THREE ESSAYS ON CONSUMER RESEARCH AND MARKET ANALYSIS FOR AGRICULTURAL PRODUCTS:

AN INTERSECTION OF AGRICULTURE, BUSINESS, AND ECONOMICS

A Dissertation

by

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DOCTOR OF PHILOSOPHY

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ABSTRACT

This dissertation is a study in consumer research and market analysis. In the first essay, I study the change in consumer willingness to pay for crapemyrtle plants due to pest infestation damage. The study showed that, the consumer willingness to pay (WTP) for crapemyrtles decreased, due to the changes in its attributes, such as flower density and bark color, resulting from crapemyrtle bark scale (CMBS). In the second essay, I study the effect of CMBS on businesses, by surveying their knowledge of CMBS, their thoughts and concerns about CMBS, and details about their business and sales. Results indicate that producers anticipate a significant decrease in the value of crapemyrtle if infested with CMBS, and suggest industry demand for CMBS control. An important finding of this research is that a majority of businesses support science-based CMBS control research. Another important finding from the study is that most producers believed that benefits of CMBS control outweigh the costs. I used a relative importance index to illustrate the ranking of different attributes of crapemyrtles that producers consider while making decisions about growing/purchasing the plants. Flower color was found to be the most important attribute, followed by disease resistance. Finally, in my third essay I study the effects of an external shock on the gardening industry. The COVID-19 pandemic has forced businesses to alter the way they operate-changing hours of operation, working with limited staff, and restricting customer access indoors. An important objective of this study is to investigate the extent of these impacts on different businesses based on their size (number of employees), business type (family or individual operation,

incorporated), type of operation (retail, wholesale, etc.), and revenue. In addition, the pandemic has also had an effect on the consumers. In this study, I conducted nationwide online consumer surveys to analyze the influence of COVID-19 on consumer behavior for plants gardening products. 46.21% of the consumers were spending more time gardening. 36.35% reported an increase in their gardening expenses, during the outbreak compared to last year. My research also incorporated the consumers' personal characteristics, such as age, gender, and income level, in the analysis of change in expenses.

DEDICATION

This dissertation is dedicated to the memory of my dearest *Daadi* and *Daadu*. This is a humble attempt on my part to honor their legacy.

ACKNOWLEDGEMENTS

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CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supervised by a dissertation committee consisting of Dr. Yu Yvette Zhang (advisor), Dr. Marco Palma, and Dr. Ximing Wu of the Department of Agricultural Economics and Dr. Mengmeng Gu of the Department of Horticultural Sciences and Dr. Yan (Lucy) Liu of the Mays Business School.

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NOMENCLATURE

CMBS	Crapemyrtle Bark Scale
MTurk	Amazon's Mechanical Turk
NASS	National Agricultural Statistics Service
TNLA	Texas Nursery and Landscape Association
USDA	United States Department of Agriculture
WTP	Willingness to Pay

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1. INTRODUCTION

Horticulture industry is an important part of the United States' economy, with the value of all horticultural crops sold being over $13.7 billion (USDA NASS 2019). Within the industry, crapemyrtle (*Lagerstroemia* spp.) is the most popular summer flowering tree (Figure 1.1) (USDA NASS 1998, 2009, 2014). Between 1998 and 2014, the total sales (by value) of crapemyrtles has almost doubled (Figure 1.1). It also saw a very sharp increase in the total volume sold between 1998 and 2014 (Figure 1.1) (USDA NASS 1998, 2009, 2014). Crapemyrtles are widely popular in the U.S. due to their beauty, relative ease in growing, availability of several varieties, and because they are comparatively free from pest issues (Pooler, 2007; Gu et al. 2014). Due to the diversity these offer, in terms of use and varieties, crapemyrtle has earned the nickname "lilac of the south" (Pooler, 2007).

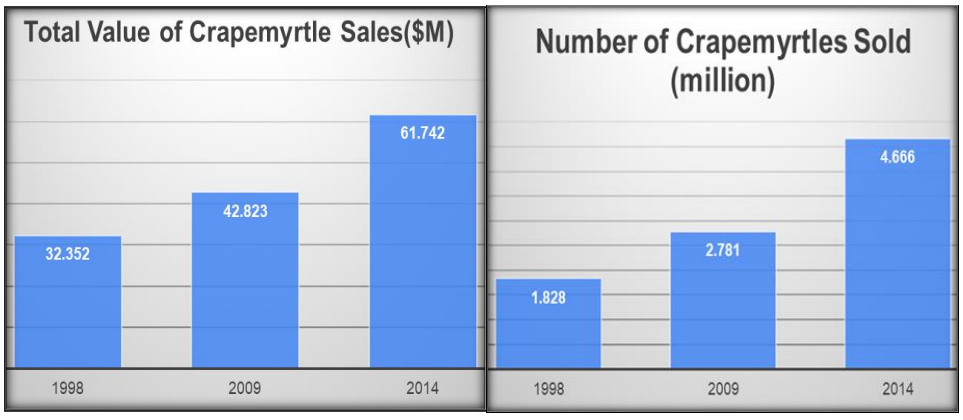

Figure 1.1 Historical Data on Crapemyrtle Sales (USDA NASS Census of Horticultural Specialties 1998, 2009, 2014)

Since crapemyrtles are valued for their aesthetic characteristics, any loss in their physical features would affect their value (Marwah et al. 2021). Pests, such as crapemyrtle bark scale (CMBS; *Acanthococcus lagerstroemiae* Borchsenius, 1960), can cause this (Gu, 2018). The first essay in this dissertation is aimed at studying the change in consumers' willingness-to-pay for crapemyrtle plants, due to loss in different physical characteristics. This research sets out to elicit consumers' willingness to pay (WTP) for important attributes affected by pest infestation. This provides a measure of monetary value to the damages caused by pests. The results suggest which attributes are valued most by the consumers. The results of the first essay indicated that the consumer willingness to pay (WTP) for crapemyrtles decreased by approximately 51.91%, due to the changes in its attributes, such as flower density and bark color, resulting from crapemyrtle bark scale (CMBS). I also analyzed the effect of consumers' personal characteristics, including their risk attitude, on their willingness-to-pay for crapemyrtle plants. The analysis showed that consumers' gender, race, age, marital status, household size, level of education, and type of employment affect their WTP for crapemyrtle plants.

Several stakeholders of the green industry such as growers, retailers, landscapers, and consumers are not aware of CMBS. Therefore, the production of crapemyrtle and its use in landscaping is expected to continue. This makes it extremely important to analyze the loss caused by CMBS, to the horticulture industry. My second essay is aimed at investigating how CMBS affected landscape plant industry in general and the crapemyrtle

growers in particular. Several crapemyrtle businesses were interviewed where they answered several questions regarding their knowledge of CMBS, their thoughts and concerns about CMBS, and details about their business and sales. The survey results indicate that producers anticipate a significant decrease in the value of crapemyrtle if infested with CMBS, and suggest industry demand for CMBS control. An important finding of my second essay is that a majority of businesses support science-based CMBS control research. Another important finding from this study is that most producers believed that benefits of CMBS control outweigh the costs.

Finally, in my third essay, I study the effects of an external shock on the gardening industry. The COVID-19 pandemic is a health tragedy on a global scale. The pandemic has forced businesses to alter the way they operate. This includes, but may not be limited to, changing hours of operation, working with limited staff, and restricting customer access indoors. This could result in several challenges for businesses. Based on my research, the major challenges faced by businesses were not having enough employees to cover the hours of operation, not having enough inventory to match consumer demand, and social distancing for employees. An important objective of this study is to investigate the extent of these impacts on different businesses based on their size (number of employees), business type (family or individual operation, incorporated), type of operation (retail, wholesale, etc.), and revenue. In addition, the pandemic has also had an effect on the consumers. In this study, I conducted nationwide online consumer surveys to analyze the influence of COVID-19 on consumer behavior for plants gardening products. First important finding was that 46.21% of the consumers were spending more time gardening. Secondly, 36.35% reported an increase

in their gardening expenses, during the outbreak compared to last year. Additionally, I was also able to analyze the effect on consumers' expenses for different plants and gardening products, during the pandemic. My research also incorporated the consumers' personal characteristics, such as age, gender, and income level, in the analysis of change in expenses.

1.1. References

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2. IMPACTS OF CRAPEMYRTLE BARK SCALE ON CONSUMERS AND THE HORTICULTURE INDUSTRY

2.1. Introduction

Horticulture industry is an important part of the United States' economy. According to the recent USDA NASS Census of Horticultural Specialties, the value of all horticultural crops sold was over $13.7 billion (USDA NASS 2019). Within the industry, crapemyrtle (*Lagerstroemia* spp.) is the most popular summer flowering tree (USDA NASS 1998, 2009, 2014). Between 1998 and 2014, the total sales (by value) of crapemyrtles has almost doubled, from approximately $32.3 million to almost $67 million, respectively (USDA NASS 1998, 2009, 2014). In addition to higher sales value, it also saw a very sharp increase in the total volume sold between 1998 and 2014, from approximately 1.9 million to over 4.8 million, respectively (USDA NASS 1998, 2009, 2014). It is also widely grown in the United States (Marwah et al. 2019; Marwah et al. 2021). According to the 2014 USDA NASS Census of Horticultural Specialties, 33 U.S. states, mostly in the southern part of the U.S., produce crapemyrtle (Figure 2.1), (USDA NASS 2014). Crapemyrtles are widely popular in the U.S. due to their beauty, relative ease in growing, availability of several varieties, and because they are comparatively pest resistant (Pooler, 2007; Gu et al. 2014). Due to the diversity these offer, in terms of use and varieties, crapemyrtle has earned the nickname "lilac of the south" (Pooler, 2007).

Since crapemyrtles are valued for their aesthetic characteristics, any loss in their physical features would affect their value (Marwah et al. 2021). Pests, such as crapemyrtle bark scale (CMBS; *Acanthococcus lagerstroemiae* Borchsenius, 1960), can cause this (Gu, 2018).

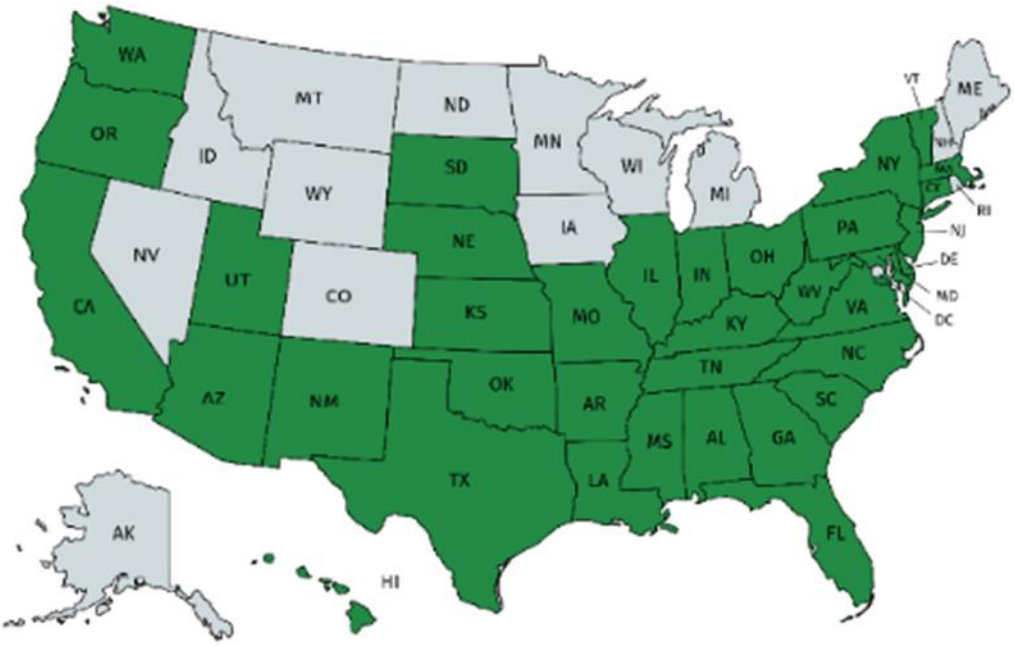

Figure 2.1 A Map Showing 33 Crapemyrtle Producing States

Crapemyrtle bark scale has been reported in at least 14 U.S. states (Alabama, Arkansas, Florida, Georgia, Kansas, Louisiana, Mississippi, New Mexico, North Carolina, Oklahoma, Tennessee, Texas, Virginia, and Washington), and is threatening the production as well as use of crapemyrtle in landscaping (Gu, 2018; Gu, 2021).

Crapemyrtle bark scale may result in the loss of crapemyrtles' visual characteristics such as sparse flowering, smaller flowers, sooty mold covering the bark, stunted growth, or in some cases plant fatality (Gu, 2018; Wang et al. 2019).

Several stakeholders of the green industry such as growers, retailers, landscapers, and consumers are not aware of CMBS. Therefore, the production of crapemyrtle and its use in landscaping is expected to continue. This makes it extremely important to analyze the loss caused by CMBS, to the horticulture industry. This study is aimed at studying the change in consumers' willingness-to-pay for plants, due to loss in different physical characteristics. In particular, I studied crapemyrtle, which is the most popular flowering tree in the U.S. A product's attributes affect consumers' evaluation of the product (Zhang et al. 2020). A lot of resources have been spent on understanding consumers' decision-making process and factors influencing their valuation for products (Kassas et al. 2016). This research sets out to elicit consumers' willingness to pay (WTP) for important attributes affected by pest infestation. This provides a measure of monetary value to the damages caused by pests. The results suggest which attributes are valued most by the consumers. To the best of our knowledge, this is the first study identifying the monetary loss for different attributes affected by pest infestation.

Choice experiments can be used to learn about the attributes valued most by the consumers. Marginal WTPs for the attributes can be estimated based on the choices made by participants (Chavez et al. 2020). In designing choice experiments, it is important to include attributes, which are relevant to consumers (Hensher, 2006). Extant literature shows that ornamental bark characteristics has contributed to the commercial

success of crapemyrtles (Pooler, 2007). Additionally, it has been documented that flower coverage is an important driving force in horticultural research (Chavez et al. 2020; Zlesak, 2006). As detailed earlier, these attributes are also affected by CMBS (Gu, 2018; SNIPM 2015). I primarily focused on these while designing the choice experiment. Additionally, I also analyzed the effect of several personal characteristics, such as age, household size, gender, race, marital status, level of education, employment type, and income, on consumers' willingness to pay for crapemyrtle plants.

2.2. Materials and Methods

2.2.1. Experimental Design

I designed a survey about consumer demand and their preferences for crapemyrtle, using Qualtrics. I collected a nationally representative sample using an online survey platform - Amazon's Mechanical Turk (MTurk). Three selection parameters for choosing participants were applied- (a) Must be at least 18 years of age (default requirement to create an Amazon MTurk account), (b) Location must be USA, and (c) Overall approval rate of participants' submissions must be over 95%. Keywords such as 'crapemyrtle', 'plants', 'flowers', 'gardening', 'landscape', and 'horticulture' were used to target consumers with some knowledge of gardening and/or landscaping. The participants who chose to participate in our survey, were presented with a consent form, followed by our survey. The study protocol was reviewed and approved by IRB (IRB No. : IRB2017-0754D).

I used choice experiments with attributes of crapemyrtle plants to identify consumers' preferences for different traits affected by CMBS, in order to estimate their

demand for CMBS control. Choice experiments are used to elicit consumers' individual preferences for different attributes of a product. In choice experiments, the respondents are presented with multiple scenarios. In each scenario, the respondents make a choice between two options (each option has different attributes and price levels) and a third 'neither' option. Through a series of such scenarios, the consumers' preferences for different attributes (and price levels) are elicited. The different attributes included in our survey (and the respective levels) are detailed in Table 2.1.

Table 2.1 Attributes used in the choice experiment to analyze effect of CMBS

Attribute	**Levels**
Flowering	Sparse Dense
Bark color	Brown Sooty Black
Price	$200 $250 $300 $350

As stated by Rihn et. al., using choice experiments has several advantages such as flexibility of attributes (flower density and bark color in our study) and price levels, understanding consumers' purchasing behavior, and the ability to identify the relative importance of different attributes (Rihn et al. 2014; Lusk and Shogren, 2007). Choice experiments have been used extensively in previous research to evaluate consumers' preferences and determine their willingness-to-pay (WTP) for horticultural products (Rihn et al. 2014; Chung and Vickers, 2007; James et al. 2009; Koelemeijer and Oppewal, 1999; Yue et al. 2007).

In the survey, the participants were presented with a hypothetical scenario and asked to choose between two options in the form of boxes with all the attributes listed, and a third 'neither' option (Figure 2.2). I had 16 such scenarios with different combinations of attributes- bark color, flower density and price (2*2*4=16).

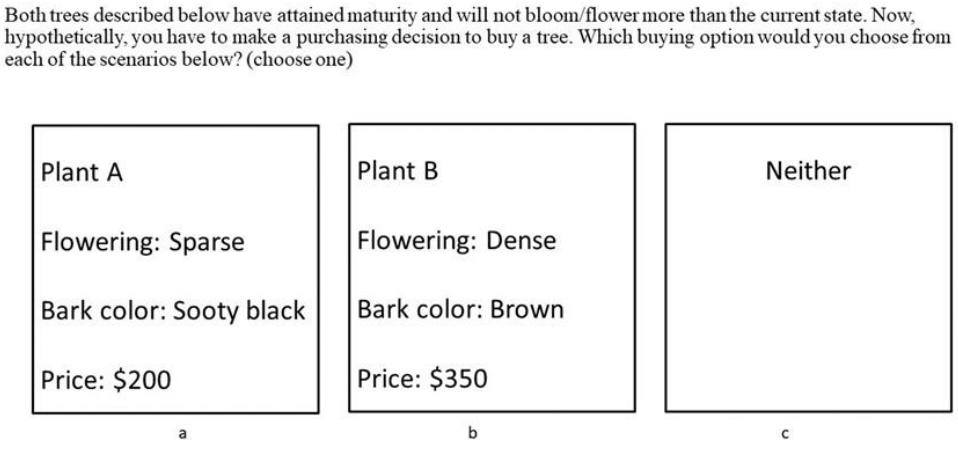

Figure 2.2 A choice scenario (with information boxes)

I also analyzed the effect of personal characteristics on consumers' willingness to pay for crapemyrtle plants. The participants were presented with hypothetical situations where they were asked to enter the price they were willing to pay for crapemyrtle plants. They were provided with specifications of the plants, such as cultivar type (Muskogee and Tuscarora), and size, in the survey. I also included consumers' risk aversion in our analysis (Zhang et al. 2019). Risk aversion is defined as "the extent to which people feel threatened by ambiguous situations, and have created beliefs and institutions that try to avoid these" (Hofstede and Bond, 1984). Risk aversion is a factor that strongly affects the consumers' decision-making process (Shimp and Bearden, 1982). I employed the Eckel and Grossman task to elicit the participants' risk aversion (Eckel and Grossman, 2002). A detailed account of the task as well as the elicitation of participants' risk aversion can be found in the work by Eckel and Grossman (Eckel and Grossman, 2002).

2.2.2. Econometric Models

As posited by Lancaster (1966), products are not the direct objects of utility, in fact the utility that consumers' gain is derived from specific attributes of the product (Gao and Schroeder, 2009; Lancaster, 1966). This study analyzes the consumers' preferences for crapemyrtle plants. This analysis operates on the assumption that the participants are utility maximizers (Chavez et al. 2020). This is consistent with theory of utility maximization by Lancaster (Lancaster, 1971). In other words, for each scenario they were presented with, the participants chose the alternative that they preferred the most. This choice implies that they valued the attributes, mentioned in that alternative, more than other alternatives. Following this assumption, we can model the participants'

choices using random utility model (RUM) (McFadden, 1974). Under the RUM framework, an individual i chooses the option j from all the alternatives (Chavez et al. 2020):

$$U_{ij} = \mu'. x_{ij} + \varepsilon_{ij} \quad (1)$$

Here, x represents a vector of individual characteristics, and εij is the stochastic disturbance term (Chavez et al. 2020; Gao and Schroeder, 2009). The choice that an individual makes gives them the highest level of U. In essence, the participants chose the alternative that provided them with the highest utility in each scenario of the study.

Additionally, another assumption that this analysis makes is that subjects make a choice in a scenario independently of other scenarios presented to them (Chavez et al. 2020). The participants were presented with 16 scenarios in this study; in each scenario they made a choice between the alternatives without being influenced by their decision in the previous scenario, as well as their choice did not influence their decision in the following scenario. The first term in (1) can be split into price and non-price attributes (Chavez et al. 2020; Gao and Schroeder, 2009; Train, 2016):

$$U_{ij} = \alpha_i . p_{ij} + \sum_{k=1}^{T} \beta_{ij} . x_{ijk} + \varepsilon_{ij} \quad (2)$$

where pij is the price of alternative j for individual i, xijk is the kth attribute of alternative j for individual i, εij is the stochastic disturbance term, and αi and βij are marginal utilities for price and kth attribute respectively (Gao and Schroeder, 2009). For our study, I was interested in two attributes related to crapemyrtles - bark color, and flower density (T=2).

A consumer's willingness-to-pay (WTP) for the kth attribute is the amount of money the individual would be willing to pay to maintain their utility level when k changes from 0 to 1 (Gao and Schroeder, 2009). In this study, I am interested in determining the consumers' WTP for flower density and bark color. Therefore, I am calculating the amount of money that a consumer would be willing to pay to derive the same utility, when the bark color attribute changes from sooty black (level=0) to brown (level=1); or when the flower density attribute changes from sparse (level=0) to dense (level=1). This can be considered as the premium that a consumer is willing to pay, when an attribute improves from level=0 (sooty black bark color; sparse flower density) to level=1 (brown bark color; dense flowering). Based on equation (1), the following equality holds (Gao and Schroeder, 2009):

$$\alpha_i \cdot p_{ij} + \sum_{\substack{l=1 \\ l \neq k}}^{T} \beta_{il} \cdot x_{ijl} + \beta_{ik} \cdot x_{ij(k=0)} =$$

$$\alpha_i \cdot (p_{ij} + WTP^k) + \sum_{\substack{l=1 \\ l \neq k}}^{T} \beta_{il} \cdot x_{ijl} + \beta_{ik} \cdot x_{ij(k=1)} \quad (3)$$

Solving the above inequality (3), the WTP is calculated by the following

$$WTP^k = - \beta_{ik} / \alpha_i \cdot (x_{ij(k=1)} - x_{ij(k=0)}) \quad (4)$$

Assuming a linear utility function, consumer's WTP for the kth attribute is the negative ratio of the kth attribute's parameter to the price parameter (Gao and Schroeder, 2009):

$$WTP^k = - \beta_{ik} / \alpha_i \quad (5)$$

I used a mixed logit model to determine consumers' preferences and WTP for different attributes, as well as WTPs for individuals in different groups based on personal characteristics (Hole, 2013; Train, 2016; Bazzani et al. 2018; Almli et al. 2019).

For the second part of our analysis, to analyze the effect of participants' personal characteristics on their willingness-to-pay for crapemyrtle plants, I employed an ordinary least squares (OLS) regression analysis. I performed the analysis with the dependent variable willingness-to-pay for crapemyrtle plants. The independent variables in our analysis were age, household size, gender, race, marital status, education, employment, income, type of residence, risk aversion, and crapemyrtle cultivar.

2.2.3. Research Hypotheses

The following hypotheses formally represent the key research questions that this study addresses:

- Hypothesis 1: There is a decrease in the value of attributes affected by infestation. The main objective of this study is to evaluate the monetary impact of CMBS due to loss of attributes in crapemyrtle plants. WTPs with a positive value would imply that consumers value the presence of attributes in crapemyrtle, which are absent in infested plants.
- Hypothesis 2: The consumers value different attributes unequally. The secondary objective of this study is to analyze the varied effect of pest infestation on different attributes of crapemyrtle plants. This can be achieved by calculating the marginal WTPs for the attributes.

2.3. Results

2.3.1. Demographics

I collected data from 8,089 participants, from all 50 states and Washington D.C., between September 2019 and May 2021. I surveyed personal characteristics such as basic demographic information including age, gender, education, race, income, and type of residence. Table 2.2 illustrates the demographic summary. The sample was 43.82% female, with a mean age of 37.21 years. In addition, 65.14% of the participants had attended at least some college, or had an associate's or a bachelor's degree. Additionally, 89.31% of the participants were employed, either part-time or full-time. 68.04% of the participants lived in a house/duplex. The average annual income reported in our survey was $ 69,914.08.

Table 2.2 Summary Statistics of Demographic Information

Variable	Mean (sd)
Age	37.21 (11.41)
Min	18
Max	93

Table 2.2 Continued

Variable	Mean (sd)
Gender	
Female	43.82%
Male	55.89%
Other	0.28%
Education	
Regular High School Diploma, GED or equivalent	6.92%
Some College, Associate's degree, or Bachelor's degree	65.14%
Master's degree, Professional degree or Doctorate degree	27.52%
Others	0.42%
Employment	
Do not work	7.39%
Full time	77.38%
Part time	11.93%
Other	3.16%
Race	
White	75.72%
Black	15.63%
Asian	6.33%

Table 2.2 Continued

Variable	Mean (sd)
American Indian or Alaska Native	1.83%
Native Hawaiian or Pacific Islander	0.49%
Hispanic	24.22%
Type of Residence	
Owned House/Duplex	51.64%
Owned Apartment/Condo/Loft	12.55%
Rented Apartment/Condo/Loft	18.64%
Rented House/Duplex	16.40%
Income	$69,914.08
	(58609.28)
Median	$55,000
Less than $30,000	17.02%
$30,000 to $49,999	23.37%
$50,000 to $59,999	15.90%
$60,000 to $69,999	8.25%
$70,000 to $79,999	10.48%
$80,000 to $89,999	5.44%
$90,000 to $99,999	5.56%
$100,000 to $149,999	9.16%

Table 2.2 Continued

Variable	Mean (sd)
$150,000 to $249,999	3.92%
$250,000 or more	1.89%
Total Subjects	8,089

2.3.2. Change in consumers' willingness-to-pay due to pest infestation

From our statistical analysis of the mixed logit model, I was able to isolate the value for the loss of attributes. The metrics in Table 2.3 illustrate that consumers value the presence of attributes in crapemyrtle, which are absent in plants infested with CMBS (Hypothesis 1).

I was able to discern the relative importance of different crapemyrtle attributes, for the consumers, by employing the marginal WTPs (Hypothesis 2). Consumer WTP for crapemyrtle significantly decreased due to CMBS infestation, with dense flowering being the most important attribute (highest WTP), followed by brown bark. The results show that consumers are willing to pay $135.36 more for densely flowered trees. They are also willing to pay $20.37 more for healthy brown bark. Overall, the consumers are willing to pay $155.73 more for a plant with attributes unaffected by infestation. This is a very important result since the average price of a healthy tree is $300, in the retail

market. In summary, there is a 51.91% decrease in the value of crapemyrtle resulting from loss of attributes, which are commonly affected by CMBS.

For WTPs for attributes based on individual characteristics, female consumers and White consumers had a higher WTP as compared to the overall sample (Table 2.3). Similarly, married consumers and consumers with children exhibited a lower WTP compared to the overall sample. The consumers' WTP decreased as their household size increased. As the consumers shifted towards higher education, and full-time employment, their WTP decreased. In terms of income, the WTP followed a U-shape curve, with higher WTP for consumers in the 'less than $30,000' and '$100,000 or more' categories. The consumers in the '$50,000 to $59,999' exhibited the lowest WTP. The different WTPs based on consumers' age is also detailed in Table 2.3.

Table 2.3 Mixed logit estimates and WTPs for different crapemyrtle attributes and individual characteristics

	coef	**se**	**z**	**p**			**WTP**
Flower	0.919	0.018	52.3	0.000	***	**Flower**	**135.36**
Bark	0.138	0.011	12.9	0.000	***	**Bark**	**20.37**
Price	-0.007	0.000	-81.6	0.000	***	**Total**	**155.73**
Signif. code: '***' 0.001							
WTPs for attributes based on individual characteristics							

Table 2.3 Continued

	WTP Flower	**WTP Bark**
Gender (Female=1; Male, Others=0)	165.14	20.76
Race (White=1; Others=0)	145.76	20.43
Age		
18-25	163.05	20.56
26-30	109.47	20.14
31-35	126.82	20.10
36-40	142.57	20.60
41-50	140.48	20.46
51 and older	159.24	20.89
Marital status (Married=1; Others=0)	110.77	20.32
Income		
Less than $30,000	132.85	20.16
$30,000 to $49,999	121.20	20.41
$50,000 to $59,999	98.97	19.96
$60,000 to $79,999	134.30	20.52
$80,000 to $99,999	154.18	20.58
$100,000 or more	191.21	20.87

Table 2.3 Continued

	WTP Flower	**WTP Bark**
Household size		
1-2	207.38	20.93
3	127.80	20.29
4	106.28	20.31
5 or more	100.25	20.00
Children (Yes=1; No=0)	104.07	20.19
Education		
No schooling/High School/GED/Others	150.50	20.22
Some college/Associate's/Bachelor's	145.17	20.41
Master's/Professional/Doctorate	111.44	20.43
Employment		
Full time	117.40	20.24
Part time	181.01	20.87
Others	224.40	21.08

2.3.3. Effects of personal characteristics on willingness-to-pay for crapemyrtle plants

The estimates from our OLS regression are presented in Table 2.4. The WTP for crapemyrtle plants, for female consumers was $11.00 lower than other consumers. Our

analysis also showed that a higher WTP was associated with married consumers ($16.76), Whites ($5.02), larger households ($4.63), more educated consumers ($8.76). I also found that as consumers' employment shifted towards part time and full time employment, their WTP increased by $9.20. In addition, the consumers in our survey exhibited a $23.97 lower WTP for a 3-4ft Tuscarora as compared to a 6-7ft. Muskogee. The effect of age, though statistically significant, was very small. The effects of income and risk attitude were not statistically significant.

Table 2.4 OLS estimates of personal characteristics on WTPs for crapemyrtle plants

Variable	**Estimate**	**Std. Error**	**Pr(>|t|)**
(Intercept)	59.84	5.05	< 2e-16***
Gender (Female=1; Male, Others=0)	-11.00	1.82	1.540E-09***
Race (White=1; Others=0)	5.02	2.11	1.720E-02**
Age	-0.34	0.08	3.100E-05***
Marital status (Married=1; Others=0)	16.76	2.16	1.020E-14***
Income (in $10,000)	-0.06	0.15	6.992E-01
Household size	4.63	0.57	4.400E-16***

Table 2.4 Continued

Variable	Estimate	Std. Error	Pr(>|t|)
Risk Attitude (Risk seeking=1; Risk neutral=0; Risk averse=-1)	1.23	1.51	4.131E-01
Education (Master's/Professional/Doctorate=2; Some college/Associate's/Bachelor's=1; No schooling/High School/GED/Others=0)	8.76	1.67	1.530E-07***
Employment (Full time=2; Part time=1; Others=0)	9.20	1.41	7.400E-11***
Crapemyrtle type (3-4 ft. Tuscarora=1; 6-7ft. Muskogee=0)	-23.97	1.76	< 2e-16***
Signif. codes: '***' 0.01; '**' 0.05			

2.4. Discussion

Horticulture industry is an important part of the U.S. economy. It is facing several challenges, a major one being pest infestation. Crapemyrtle, the main focus of this study, is no exception. Even though it is fairly pest resistant, CMBS results in the

loss of its attributes. Extant literature has focused on studying the causal organism and mechanism of CMBS (Wang et al. 2019; Vafaie and Knight, 2017; Wang et al. 2016). Additionally, it also sheds light on countering the CMBS issue including systemic strategies, cleaning/washing, and scientific control strategies (Gu et al. 2014). However, CMBS is an issue that needs to be dealt with, on multiple fronts. It is not enough just to focus on strategies to control it; there is an immediate need to evaluate its economic impact. It results in loss of attributes such as flower density and bark color, which are of immense commercial value. The current study addresses this issue, and contributes to the current literature, by isolating the change in a plant's monetary value due to change in its attributes. This value was calculated to be over 46% of the plant's price. This provides producers with an estimate of the potential loss due to the infestation, and suggests the importance of effective CMBS control. Such economic analyses contribute towards increasing knowledge of the scale, importance of control strategies, and minimize the potential loss caused by this pest to consumers, growers and the environment. Crapemyrtle bark scale can not only result in a decrease in crapemyrtle demand, it can also nudge the horticulture industry towards potential replacements. This provides important insights for producers in order to create better supply chain to meet the demand of the consumers, and sustainable operation of business.

Our analysis also showed the effects of consumers' personal characteristics on their willingness-to-pay for crapemyrtle plants. This can help the businesses to adjust their marketing strategies based on consumers they are targeting. The results of this

study will provide important information to the production and marketing practices of the green industry.

An important finding of this research is that the importance of different attributes affected by CMBS varies, and CMBS results in the overall loss in value of crapemyrtle. This implies that the society would benefit from effective CMBS control strategies. This would motivate researchers and public organizations to invest in CMBS control. It will also encourage the creation of effective communication/information material regarding CMBS and its control, for different stakeholders of the horticulture industry – producers, retailers, landscapers, and most importantly consumers. It is also important to note that curating sustainable control practices is of the utmost priority; since the current control strategies for CMBS include insecticides, particularly neonicotinoids, which risk pollinators (Thurmond, 2019).

Finally, the experimental design employed in this study can be easily modified to evaluate the impact that other pests have on the products of horticulture industry, as well as the rest of the agriculture industry.

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3. INVESTIGATING PRODUCERS' PREFERENCES FOR CRAPEMYRTLE AND THEIR PERCEPTIONS REGARDING CRAPEMYRTLE BARK SCALE*

3.1. Introduction

Crapemyrtle (*Lagerstroemia* spp.) is the most popular flowering tree in the U.S. (USDA NASS 1998, 2009, 2014). The total value of crapemyrtles sold has almost doubled since 1998, from approximately US $32.3 million in 1998 to almost US$67 million in 2014 (annual wholesale values) (USDA NASS 1998, 2009, 2014). It is produced in 33 states, most of which are located in the southern part of the continental U.S., according to the 2014 USDA NASS Census of Horticultural Specialties (USDA NASS 2014; Marwah et al. 2019). The total number of crapemyrtles sold rose sharply by 152.6%, from approximately 1.9 million in 1998 to over 4.8 million in 2014 (USDA NASS 1998, 2009, 2014). The reason why crapemyrtles are so popular in the U.S. is not only that they are relatively easy to grow, it is also because they offer a lot of variety with respect to color, plant size, growth habit, and their use (Pooler, 2007). Consumers prize crapemyrtles for their beauty, but they are also relatively free from pest issues (Gu et al. 2014).

Crapemyrtle bark scale (CMBS; *Acanthococcus lagerstroemiae* Borchsenius, 1960) is a novel pest affecting crapemyrtles in the U.S. (Vafaie and Knight, 2017).

Biologically, A. *lagerstroemiae* is sexually dimorphic (Wang et al. 2019). For most of its lifetime, the adult female is sessile on the bark (Wang et al. 2016; Wang et al. 2019). The insect secretes honeydew, which encourages sooty mold growth on the plants (Wang et al. 2019). Not only does this limit the plants' photosynthesis, it also reduces their aesthetic value (Wang et al. 2019). Additionally, if the infestation gets out of control, the sooty mold can coat the bark, which can be a huge concern for growers (Vafaie and Knight, 2017). Crapemyrtle bark scale may result in sooty mold covering the bark, branch dieback, sparse flowering, and smaller flowers (Gu, 2018). In some cases, it may also result in stunted growth, or even fatality of the plants (Gu, 2018). Several characteristics of plants such as size, overall visual quality, and photosynthesis rate, are significantly affected due to CMBS infestation (Wang, 2017). Crapemyrtle bark scale is native to East Asia and poses a serious threat to several plants such as persimmon, pomegranate, and crapemyrtles (Gu, 2018). However, current crapemyrtle production and use is being threatened by CMBS (Gu, 2018). It has been confirmed in at least 14 U.S. states (Alabama, Arkansas, Florida, Georgia, Kansas, Louisiana, Mississippi, New Mexico, North Carolina, Oklahoma, Tennessee, Virginia, and Washington), after it was first sighted in north Texas in 2004 (Gu, 2018; Gu, 2021).

A few insecticides, particularly neonicotinoids, that control CMBS to some extent, pose a high risk to pollinators (Thurmond, 2019). The Pest Management Strategic Plan for Container and Field-Produced Nursery Crops in FL, GA, KY, NC, SC, TN, and VA: Revision 2015, mentioned that there is no known biological control for CMBS (SNIPM, 2015). Even though currently there are no reported instances of CMBS in

California, the California Department of Food and Agriculture has given CMBS a rating of 14 in its pest-rating proposal, on a scale of 1 to 15 (the highest). Furthermore, it also mentions that CMBS can widely spread across California (California Department of Food and Agriculture). Even though it has a moderate host range, it has high reproduction as well as dispersal potential, due to which it can have an impact on the environment and cause economic repercussions in California (California Department of Food and Agriculture).

Production of, and landscaping with, crapemyrtles is expected to continue since a majority of stakeholders of the green industry (e.g., growers, retailers, consumers, and landscape professionals) are unaware of the CMBS problem. This study aimed at investigating how CMBS affected landscape plant industry in general and the crapemyrtle growers in particular.

3.2. Materials and Methods

In this study, I conducted in-person interviews of business representatives at the Texas Nursery/Landscape EXPO in 2018 and 2019 (IRB Number: IRB2017-0754D). The survey participants were provided with a paper survey that they filled out themselves. The survey administrator was available to answer questions that the participants had. The participants were not provided any monetary compensation to take the survey. I have surveyed 32 and 47 businesses, in 2018 and 2019, respectively, from eight states—Alabama, California, Florida, Georgia, Louisiana, Mississippi, Tennessee, and Texas. Out of the 79 respondents, 75 were growers. The other four businesses included a wholesaler, re-wholesaler, nursery, and a broker.

Based on the responses in the surveys, I was able to divide the businesses into different categories based on several parameters such as their legal status, and the gross annual sales of the operation (Table 3.1).

Table 3.1 Classification of producers based on business types in the crapemyrtle survey sample.

Parameter	Categories (Number in Each)	Number of Businesses Surveyed
Legal status	Family or individual operation, and Partnership	26
	Incorporated under state law	37
	Others	3
	Declined to answer	13
Gross annual sales value of the operation	US$1,000,000 or more	50
	Under US$1,000,000	18
	Declined to answer	11
Gross annual value of crapemyrtle-related business for the operation	US$100,000 or more	29
	Under US$100,000	35
	Declined to answer	15

These surveys provided us with knowledge about the crapemyrtle production. The business representatives answered several questions regarding their knowledge of CMBS, their thoughts and concerns about CMBS, and details about their business and sales. The questions were presented using a Likert scale; the questions are listed in Table 3.2.

I used the Kruskal–Wallis test (KW test) to compare the producers' responses to several questions among the different producer categories based on legal status, gross annual sales value of the operation, and gross annual crapemyrtle sales (Kruskal and Wallis, 1952). The KW test is a distribution-free nonparametric approach (Sun et al. 2015) to compare different groups based on a dependent variable measured by the ordinal level.

Table 3.2 Survey questions included in our interview of producers for CMBS study

Survey Questions
Anticipate that CMBS will result in a significant drop in sales and use of crapemyrtles in your area.
Magnitude by which the price value for crapemyrtles will decrease if it is infested by CMBS.
Change in your willingness to grow crapemyrtles if it is infested by CMBS.
General opinion about developing systemic strategies to control CMBS.
Do you think that your operation will benefit from science-based CMBS control strategies?
Do you think the overall benefits from CMBS control will be higher than the cost of CMBS control?

In the survey, I also asked the business representatives about the importance of different attributes of crapemyrtles when they are making decisions about growing/purchasing the plants. The relative importance index can be used to see the ranking of all the attributes based on their respective importance (Tonidandel and LeBreton, 2011). It has been commonly used in project management and engineering research (Odeh and Battaineh, 2002; Gündüz et al. 2013; Torghabeh et al. 2013; Chan

and Kumaraswamy, 1997; Kometa et al. 1994). The relative index (RI) is calculated by the following formula (Rooshdi et al. 2018):

$$RI = \sum \frac{W}{A \times N}$$

Here, W is the "importance" assigned by the survey respondents, on a scale of one to four (1 = least important, 4 = highest in importance), A is the value for highest importance and N is the total number of respondents (Odeh and Battaineh, 2002; Rooshdi et al. 2018).

3.3. Results

3.3.1. Survey Responses

According to the producers I surveyed, the three cultivars with the greatest sales are Natchez, Muskogee, and Tuscarora. Additionally, the three most popular sizes for crapemyrtles are 15 gal, 30 gal, and 45 gal. These sizes refer to the volume of the containers in which the plants are potted. Our survey results, from both 2018 and 2019, indicate that producers anticipate a significant decrease in the value of crapemyrtle due to CMBS. Our surveys from 2018 showed that they anticipated a 29.93% decrease in the value of crapemyrtle due to CMBS; our surveys from 2019 showed that the producers anticipated a 33.79% decrease in the value of crapemyrtle due to CMBS. This is an alarming number, especially since crapemyrtle production is an important part of the horticulture industry.

Quite a number of the producers interviewed (72% and 61% in 2018 and 2019, respectively) also anticipated a decrease in the sale and use of crapemyrtles, in general,

if the CMBS problem persists (Figure 3.1). Their willingness to grow crapemyrtle would also decrease if it were infested by CMBS. For example, 30% of the producers interviewed in 2018, and 43% of the producers interviewed in 2019 mentioned that their willingness to grow crapemyrtle would be significantly decreased if it were infested by CMBS. Another 30% and 23% of the producers in 2018 and 2019, respectively, mentioned that their willingness to grow crapemyrtle will be somewhat decreased if it were infested with CMBS (Figure 3.2).

I also surveyed the business representatives about the most popular landscape plants that can potentially replace crapemyrtle. In the opinion of participants I surveyed, those were *Vitex agnus-castus* (Texas lilac), *Magnolia* spp., and *Hibiscus* spp.

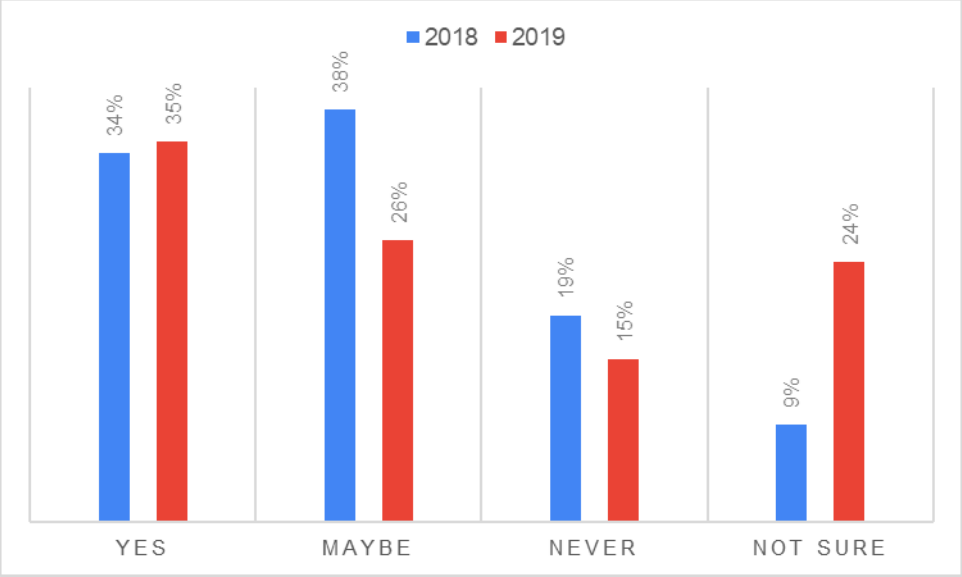

Figure 3.1 Producers anticipating a significant drop in sales and use of crapemyrtle if infested with CMBS (in %).

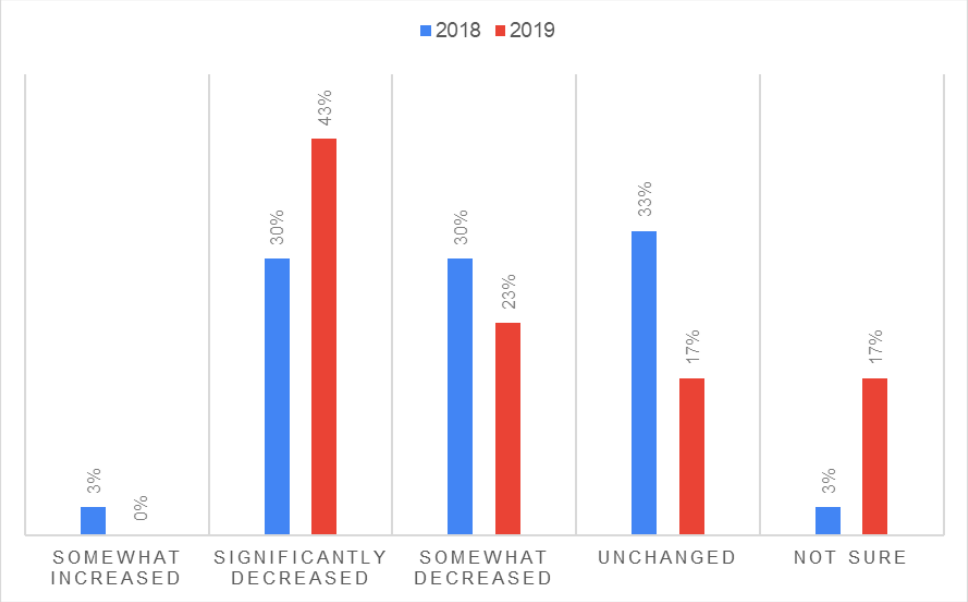

Figure 3.2 Decline in willingness to grow crapemyrtle if infested by CMBS (in %).

The producers demonstrated support for systemic and scientific control strategies. Scientific control strategies include sustainable chemical control, the use of biological control agents, and other environmental-friendly methods, such as the development of insect-resistant cultivars (Wang et al. 2016; Vafaie and Gu, 2019; Vafaie, 2019; Wu et al. 2020; Wu et al. 2021). A total of 69% of the producers interviewed in 2018, and 59% interviewed in 2019, strongly supported the development of systemic strategies for CMBS control (Figure 3.3). Another 9% and 15% of the producers

interviewed in 2018 and 2019, respectively, were somewhat supportive of systemic strategies. 72% of the producers interviewed in 2018, and 55% interviewed in 2019, strongly supported science-based CMBS control (Figure 3.4). Another 16% and 30% of the producers inter-viewed in 2018 and 2019, respectively, were somewhat supportive of science-based CMBS control.

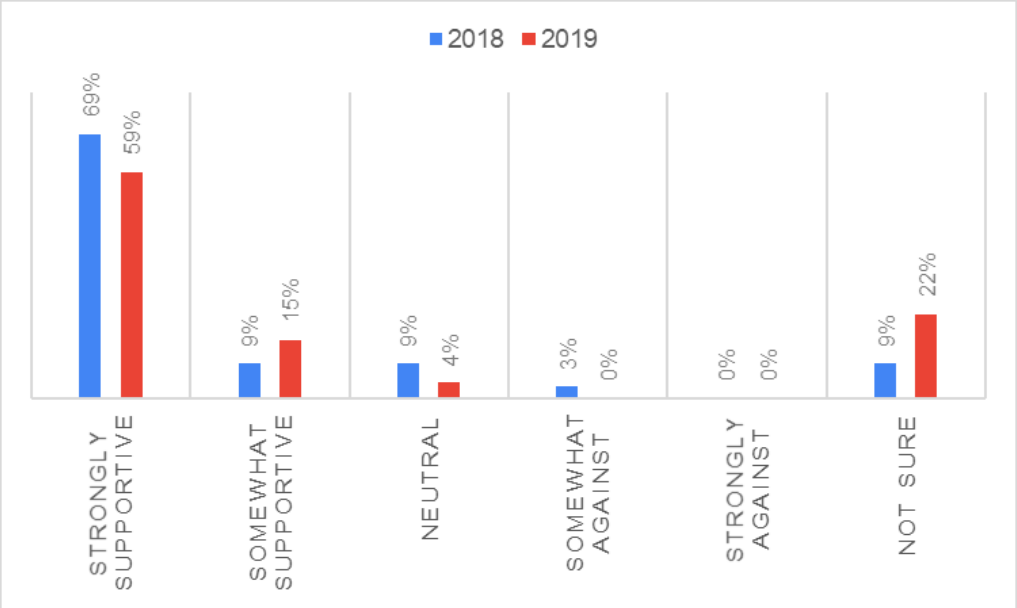

Figure 3.3 Producer support for development of systemic strategies for CMBS control (in %).

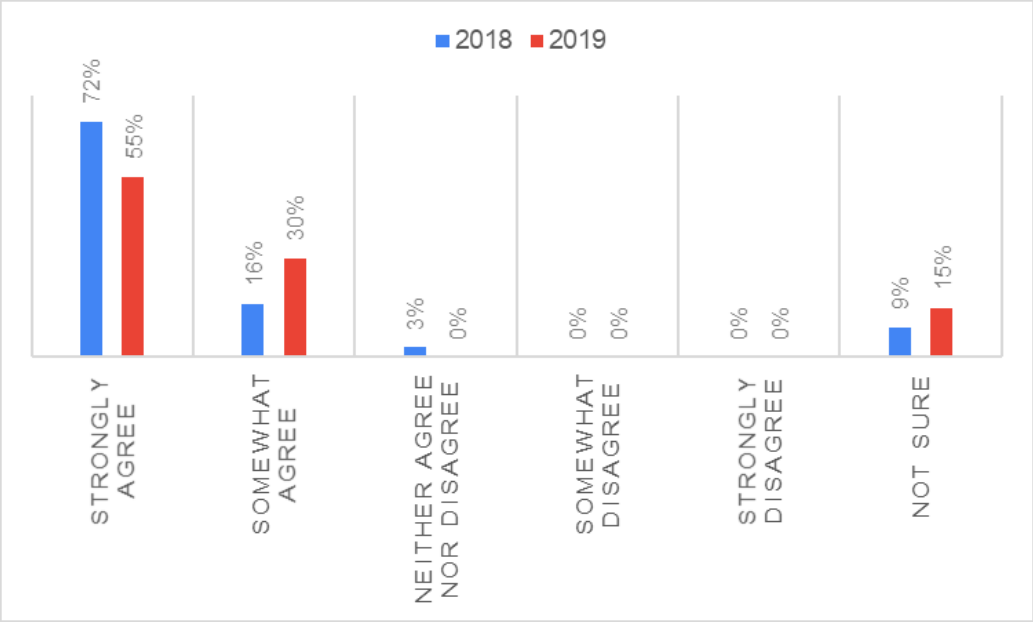

Figure 3.4 Producer support for science-based CMBS control research (in %).

3.3.2. Categorical Comparison by Business Types

There was a significant difference among different producer types based on gross annual sales (KW test p-value=0.081), as well as crapemyrtle-related sales (KW test p-value=0.070), regarding their thoughts on the magnitude by which the price value for crapemyrtles would decrease (in %) if it is infested by CMBS. Less than 6% of the representatives from businesses with under US$1,000,000 gross annual sales value thought that the value of crapemyrtles would fall by more than 60% if infested by CMBS, whereas 26% of the representatives from businesses with over US$1,000,000 gross annual sales value thought so (Figure 3.5). 31% of the representatives from businesses with under US$100,000 gross annual crapemyrtle sales anticipated that the

value of crapemyrtles would fall by over 60%, if infested by CMBS, whereas less than 7% of the representatives from businesses with more than US$100,000 gross annual crapemyrtle sales thought so (Figure 3.6). In conclusion, representatives of large businesses, and businesses with low volume of crapemyrtle-related sales predicted a more serious decrease in crapemyrtles' value if infested by CMBS as compared to others. There was no significant difference in the anticipated decrease in the price value of crapemyrtles if infested by CMBS, between business types based on legal status (Figure 3.7).

Figure 3.5 Magnitude of anticipated decrease in the price value for crapemyrtles (%) if infested by CMBS, by different producer types based on gross annual sale.

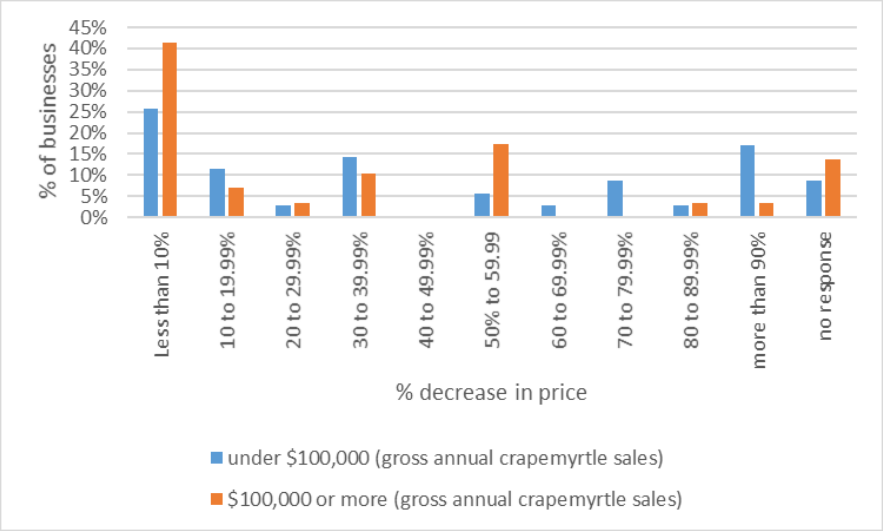

Figure 3.6 Magnitude of anticipated decrease in the price value for crapemyrtles (%) if infested by CMBS, by different producer types based on gross annual crapemyrtle-related sales.

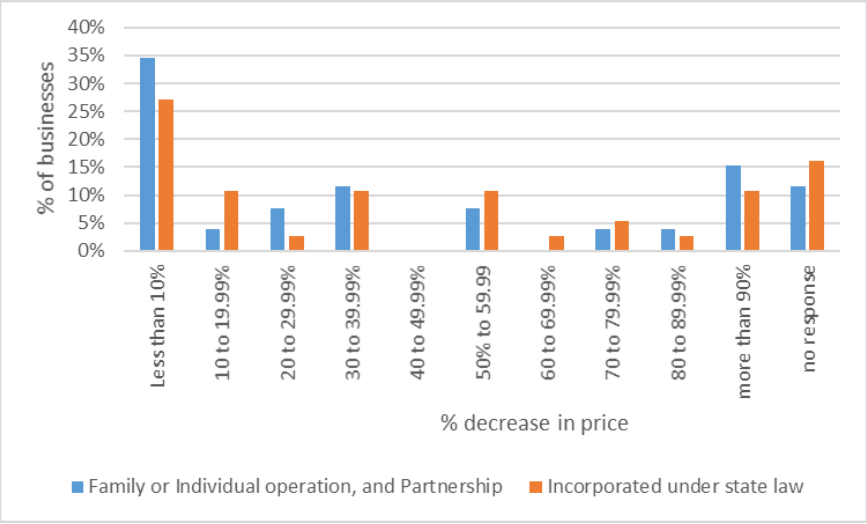

Figure 3.7 Magnitude of anticipated decrease in the price value for crapemyrtles (%) if infested by CMBS, by different producer types based on legal status.

In our analysis I also found that there was a significant difference about thoughts on whether the overall benefits from CMBS control will be higher than the cost of CMBS control, among business types based on gross annual value of crapemyrtle-related sales (KW test p-value=0.027). On one hand, approximately 59% of representatives from businesses with over US$100,000 worth of crapemyrtle-related sales agreed that overall benefits from CMBS control would be higher than its cost; less than 4% disagreed with that statement. On the other hand, 49% of the representatives from businesses with under US$100,000 worth of crapemyrtle-related sales agreed, and 15% disagreed with that statement (Figure 3.8). In summary, more business representatives with high volume of crapemyrtle-related sales considered the benefits of CMBS-control to be higher than its cost, as compared to others. There was no significant difference regarding opinion on benefits of CMBS control outweighing its cost, between business types based on gross overall sales, as well as legal status. Approximately 65% of representatives for family or individual operations, and partnerships, agreed that overall benefits from CMBS control would be higher than its cost; less than 8% disagreed with that statement. 43% of the representatives for incorporated businesses agreed, and less than 11% disagreed with that statement (Figure 3.9). Similarly, 56% of representatives from business with over US$1,000,000 worth of gross annual sales value agreed, and 6% disagreed with that statement; 44% of the business representatives with under US$1,000,000 worth of gross annual sales value agreed, and less than 17% disagreed with that statement (Figure 3.10).

Finally, there was a difference in support for science-based control strategies between business types (KW test p-value=0.064). 81% of representatives for family or individual operation, and partnerships, agreed that their operation would benefit from science-based CMBS control strategies; 89% of the representatives for incorporated businesses agreed with the statement. In summary, representatives of incorporated businesses showed more support, as compared to partnerships and family/individual operations, for science-based CMBS control research. These findings suggest an immediate need for CMBS control. Our surveys indicated that overall, most producers believed that benefits of CMBS control were higher than the costs (Figure 3.11). This implies that there is industry demand for CMBS control.

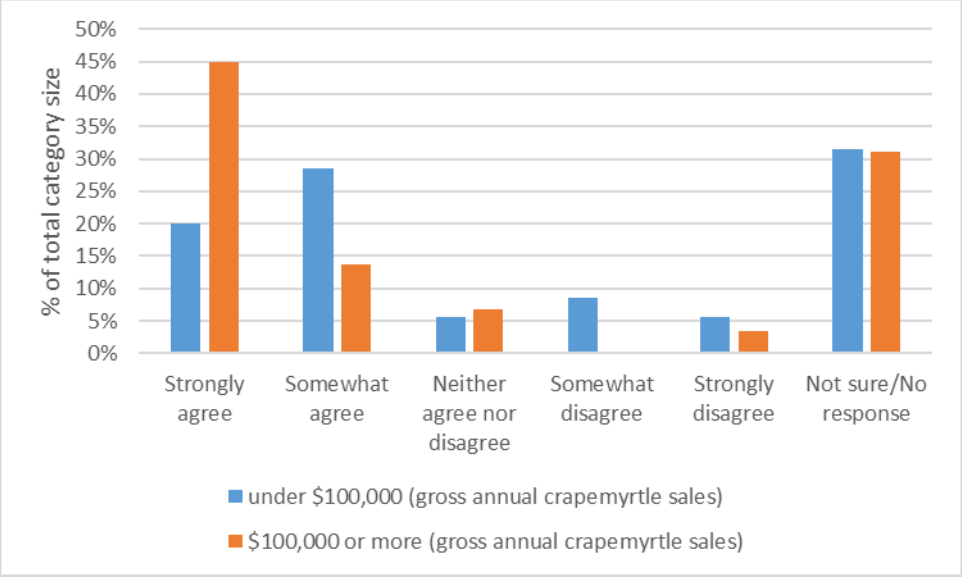

Figure 3.8 Overall benefits from CMBS control higher than its cost by different producer types based on gross annual crapemyrtle-related sales

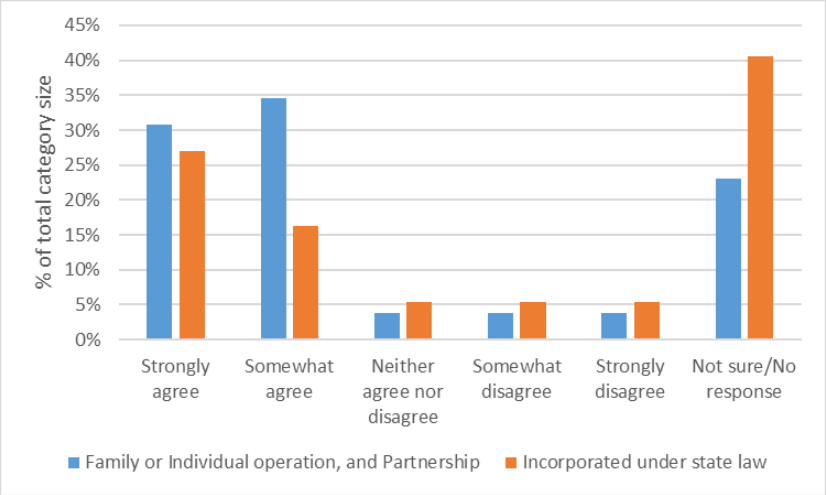

Figure 3.9 Overall benefits from CMBS control higher than its cost by different producer types based on legal status

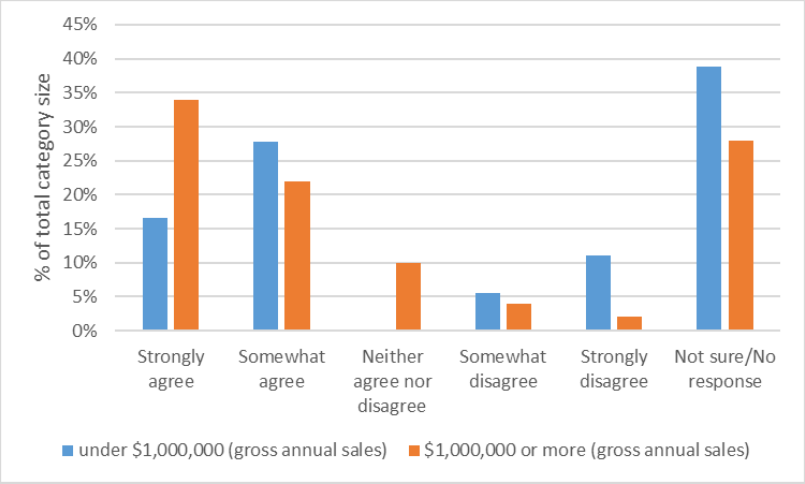

Figure 3.10 Overall benefits from CMBS control higher than its cost by different producer types based on gross annual sale

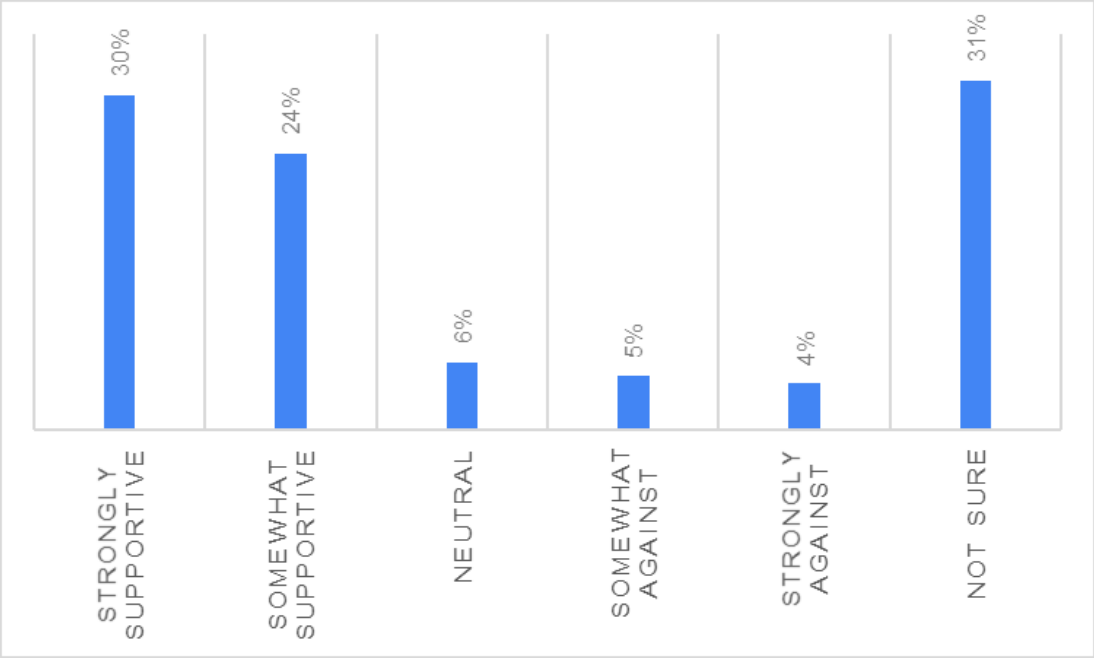

Figure 3.11 Crapemyrtle bark scale control: benefits higher than cost (in %).

3.3.3. Relative Importance Index

Business representatives ranked the importance of different attributes of crapemyrtles that they consider when they are making decisions about growing/purchasing the plants (Figure 3.12). The relative importance indices for different attributes are shown in Table 3.3. Flower color was found to be the most important attribute. This result is intuitive since the producers would choose what colors to grow based on the consumers' demand in the previous years. Flower color was followed by disease resistance. This is an important finding. It implies that once the producer makes the decision regarding which color crapemyrtle to grow, the next

attribute that holds the highest importance is disease resistance. This suggests how important CMBS control is for producers. I used the KW test to compare the rankings between the two years included in our sample (Kruskal and Wallis, 1952). There was no significant difference in the relative importance of attributes between 2018 and 2019. The relative index (RI) can be used to assign the importance levels to the attributes. There are five levels corresponding to the relative index values: a. $0.8 \leq RI \leq 1$: high (H), b. $0.6 \leq RI \leq 0.8$: high-medium (H–M), c. $0.4 \leq RI \leq 0.6$: medium (M), d. $0.2 \leq RI \leq 0.4$: medium-low (M–L), and e. $0 \leq RI \leq 0.2$: low (L) (Akadiri, 2011). In addition to a comparative analysis, this importance level helps in identifying the individual importance of each attribute (Table 3.3). In our analysis, flower color, disease resistance, height, and growth habit were determined to be of "High" importance level. In addition, easy maintenance, foliage color, and bark color were determined to be of "High-Medium" importance level. This suggests that all of the attributes are extremely important while making purchasing/growing decisions.

Table 3.3 Relative Importance Index (RII) of plant attributes for producers when making crapemyrtle purchasing decisions.

Attribute	2018	2019	Overall		
	RII	RII	Mean RII	Rank	Importance Level
Flower color	0.90	0.91	0.91	1	High
Disease resistance	0.85	0.87	0.86	2	High
Height	0.84	0.82	0.83	3	High
Growth habit	0.82	0.81	0.81	4	High
Easy maintenance	0.76	0.80	0.78	5	High-Medium
Foliage color	0.75	0.75	0.75	6	High-Medium
Bark color	0.69	0.72	0.70	7	High-Medium

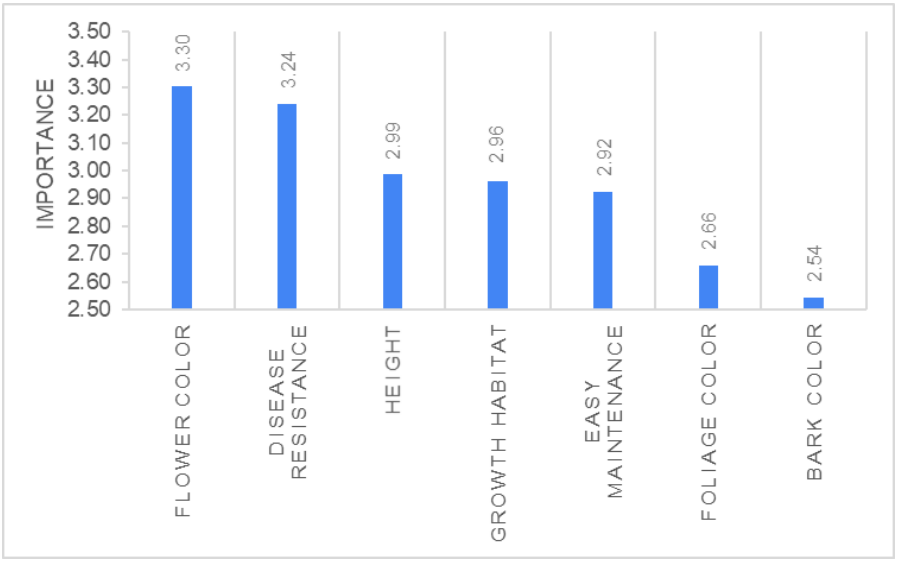

Figure 3.12 Importance of different attributes (on a scale of 0 to 4).

3.4. Discussion

Previous research has looked into the causal organism and mechanism of CMBS (Vafaie and Knight, 2017; Wang et al. 2016; Wang et al. 2019). Extant literature also provides some insights into ways to manage CMBS—physical cleaning, systemic strategies, and scientific control strategies (Gu et al. 2014). While previous research can be used to control CMBS, there is an immediate need to analyze the economic impact of this pest. Managing CMBS is associated with various economic costs. This includes loss of commercially important attributes such as sooty black bark color and reduced flower density; it also includes the financial costs associated with the control of CMBS as well as the time and resources spent on researching more effective control strategies. Since crapemyrtle has enjoyed increased popularity over time, is produced in almost two-third of the states, and is a US$67 million industry, it is imperative to counter these economic impacts of CMBS. If the issue of CMBS gets out of control, it might have two serious implications. First, it could result in a decrease in the demand for crapemyrtles. Second, the horticulture industry would need to find potential replacements to crapemyrtle. In essence, it may induce a shift in the demand of different products within the horticulture industry. Both of these shifts can potentially have a huge impact on businesses. Our findings indicate industry demand for CMBS control, and show that producers anticipated a decrease in crapemyrtle value and sales, if infested with CMBS.

It is important to note here that our analysis results indirectly from the subjective opinions of business owners based on our survey. Further analysis into direct economic indicators can be carried out as part of future research. Crapemyrtle bark scale can be controlled using a variety of methods, including physical cleaning/washing of plants (Gu et al. 2014). Systemic strategies are also useful for its control, and in fact shown the most promise in experiments (Gu et al. 2014). Soil-applied neonicotinoids were found to suppress CMBS to a significant extent (Gu et al. 2014). An important finding of our research is that a majority of business representatives support science-based CMBS control research. In addition, more business representatives with high volume of crapemyrtle-related sales considered the benefits of CMBS control to be higher than its cost, as compared to other businesses. These findings usher in optimism for researchers working on CMBS control, and it would motivate more projects researching control strategies. It is therefore important to create effective communication and information material regarding CMBS and its control, tailored to different business types—growers, wholesalers, retailers, and landscapers.

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4. INFLUENCE OF COVID-19 ON CONSUMER BEHAVIOR FOR GARDENING PRODUCTS, AND THE GARDENING INDUSTRY

4.1. Introduction

The COVID-19 pandemic is a health tragedy on a global scale. It has changed the world in numerous ways- quality of life, political, environmental, and economic sustainable development (Keshky et al. 2020). Businesses worldwide, as well as the United States economy, have been impacted. It is estimated that the United States real GDP suffered a year-on-year contraction of almost 11% in 2020 (Baker et al. 2020). Gardening industry is an important part of United States economy. According to the 2019 USDA NASS Census of Horticultural Specialties, the value of all horticultural crops sold was over $13.7 billion. Therefore, understanding the effect of this pandemic on the industry, for plants and gardening products/services, is important. This study is aimed at evaluating this effect. I conducted online producer surveys to analyze the influence of COVID-19 on the gardening industry. The pandemic has forced businesses to alter the way they operate. This includes, but may not be limited to, changing hours of operation, working with limited staff, and restricting customer access indoors. This could result in several challenges for businesses. I was able to shortlist the major challenges faced by businesses due to the pandemic. I also evaluate the effect of the pandemic on the sales of different plants, gardening products/services, and the overall revenues of businesses. An important objective of this study is to investigate the extent of these impacts on different businesses based on their size (number of employees),

business type (family or individual operation, incorporated), type of operation (retail, wholesale, etc.), and revenue. A higher percentage of producers reported increased overall sales, as compared to those reporting decreased sales. Over 46% of the producers reported that COVID-19 was a factor that increased their sales in 2020. Based on our survey, the major challenges faced by businesses were not having enough employees to cover the hours of operation, not having enough inventory to match consumer demand, and social distancing for employees. Our analysis showed that based on the type of operation, the retail type businesses were associated with 16 times higher probability of increased sales, compared to the growers (base), in terms of changes in overall sales during COVID. There were no significant differences between businesses based on revenue, number of employees, business type (family or individual operation, incorporated), and due to modified operations.

In addition, the pandemic has also had an effect on the consumers, making it imperative for businesses to adapt to the new normal. According to Keshky et. al. (2020), the restrictions due to the pandemic have affected people psychologically, and adversely influenced their activities including gardening. Additionally, the pandemic has aggravated food insecurity in urban areas (Lal, 2020). Home gardening and urban agriculture can be an important strategy to alleviate this concern (Lal, 2020). Therefore, understanding changes in consumer preferences and shopping patterns, for plants and gardening products/services, due to COVID-19 is important. In this study, I conducted nationwide online consumer surveys to analyze the influence of COVID-19 on consumer behavior for plants gardening products. First important finding was that 46.21% of the

consumers were spending more time gardening. Secondly, 36.35% reported an increase in their gardening expenses, during the outbreak compared to last year. Additionally, I was also able to analyze the effect on consumers' expenses for different plants and gardening products, during the pandemic. Our study also incorporated the consumers' personal characteristics, such as age, gender, and income level, in the analysis of change in expenses.

4.2. Methodology

4.2.1. Producer survey

I conducted an online survey with 67 members of Texas Nursery & Landscape Association. I asked producers questions regarding the impact that the pandemic has had on the different components of their businesses, such as availability of employees, market access, and inventory management, as detailed in Table 4.1. The producers were asked to rate each issue on a scale of 1 to 5 (1=not challenging at all, 2=slightly challenging, 3=challenging but manageable, 4=definitely challenging, 5=very challenging). The survey participants were also asked about the changes in their business operations that they had to incorporate in light of the pandemic, such as changing hours of operation, working with limited staff, and restricting customer access indoors. I also asked the producers to choose the main factor affecting their sales (increase in sales, decrease in sales, and no effect) in 2020, from the following- COVID-19, weather, and general economy prior to COVID-19. Additionally, I also collected data on the size (number of employees) and revenue for the businesses, in order to study the effect that the pandemic has had on different types of businesses.

4.2.2. Econometric Model

I investigated the impact of business size and revenue on the change in overall sales of businesses during COVID-19. I also studied the effect of changes in business operations, such as being open with modified procedures or with no access for customers, on the overall sales during the pandemic. One producer was completely closed due to the pandemic, and has been excluded from our analysis. I employed an ordered logit model for our analysis as described in Equation 1 (Nawrotzki and Bakhtsiyarava, 2017):

$$\text{logit (Y)} = \alpha_0 + \alpha_1 (operation) + \alpha_2 (size) + \alpha_3 (revenue) + \\ + \alpha_4 (operation\ type) + \alpha_5 (business\ type) \quad \varepsilon \quad (1)$$

α0 represents an intercept, while the effects of changes in operation (open with modifications/no customer access), business size (employees), revenue, operation type (grower, retailer, landscaper, etc.), and business type (partnership/individual/incorporated) are reflected by parameters α1, α2, α3, α4, and α5 respectively (Nawrotzki and Bakhtsiyarava, 2017). The dependent variable in our analysis is the change in sales for the businesses. For a more detailed account of ordered logit model, please refer to work by Williams (2016).

4.2.3. Consumer Surveys

I designed an online survey about consumer behavior and their preferences for gardening products and services, using Qualtrics. I collected a nationally representative sample using an online survey platform - Amazon's Mechanical Turk (MTurk). Three selection parameters for choosing participants were applied- (a) Must be at least 18 years

of age (default requirement to create an Amazon MTurk account), (b) Location must be USA, and (c) Overall approval rate of participants' submissions must be over 95%. Keywords such as 'plants', 'flowers', 'gardening', 'landscape', and 'horticulture' were used to target consumers with some knowledge of gardening and/or landscaping. The study protocol was reviewed and approved by IRB (IRB No. : IRB2017-0754D).

I asked the consumers questions regarding change in their expenses and time spent on gardening related activities. Demographic information and personal characteristics, such as income, age, household size, education, gender, race/ethnicity, employment type, type of residence, were also surveyed to identify important factors that affect consumers' demand. In addition to demographic variables, I also asked consumers about the changes they have experienced due to the pandemic. These are represented by the following variables- 'news', 'infected', 'impact', and 'stimulus'. The 'news' variable refers to consumers' agreement with the following statement- 'I often watch/read news on COVID 19', on a scale from 1 to 5 where 1=do not agree at all, and 5=totally. The 'infected' variable refers to their response to the following question- 'Have you or someone you know, ever been infected with COVID 19?' with 1=yes and 0=no. The 'impact' variable refers to their response to the following question- 'How does the outbreak of COVID-19 in the US impact your life?' on a scale of -5 to +5 where -5=Significant negative impact, and 5=Significant positive impact. The 'stimulus' variable referred to whether they/their household received a stimulus check.

4.2.4. Econometric Model

I investigated the impact of different demographic variables as well as the pandemic related variables, on the change in expenses and time spent on gardening during COVID-19. I employed an ordered logit model for our analysis as described in Equation 2 (Nawrotzki and Bakhtsiyarava, 2017):

$$\text{logit (Y)} = \alpha_0 + \alpha_1 (demographic\ variables) + \alpha_2 (pandemic\ related\ variables) + \alpha_3 (time) + \alpha_4 (time^2) + \varepsilon \quad (2)$$

α0 represents an intercept, while the effects of demographic and pandemic-related variables reflected by parameters α1, and α2 respectively (Nawrotzki and Bakhtsiyarava, 2017). α3 and α4 are parameters for time and time squared, respectively. The dependent variables in our analysis is the change in time spent on gardening, change in expenses on gardening, as well as different plants and gardening products. I ran the logit analysis for each dependent variable. For a more detailed account of ordered logit model, please refer to work by Williams (2016).

4.3. Results

4.3.1. Producer sales

For all types of plants as well as gardening products and services included in our study, with the exception of bare root plants, the percentage of producers reporting higher sales outweighed the percentage of producers reporting decreased sales (Figures 4.1 and 4.2). In our survey, over 46% of the producers reported that COVID-19 was a factor that increased their sales in 2020. 64% of the producers indicated higher overall sales

(compared to same season previous year), while less than 24% of the producers reported decreased sales.

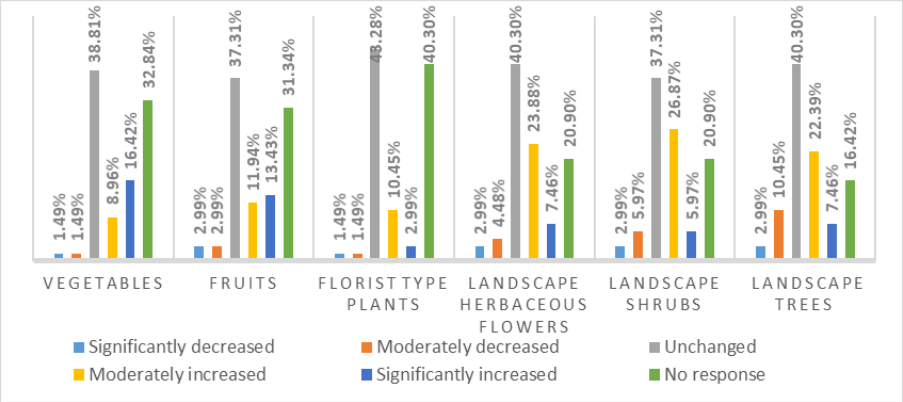

Figure 4.1 Change in purchases of plants during the pandemic, based on producer surveys

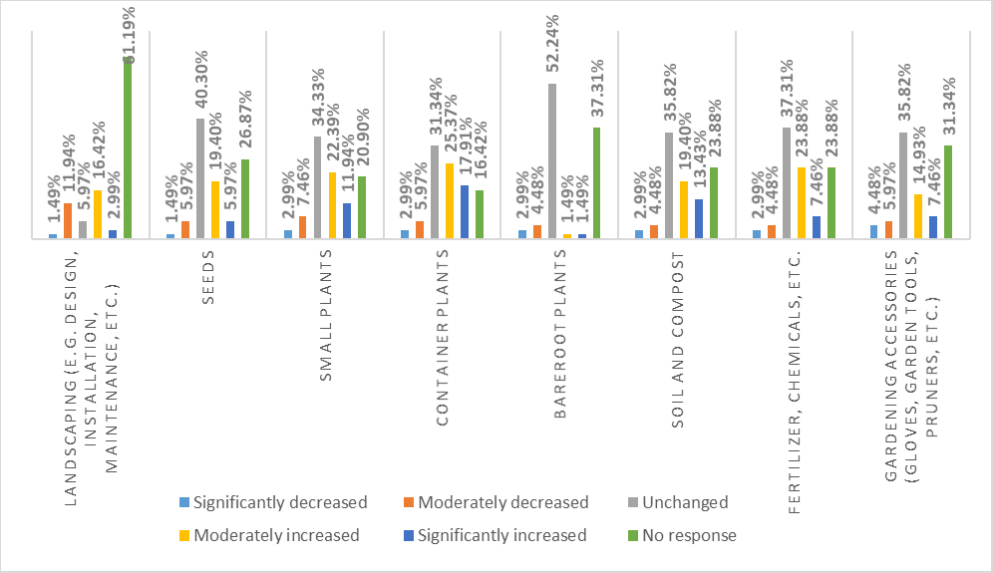

Figure 4.2 Change in purchasing of gardening products/services during the pandemic, based on producer surveys

4.3.2. Challenges faced by producers due to COVID-19

Table 4.1 shows the weighted average rating on a scale of 1 to 5 (1=not challenging at all, 2=slightly challenging, 3=challenging but manageable, 4=definitely challenging, 5=very challenging) for several issues faced by producers due to the pandemic. Our findings indicated that the major challenges faced by the producers were not having enough employees to cover the work hours, not having enough inventory to meet customer demand, and social distancing for employees.

Table 4.1 Severity of challenges faced by producers due to the pandemic on a scale of 1 to 5 (1=not challenging at all, 2=slightly challenging, 3=challenging but manageable, 4=definitely challenging, 5=very challenging)

Challenge	Rating
Not enough employees to keep up with demand	2.86
Not enough inventory to meet customer demand	2.81
Social distancing for employees	2.54
Social distancing for customers	2.48
Compliance with government covid-19 mandates	2.47
Covering work hours with available employee	2.45
Increase in operation costs due to covid-19	2.38

Table 4.1 Continued

Challenge	Rating
Access to government relief programs	2.29
Market access	2.26
Training workers	2.23
Delivering to other state	1.93
Keeping staff employed	1.90
Taxes	1.87
Cash flow obligations	1.84
Billing and collections	1.81

4.3.3. Effects of business size and total revenue

The summary statistics for our survey are described in Table 4.2.

Table 4.2 Summary statistics for the survey

Category	Percentage
Operation Type	
Landscaper	31.34%
Grower	29.85%

Table 4.2 Continued

Category	Percentage
Retail	17.91%
Supplier	14.93%
Arborist	4.48%
Re-wholesaler	1.49%
Change in Operation due to COVID	
Open, as before COVID-19	58.21%
Open -with modified procedures (remote staff, limited staff, limited hours)	34.33%
Open -No Customer Access (phone or online ordering, pick-up or delivery only)	5.97%
Closed -Management decision	1.49%
Change in Sales during COVID	
significantly decreased	14.93%
moderately decreased	8.96%

Table 4.2 Continued

Category	Percentage
no change	11.94%
moderately increased	40.30%
significantly increased	23.88%
Business Type	
Incorporated under state law	70.15%
Partnership – Include family partnerships	17.91%
Family or Individual operation – Exclude partnerships and corporations	10.45%
Other, such as estate or trust, prison farm, grazing association, American Indian Reservation, etc. Please specify	1.49%
Number of Employees	
Less than 10	23.88%
10 to 49	46.27%
50 to 99	10.45%
100 to 499	14.93%
more than 500	4.48%

Table 4.2 Continued

Category	Percentage
Total Revenue	
$0 to $9,999	1.49%
$100,000 to $249,999	5.97%
$250,000 to $349,999	5.97%
$350,000 to $500,000	5.97%
$500,000 to $749,999	2.99%
$750,000 to $999,999	8.96%
$1,000,000 to $1,099,999	4.48%
$1,100,000 to $4,999,999	34.33%
$5,000,000 to $7,999,999	1.49%
over $8,000,000	28.36%

The estimates from our ordered logit model are shown in Table 4.3.

Table 4.3 Ordered logit model estimates for change in overall sales due to modified operations, business size, business type, operation type, and revenue

Change in sales	Odds Ratio	SE	P>|z|
Change in operation (Base=Open- as before COVID)			
Open- with modifications	0.795	0.487	0.708
Open- no customer access	0.680	0.669	0.695
Operation Type (Base= Grower)			
Arborist	0.292	0.366	0.326
Landscaper	0.393	0.287	0.201
Retail	**16.515*** **	14.564	0.001
Supplier	1.685	1.361	0.518
Business Type (Base=Family or Individual operation)			
Incorporated under state law	0.479	0.439	0.422
Partnership – Include family partnerships	0.539	0.561	0.553
Size (per 10 employees)	1.032	0.029	0.255
Revenue (in $100,000)	1.005	0.012	0.667

*** $p < 0.01$, ** $p < 0.05$, *$p<0.10$

Based on the type of operation, the retail type businesses were associated with 16 times higher probability of increased sales, compared to the growers (base). The results were not statistically significant for other business types. In terms of change in daily operations, the difference was not statistically significant as businesses shift from "open – as before COVID" to "open – with modifications" or "open – with no customer access". I also found that the effects of number of employees and revenue on overall sales during the pandemic were not statistically significant.

Table 4.4 Ordered logit model estimates for change in sales of plants and gardening products

Change in sales	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
	Landscaping		**Seeds**		**Small Plants**	
Change in operation (Base=Open- as before COVID)						
Open- with modifications	1.35	0.80	2.75	0.21	1.63	0.52
Open- no customer access	-	-	**0.00****	0.01	0.20	0.25

Table 4.4 Continued

Change in sales	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
Operation Type (Base= Grower)						
Arborist	-	-	0.22	0.35	0.18	0.19
Landscaper	0.53	0.66	0.50	0.50	**0.12****	0.02
Retail	3.63	0.42	**46.02*****	0.00	**16.92*****	0.01
Supplier	3.97	0.43	0.99	1.00	**0.14****	0.04
Business Type (Base=Family or Individual operation)						
Incorporated under state law	1.37	0.82	0.44	0.56	0.60	0.64
Partnership – Include family partnerships	2.99	0.55	0.50	0.68	0.48	0.57
Size (per 10 employees)	0.99	0.77	0.99	0.86	1.02	0.55
Revenue (in $100,000)	1.00	0.97	0.98	0.31	1.00	0.99

Table 4.4 Continued

Change in sales	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
	Container Plants		**Soil and Compost**		**Fertilizer and Chemicals**	
Change in operation (Base=Open- as before COVID)						
Open- with modifications	1.64	0.51	2.38	0.24	1.70	0.47
Open- no customer access	3.12	0.40	**0.06***	0.06	0.12	0.15
Operation Type (Base= Grower)						
Arborist	0.12	0.11	0.21	0.28	0.41	0.54
Landscaper	**0.09****	0.01	0.51	0.47	0.48	0.43
Retail	**28.31*****	0.00	**11.44****	0.01	**8.68****	0.02
Supplier	**0.07*****	0.01	0.80	0.83	0.99	0.99
Business Type (Base=Family or Individual operation)						

Table 4.4 Continued

Change in sales	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
Incorporated under state law	0.60	0.65	1.63	0.65	1.63	0.70
Partnership – Include family partnerships	0.50	0.60	1.16	0.91	1.16	0.92
Size (per 10 employees)	1.03	0.35	0.98	0.60	1.03	0.42
Revenue (in $100,000)	1.00	0.92	0.99	0.42	0.99	0.59
	Gardening Accessories		**Vegetables**		**Fruits**	
Change in operation (Base=Open- as before COVID)						
Open- with modifications	2.07	0.34	6.59	0.10	1.30	0.75
Open- no customer access	1.50E+07	0.99	0.00	0.20	0.99	1.00
Operation Type (Base= Grower)						
Arborist	0.70	0.83	0.02	0.14	**0.04***	0.08

Table 4.4 Continued

Change in sales	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
Landscaper	**0.13***	0.08	**0.03****	0.02	**0.01*****	0.00
Retail	**21.18****	0.01	7.67*	0.06	3.78	0.14
Supplier	2.63	0.42	**0.04****	0.03	**0.03****	0.02
Business Type (Base=Family or Individual operation)						
Incorporated under state law	0.18	0.22	0.39	0.51	0.24	0.25
Partnership – Include family partnerships	0.14	0.24	**0.03***	0.06	0.33	0.47
Size (per 10 employees)	1.00	0.97	0.94	0.16	1.03	0.49
Revenue (in $100,000)	1.02	0.47	1.02	0.29	1.00	0.85
	Florist Type Plants		**Landscape Herbaceous Plants**		**Landscape Shrubs**	
Change in operation						
Open- with modifications	**12.08***	0.07	2.43	0.24	1.13	0.86

Table 4.4 Continued

Change in sales	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
Open- no customer access	0.00	1.00	0.20	0.22	1.25	0.87
Operation Type						
Arborist	0.41	0.76	0.12	0.16	0.24	0.32
Landscaper	0.08	0.20	**0.06*** **	0.00	0.25	0.14
Retail	**28.84** **	0.04	2.79	0.23	4.15	0.14
Supplier	0.09	0.33	**0.11** **	0.03	**0.13** **	0.05
Business Type						
Incorporated under state law	6.00E+11	1.00	2.28	0.51	0.74	0.81
Partnership – Include family partnerships	2.00E+10	1.00	4.46	0.31	0.68	0.78
Size (per 10 employees)	0.83	0.14	1.00	0.91	1.05	0.14
Revenue (in $100,000)	1.05	0.21	1.00	0.84	1.00	0.92

Table 4.4 Continued

Change in sales	Odds Ratio	P>|z|				
	Landscape Trees					
Change in operation (Base=Open- as before COVID)						
Open- with modifications	1.20	0.79				
Open- no customer access	1.86	0.58				
Operation Type (Base= Grower)						
Arborist	0.34	0.39				
Landscaper	0.56	0.47				
Retail	1.46	0.65				
Supplier	0.31	0.18				
Business Type (Base=Family or Individual operation)						

Table 4.4 Continued

Change in sales	Odds Ratio	P>|z|				
Incorporated under state law	0.43	0.43				
Partnership – Include family partnerships	0.60	0.68				
Size (per 10 employees)	**1.05***	0.08				
Revenue (in $100,000)	0.99	0.34				

*** p < 0.01, ** p < 0.05, *p<0.10

4.3.4. Change in consumers' behavior during COVID-19

I collected data from 5,683 consumers from all 50 states and Washington D.C. between April 2020 and May 2021. Table 4.5 illustrates the demographic summary. The sample was 43.16% female, with a mean age of 37.28 years. In addition, 63.82% of the participants had attended at least some college, or had an associate's or a bachelor's degree. Additionally, 90.32% of the participants were employed, either part-time or full-time. 67.40% of the participants lived in a house/duplex, and the average household size was 3.64. The average annual income reported in our survey was $ 69,103.47.

Table 4.5 Summary Statistics of Demographic Information

Variable	Mean (sd)
Age	37.28 (11.19)
Min	18
Max	93
Household Size	3.64 (1.67)
Min	1
Max	12
Gender	
Female	43.16%
Male	56.61%
Other	0.23%
Education	
No schooling completed	0.28%
Regular High School Diploma, GED or equivalent	6.99%
Some College, Associate's degree, or Bachelor's degree	63.82%
Master's degree, Professional degree or Doctorate	28.79%
degree	0.12%
Others	

Table 4.5 Continued

Variable	Mean (sd)
Employment	
Full time	79.20%
Part time	11.12%
Do not work	6.79%
Other	2.89%
Race	
White	75.35%
Black	16.72%
Asian	5.75%
American Indian or Alaska Native	1.74%
Native Hawaiian or Pacific Islander	0.44%
Hispanic	25.83%
Type of Residence	
Owned House/Duplex	51.12%
Owned Apartment/Condo/Loft	13.39%
Rented Apartment/Condo/Loft	18.12%
Rented House/Duplex	16.28%
Other	0.69%

Table 4.5 Continued

Variable	Mean (sd)
Income	$69,103.47
	(56,619.79)
Median	$55,000
Less than $30,000	16.49%
$30,000 to $49,999	22.75%
$50,000 to $59,999	16.59%
$60,000 to $69,999	8.20%
$70,000 to $79,999	11.00%
$80,000 to $89,999	5.47%
$90,000 to $99,999	5.51%
$100,000 to $149,999	8.36%
$150,000 to $249,999	3.78%
$250,000 or more	1.84%
Total Subjects	5,683

I found that COVID-19 had an impact on consumers' behavior. First important finding was that 46.21% of the consumers were spending more time gardening (Figure

4.3). Secondly, 36.35% reported an increase in their gardening expenses, during the outbreak compared to last year (Figure 4.4). A time trend for overall change in consumers' expenses and time spent on gardening during each month of the pandemic is illustrated in Figure 4.5. There was a generally increasing trend in our data.

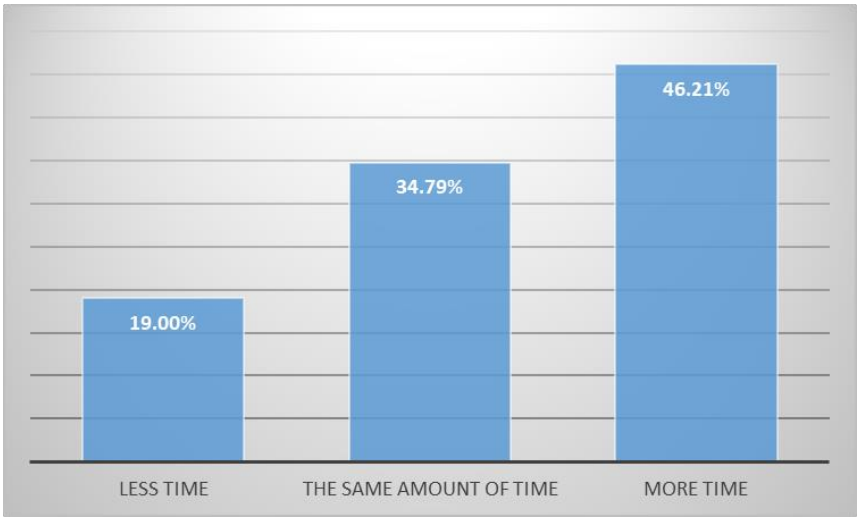

Figure 4.3 Change in consumers' time spent on gardening during the pandemic

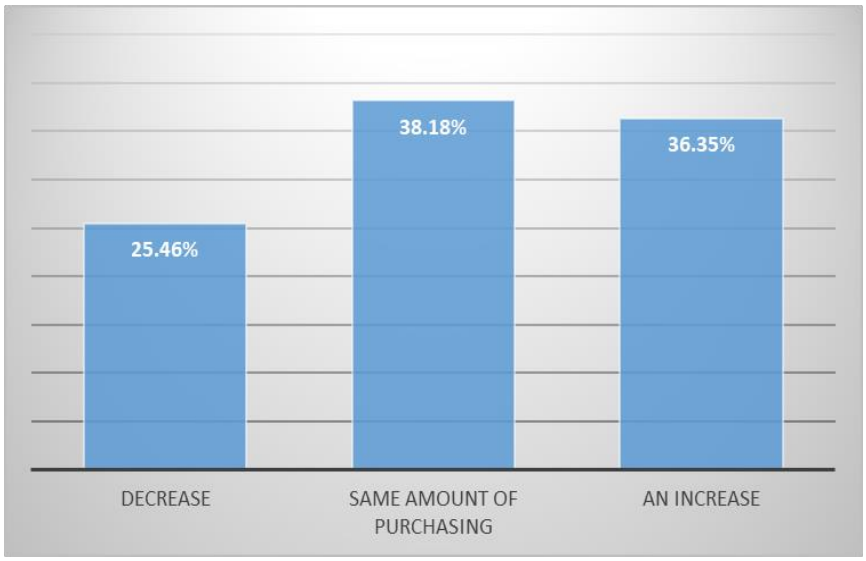

Figure 4.4 Change in consumers' expenses on gardening during the pandemic

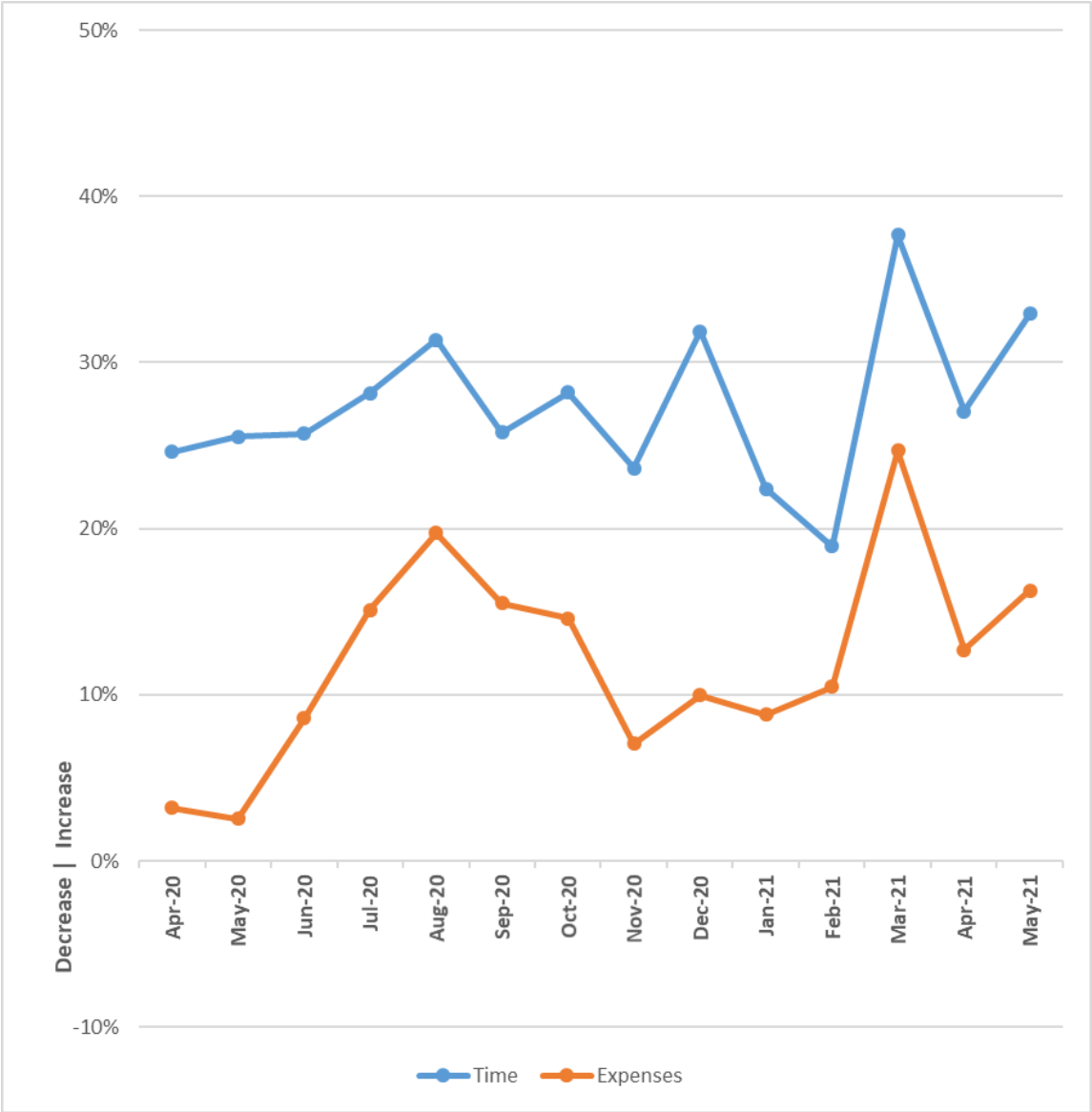

Figure 4.5 Time trend for overall change in consumers' expenses and time spent on gardening during each month of the pandemic

Thirdly, the consumers also preferred shopping online with mail delivery during the outbreak, as compared to in-store purchases during normal times (Figure 4.6).

Finally, I was able to study the change in spending on different gardening products and plants, during the pandemic (Figures 4.7 and 4.8). Among plants, fruits and vegetables reported highest increase in purchases.

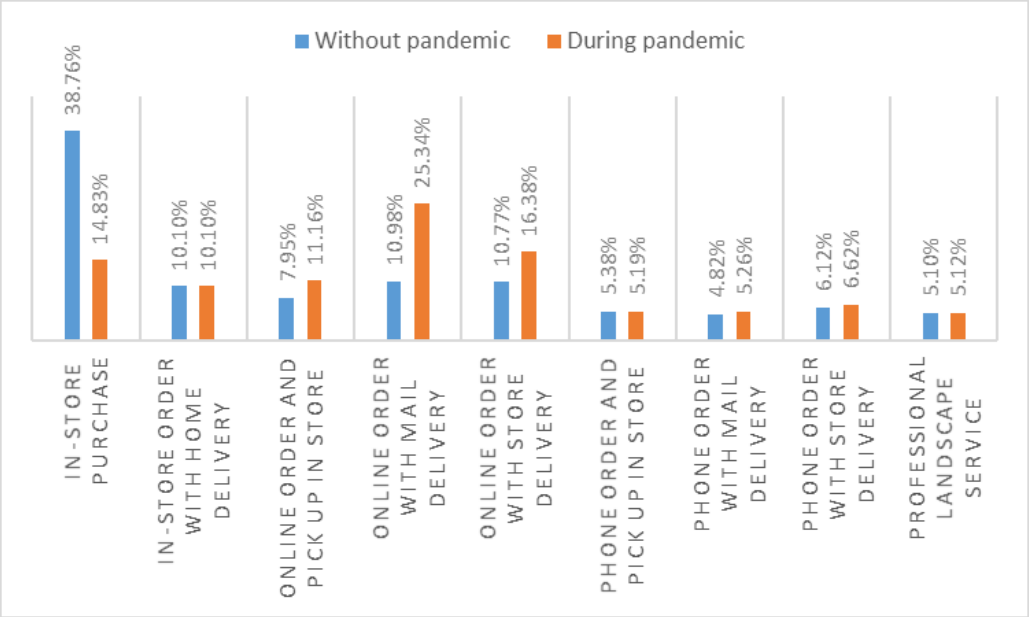

Figure 4.6 Main purchasing outlets during/without an outbreak

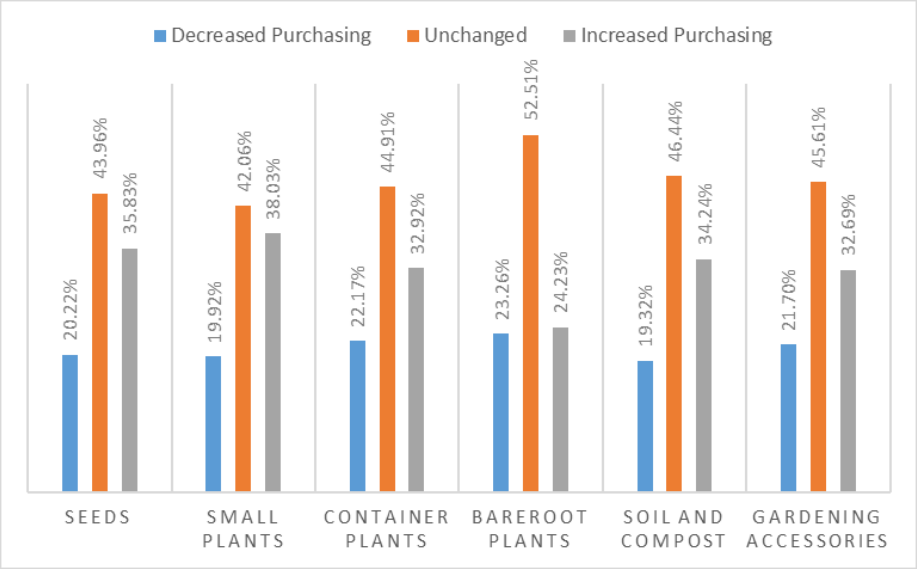

Figure 4.7 Change in consumers' expenses on gardening products during the pandemic

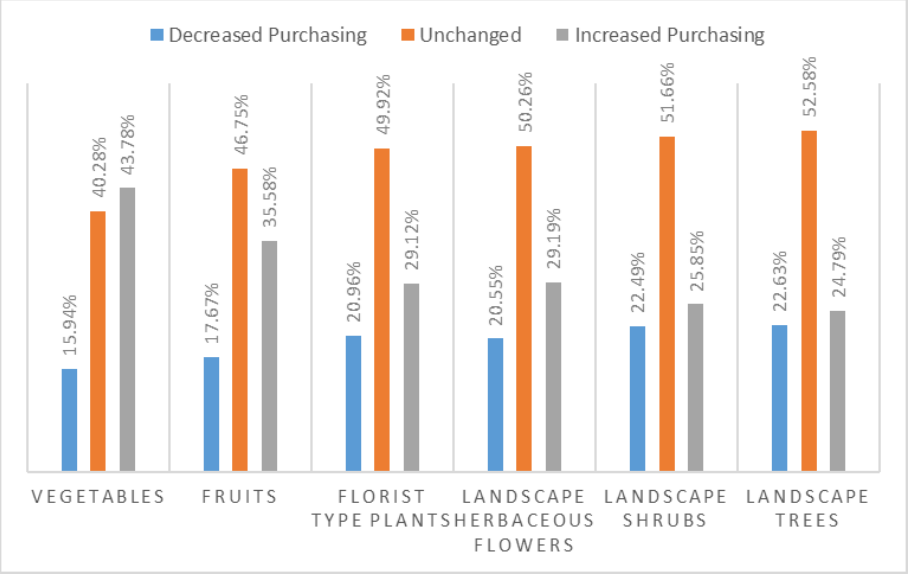

Figure 4.8 Change in consumers' expenses on plants during the pandemic

The estimates from our logit regression are detailed in Tables 4.6 and 4.7. Our analysis showed that higher probability of increased time spent gardening was associated with married people (32.7% higher), Whites (26.2% higher), and people with children (15% higher). The probability of increased time spent was also positively associated with higher education (21.9%) and part time/full time employment (31.7% and 22.1% respectively). People who watched the news on COVID-19 more often were more likely to spend more time gardening (12.8%), and so were the people who were infected with COVID-19 or knew someone who was (14.2%). The people for whom COVID-19 had resulted in a more positive impact on their lives, were less likely to spend time gardening (2.6% lower). In addition, people were more likely to spend a higher amount of time gardening, during spring season (41.3% higher). Effects of gender, age, household size, and receiving stimulus payment were not significant on time spent gardening.

Table 4.6 Ordered logit estimates for factors affecting change in time spent on gardening during the pandemic

Gardening Time	Odds Ratio	SE	P>|z|
Gender (Female=1; Male, Others=0)	1.061	0.055	0.260
Marital status (Married=1; Others=0)	**1.327*** **	0.096	0.000
Race (White=1; Others=0)	**1.262*** **	0.076	0.000

Table 4.6 Continued

Gardening Time	Odds Ratio	SE	P>|z|
Age	0.999	0.002	0.677
Household size	1.020	0.018	0.281
Children (Yes=1; No=0)	**1.150***	0.086	0.062
Education (base= No schooling/High School/GED/Others)			
Some College, Associate's degree, or Bachelor's degree	**1.288*****	0.125	0.009
Master's degree, Professional degree or Doctorate degree	**1.240****	0.132	0.043
Income (in $10,000)	**1.012*****	0.005	0.009
Employment (Do not work)			
Part time job	**1.317****	0.143	0.011
Full time job	**1.221****	0.108	0.024
News (How often watch news on COVID-19; scale of 1 to 5)	**1.128*****	0.029	0.000

Table 4.6 Continued

Gardening Time	Odds Ratio	SE	P>|z|
Infected (Participant or someone they know got COVID=1; otherwise=0)	**1.142****	0.062	0.015
Impact of COVID on life (-5=significant negative to +5=significant positive)	**0.974*****	0.009	0.006
Stimulus (received stimulus check=1; otherwise=0)	0.995	0.055	0.933
Time	**1.169***	0.109	0.093
Time^2	**0.991***	0.005	0.093
Seasonality (base=winter)			
Summer	1.165	0.122	0.143
Spring	**1.413****	0.221	0.027
Fall	0.985	0.095	0.878

*** $p < 0.01$, ** $p < 0.05$, *$p<0.10$

In terms of gardening expenses, I found that a higher probability of increased expenses was associated with married people (30.4% higher), and Whites (22.4% higher). Older people were less likely to spend more on gardening (0.6% lower). More educated people, people with part time and full time employment, and people with higher income were more likely to spend more money on gardening (21.9%, 35.3% and 1.6% respectively). The probability of higher expenses also increased for people who watched news on COVID-19 more often (5.1% higher), people who knew someone or themselves were infected with COVID-19 (9.2% higher), people who experienced a positive impact of COVID-19 on their lives (2.9% higher), and people who belonged to households that received stimulus checks (18.4% higher). In addition, people were more likely to spend more money on gardening, during summer (29.1%) and spring season (35.9% higher). The effects of gender, household size, and having children were not significant.

Table 4.7 Ordered logit estimates for factors affecting change in expenses on gardening during the pandemic

Gardening Expenses	**Odds Ratio**	**SE**	**P>|z|**
Gender (Female=1; Male, Others=0)	1.072	0.055	0.173
Marital status (Married=1; Others=0)	**1.304*** **	0.093	0.000

Table 4.7 Continued

Gardening Expenses	Odds Ratio	SE	P>|z|
Race (White=1; Others=0)	**1.224*** **	0.073	0.001
Age	**0.994** **	0.002	0.017
Household size	1.020	0.018	0.269
Children (Yes=1; No=0)	0.988	0.073	0.868
Education (base= No schooling/High School/GED/Others)			
Some College, Associate's degree, or Bachelor's degree	**1.235** **	0.120	0.030
Master's degree, Professional degree or Doctorate degree	**1.219***	0.129	0.061
Income (in $10,000)	**1.016*** **	0.005	0.001
Employment (Do not work)			
Part time job	**1.306** **	0.143	0.015
Full time job	**1.353*** **	0.121	0.001
News (How often watch news on COVID-19; scale of 1 to 5)	**1.051***	0.027	0.053

Table 4.7 Continued

Gardening Expenses	Odds Ratio	SE	P>|z|
Infected (Participant or someone they know got COVID=1; otherwise=0)	**1.092***	0.058	0.099
Impact of COVID on life (-5=significant negative to +5=significant positive)	**1.029*****	0.010	0.003
Stimulus (received stimulus check=1; otherwise=0)	**1.184*****	0.064	0.002
Time	**1.211****	0.111	0.037
Time^2	**0.990***	0.005	0.060
Seasonality (base=winter)			
Summer	**1.291****	0.133	0.013
Spring	**1.359****	0.209	0.045
Fall	1.052	0.100	0.598

*** $p < 0.01$, ** $p < 0.05$, *$p<0.10$

The ordered logit estimates for factors affecting change in expenses on plants and gardening products are detailed in Table 4.8 below.

Table 4.8 Ordered logit estimates for factors affecting change in expenses on plants and gardening products

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
	Seeds	**Small Plants**	**Container Plants**
Gender (Female=1; Male, Others=0)	1.020	**1.103***	**1.156*****
Marital status (Married=1; Others=0)	1.074	1.017	1.06
Race (White=1; Others=0)	**1.197*****	**1.239*****	**1.190*****
Age	0.997	0.998	0.999
Household size	1.029	1.005	1.023
Children (Yes=1; No=0)	**1.132***	1.09	0.997
Education (base= No schooling/High School/GED/Others)			
Some College, Associate's degree, or Bachelor's degree	**1.318*****	**1.381*****	**1.330*****

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
Master's degree, Professional degree or Doctorate degree	**1.204***	1.228*	1.226*
Income (in $10,000)	0.999	**1.015*****	**1.008***
Employment (Do not work)			
Part time job	1.127	1.12	1.063
Full time job	**1.257*****	**1.291*****	**1.292*****
News (How often watch news on COVID-19; scale of 1 to 5)	**1.096*****	**1.108*****	**1.083*****
Infected (Participant or someone they know got COVID=1; otherwise=0)	**1.128****	1.015	1.061
Impact of COVID on life (-5=significant negative to +5=significant positive)	1.003	0.994	**1.018***

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
Stimulus (received stimulus check=1; otherwise=0)	1.014	1.061	1.092
Time	1.057	0.963	0.879
Time^2	0.998	1.004	**1.009***
Seasonality (base=winter)			
Summer	0.969	0.915	0.899
Spring	1.003	0.802	**0.715****
Fall	1.029	1.057	1.048
	Bareroot Plants	**Soil and Compost**	**Gardening Accessories**
Gender (Female=1; Male, Others=0)	0.953	**1.161*****	0.983
Marital status (Married=1; Others=0)	**1.249*****	**1.156****	1.101
Race (White=1; Others=0)	**1.180*****	**1.135****	**1.105***
Age	0.997	**0.995****	0.998

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
Household size	1.024	1.023	1.019
Children (Yes=1; No=0)	1.047	0.975	**1.164****
Education (base= No schooling/High School/GED/Others)			
Some College, Associate's degree, or Bachelor's degree	**1.378*****	**1.390*****	1.141
Master's degree, Professional degree or Doctorate degree	**1.377*****	**1.300****	0.985
Income (in $10,000)	0.999	**1.018*****	1.006
Employment (Do not work)			
Part time job	1.016	1.069	1.024
Full time job	**1.308*****	1.094	**1.334*****
News (How often watch news on COVID-19; scale of 1 to 5)	**1.045***	**1.085*****	**1.106*****

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
Infected (Participant or someone they know got COVID=1; otherwise=0)	1.087	0.978	1.015
Impact of COVID on life (-5=significant negative to +5=significant positive)	**1.056*** **	**1.019***	**1.022****
Stimulus (received stimulus check=1; otherwise=0)	1.023	**1.154*** **	1.053
Time	0.863	0.979	1.038
Time^2	**1.010***	1.002	1
Seasonality (base=winter)			
Summer	0.872	0.862	1.105
Spring	**0.676****	0.832	0.98
Fall	1.119	1.026	1.152

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
	Vegetables	**Fruits**	**Florist Type Plants**
Gender (Female=1; Male, Others=0)	**1.149*** **	1.014	0.958
Marital status (Married=1; Others=0)	**1.171** **	**1.217*** **	**1.252*** **
Race (White=1; Others=0)	1.074	1.073	1.09
Age	0.997	**0.992*** **	**0.993*** **
Household size	**1.031***	**1.047** **	**1.046** **
Children (Yes=1; No=0)	1.097	**1.295*** **	0.984
Education			
(base= No schooling/High School/GED/Others)			
Some College, Associate's degree, or Bachelor's degree	**1.357*** **	1.169	**1.385*** **
Master's degree, Professional degree or Doctorate degree	1.175	1.147	**1.263** **
Income (in $10,000)	0.998	**0.989** **	1.002

Employment			

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
(Do not work)			
Part time job	1.038	1.109	0.919
Full time job	1.158	**1.264*** **	**1.245** **
News (How often watch news on COVID-19; scale of 1 to 5)	**1.198*** **	**1.197*** **	**1.066** **
Infected (Participant or someone they know got COVID=1; otherwise=0)	**1.142** **	1.085	1.083
Impact of COVID on life (-5=significant negative to +5=significant positive)	**0.980** **	**1.023** **	**1.051*** **
Stimulus (received stimulus check=1; otherwise=0)	0.938	**0.765*** **	**1.109** *
Time	0.943	0.879	0.954
Time^2	1.004	1.008	1.004

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
Seasonality (base=winter)			
Summer	1.134	0.976	1.171
Spring	0.852	0.82	0.95
Fall	**1.222****	**1.303*****	**1.239****
	Landscape Herbaceous Flowers	**Landscape Shrubs**	**Landscape Trees**
Gender (Female=1; Male, Others=0)	0.976	0.937	0.989
Marital status (Married=1; Others=0)	**1.152****	**1.175****	**1.250*****
Race (White=1; Others=0)	1.104	**1.243*****	**1.148****
Age	**0.996***	0.999	**0.996***
Household size	**1.047****	1.018	1.02
Children (Yes=1; No=0)	1.047	1.104	1.072
Education			

(base= No schooling/High School/GED/Others)			

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
Some College, Associate's degree, or Bachelor's degree	**1.492*** **	**1.461*** **	**1.317*** **
Master's degree, Professional degree or Doctorate degree	**1.513*** **	**1.414*** **	**1.334*** **
Income (in $10,000)	1.007	**1.009***	1.001
Employment (Do not work)			
Part time job	1.091	1.09	**1.207***
Full time job	**1.338*** **	**1.392*** **	**1.439*** **
News (How often watch news on COVID-19; scale of 1 to 5)	**1.045***	**1.053****	1.037

Infected (Participant or someone they know got COVID=1; otherwise=0)	1.035	1.033	**1.119****
Impact of COVID on life (-5=significant negative to +5=significant positive)	**1.041*****	**1.059*****	**1.067*****

Table 4.8 Continued

Expenses	**Odds Ratio**	**Odds Ratio**	**Odds Ratio**
Stimulus (received stimulus check=1; otherwise=0)	1.052	0.988	0.972
Time	1.059	1.016	1.009
Time^2	0.998	1.001	1.001
Seasonality			
(base=winter)			
Summer	1.146	1.086	1.007
Spring	1.079	0.906	0.916
Fall	**1.202***	1.145	**1.194***

*** $p < 0.01$, ** $p < 0.05$, *$p<0.10$

4.4. Discussion

In general, producers reported higher overall sales for all plants and gardening supplies included in our survey, with the exception of bare root plants. 64% of the producers indicated higher overall sales compared to same season previous year. Over 46% of the producers attributed higher sales to COVID-19. These are interesting findings, which imply a greater demand potential for plants and gardening products/services from consumers, in light of this pandemic. It is very important for producers to match this potential demand in order to move towards economic recovery in the aftermath of the pandemic. The major challenges that all businesses faced were lack of enough employees to cover hours of operation, not enough inventory to keep up with the consumer demand, and social distancing for employees. Based on the type of operation, the retail type businesses were associated with 16 times higher probability of increased sales, compared to the growers (base). The results were not statistically significant for other business types. In terms of change in daily operations, the difference was not statistically significant as businesses shift from “open – as before COVID” to “open – with modifications” or “open – with no customer access”. I also found that the effects of number of employees and revenue on overall sales during the pandemic were not statistically significant. This suggests that in general, the pandemic has affected diverse businesses in a similar manner. Awareness regarding these major challenges, and the impact of the pandemic on businesses would provide insight to governmental agencies while planning aid, relief programs, and assistance. The results from our

producer surveys indicate that the pandemic has had a huge impact on the gardening industry.

46.21% of the consumers reported an increase in time spent on gardening, as well as 36.35% reported an increase in gardening expenses. Both these findings show that there is a huge potential for increased demand for plants and gardening products. In addition, consumers preferred online shopping and mail delivery during the pandemic. Given that there are multiple modes of shopping for consumers and several distribution channels available to producers, this is an important finding since it can provide businesses with some insights for streamlining their supply chain. Additionally, these findings reveal spending changes for various plants and gardening supplies. This product-specific impact is critical for diverse types of businesses, since it gives an excellent snapshot of how different products/services have been affected specifically, and can guide them in managing the supply chain for different products during these times with altered demand. Finally, our analysis also showed the role of consumers' personal characteristics, such as age, income, and level of education, on their expenses and time spent on gardening. This information can help businesses in developing effective marketing strategies based on their target customer base. The results from the consumer surveys indicate that the pandemic has had a huge impact on the gardening industry.

Results of this study provide important information for supply chain management, general operations, and marketing practices for businesses in the gardening industry; it is

useful to guide the nursery owners and the green industry to drive towards the economic recovery from COVID-19.

4.5. References

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5. CONCLUSIONS

Horticulture industry is an important part of the U.S. economy. It is facing several challenges, a major one being pest infestation. Crapemyrtle, the main focus of this study, is no exception. As detailed earlier, extant literature has focused on studying the causal organism and mechanism of CMBS and sheds light on countering the CMBS issue. However, CMBS is an issue that needs to be dealt with, on multiple fronts. It is not enough just to focus on strategies to control it; there is an immediate need to evaluate its economic impact. It results in loss of attributes such as flower density and bark color, which are of immense commercial value. The first essay showed that CMBS results in a decrease in consumers' WTP for crapemyrtle plants, by over 46%. This provides producers with an estimate of the potential loss due to the infestation, and suggests the importance of effective CMBS control. The analysis also showed the effects of consumers' personal characteristics on their willingness-to-pay for crapemyrtle plants. This can help the businesses to adjust their marketing strategies based on consumers they are targeting. The results of this study will provide important information to the production and marketing practices of the green industry.

The findings from my second essay indicate industry demand for CMBS control, and show that producers anticipated a decrease in crapemyrtle value and sales, if infested with CMBS. An important finding of this research is that a majority of business representatives support science-based CMBS control research. In addition, more business representatives with high volume of crapemyrtle-related sales considered the benefits of CMBS control to be higher than its cost, as compared to other businesses.

These findings usher in optimism for researchers working on CMBS control, and it would motivate more projects researching control strategies. It is therefore important to create effective communication and information material regarding CMBS and its control, tailored to different business types—growers, wholesalers, retailers, and landscapers.

I address the impact of COVID-19 on the business as well as consumers, in my third essay. In general, producers reported higher overall sales for all plants and gardening supplies included in our survey, with the exception of bare root plants. This implies a greater demand potential for plants and gardening products/services from consumers, in light of this pandemic. Similarly, the consumers reported an increase in time spent on gardening, as well as in gardening expenses. The product-specific impact is critical for diverse types of businesses, since it gives an excellent snapshot of how different products/services have been affected specifically, and can guide them in managing the supply chain for different products during these times with altered demand. Finally, the analysis also showed the role of consumers' personal characteristics, such as age, income, and level of education, on their expenses and time spent on gardening. This information can help businesses in developing effective marketing strategies based on their target customer base.

Results of this study provide important information for supply chain management, general operations, and marketing practices for businesses in the gardening industry; it is useful to guide the nursery owners and the green industry to drive towards the economic recovery from COVID-19.

APPENDIX A

CMBS CONSUMER SURVEY

End of Block: Consent

Start of Block: Demographic Information

Q26 Please enter your MTurk Worker ID

_____

Q27 Gender

- Male
- Female
- Other

6.

Q28 What is your current marital status?

- Never married
- Separated
- Divorced
- Widowed
- Married

Q29 Please indicate your country of citizenship

_____

7.

Q30 Which state do you live in?

▼ Alabama ... Wyoming

Q45 What is your zip code?

_____

8.

Q32 Race/Ethnicity Information 1

- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or Pacific Islander

9. 

Q46 Race/Ethnicity Information 2

- Hispanic
- Non-hispanic

Q33 Age (years)

_____

Q36 Household Size (Including you)

▼ 1 ... 12

Q37 Number of children in the household.

▼ 0 ... 10

10. 

Q48 Type of Residence

- ○ Rented Apartment/Condo/Loft
- ○ Rented House/Duplex
- ○ Owned Apartment/Condo/Loft
- ○ Owned House/Duplex
- ○ Other _____

Q31 Please indicate the highest degree or level of school you have completed:

- ○ No schooling completed
- ○ Regular High School Diploma, GED or equivalent
- ○ Some College, Associate's degree, or Bachelor's degree
- ○ Master's degree, Professional degree or Doctorate degree
- ○ Other _____

Q40 Annual household income (in US Dollars). Please indicate your household yearly income for last year. (Include all forms of income, including salary, interest and dividend payments, tips, scholarship support, student loans, parental support, social security,

child support, and allowance). IMPORTANT NOTE: If you receive income in a currency other than US Dollars, please convert it into US Dollars before entering it here.

- ○ Less than $20,000
- ○ $20,000 to $29,999
- ○ $30,000 to $39,999
- ○ $40,000 to $49,999
- ○ $50,000 to $59,999
- ○ $60,000 to $69,999
- ○ $70,000 to $79,999
- ○ $80,000 to $89,999
- ○ $90,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 to $199,999
- ○ $200,000 to $249,999
- ○ $250,000 to $299,999

- ○ $300,000 to $349,999
- ○ $350,000 to $399,999
- ○ $400,000 to $449,999
- ○ $450,000 to $499,999
- ○ $500,000 or more

---

11. 

Q49 What is your employment status?

- ○ Do not work
- ○ Full time
- ○ Part time
- ○ Other _____

Q44 What is your weight (in lbs)?

- ○ lbs _____

Q54 What is your height?

	1 2 3 4 5 6 7 8 9 10 11
ft	
in	

12.

Q50 Before moving on to the next question, can you answer the following calculation based question:
3 + 5 = 9

- True
- False

13.

Q51 Do you trust that you will be paid exactly as stated in the instructions?

- Yes
- No

End of Block: Demographic Information

Start of Block: Next Section

14.

Q52 Do you know what crapemyrtle is?

- ○ Yes
- ○ No

---

15. 

Q53 Which of the following colors of crapemyrtles are you aware of (select all that apply)?

- ☐ Purple
- ☐ Pink
- ☐ White
- ☐ Red
- ☐ None of these
- ☐ Other: _____

Q55 Short description of crapemyrtle

Crape myrtle is a medium to large shrub or a small multi-stemmed tree that can grow up to 40 feet. Flowering begins as early as May in some cultivars and continues into the fall. Each 6- to 18- inch cluster of flowers (or panicle) develops on the tips of new growth and is composed of hundreds of 1-to 2-inch flowers. Color ranges include

shades of purple, white, pink and red, including "true" red, a relatively recent development. Source: https://www.usda.gov/

16.

Q56 Have you ever bought crapemyrtle?

- Yes
- No

Skip To: End of Block If Have you ever bought crapemyrtle? = No

Q59 Where did you purchase your most recent crapemyrtle from?

_____

17.

Q60 Which of the following colors of crapemyrtles did you buy during your most recent trip to the above mentioned seller (select all that apply)?

- [ ] Purple
- [ ] Pink
- [ ] White
- [ ] Red
- [ ] None of these
- [ ] Other _____

Q61 How much did you spend (in $) at the above mentioned seller during your most recent trip?

_____

Q62 How many crapemyrtle plants did you buy from the above mentioned seller during your most recent trip?

_____

18. 

Q63 What kind of a seller is the above mentioned seller?

- ○ Nursery
- ○ Garden Center
- ○ Wholesaler
- ○ Retail Chain
- ○ Online Seller
- ○ Other: _____

Q64 How many times in the past 10 years have you bought crapemyrtle from the above mentioned seller?

_____

Q65 In the past 10 years how many crapemyrtle plants (total) have you bought from all the sellers combined?

_____

Q66 In the past 10 years how many crapemyrtle plants in your home have died, or have been discarded?

_____

Q67 Currently, how many crapemyrtle plants do you have at your residence?

_____

19.

Q68 Which of the following colors of crapemyrtles (total) have you bought up until now (select all that apply)?

- [ ] Purple
- [ ] Pink
- [ ] White
- [ ] Red
- [ ] None of these
- [ ] Other _____

Q69 How much have you spent (in $) up until now on crapemyrtle plants?

_____

20.

Q70 What type of sellers have you bought crapemyrtle plants from, up until now? (select all that apply)

- [ ] Nursery
- [ ] Garden Center
- [ ] Wholesaler
- [ ] Retail Chain
- [ ] Online Seller
- [ ] Other: _____

21.

Q71 Before moving on to the next question, can you answer the following calculation based question:

5 + 2 = 9

- ○ True
- ○ False

End of Block: Next Section

Start of Block: Next Section

22.

Q156 How important are the following factors to you when making crapemyrtles purchasing decision?(Please select only one level of importance per row).

	Not Important At All	Not Very Important	Somewhat Important	Very Important
Easy maintenance	○	○	○	○
Disease Resistance	○	○	○	○
Flower color	○	○	○	○
Foliage color	○	○	○	○
Bark color	○	○	○	○
Height	○	○	○	○
Growth Habit	○	○	○	○

Q145 What are your top three most preferred crapemyrtle cultivars and their most preferred respective size?

- Cultivar 1 _____
- Size (in gal) _____
- Cultivar 2 _____
- Size (in gal) _____
- Cultivar 3 _____
- Size (in gal) _____

---

23. 24.

Q58 Please rank the following colors of crapemyrtle based on what you prefer. Rank 1 being what you like the most, rank 4 being what you like the least.

_____ Purple
_____ Pink
_____ White
_____ Red

25.

Q72 Please rank the following sizes of crape myrtle plants sold, based on what you prefer. Rank 1 being what you like the most, rank 8 being what you like the least.

_____ Half gallon
_____ 1 gallon
_____ 3 gallon
_____ 5.5 gallon
_____ 10.25 gallon
_____ 15 gallon
_____ 30 gallon
_____ 45 gallon

Q73 How much would you be willing to pay for one 3-4 ft. tall Tuscarora crapemyrtle plant, by physically going to the store? (enter values in dollars)

_____

Q74 How much would you be willing to pay for the same crapemyrtle plant, if it were delivered to your residence? (enter values in dollars)

_____

Q76 How much would you be willing to pay for a 6-7 ft. tall, Muskogee crapemyrtle plant, by physically going to the store? (enter values in dollars)

_____

Q77 How much would you be willing to pay for the same crapemyrtle plant, if it were delivered to your residence? (enter values in dollars)

_____

Q78 The tree shown in the picture below has attained maturity and will not bloom/flower more than the current state. How much would you be willing to pay for the crapemyrtle plant in the picture below, if it were delivered to your residence and planted by a landscaper? (enter values in dollars)

Q79 The tree shown in the picture below has attained maturity and will not bloom/flower more than the current state. How much would you be willing to pay for the crapemyrtle plant in the picture below, if it were delivered to your residence and planted by a landscaper? (enter values in dollars)

Q80 The tree shown in the picture below has attained maturity and will not bloom/flower more than the current state. Now, hypothetically, you're provided with $300 as your budget for buying crape myrtle. From the $300, you can keep the unspent money. How much would you be willing to pay for the crapemyrtle plant in the picture below, if it were delivered to your residence and planted by a landscaper? (enter values in dollars)

Q81 The tree shown in the picture below has attained maturity and will not bloom/flower more than the current state. Now, hypothetically, you're provided with $300 as your budget for buying crape myrtle. From the $300, you can keep the unspent money. How much would you be willing to pay for the crapemyrtle plant in the picture below, if it were delivered to your residence and planted by a landscaper? (enter values in dollars)

Q82 Now, hypothetically, you have the option to receive a crape myrtle plant for free. Both trees shown in the picture below have attained maturity and will not bloom/flower more than the current state. Which buying option would you choose from the picture below? (choose one)

a

b

c

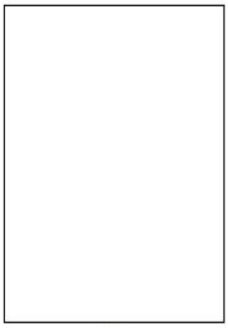
- ○ Plant on the left
- ○ Plant on the right
- ○ Neither

Q83 Both trees shown in the picture below have attained maturity and will not bloom/flower more than the current state. Now, hypothetically, you have to make a purchasing decision to buy a tree. Which buying option would you choose below?

Q143 Scenario 1

$250 for this plant
a

$350 for this plant
b



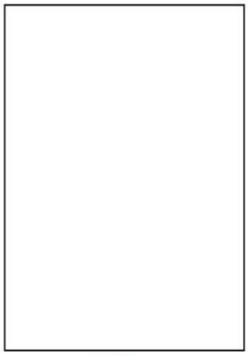
Neither
c

- ○ Plant on the left
- ○ Plant on the right
- ○ Neither

Q84 Scenario 2

$350 for this plant
a

$250 for this plant
b



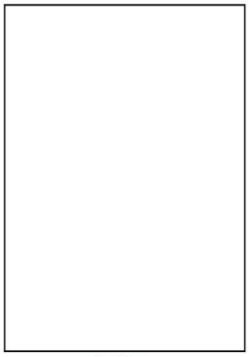
Neither
c

- ○ Plant on the left
- ○ Plant on the right
- ○ Neither

Q85 Scenario 3

$300 for this plant
a

$350 for this plant
b



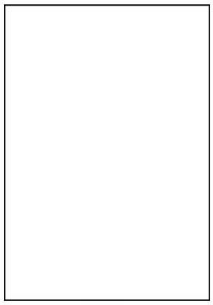
Neither
c

- ○ Plant on the left
- ○ Plant on the right
- ○ Neither

Q86 Scenario 4

$350 for this plant
a

$300 for this plant
b



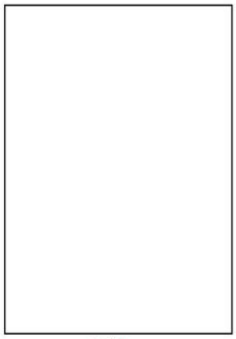
Neither
c

- ○ Plant on the left
- ○ Plant on the right
- ○ Neither

Q87 Scenario 5

$200 for this plant
a

$200 for this plant
b



Neither
c

- ○ Plant on the left
- ○ Plant on the right
- ○ Neither

26.

Q88 Before moving on to the next question, please answer the following calculation based question:

7 + 2 = 9

- ○ True
- ○ False

End of Block: Next Section

Start of Block: Next Section

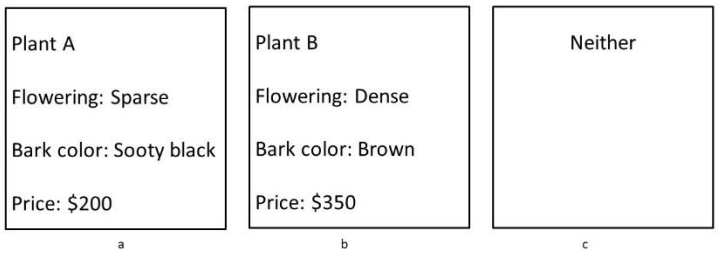
Q89 Both trees described below have attained maturity and will not bloom/flower more than the current state. Now, hypothetically, you have to make a purchasing decision to

buy a tree. Which buying option would you choose from each of the scenarios below? (choose one)

Q90 Scenario 1

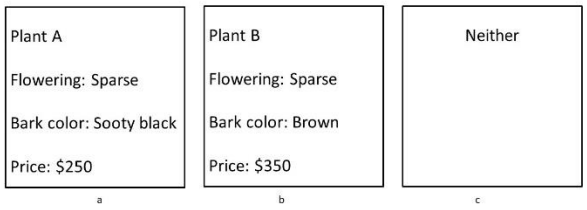
- a
- b
- c

Q91 Scenario 2



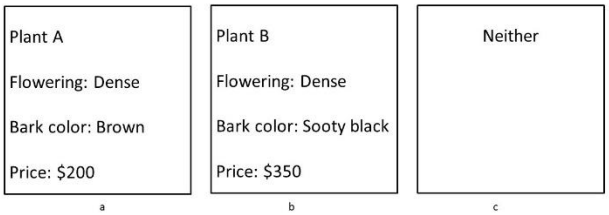
- ○ a
- ○ b
- ○ c

Q92 Scenario 3



- ○ a
- ○ b
- ○ c

Q93 Scenario 4

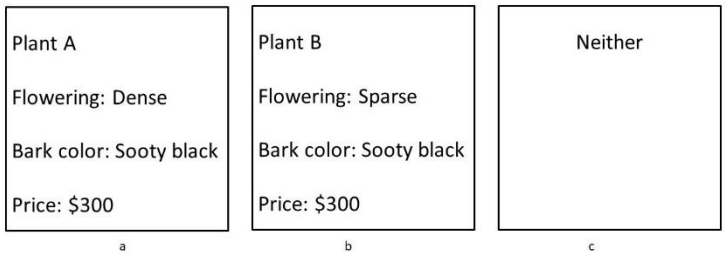


- a
- b
- c

Q94 Scenario 5

- a
- b
- c

Q95 Scenario 6

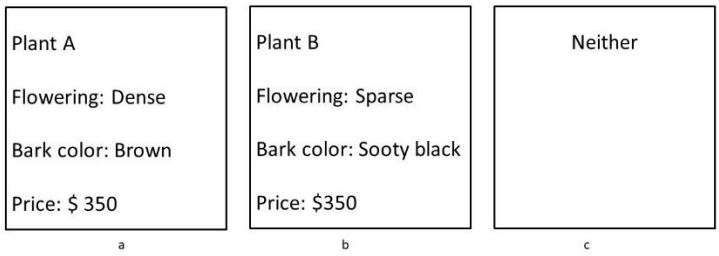


- a
- b
- c

Q96 Scenario 7

- ○ a
- ○ b
- ○ c

Q97 Scenario 8



- a
- b
- c

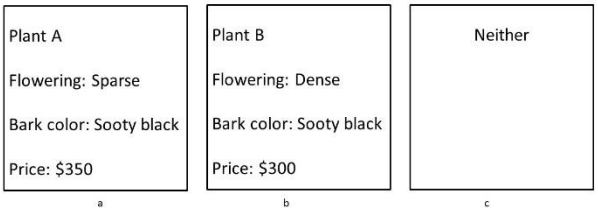
Q98 Scenario 9

- a
- b
- c

Q99 Scenario 10

- a
- b
- c

Q100 Scenario 11



- a
- b
- c

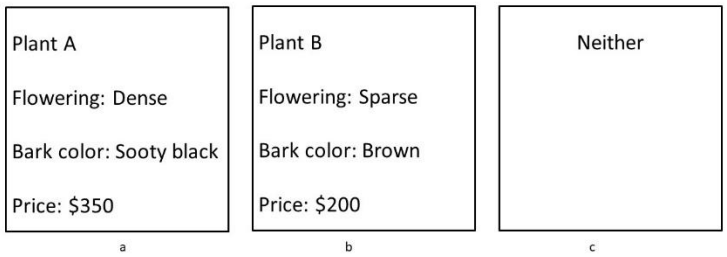
Q101 Scenario 12

- a
- b
- c

Q102 Scenario 13

- a
- b
- c

Q103 Scenario 14

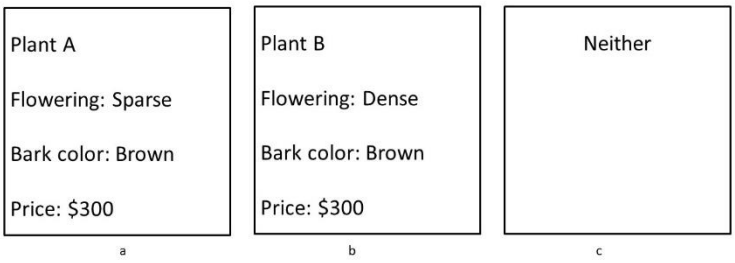


- a
- b
- c

Q104 Scenario 15

- a
- b
- c

Q105 Scenario 16



- a
- b
- c

27.

Q106 Before moving on to the next question, can you answer the following calculation based question? 6 + 1 = 7

- True
- False

End of Block: Next Section

Start of Block: Next Section

28.

Q144 If crapemyrtle becomes unavailable, what is your most preferred replacement plant?

- ○ Magnolia
- ○ Hibiscus
- ○ Callistemon (Bottlebrush)
- ○ Vitex (Texas lilac)
- ○ Nerium (Oleander)
- ○ Wax Myrtle
- ○ Nothing can replace crapemyrtle
- ○ Other: _____

29.

Q107 Have you ever bought any of the following flowering plants (select all that apply)?

- [ ] Magnolia
- [ ] Hibiscus
- [ ] Callistemon (Bottlebrush)
- [ ] Vitex (Texas lilac)
- [ ] Nerium (Oleander)
- [ ] Wax Myrtle
- [ ] Never bought any of these
- [ ] Other: _____

30.

Q108 Please rank the following based on what you prefer. Rank 1 being what you like the most, rank 6 being what you like the least.

_____ Magnolia
_____ Hibiscus
_____ Callistemon (Bottlebrush)
_____ Vitex (Texas lilac)
_____ Nerium (Oleander)
_____ Wax Myrtle

End of Block: Next Section

Start of Block: Next Section

31.

Q109 Are you aware of any of the following pests and diseases in crapemyrtle plants (select all that apply)?

- [ ] Mildew
- [ ] Leaf spots
- [ ] Bark scale
- [ ] Beetles
- [ ] Lichens
- [ ] Aphids
- [ ] None of these
- [ ] Other: _____

Q157 Crapemyrtle bark scale (CMBS) is a relatively new insect found mainly on crapemyrtles. This scale causes heavy honeydew deposits followed by a black sooty mold, which severely diminishes the landscape value of this important ornamental plant. And some field observations suggest heavy infestations of CMBS reduces the size of panicles, delays flowering, and kills small twigs on crapemyrtle.

Q158 Have you noticed symptoms of possible Crapemyrtle Bark Scale (CMBS) infestation in your plants?

- Yes
- Never
- Maybe
- I do not have crapemyrtles

Q159 Do you anticipate that CMBS will result in a significant drop in use of crapemyrtles in your area?

- Yes
- Never
- Maybe
- Not sure

Q160 Your willingness to purchase crapemyrtles will be_____ if it's infested by CMBS.

- Significantly decreased
- Somewhat decreased
- Unchanged
- Somewhat increased
- Significantly increased
- Not sure

Q161 Do you think the overall benefits from CMBS control will be higher than the cost of CMBS control?

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Strongly agree
- ○ Not sure

End of Block: Next Section

Start of Block: Next Section

Q162 To what extent do you agree with the following statement during the COVID19 outbreak? (please indicate your own judgment on a scale from 1 to 5 where 1= do not agree at all, and 5= totally agree).

	1	2	3	4	5
I often watch/read news on COVID 19.	○	○	○	○	○

32. 

Q170 Have you or someone you know, ever been infected with COVID 19?

- ○ Yes
- ○ No

Q163 How does the outbreak of COVID-19 in the US impact your life?

	Significant negative impact			Slightly negative impact		No impact		Slightly positive impact		Significant positive impact
	-5	-4	-3	-2	-1	0	1	2	3	4	5
.											

Q167 To what extent are you concerned about unemployment, caused by the COVID19 outbreak?1= I'm not concerned about it at all, to 10= I'm concerned about it very much.

	I'm not concerned about it at all									I'm concerned about it very much
	1	2	3	4	5	6	7	8	9	10
.										

Q168 To what extent are you concerned about a decline in your income or your household income, caused by the COVID19 outbreak?1= I'm not concerned about it at all, to 10= I'm concerned about it very much.

	I'm not concerned about it at all									I'm concerned about it very much
	1	2	3	4	5	6	7	8	9	10
.										

33.

Q147 Given the current situation with COVID-19, you are spending _____ gardening, compared to the same season last year.

- more time
- the same amount of time
- less time

34.

Q148 Do you now spend more time gardening by yourself or along with family members?

- By yourself
- With family members

35.

Q149 There has been _____ in your general household gardening expenses during COVID-19, compared to the same season last year.

- an increase
- same amount of purchasing
- decrease

36.

Q150 The increased/decreased expenses in gardening products, is (are) in what categories?

	Increased Purchasing	Unchanged	Decreased Purchasing
Seeds	○	○	○
Small Plants	○	○	○
Container Plants	○	○	○
Bareroot Plants	○	○	○
Soil And Compost	○	○	○
Gardening Accessories (gloves, garden tools, pruners, etc.)	○	○	○

37. 

Q152 The increased/decreased expenses in plants, is (are) in what type(s)?

	Increased Purchasing	Unchanged	Decreased Purchasing
Vegetables	○	○	○
Fruits	○	○	○
Florist Type Plants	○	○	○
Landscape Herbaceous Flowers	○	○	○
Landscape Shrubs	○	○	○
Landscape Trees	○	○	○

38.

Q151 What are your main purchasing outlets so far this season, under COVID-19 outbreak (select all that apply)?

- [ ] in-store purchase
- [ ] in-store order with home delivery
- [ ] online order and pick up in store
- [ ] online order with mail delivery
- [ ] online order with store delivery
- [ ] phone order and pick up in store
- [ ] phone order with mail delivery
- [ ] phone order with store delivery
- [ ] professional landscape service.

---

39. 

Q153 What were your main purchasing outlets before COVID-19 outbreak (select all that apply)?

- [ ] in-store purchase
- [ ] in-store order with home delivery
- [ ] online order and pick up in store
- [ ] online order with mail delivery
- [ ] online order with store delivery
- [ ] phone order and pick up in store
- [ ] phone order with mail delivery
- [ ] phone order with store delivery
- [ ] professional landscape service.

40.

Q154 What is your most preferred purchasing outlet if there is an outbreak of an infectious disease, like COVID-19? (select one)

- ○ in-store purchase
- ○ in-store order with home delivery
- ○ online order and pick up in store
- ○ online order with mail delivery
- ○ online order with store delivery
- ○ phone order and pick up in store
- ○ phone order with mail delivery
- ○ phone order with store delivery
- ○ professional landscape service.

---

41. 

Q155 What is your most preferred purchasing outlets in general if there is no outbreak of an infectious disease? (select one)

- ○ in-store purchase
- ○ in-store order with home delivery
- ○ online order and pick up in store
- ○ online order with mail delivery
- ○ online order with store delivery
- ○ phone order and pick up in store
- ○ phone order with mail delivery
- ○ phone order with store delivery
- ○ professional landscape service.

End of Block: Next Section

Start of Block: Next Section

Q169 Have you or anyone in your household received or expect to receive a coronavirus stimulus check?

- Yes
- No
- Not sure

Q171 How would you like to spend your stimulus check?

	Spend all the money in a month	Spend more than 75% of the stimulus check in a month	Spend more than 50% of the stimulus check in a month	Spend 25% of the stimulus check	Save all the money
	1	2	3	4	5
.					

42. 43.

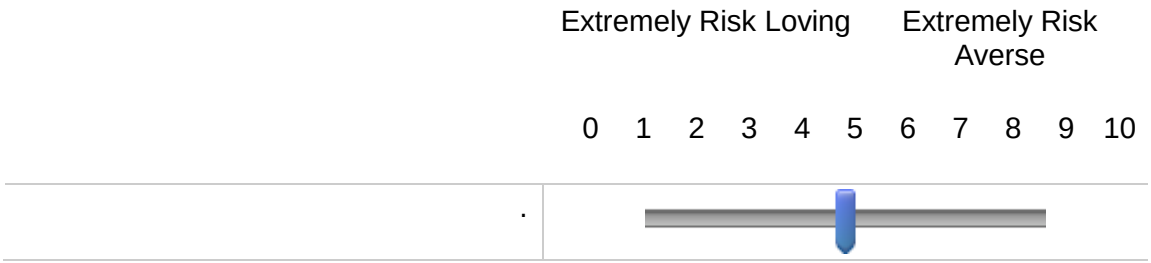
Q172 How would you spend your stimulus check if you have received it or expect to receive it? (sum of all categories should be 100%)

_____ Food
_____ Entertainment
_____ Housing (Rent/Mortgage)/ Bills/Utilities/Loan Payments/Transportation
_____ Medicine & Healthcare
_____ Insurance
_____ Clothes/Consumer goods/Personal spending (grooming, gym memberships, etc.)
_____ Home appliances
_____ Gardening/Landscaping
_____ Education
_____ Charity/Donations
_____ Others:
_____ Savings

End of Block: Next Section

Start of Block: Next Section

Q110 On a scale of 0 to 10, zero being extremely risk loving and ten being extremely risk averse, how risk averse are you?



Q111 Hypothetically, suppose you have $100,000 to invest. There are two options.

Plan A: you are certain to receive $10,000 or a 10 % return. Thus, at the end of the year, you will have $1,10,000.

Plan B: you have 50% chance to receive $25,000 or a 25% return, which gives you $125,000 at the end of the year. But you also have 50% chance to lose $5,000 and only end up with $95,000 at the end of the year.

Which one of the investment plan will you choose? Mark only one oval.

- ○ Invest all your money in plan A
- ○ Invest most of your money in plan A and the rest in plan B
- ○ Invest half of your money in plan A and the other half in plan B
- ○ Invest most of your money in plan B and the rest in plan A
- ○ Invest all your money in plan B

---

44. 

Q130 Before moving on to the next question, can you answer the following calculation based question? 2 + 3 = 7

- ○ True
- ○ False

Q114 Now hypothetically you will select from six different gambles.

Each gamble has two possible outcomes, LOW payment or HIGH payment.

For every gamble, each outcome is equally likely, or has a 50% chance of happening.

Mark the **one** gamble you would prefer to play if you faced this situation in real life.

- ○ a
- ○ b
- ○ c
- ○ d
- ○ e
- ○ f

Q146 Hypothetically, if you received $1,000 from this study, and you were given the option to either accept $1,000 today or wait a year and receive a higher payment. Which one would you choose? Please select the option that you prefer, for each scenario.

	Payment Option A	Payment Option B
Scenario 1	○	○
Scenario 2	○	○
Scenario 3	○	○
Scenario 4	○	○

End of Block: Next Section

APPENDIX B

TNLA PRODUCER SURVEY (CMBS)

1. Were you aware of the reports of Crapemyrtle Bark Scale (CMBS) infestation in the US before coming to this expo?
   a. Yes b. No

2. Have you noticed symptoms of possible Crapemyrtle Bark Scale infestation in your operation?
   a. Yes b. Never c. Maybe

   Describe the symptoms _____

3. Do you anticipate that CMBS will result in a significant drop in sales & use of crapemyrtles in your area?
   a. Yes b. Never c. Maybe d. Not sure

4. The price value for crapemyrtles will decrease by _____ if it's infested by CMBS.
   a. Less than 2% b. 2 to 4.99% c. 5 to 9.99% d. 10 to 19.99%
   e. 20 to 29.99% f. 30 to 39.99% g. 40 to 49.99% h. 50% to 59.99
   i. 60 to 69.99% j. 70 to 79.99% k. 80 to 89.99% l. more than 90%

5. Your willingness to grow crapemyrtles will be_____ if it's infested by CMBS.
   a. Significantly decreased b. Somewhat decreased c. Unchanged
   d. Significantly increased e. Somewhat increased f. Not sure

6. What is the most likely substitute plant for crapemyrtles your operation would use if CMBS is out of control?
   a. Magnolia b. Vitex (Texas lilac) c. Nerium (Oleander)
   d. Hibiscus e. Callistemon (Bottlebrush)
   f. Nothing could replace crapemyrtle in landscapes
   g. Others. Please Specify _____

7. What is your general opinion about developing systemic strategies to control CMBS?
   a. Strongly supportive b. Somewhat supportive c. Neutral

d. Somewhat against e. Strongly against f. Not sure

8. Do you think that your operation will benefit from science-based CMBS control strategies?
   a. Strongly agree b. Somewhat agree c. Neither agree nor disagree
   d. Somewhat disagree e. Strongly disagree f. Not sure

9. Do you think the overall benefits from CMBS control will be higher than the cost of CMBS control?
   a. Strongly agree b. Somewhat agree c. Neither agree nor disagree
   d. Somewhat disagree e. Strongly disagree f. Not sure

10. Over the next 5 years, how much crapemyrtle-related business (in $) does your operation expect to have? (Please mention the average annual expected value)

_____

11. How important are the following factors to you when making crapemyrtles purchasing decision? (Please select only one level of importance per row).

	Not Important At All	**Not Very Important**	**Somewhat Important**	**Very Important**
Easy maintenance				
Disease Resistance				
Flower color				
Foliage color				
Bark color				
Height				
Growth Habitat				

Please list other important factors you may consider when purchasing crapemyrtles.

_____
_____

12. What are your top three most selling crapemyrtle cultivars, most popular sizes, and what is their price?

1. No.	2. Most Selling Cultivar	3. 3 Most Popular Sizes	4. Price
5. 1.	6.	7. 1.	8.
		9. 2.	10.

		11. 3.	12.
13. 2.	14.	15. 1.	16.
		17. 2.	18.
		19. 3.	20.
21. 3.	22.	23. 1.	24.
		25. 2.	26.
		27. 3.	28.

13. Your business type is _____. **Please select all that apply.**
    a. Grower b. Re-wholesaler c. Retailer
    d. Landscaper e. consultant f. Other. Please specify_____.

14. In the past year, what was your operation's legal status for tax purposes?
    a. Family or Individual operation – Exclude partnerships and corporations
    b. Partnership – Include family partnerships
    c. Incorporated under state law
    d. Other, such as estate or trust, prison farm, grazing association, American Indian Reservation, etc. Please specify _____.

15. In the past 5 years, what was the average total gross annual sales value of your operation?
    a. $0 to $24,999 b. $25,000 to $99,999 c. $100,000 to $249,999
    d. $250,000 to $499,999 e. $500,000 to $999,999 f. $1,000,000 or more

16. In the past 5 years, what was the average total gross annual value of crapemyrtle-related business for your operation?
    a. $0 to $24,999 b. $25,000 to $99,999 c. $100,000 to $249,999
    d. $250,000 to $499,999 e. $500,000 to $999,999 f. $1,000,000 or more

APPENDIX C

TNLA PRODUCER SURVEY (COVID)

Q1 Are you a current TNLA member?

- ○ Yes
- ○ No

Q3 Your operation is in Region _____ . (Please answer the survey based on all of your operations in each region and fill out a separate survey for each region where you have operations)

- ○ REGION I - GREATER SAN ANTONIO
- ○ REGION II - GREATER HOUSTON
- ○ REGION III - EAST TEXAS
- ○ REGION IV - GREATER DALLAS
- ○ REGION V - GREATER FORT WORTH
- ○ REGION VI - WEST TEXAS
- ○ REGION VII - RIO GRANDE VALLEY
- ○ REGION VIII - CENTRAL TEXAS
- ○ Out of state

Q2 The type of your main operation in the region above is _____.

- ○ Grower
- ○ Landscaper
- ○ Retail
- ○ Arborist
- ○ Re-wholesaler
- ○ Irrigator
- ○ Consultant
- ○ Supplier
- ○ Affiliated

Q4 During COVID-19, your business is _____ **BEFORE** July 01.

- ○ Open, as before COVID-19
- ○ Open -with modified procedures (remote staff, limited staff, limited hours)
- ○ Open -No Customer Access (phone or online ordering, pick-up or delivery only)
- ○ Closed -Management decision
- ○ Closed -Mandated to close by state and/local order
- ○ Closed -Selling my business
- ○ Other (please specify)

_____

Q5 During COVID-19, your business is _____ **AFTER** July 01.

- ○ Open, as before COVID-19
- ○ Open -with modified procedures (remote staff, limited staff, limited hours)
- ○ Open -No Customer Access (phone or online ordering, pick-up or delivery only)
- ○ Closed -Management decision
- ○ Closed -Mandated to close by state and/local order
- ○ Closed -Selling my business
- ○ Other (please specify)

_____

Q6 Compared to the same season last year, your business has seen sales in 2020 **BEFORE** July 01 _____.

- ○ significantly decreased
- ○ moderately decreased
- ○ no change
- ○ moderately increased
- ○ significantly increased

Q7 Your business expects sales in 2020 **AFTER** July 01 _____ compared to the same season last year.

- ○ significantly decreased
- ○ moderately decreased
- ○ no change
- ○ moderately increased
- ○ significantly increased

Q8 The following factors have affected ___ your overall 2020 sales so far to what degree?

	Significantly decreased	Moderately decreased	No effect	Moderately increased	Significantly increased	Not Applicable
Weather	○	○	○	○	○	○
COVID-19	○	○	○	○	○	○
General economy prior to COVID-19	○	○	○	○	○	○

Q9 How challenging are the following issues for your business in light of the COVID-19 Pandemic?(Check ONLY one per row)

	Not Challenging	Slightly Challenging	Challenging but Manageable	Definitely Challenging	Very Challenging	Not Applicable
Cash Flow Obligations	○	○	○	○	○	○
Billing and Collections	○	○	○	○	○	○
Market Access	○	○	○	○	○	○
Delivering to other State	○	○	○	○	○	○
Social Distancing for Employees	○	○	○	○	○	○
Social Distancing for Customers	○	○	○	○	○	○
Compliance with government COVID-19 mandates	○	○	○	○	○	○
Covering Work Hours with available Employee	○	○	○	○	○	○

Keeping Staff Employed	○	○	○	○	○	○
Training Workers	○	○	○	○	○	○
Taxes	○	○	○	○	○	○
Access to government relief programs	○	○	○	○	○	○
Increase in operation costs due to COVID-19	○	○	○	○	○	○
Not enough Inventory to meet customer demand	○	○	○	○	○	○
Not enough employees to keep up with demand	○	○	○	○	○	○

Q10 Where do you get business-related COVID-19 resources? Choose all that apply.

- [ ] TNLA
- [ ] Texas A&M University Systems (including Texas A&M AgriLife Extension)
- [ ] State and local news
- [ ] Federal government agencies
- [ ] Other (please specify) _____

Q11 In the past year, what was your operation's legal status for tax purposes?

- ○ Family or Individual operation – Exclude partnerships and corporations
- ○ Partnership – Include family partnerships
- ○ Incorporated under state law
- ○ Other, such as estate or trust, prison farm, grazing association, American Indian Reservation, etc. Please specify _____

Q13 What is the average number of full-time or part-time employees in your business over the last 12 months?

- ○ Less than 10
- ○ 10 to 49
- ○ 50 to 99
- ○ 100 to 499
- ○ more than 500

Q14 Have you seen increased or decreased purchasing of the following gardening products/services in your operation?

	Significantly decreased	Moderately decreased	Unchanged	Moderately increased	Significantly increased	Not Applicable
Landscaping (e.g. design, installation, maintenance, etc.)	○	○	○	○	○	○
Seeds	○	○	○	○	○	○
Small Plants	○	○	○	○	○	○
Container Plants	○	○	○	○	○	○
Bareroot Plants	○	○	○	○	○	○
Soil and Compost	○	○	○	○	○	○
Fertilizer, chemicals, etc.	○	○	○	○	○	○
Gardening Accessories (gloves, garden tools, pruners, etc.)	○	○	○	○	○	○

Q15 Have you seen increased or decreased purchasing of these plants in your operation?

	Significantly decreased	Moderately decreased	Unchanged	Moderately increased	Significantly increased	Not Applicable
Vegetables	○	○	○	○	○	○
Fruits	○	○	○	○	○	○
Florist Type Plants	○	○	○	○	○	○
Landscape Herbaceous Flowers	○	○	○	○	○	○
Landscape Shrubs	○	○	○	○	○	○
Landscape Trees	○	○	○	○	○	○

Q16 Are you aware of the COVID-19 relief programs and resources for businesses posted on TNLA website (https://www.tnlaonline.org/covid-19-resource-center.html) before participating in this survey?

○ Yes

○ No

Q12 How much was the annual revenue of your operation over the last fiscal year?

- ○ $0 to $9,999
- ○ $10,000 to $49,999
- ○ $50,000 to $99,999
- ○ $100,000 to $249,999
- ○ $250,000 to $349,999
- ○ $350,000 to $500,000
- ○ $500,000 to $749,999
- ○ $750,000 to $999,999
- ○ $1,000,000 to $1,099,999
- ○ $1,100,000 to $4,999,999
- ○ $5,000,000 to $7,999,999
- ○ over $8,000,000

Q18 What type of research would you like to see from Texas A&M University System?

_____

_____

_____

_____

_____