discussions with scientists at local coffee shops or diners are one way to encourage discussion and lessen the complexity related to GM science. These strategies could ease extension agents' concerns about balancing consumers' worries related to both values and facts (Brown et al., 2002).

Trialability of GM science may be difficult for consumers to recognize they are participating in (Weick & Walchi, 2002), and extension agents should consider providing opportunities for people to try and reflect upon eating GM food. Hosting lunch and learns could help people identify what foods have been developed with GM science and recognize what GM food they are exposed to on a daily basis. Additionally, if GM science is used with citrus in the future, extension agents will need to proactively provide opportunities for consumers to try the fruit. Focusing on increasing trialability with opinion leaders would also help to increase the rate of adoption for GM citrus (Rogers, 2003).

Future research could utilize qualitative methods to gather deeper insight into people's perceptions and knowledge of GM science and their likelihood to consume GM citrus. Future research should seek to understand why consumers in the Midwest were less likely to consume GM citrus compared to the Northeast. To best understand this phenomenon, focus groups and interview should be used to gain an in-depth understanding of how consumers in the Midwest and other regions develop perceptions toward GM science and decide whether or not to consume the product. Additionally, this study measured likelihood to consume GM citrus, but providing respondents with the opportunity to try a hypothetical GM citrus (and telling them it was not GM after the study if the products are not on the market yet) would give researchers a better idea of people's behavior related to GM citrus consumption. This would help communicators and marketers best position GM citrus once they make it to market and provide extension the information needed to develop outreach related to GM citrus without losing time waiting to see consumers' actual intent to consumer the citrus. Another research possibility includes hosting a science café or discussion about GM science and collecting information about knowledge and perceptions of the technology. This information could provide extension agents with guidance for program development around GM science. With the passing of the labelling law for GM food, another potential line of research would be to see if consumers notice the label and how that affects their purchasing behaviors.

While this survey used post-stratification weighting to lessen the effects of non-probability sampling, simple random sampling of the US population would help increase the generalizability of the study. This study was also confined to US residents alone. Replicating the survey in other citrus producing countries, or to countries the US exports citrus to, could provide valuable insight into cultural differences in perceptions of GM science. While differences in perceptions were not found between the identified regions in the study, analyzing perceptions of GM science between citrus producing states and non-citrus producing states could yield different results.

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