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An Economic Analysis in Relation to Aspects of Kale and Rice Agricultural Production in South Carolina and the Broader Southeastern U.S.

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AN ECONOMIC ANALYSIS IN RELATION TO ASPECTS OF KALE AND RICE AGRICULTURAL PRODUCTION IN SOUTH CAROLINA AND THE BROADER SOUTHEASTERN U.S.

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ABSTRACT

Agriculture has been crucial to the economic and cultural well-being of South Carolina throughout the state's storied history. This importance has not diminished in our contemporary world. Agribusiness, which includes the agriculture and forestry sectors, is the largest industry in the state, providing nearly 260,000 jobs and 51.8 billion in annual economic impact. Almost 25,000 working farms encompass 4.8 million acres of land in South Carolina .

It is no stretch to claim that South Carolina's agricultural industry affects almost every individual in the state. If not directly involved in the agriculture industry, it is nearly certain all residents have at least consumed a commodity grown in South Carolina. The encompassing impact of South Carolina's agricultural industry emphasizes the necessity for robust research on the topic. This work focuses on two commodities grown in South Carolina: kale and rice. These crops each in part represent the past, present, and future of South Carolina's agricultural production.

This thesis is delineated into two separate research projects. Chapter one performs a willingness to pay (WTP) analysis on visually imperfect (VI) organic kale in the Southeastern U.S. using a payment card approach. Factors are evaluated for their effect on WTP, and a profitability case study for a large organic kale producer is conducted. Kale growers will be interested in the results of this study as it sheds light on the marketability of VI kale, most of which is currently unsold. Similarly, the results hold significance for kale markets in the Southeast, including grocery stores and farmer's markets.

Chapter two discusses the history of South Carolina's rice industry and why climatic changes are prompting renewed interest in the commodity. An enterprise budget for rice production specific to South Carolina's rice production is constructed. Using this data, sensitivity and breakeven point analyses are performed to examine profitability. Current growers, potential growers, and local rice markets are all stakeholders with relevant interests to these results.

DEDICATION

The is work is dedicated to my parents for their constant love and support, and to all the teachers who have guided me throughout my education.

ACKNOWLEDGMENTS

This thesis would not have been possible without the support and guidance of my committee members. I owe Dr. Felipe de Silva, Dr. Michael Vassalos, and Dr. David Willis my immense gratitude.

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CHAPTER ONE

CONSUMER WILLINGNESS TO PAY FOR VISUALLY IMPERFECT ORGANIC KALE[1]

1. Introduction

Visually Imperfect (VI) produce describes food products with physical blemishes or abnormalities. Although these imperfections do not decrease the potential health benefits or nutritional quality of the food, many grocery stores do not purchase VI produce due to the enforcement of strict cosmetic standards (Yuan et al., 2019). To illustrate the extent of this practice, in California, 20 to 50 percent of citrus, stone fruits, and grapes, and almost 70 percent of cucumbers do not meet such cosmetic standards (Gunders, 2012). Overall, about 10 million pounds of food with cosmetic imperfections is wasted annually (Bhandarkar, 2020).

A consequence of cosmetic standards is that farmers often do not harvest VI produce, which can potentially translate to substantial economic losses (Johnson, et al., 2019). Additionally, enforcement of cosmetic standards discourages consumer demand for VI produce as it alters realistic expectations of produce appearances (Qi et al., 2022). However, over the last few years, some grocery stores have started introducing sections with "ugly" produce and/or implementing "ugly food campaigns" (e.g., Kroger, Haris Teeter)[2]. Nevertheless, as there is still limited knowledge about consumer preferences for

[1] Chapter one was previously published in the Journal of Agricultural and Applied Economics. Behler, Shane, et al. "Consumer willingness to pay for visually imperfect organic kale." *Journal of Agricultural and Applied Economics*, vol. 56, no. 1, 8 Jan. 2024, pp. 21–45, https://doi.org/10.1017/aae.2023.42.

[2] The trend in marketing attempts of ugly produce is highlighted by Qi et al. (2022) and by Pfeiffer et al. (2021).

ugly produce, it is necessary to quantify consumer willingness to pay (WTP) for suboptimal food items and to determine the potential marketability of these products (Pfeiffer et al., 2021).

Previous research indicates that consumers will often purchase suboptimal food items when given a discount that corresponds to the respective suboptimality (de Hooge et al., 2017; Helmert, et al, 2017). Studies conducted specifically on VI fruits and vegetables have found that consumers associate these food products with lower price points (Grewal, 2018). Consumers in Uruguay accepted VI apples only when the price became sufficiently low (Aschemann-Witzel et al., 2018). Interestingly, Yue et al. (2009) determined consumer WTP decreased more for organic VI apples than conventionally produced VI apples.

A different strand of the literature highlights that the marketability of VI produce can be enhanced when VI produce is supplemented with informational messaging such as: i) naturalness/authenticity of VI (Qi et al., 2022), or ii) information about the societal problems caused by excessive food waste (Collart et al., 2022). This finding is further supported by a recent meta-analysis of 40 studies related to imperfect foods that found that positive messaging about VI produce increases WTP for these products (Hartmann et al., (2021). Lastly, certain designs of the price labels of suboptimal foods can increase consumer attention towards these products as well (Helmert et al., 2017).

Despite the aforementioned literature, studies examining consumer WTP for leafy greens with VI are rather limited[3]. The first objective of our research extends the literature by examining how consumer characteristics (i.e., demographics, lifestyle preferences) affect WTP for organic VI kale. Kale was selected as a product of study because of recent increases in demand due to its purported health benefits. We specifically examined organic kale because most kale production in the United States is certified organic (Pullano, 2015).

Our second objective is twofold. We first examined how explicitly highlighting (with an arrow) where the imperfections are on the leaf impacts WTP. We also examined how informational treatments on safety of consumption and produce origin impact WTP. We then developed a pre-post analysis where consumers are informed of the percentage of leaf area affected by imperfections to test if straightforward information changes purchasing decisions. The first two objectives are evaluated with organic kale that features 2% and 10% surface areas of visual imperfections. The pre-post analysis is only conducted with the 10% VI organic kale.

We developed seven treatments[4] to test whether information on produce origin, safety of consumption, and explicitly highlighting areas of imperfections affect the purchasing decision and/or WTP. A probit model was utilized to test whether these treatments impact the decision to purchase VI organic kale. Second, an ordered probit model was utilized to examine if the treatments impact WTP for VI organic kale.

[3] We are aware of only one consumer valuation study on VI leafy green vegetables. It determined that consumers were more likely to reject spinach deteriorated in appearance even when it is perfectly edible (Dusoruth and Peterson, 2020).
[4] See table one for a description of treatments.

As a preview of the results, our findings indicate that several consumer characteristics and lifestyle traits, including but not limited to gender, dietary preference, age, and past purchases of VI produce significantly affect both the purchasing decision and WTP. None of the treatments had a statistically significant impact on the purchasing decision. However, several treatments, such as explicitly highlighting the imperfections, had a statistically significant effect on WTP at both the 2% and 10% imperfection level.

Our findings can help organic kale producers identify potential unrealized gains by marketing VI organic kale instead of discarding or not harvesting it. We conduct a profitability analysis using the mean price selection from the control payment card at the 10% imperfection level to evaluate the potential unrealized gains in this market. This result has significant implications for organic kale production as kale grows in popularity with both consumers and producers across the study area and beyond (Boehm, 2019).

2. Methodology

2.1 Data Collection

The data for the study was collected over two weeks in November of 2022, one week in January 2023, and one week in March of 2023 using an online survey instrument distributed by Qualtrics XM. The survey instrument was developed with input from South Carolina agricultural extension agents[5], agricultural researchers, and organic kale producers. Several pilots were conducted before the survey was implemented. A pretrial

[5] South Carolina extension agents were used in the pilot because organic kale production is growing in popularity in the state.

with university students and faculty was first performed[6]. Then, a second larger pilot was distributed by Qualtrics XM that garnered 40 responses from members of the study population. Based on the feedback received, the survey instrument wording, length etc. was modified.

The final sample size included 802 responses from consumers in the Southeast region of the United States (Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, and Tennessee). The survey instrument was divided into five sections. The first section included a set of screening questions; respondents who indicated that they lived in the Southeast U.S., were born before 2003, are the primary grocery shopper for their household, and that they buy vegetables every month were eligible to complete the survey. Also included in this section was a question on the varieties of kale consumers typically eat. Response options included red kale, green kale, kale lacinato/Tuscan, and/or "other (please specify)." "I do not eat kale" was a response option for this question as well. The second part of the survey instrument focused on respondents' perceptions, purchasing habits, and knowledge of organic products. To assess consumer knowledge, the survey asked respondents if they had heard of the term "organic food products," if they were familiar with common food attribute labels, and their reasonings for purchasing organic food products.

Following Umberger et al., (2009), and Verhoef (2005), payment cards were utilized to evaluate consumer WTP for VI organic kale in the third section of the survey.

[6] The pretrial with Clemson University students was conducted on both computer and smart phone devices. The researchers determined that both formats provided appropriate means for data collection.

The final two sections of the survey instrument explored participants' dining preferences at restaurants and their demographic information.

Description of the Payment Card Design

In the payment card, participants were presented with two pictures of kale products. The first picture included a bunch of healthy leaves, while the second one included leaves with visual imperfections. Two levels of visual imperfection were included (2% and 10%)[7]. Consumers were presented with eight bid intervals, with the highest bid set at $1.33 per bunch and subsequent bids decreasing by 4% increments[8]. Participants were asked to select the amount they thought it is reasonable to pay for the VI kale and the maximum amount they would pay. Participants were also able to select an option stating, "I would not buy kale with VI." The variety used in the payment cards was "green kale" given that it is the most widely consumed variety. Nearly 74% of the consumers in our sample indicated that they eat green kale.

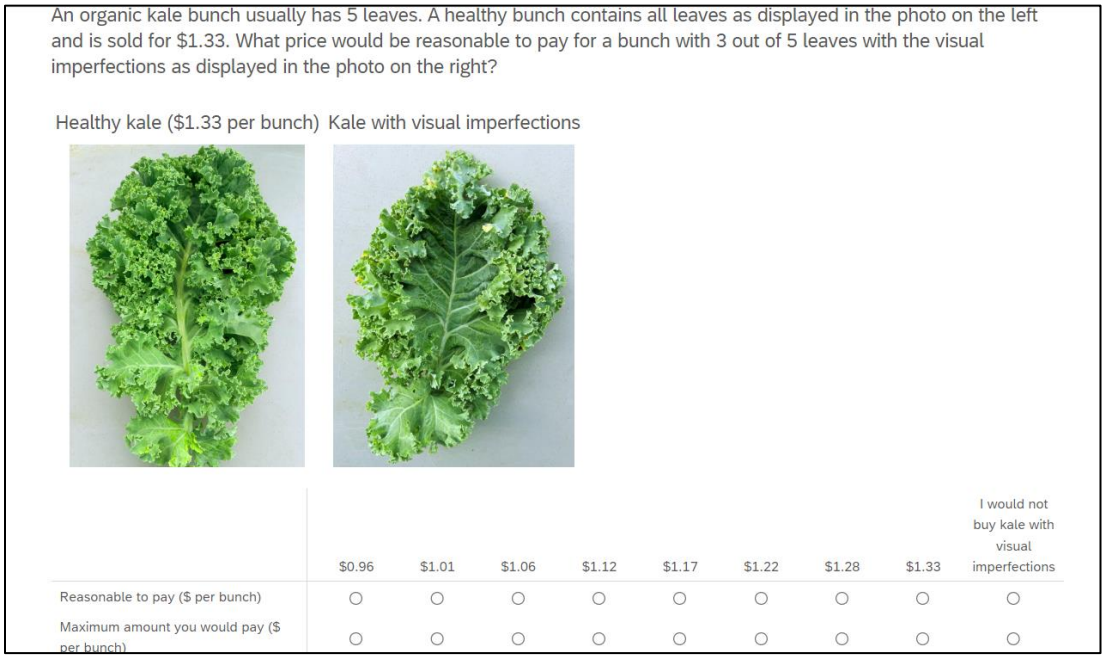
Survey participants were divided into two groups and were provided with eight payment card questions. While the content of the payment cards was similar for both groups, the first group received cards with arrows highlighting kale imperfections, while

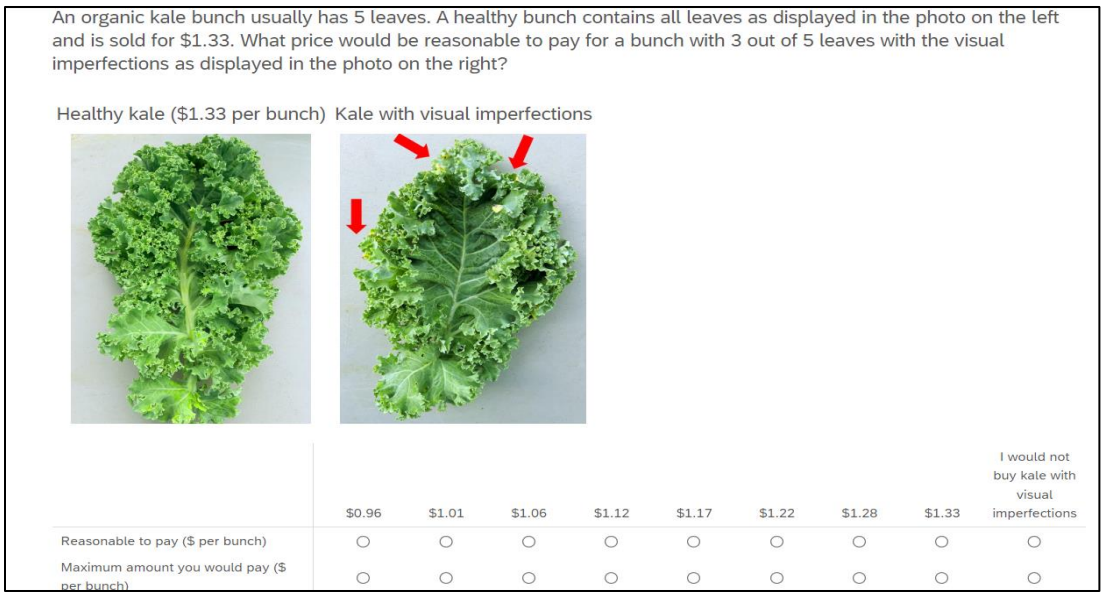
[7] Organic kale growers typically discard produce with more than 2% visible imperfections, as they fail to meet the standards of U.S. No. 1 and U.S. Commercial (USDA, 2008). The 10% imperfection level was selected because it captures a rate of imperfection that is five times greater than the 2% baseline imperfection level. The differences between the 2% and 10% imperfections are very pronounced, which we believe led to higher quality results.

[8] The highest bid ($1.33) was determined by calculating the median of the lowest and highest retail prices of kale in the Southeast from January to February 2022 (USDA, 2022). To reflect the discount attributed to the visual imperfections of kale, we implemented a pricing structure in which the remaining bids were gradually reduced by 4% increments, thereby setting the lowest bid at $0.96 per bunch. The lowest bid is comparable to the price of conventionally produced kale of the same period ($0.98 per bunch) (USDA, 2022).

the second group did not (Figure 1). The arrows were incorporated to test whether explicitly highlighting visual imperfections impacted consumer WTP.

Figure 1.1 Payment cards WOA and WA.





Among the eight payment cards, four cards displayed a bunch of kale where three out of five leaves exhibited visual imperfections covering 2% of the leaf surface area. The remaining four cards included a bunch of kale in which three leaves from a bunch of five leaves had 10% of the leaf surface area affected by visual imperfections. The difference between the two blocks allowed us to test how increasing the imperfection level from 2 to 10 percent alters purchasing behavior and price selection.

The first payment card served as the status quo, in which no additional information was given. The second payment card was identical to the status quo, except that it contained a statement claiming that the kale was safe to eat (WAS and WOAS). The third payment card was also identical to the status quo, but contained a statement claiming that the kale was grown locally (WAL and WOAL). Lastly, the fourth payment card stated that the kale was both safe to eat and grown locally (WASL and WOASL)[9]. The payment cards were presented to respondents in a randomized order. The differences in willingness to pay between the four payment cards allowed us to test how statements about locality of production and/or food safety impact consumer WTP. Table 1 summarizes the respective treatment of each payment card.

[9] The payment cards are referred to in subsequent order for sake of clarity. The payment cards were presented to respondents in a randomized order.

Table 1.1 Description of the payment card treatments explored in our survey

	Payment Card	Arrows pointing to imperfections	Safe to eat statement	Grown locally statement
Block 1	WOA (1)			
	WOAS (2)		X	
	WOAL (3)			X
	WOASL (4)		X	X
Block 2	WA (5)	X		
	WAS (6)	X	X	
	WAL (7)	X		X
	WASL (8)	X	X	X

Note: WOA (1) represents the treatment "without arrow", WOAS (2) represents the treatment without arrows and safe to eat, WOAL (3) represents the treatment without arrows and locally grown, and WOASL (4) represents the treatment without arrows, safe to eat, and locally grown. WA (5) represents the treatment with arrows, WAS (6) represents the treatment with arrows and safe to eat, WAL represents the treatment with arrows and locally grown, and WASL (8) represents the treatment with arrows, safe to eat, and locally grown.

After the last payment card, respondents were asked a follow-up question soliciting their opinion on the percentage of the leaf damage. Then, consumers were informed of the exact percent of leaf area affected by imperfections. The respondents were then prompted to answer another payment card, which allowed us to analyze how information on the level of imperfection impacts WTP. The presence of arrows on the post-analysis payment card was kept consistent with the response block that each respondent was in through the payment card section.

2.2 Data

A comparison of the demographic characteristics of the survey participants and the demographics of the population in the focus region is presented in Table 2. The sample composition of states is similar to the population metrics based on the American

Community Survey (2021), with participants from Florida constituting the highest percentage of our sample and Mississippi constituting the lowest.

Females are overrepresented in our sample. However, this is not uncommon for WTP studies of food products as females are most commonly the primary grocery shoppers in households (Grannis and Thilmany, 2002). The racial composition of the population is 56.9% White, 21.1% Black, and 14.6% Hispanic or Latino (Decennial Census, 2020), which is comparable to our sample composition. The median age of our sample is 34 years old, which is a few years lower than the median age of the analyzed states (American Community Survey, 2021).

Educational attainment is comparable to the regional averages of 20.0% for a bachelor's degree and 12.4% for a graduate or professional degree (American Community Survey, 2021). Full employment status of the population is 56.3% and the unemployment rate is 3.3% (American Community Survey, 2021), and 45.9% of our sample is employed full time and 12.0% is unemployed. Respondents also had the option of selecting if there were retired, students, disabled, or employed part time. These individuals collectively constituted 42.1% of our sample. Of our sample, 73.9% typically eat green kale, 25.3% typically eat red kale, 12.8% typically eat kale lacinato/Tuscan, and 1.4% typically eat an unlisted kale variety[10].

[10] It is important to note that the survey screened for individuals that buy vegetables every month. Therefore, it is likely that a greater percentage of our sample buys kale than that of the study's population.

Table 1.2 Respondent summary statistics

Respondent Demographics	Percentage of Sample	Percent of Population
Florida Resident	32.4	34.3
Georgia Resident	18.8	17.1
North Carolina Resident	15.3	16.6
Tennessee Resident	11.2	11.1
Alabama Resident	9.6	8.0
South Carolina Resident	8.2	8.3
Mississippi Resident	4.5	4.6
Female	73.4	51.8
Median Age (not a %)	34.0	39.6
White	59.4	56.9
Black	28.2	21.1
Hispanic or Latino	7.2	14.6
Bachelor's Degree	18.7	20.0
Graduate or Professional Degree	11.2	12.4
Employed Fulltime	45.9	56.3
Unemployed	12.0	3.3

2.3 Empirical Strategy

In the payment cards, respondents had the option of selecting one of eight price bids, or to indicate that they were not willing to purchase the kale. This format yielded two dependent variables: whether the consumers prefer to purchase VI kale, and for the consumers who do purchase, the price decision on the payment card (WTP_i).

We modeled the two dependent variables in separate regressions[11]. A probit analysis modeled the dependent variable bought or not (BON_i). We considered three sets

[11] We also estimate an ordered probit with sample selection to account for the potential sample selection problem (Chiburis and Lokshin, 2007). However, the LR test indicates that we cannot reject the null hypothesis that the errors for the ordered probit and probit are uncorrelated. Therefore, we opted to estimate the two equations separately. See De Luca and Perotti (2011) for more details on the estimation (performed in Stata 17 MP using *heckoprobit*).

of independent variables – **X**, **Z** and **T**. **X** is a vector of variables capturing respondent demographics, **Z** is a vector of variables capturing lifestyle variables, and **T** is a vector of dummy variables capturing the seven payment card treatments discussed above. All variables were included as binary dummy variables with the exception of age and state of residence. These variables allow us to determine how their respective capacities affect the purchasing decision and/or WTP.

To capture the treatment effect, **T**, seven dummy variables were included (Table 1). The status quo without arrows (WOA) was chosen as the reference treatment (control). We expected treatments with greater information to have a positive marginal effect on WTP. An ordered probit analysis modeled price selection on the payment card. The independent variables are kept the same as in the prior probit analysis. The dependent variable accounts for all eight price levels as they decrease from $1.33 to $0.96 by 4% increments. To capture potential correlation, the standard errors are clustered at the respondent level.

We employed nested regression models to examine how the addition of different vectors of variables impact regression results, specifically the treatment variables (Allen, 1997). This process was completed for both the probit and ordered probit regressions. A total of four regressions were performed for each decision stage (probit and ordered probit). In the first regression only the payment card treatment vector (**T**) was included as independent variables. To test whether the marginal effects of treatments change as we add respondent characteristics, the second regression added the demographic variable vector (**X**). A third regression added the lifestyle variables vector (**Z**) aiming to test

whether the treatment variables were capturing respondent lifestyle decisions. A final fourth regression was estimated that included dummy variables for the state of residency in addition to the three other variable vectors that sought to capture respondent characteristics intrinsic to a given state. In all eight regressions, standard errors were clustered at the respondent level. The accuracy of the nested regressions was compared by Akaike Information Criterion (AIC) values. Likelihood ratio (LR) tests[12] between the models were conducted as well.

3. Results

Regarding respondents' food consumption habits, 79.8% indicated that they have purchased at least one variety of kale before[13], and 13.9% indicated that they follow a vegetarian or vegan diet. The overwhelming majority (96.3%) were familiar with the term "organic food product." On eating locally sourced kale, 54.9% of the respondents preferred local kale, 11.6% did not prefer local kale, and 33.5% were indifferent to whether kale was grown locally or not.

Respondents were also asked if they were willing to pay a premium for organic kale grown in the southeastern U.S., and 49.9% indicated they were willing to do so. Around 40% of the respondents regularly purchase groceries from farmers markets, 33.3% from health food stores, and 20.9% regularly purchase groceries from both of

[12] Non-clustered standard error versions of the models were used in the likelihood ration tests.
[13] We reiterate that the survey screened for individuals that buy vegetables every month. Therefore, it is likely that a greater percentage of our sample buys kale than that of the study's population.

these markets. Respondents purchased groceries from other markets at the follow percentages: 81.7% at Walmart; 74.6% at grocery stores; 46.9% at super centers; 24.3% online; and 17.21% from other markets. Approximately 44% of survey participants had purchased discounted VI produce before. More than 52% of respondents indicated that they were very likely or likely to eat VI produce at home, while 23.6% of respondents indicated that they were unlikely or very unlikely to do so. Lastly, 40.6% of the sample spent more than 51 dollars per month on fresh produce. The above results that are attributed to variables included in the regression models are summarized in Table 3.

Table 1.3 Food consumption habits

Questions	**% "yes"**
Have purchased at least one variety of kale before	79.8%
Familiar with the term "organic food product"	96.3%
Follow a vegan or vegetarian diet	13.9%
Prefer locally sourced kale	54.9%
Willing to pay a premium for organic kale grown in the southeast U.S.	49.9%
Purchase groceries from farmers markets	40.4%
Purchase groceries from health food stores	33.3%
Have bought discounted VI produce before	44.4%
Likely or very likely to eat VI produce at home	52.6%
Spend more than 51 dollars per month on produce	40.6%

On average, 85% of respondents indicated that they would purchase VI organic kale in the payment cards, ranging from 84.10% under WAS treatment to 85.79% in

WOAS treatment, at the two percent imperfection level. The average WTP for the two percent imperfection level across all payment cards is $1.12 and the standard deviation is 0.123. This is approximately 21 cents cheaper than the median retail price of a bunch of kale in the Southeast from January to February 2022 (USDA, 2022). The average WTP per payment card range from a low of $1.112 on payment card WA to a high of $1.129 on payment card WOA, a difference of only 1.7 cents. Table four depicts the share of respondents that selected each price level by treatment at the two percent imperfection level. Results from the ten percent imperfection level analysis are found in the appendix.

Table 1.4 Price selected by payment card, 2% imperfection level

Price Selected	WOA	WOAS	WOAL	WOASL	WA	WAS	WAL	WASL
0.96	14.99%	14.99%	17.57%	15.76%	17.83%	16.39%	15.18%	16.63%
1.01	11.89%	13.18%	12.66%	12.40%	11.81%	10.12%	13.01%	13.49%
1.06	12.66%	21.14%	11.89%	12.40%	10.36%	11.33%	10.60%	9.88%
1.12	11.11%	9.04%	7.75%	8.53%	11.57%	8.67%	11.08%	10.12%
1.17	6.72%	11.37%	8.79%	8.79%	8.67%	11.08%	10.84%	7.71%
1.22	5.94%	7.24%	6.98%	5.94%	7.23%	6.99%	6.99%	7.47%
1.28	5.68%	5.43%	5.43%	5.17%	6.02%	6.27%	6.75%	4.82%
1.33	16.28%	12.40%	13.18%	15.25%	9.64%	13.25%	10.84%	14.22%
WNB	14.73%	14.21%	15.76%	15.76%	16.87%	15.90%	14.70%	5.66%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Table note: Total respondent number for the WOA response block (columns 2-5) is 387. Total respondent number for the WA response block (columns 6-9) is 415.

Table 5 breaks down WTP selected on payment card WOA at the 2% imperfection level by demographics. WTP is grouped into three levels: high, medium, and low. The high category includes price bids $1.33 and $1.28; the medium category includes price bids $1.22, $1.17, and $1.12; the low category includes price bids $1.06,

$1.01, and $0.96; did not buy is included in the table as well. The pattern of price selection across the demographics is generally consistent, with most individuals typically selecting the low category of price bids. Notable exceptions to this pattern are that a greater proportion of males are likely to select the high price bids compared to females, and that a greater share of individuals with household incomes of less than $75,000 selected the high and medium price bids compared to individuals with household incomes of greater than $75,000. The consistency of preferences extends across states of residence with the exception of Mississippi. However, Mississippi residents constitute the lowest representation in the sample by state of residence.

Table 1.5 WTP category selected by demographics for payment card WOA

Demographic	High WTP	Medium WTP	Low WTP	Will not Buy	Total, out of 387
Female	20.2%	25.8%	38.7%	15.3%	287
Male	27.0%	18.0%	42.0%	13.0%	100
Caucasian	22.1%	22.1%	41.3%	14.5%	235
Non-Caucasian	21.7%	26.3%	36.8%	15.1%	152
Bachelor's degree or higher	22.5%	23.4%	43.2%	10.8%	111
Less than a bachelor's degree	21.7%	23.9%	38.0%	16.3%	276
Income greater than $75,000	18.8%	19.8%	46.9%	14.6%	96
Income less than $75,000	23.0%	25.1%	37.1%	14.8%	291
Employed Fulltime/Retired	20.9%	25.3%	39.1%	14.7%	225
Other employment status	23.5%	21.6%	40.1%	14.8%	162

Alabama Resident	20.5%	7.7%	53.8%	17.9%	39
Florida Resident	19.7%	25.6%	38.5%	16.2%	117
Georgia Resident	22.0%	24.4%	35.4%	18.3%	82
Mississippi Resident	37.5%	25.0%	37.5%	0.0%	16
North Carolina Resident	24.3%	27.1%	37.1%	11.4%	70
South Carolina Resident	25.0%	17.9%	46.4%	10.7%	28
Tennessee Resident	17.1%	31.4%	37.1%	14.3%	35

Table note: The high WTP category includes price bids $1.33 and $1.28; the medium WTP category includes price bids $1.22, $1.17, and $1.12; the low WTP category includes price bids $1.06, $1.01, and $0.96; did not buy is included as well.

Based on the AIC and the LR test, model P4, which included the state of residence dummy variables, provides the best fit at both the 2 and 10 percent imperfection levels for the probit analysis. On the other hand, model O3, which excluded the state of residence dummy variables, provided the best fit at both the 2 and 10 percent imperfection levels for the ordered probit analysis. Thus, the results from models P4 and O3 are interpreted at both levels of imperfection.

3.1. Purchase or not purchase?

The regression results from the nested probit models (both the estimated coefficients for models P1, P2, P3, and P4, and the marginal effects for model P4) for the 2% imperfection level are found in Table 6. The findings indicate that older consumers are less likely to purchase VI kale. Those who have bought VI produce before and those

that stated they are very likely or likely to eat VI produce at home are more likely to purchase VI kale. Also, those who are willing to pay a premium for organic kale grown in the southeastern U.S., and those who prefer local products are more likely to purchase VI kale. Lastly, South Carolina residents are more likely to purchase VI kale.

None of the payment card treatments are statistically significant in any of the models. Thus, it is concluded that the treatments do not impact respondents' purchasing decision of VI kale at this level of imperfection.

Table 1.6 Probit regression results, 2% imperfection level

Variable	**(P1)**	**(P2)**	**(P3)**	**(P4)**	**Marginal effects**
WOAS (2)	0.023	0.017	0.022	0.021	0.004
	(0.0682)	(0.0711)	(0.0788)	(0.0803)	(0.0152)
WOAL (3)	-0.044	-0.052	-0.058	-0.056	-0.011
	(0.0728)	(0.0755)	(0.0841)	(0.0853)	(0.0168)
WOASL (4)	-0.044	-0.058	-0.062	-0.059	-0.012
	(0.0658)	(0.0690)	(0.0770)	(0.0781)	(0.0154)
WA (5)	-0.089	-0.096	-0.175	-0.184	-0.038
	(0.1071)	(0.1093)	(0.1151)	(0.1157)	(0.0241)
WAS (6)	-0.050	-0.049	-0.130	-0.137	-0.028
	(0.1078)	(0.1095)	(0.1156)	(0.1159)	(0.0236)
WAL (7)	0.001	0.003	-0.055	-0.063	-0.012
	(0.1088)	(0.1105)	(0.1151)	(0.1159)	(0.0229)
WASL (8)	-0.040	-0.038	-0.102	-0.108	-0.022
	(0.1080)	(0.1097)	(0.1146)	(0.1150)	(0.0231)
Female		-0.091	-0.040	-0.045	-0.009
		(0.1072)	(0.1106)	(0.1118)	(0.0223)
High_income		-0.012	-0.095	-0.103	-0.021
		(0.1114)	(0.1147)	(0.1148)	(0.0234)
Race		0.115	0.115	0.115	0.023
		(0.0949)	(0.0992)	(0.1001)	(0.0205)
Employed/retired		0.1596*	0.131	0.119	0.024
		(0.0967)	(0.0986)	(0.0992)	(0.0202)
High_education		0.172	0.102	0.093	0.019
		(0.1113)	(0.1115)	(0.1123)	(0.0229)
Age		-0.0189***	0.0130***	0.0129***	-0.003***
		(0.0029)	(0.0030)	(0.0031)	(0.0006)
Farmers_market			0.138	0.137	0.028
			(0.1004)	(0.1006)	(0.0207)
Health_store			0.131	0.155	0.032
			(0.1085)	(0.1096)	(0.0224)
Bought_VI			0.4330***	0.4346***	0.089***

			(0.1006)	(0.1072)	(0.0221)
Aware_organic			-0.048	-0.026	-0.005
			(0.2351)	(0.2380)	(0.0487)
Wtp_premium			0.3335***	0.3532***	0.072***
			(0.0989)	(0.0989)	(0.0204)
Veg			0.130	0.109	0.022
			(0.1544)	(0.1087)	(0.0321)
Fifty_spent			0.067	0.053	0.011
			(0.0987)	(0.0999)	(0.0204)
Eat_home			0.3020***	0.3058***	0.063***
			(0.0937)	(0.0945)	(0.0192)
Pref_local			0.1913**	0.1811*	0.037*
			(0.0962)	(0.0961)	(0.0196)
Florida				0.123	0.026
				(0.1699)	(0.0369)
Georgia				-0.007	-0.002
				(0.1778)	(0.0396)
Mississippi				0.434	0.080
				(0.2769)	(0.0474)
North Carolina				0.065	0.014
				(0.1847)	(0.0403)
South Carolina				0.5420***	0.095***
				(0.2064)	(0.0377)
Tennessee				-0.084	-0.019
				(0.2011)	(0.0461)
Constant	1.0481***	1.6776***	0.9080***	0.8085**	
	(0.0783)	(0.1770)	(0.2968)	(0.3317)	
AIC	2777.353	2660.718	2438.875	2424.003	

Legend: * p<.1; ** p<.05; *** p<.01. Data represents the beta coefficients of the nested probit models. 3,208 observations.

3.2. WTP ordered probit models

The regression results from the nested ordered probit models on the kale with a two percent imperfection area are presented in Table 7. The findings from Model O3 are interpreted in this section. (Model three is interpreted in the ordered probit regressions based on the results of the AIC and the LR test). Only a few of the treatments, respondent characteristics, and response variables are statistically significant. The payment card WOAL (3) was statistically significant at 10% and payment card WA (5) was significant at 5%. Both treatments had negative coefficients.

Table 1.7 Ordered probit regression results, 2% imperfection level

Variable	**(O1)**	**(O2)**	**(O3)**	**(O4)**
WOAS (2)	-0.058	-0.055	-0.054	-0.052
	(0.0557)	(0.0559)	(0.0571)	(0.0572)
WOAL (3)	-0.1003*	-0.0979*	-0.1003*	-0.0997*
	(0.0581)	(0.0584)	(0.0592)	(0.0592)
WOALS (4)	-0.036	-0.032	-0.033	-0.032
	(0.0540)	(0.0542)	(0.0551)	(0.0551)
WA (5)	-0.1522*	-0.1540*	-0.1717**	-0.1718**
	(0.0802)	(0.0805)	(0.0820)	(0.0824)
WAS (6)	-0.033	-0.036	-0.056	-0.057
	(0.0813)	(0.0818)	(0.0828)	(0.0830)
WAL (7)	-0.073	-0.074	-0.093	-0.094
	(0.0788)	(0.0794)	(0.0801)	(0.0805)
WASL (8)	-0.069	-0.070	-0.091	-0.092
	(0.0820)	(0.0821)	(0.0830)	(0.0834)
Female		-0.1577**	-0.1276*	-0.1384*
		(0.0738)	(0.0736)	(0.0747)
High_income		-0.024	-0.088	-0.097
		(0.0786)	(0.0787)	(0.0796)
Race		0.017	0.054	0.052
		(0.0638)	(0.0670)	(0.0679)
Employed/retired		0.075	0.047	0.048
		(0.0693)	(0.0706)	(0.0710)
High_education		-0.001	-0.008	-0.001
		(0.0787)	(0.0788)	(0.0794)
Age		-0.0060**	-0.004	-0.004
		(0.0023)	(0.0024)	(0.0025)
Farmers_market			0.025	0.024
			(0.0685)	(0.0687)
Health_store			0.070	0.076
			(0.0724)	(0.0727)
Bought_VI			-0.088	-0.087
			(0.0739)	(0.0736)
Aware_organic			-0.213	-0.209
			(0.1309)	(0.1346)
Wtp_premium			0.2372***	0.2379***
			(0.0721)	(0.0726)
Veg			0.2612***	0.2666***
			(0.0841)	(0.0850)
Fifty_spent			0.058	0.059
			(0.0697)	(0.0710)
Eat_home			0.036	0.035
			(0.0670)	(0.0666)
Pref_local			0.096	0.083
			(0.0695)	(0.0710)
Florida				0.014
				(0.1173)
Georgia				0.049
				(0.1268)
Mississippi				0.083

				(0.1737)
North Carolina				0.099
				(0.1319)
South Carolina				0.121
				(0.1544)
Tennessee				0.148
				(0.1396)
/cut1	-0.9390***	-1.2344***	-1.1200***	-1.0633***
	(0.0646)	(0.1312)	(0.1821)	(0.2170)
/cut2	-0.4864***	-0.7761***	-0.6530***	-0.5960***
	(0.0646)	(0.1290)	(0.1811)	(0.2163)
/cut3	-0.1369**	-0.4233***	-0.293	-0.236
	(0.0611)	(0.1284)	(0.1813)	(0.2170)
/cut4	0.1543**	-0.130	0.005	0.063
	(0.0617)	(0.1282)	(0.1819)	(0.2178)
/cut5	0.4491***	0.166	0.3077*	0.3652*
	(0.0623)	(0.1280)	(0.1816)	(0.2173)
/cut6	0.6992***	0.4159***	0.5637***	0.6216***
	(0.0650)	(0.1295)	(0.1833)	(0.2190)
/cut7	0.9511***	0.6676***	0.8197***	0.8781***
	(0.0676)	(0.1303)	(0.1853)	(0.2206)
AIC	11049.81	11029.39	10955.05	10961.08

Legend: * p<.1; ** p<.05; *** p<.01. Data represents the beta coefficients of the nested ordered probit models. 2712 observations.

We found that female respondents are more likely[14] to select a lower price on the payment card than males. Also, respondents willing to pay a premium for organic kale grown in the Southeastern U.S. and who follow a vegan or vegetarian diet are more likely to select a higher price on the payment card.

3.3. Analysis of 10% VI organic kale

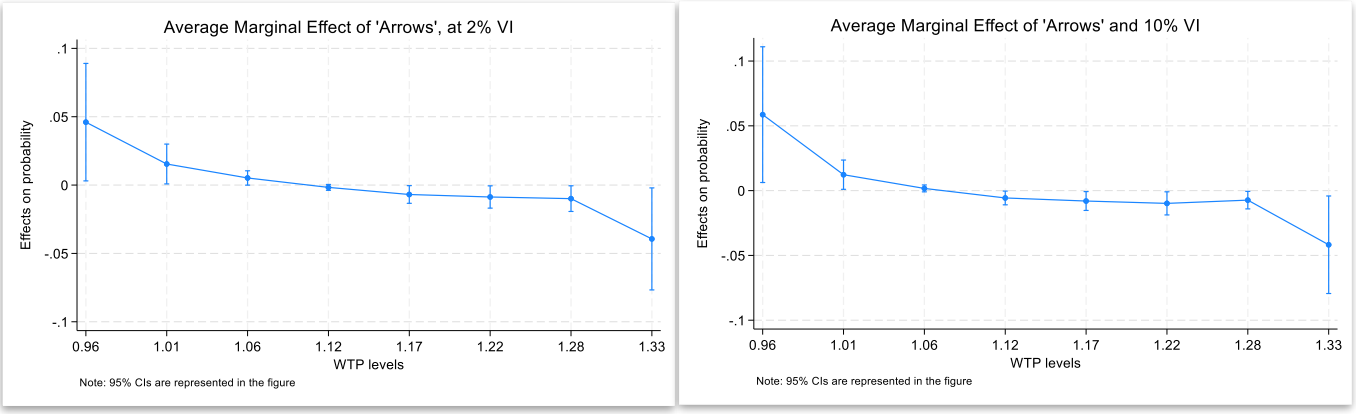
We conducted the same analyses on the payment cards with the 10% imperfection level. The mean WTP selection on the payment cards ranged from $1.095 to $1.112, which is slightly less than the average price selections from the 2% imperfect kale. Consistent with the findings for the 2% VI, none of the payment card treatments

[14] The estimate of the marginal effects for each of the regressions can be obtained upon request.

significantly impacted the purchasing decision (probit regression). The same independent variables as in the 2% VI probit analysis were found to be significant in the fourth regression, with the addition of respondents who frequently shop at health food stores and Mississippi residents. The same independent variables (excluding Mississippi) were significant in the 10% VI ordered probit analysis, with the addition of consumers who were aware of the definition of organic, which had negative coefficient. However, the ordered probit regression revealed significant variations between the treatment effects. Treatments WOAS (2), WA (5), WAS (6) and WAL (7) were statistically significant in the fourth regression, and all had negative coefficients.

One of the treatments, with arrow (WA5), was statistically significant at both VI levels. We depicted the marginal effects in Figure 2. The effects on probability are very similar between the imperfection levels. Both margin plots reveal that consumers are more likely to select lower prices compared to the base payment card that lacked arrows.

Figure 1.2 Marginal effects of 'arrows' at the 2 and 10% imperfection levels



3.4. Pre-post analysis

The statically insignificant results of the dummy variables on treatments and the marginal effects raise the question as to whether explicit information on the amount of imperfection would affect the WTP. Therefore, the effect of informing respondents of the exact percentage of leaf area impacted by imperfections on WTP was examined using a simple pre-post analysis. This analysis was only conducted with the 10% visual imperfect kale payment cards in both the with arrow and without arrow response blocks. We first asked respondents to estimate the level of VI in the picture shown in the 10% VI payment cards. Then, we inform them of the true VI level. In the "with arrow" response block, 25.30% of the respondents selected the correct VI level; 26.36% of respondents selected the correct VI level in the "without arrow" response block. Then, we asked them to provide their WTP for 10% VI organic kale if they initially chose to purchase it. Many respondents did not alter their WTP after the information was presented: 57% respondents who reported a WTP of $0.96 to payment card WOA (1) reported the same WTP post-information. In the arrow treatment block, 52% respondents who originally selected $0.96 on payment card WA (5) did so again.

However, there were some substantial shifts in WTP after the imperfection information was presented. In the without arrows response block, 45.6% of respondents who did not previously purchase did so after the imperfection rate was presented; 32.8% of respondents who had previously chosen to purchase did not purchase after the imperfection rate was presented. Likewise, in the arrow response block, 33.3% of

respondents flipped from not purchasing to purchasing and 28.8% of respondents flipped from purchasing to not purchasing after the imperfection rate was presented.

3.5 Profitability Analysis

We perform a profitability analysis using the mean price selection for respondents who chose to purchase on the control payment card (WOA) at the 10 percent imperfection level. Mean price selection was determined to be $1.10, which implies that consumers, on average, expect a $0.23 discount to purchase organic kale with this imperfection rate[15]. An organic kale producer indicated to us in conversation that they anticipate that, on average, 10% of kale goes unharvested due to visual imperfections. Based on a Clemson University (CU) Enterprise budget[16] on conventional and organic kale, farmers received, on average, $0.58 per bunch of organic kale and produce a yield almost 17 thousand non-VI bunches per acre[17]. We assume that the farmer would receive a price per bunch of $0.35 for VI organic kale given the results from our payment card analysis. If 10% of kale bunches remain unharvested because of imperfections, this represents a lost yield of an estimated 1,860 bunches. Therefore, at the discounted price we estimate an unrealized gross revenue of $651 per acre. Total harvest and post-harvest costs per acre add to $3,552.24 per acre, resulting in an additional cost of $393.58[18] per

[15] This discount was calculated by subtracting the mean price selection on payment card WOA at the 10% imperfection level ($1.10) from the median price per bunch of organic kale ($1.33).
[16] Research on the CU Enterprise Budget is ongoing. Contact information for the researchers will be made public once the budget is published.
[17] Assuming that the yield reported in the budget already accounts for the 10% losses, the 10% loss is then equivalent to 1,860 bunches that go unharvested because of visual imperfections.
[18] This estimate is based on the cost per acre per bunch of $0.212 ($355.24/16,800 harvested bunches).

acre to harvest the VI kale. Then, the estimated profit per acre of harvesting VI organic kale with VI rates between 2 and 10% is $257.42 per acre. Provided they have access to the markets that are willing to sell VI organic kale, these estimates using the WTP results and CU budget indicate that there are unrealized profits.

4. Discussion and Conclusions

Every year, a substantial amount of food production is not harvested because of cosmetic regulations in grocery stores and consumers reluctance to purchase visually imperfect produce. This phenomenon accentuates the negative externalities associated with agriculture and represents lost economic opportunities. However, recent efforts have been made in marketing VI food products. For example, grocery stores have started selling fresh produce and vegetables that are misshapen or have other visual imperfections. Nevertheless, there is limited research examining consumers' preferences and willingness to pay for leafy green vegetables with visual imperfections. We extend this literature by examining consumer WTP for organic kale with visual imperfections using data from an online survey instrument (n=802).

Results from the purchase decision (probit model) and pricing decision (ordered probit) indicate that none of the messaging techniques increase the likelihood of purchase or lead to a higher WTP. This finding differs from the results of other WTP studies on VI produce found in the literature (Grewel, et al., 2019; Hartmann, et al., 2021). We find that in some cases messaging lowered reported WTP. While a majority of studies examining the WTP for organic food products found locality of production to have a significant

increase on WTP, the finding is not unanimous in the literature (Katt and Meixner, 2020). The impacts of food safety concerns on WTP for organic foods are less clear (Katt and Meixner, 2020). There is a scarcity of research on consumer WTP for VI and/or organic leafy green vegetables. It is plausible that the factors affecting consumer WTP for these products differ from other more heavily studied VI foods, such as carrots or potatoes. Addition research examining WTP for VI/organic leafy green vegetables will better elucidate the factors that affect consumer WTP for these products.

The implication of the finding that messaging on safety and locality of production do not increase reported WTP is notable for potential markets of VI organic kale. Caution should be practiced when investing in messaging, labels, or marketing techniques that highlight the safety of consumption or localness of production for this product.

We also find that highlighting the specific areas of imperfections reduces reported WTP. In a supermarket setting, sellers would not be able to use arrows to highlight the areas of imperfections on a kale leaf. While it would be feasible for online grocers to highlight imperfections, our results indicate that this approach may not be necessary. The results derived from the pre-post information analysis confirm this finding. When faced with the exact knowledge of the level of imperfection, most consumers altered their price selection by either a small margin or not at all. While some consumers switched their purchasing decision after the information was presented, a nearly even amount switched from buying to not buying and vice versa.

Prior purchases of VI produce and a stated willingness to eat VI produce at home are found to significantly increase the likelihood of purchasing VI organic kale. These

findings highlight the importance of initial exposure to VI produce to ensure continued acceptance of these products. The ambiguity of the term "produce" is crucial in this analysis: respondents did not have to have previously purchased VI organic kale specifically or be willing to eat only VI organic kale at home to be more likely to purchase VI organic kale. This indicates that experiences with any type VI produce will likely increase the probability of purchase for a variety of other types of VI produce. Therefore, our findings demonstrate the importance of gaining consumer acceptance toward any type of VI produce. Programs that educate the public about VI produce, provide free samplings of VI produce, and/or encourage the serving of VI produce in restaurants and/or grocery stores can potentially increase overall acceptance of these products.

We did not determine WTP for VI organic kale to be higher among respondents who frequently shop at farmers markets or health food stores. These respondents were also not found to be more likely to purchase VI organic kale. However, we did find that respondents with vegan or vegetarian dietary preferences had a higher WTP for VI organic kale. This has a significant implication on marketing techniques for VI organic kale. Selling VI organic kale in stores that specifically cater to consumers with vegan/vegetarian dietary preferences or in aisles of larger grocery stores featuring other plant-based food items could be a successful strategy towards increasing VI organic kale sales.

The results from our profitability analysis indicate that it can be profitable for organic kale producers to harvest and sell organic kale with VI rates between 2 and 10%

at the price point preferred by survey participants. Thus, even if farmers are unable to sell this kale through grocery stores because of cosmetic standards, they are recommended to sell directly to consumers through farmers markets and/or other markets.

There are several limitations to our work that we would like to address. A potential source of bias in our sample may have been caused by screening for participants who stated that they purchased vegetables at least once a month. This strategy may have resulted in sample that is more health conscious and more environmentally aware than the general population of the S.E. United States. It is feasible that the prices and availability of substitute products affect WTP for organic VI kale; unfortunately, the payment card methodology does not allow us to directly capture this potential effect. Future research should consider alternative ways of estimating WTP that allows researchers to account for substitutes.

The online format of our survey did not allow us to capture how physical factors other than appearance (such as taste) affect WTP. While studies indicate that results from in-person and online data collection do not differ considerably (Lindhjem and Navrud, 2011), future research should consider testing whether this has any impact on WTP for visually imperfect produce.

Future research could further examine WTP for visually imperfect produce using latent class models. The model would allow researchers to determine expenditure share on imperfect produce across different demographics, which would aid markets in identifying consumers most willing to pay higher prices for VI produce.

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CHAPTER TWO

ENTERPRISE BUDGET ANALYSIS OF SOUTH CAROLINA'S RICE PRODUCTION

1. Introduction

Rice was one of the first grain crops domesticated by human societies, with evidence of its cultivation dating as far back as 8000 BC (Sweeney and McCouch, 2007). The nutritional and economic importance of rice—both through history and in the contemporary world—cannot be understated. Rice is a staple food for over half of the global population (Kumar and Ladha, 2011), and in many Asiatic countries, rice is a cornerstone of the culture and cuisine (Muthayya, et al., 2014). With billions of people relying on the crop for sustenance, a robust understanding of the agronomic and economic conditions of rice production is needed (Gnanamanickam, 2009).

Economically viable rice production is geographically constrained because of the growing conditions required by the crop. High daytime temperatures, followed by cooler nights, are necessary during the growing season. A smooth land surface with a hard-pan subsoil is needed to accommodate the temporary flooding characteristic of rice production; as such, a plentiful water supply is required to meet the irrigation requirements (Childs, 2023). While about 90% of global rice production (and most rice consumption) occurs in Asia, the United States is still a significant producer and consumer of rice (Childs, 2023).

Historically, rice was an economically and culturally important crop in the state of South Carolina (Coclanis, 2022). However, market changes[19] and the expansion of rice cultivation to other regions of the U.S. (including the Arkansas Grand Prairie, the Mississippi Delta, the Gulf Coast of Texas and Louisiana, and California's Sacramento Valley) caused South Carolina's rice industry to collapse in the late 19th century (Coclanis, 2022). Changing environmental conditions in South Carolina's Lowcountry are renewing interest in commercial-scale rice production in the region (Bradley, 2021). This research aims to determine whether the adoption of rice cultivation in South Carolina is profitable for agricultural producers.

1.2 The History of South Carolina's Rice Industry

Commercial rice varieties were brought to the Americas through the Columbian exchange that occurred when European colonization of the New World began in earnest. During the early stages of colonization, settlers likely grew rice at a subsistence level (Coclanis, 2022). However, as settlement expanded across the Eastern seaboard of what would eventually be the United States, the Lowcountry of South Carolina became a major region of agricultural output. As the wealth and infrastructure of the Carolina Colonies grew, agrarian commodities could be produced and transported in sufficient quantities to fuel commercial production and export markets.

[19] Market changes include the physical destruction of property during the Civil War, emancipation following the Civil War, the emergence of other rice markets domestically and abroad, and changes in production techniques that were incompatible with the soil types present in South Carolina's coastal plain (Coclanis, 2022).

The rise of commercially grown rice in South Carolina began in the early 18th century (Coclanis, 2022). Most of this initial production occurred in inland freshwater swamps. By 1750, centers of rice production shifted to drained swamps along the banks of tidally influenced rivers (Coclanis, 2022). Daily tidal fluctuations provided a reliable water source and the other requirements for large-scale rice production (Coclanis, 2022). Within several decades, the tidal basins of South Carolina's Waccamaw, Santee, Cooper, Ashley, Savannah, and Combahee rivers were all major hubs of rice production (Coclanis, 2022). Rice became a crucial driver of the South Carolina colonial economy, helping propel Charleston to its status as the wealthiest city in the American colonies (Spencer, 2015). At peak output, 80,000-120,000 acres in South Carolina were under rice cultivation (Coclanis, 2022).

Contributing to the success of South Carolina's rice industry was the commonly grown Carolina Gold cultivar. The cultivar's rich texture and flavor were lauded across the colonies and abroad, with export markets flourishing in France, England, and even Asia (Pandolfi, 2023). The cobbled streets, grand churches, and pastel homes of Charleston and other Southeastern coastal cities were largely built by profits reaped from Carolina Gold.

Despite its past fame, the flavor, recipes, and cultural traditions associated with Carolina Gold were nearly lost to history. The international market share available to South Carolina's rice producers was reduced by the emergence of export markets in Asia. With profitability already diminishing preceding the Civil War (Coclanis, 2022), the war's destruction of land and infrastructure further hurt South Carolina rice growers.

Emancipation provided another hurdle to rice growers (Coclanis, 2022). During the antebellum period, slaves conducted nearly all the physical labor involved in rice production (Coclanis, 2022).

South Carolina's rice industry completely collapsed when rice production expanded to other U.S. regions. Because of differences in soil compositions, growers in Texas, Louisiana, Arkansas, and California—the same regions responsible for most of today's domestic rice production—were able to replace labor with heavy machinery, while South Carolina rice growers could not (Coclanis, 2022). A few rice growers remained operable into the early decades of the 20th century, but eventually, these, too, met the same fate as their predecessors (Coclanis, 2022). The last commercial harvest of Carolina Gold in South Carolina was recorded in 1927 (Taylor, 1988). It would be sixty years before Carolina Gold would be planted in the Southeast again (Taylor, 1988).

1.3 The Return of Carolina Gold

Carolina Gold disappeared alongside South Carolina's rice industry as the new production regions favored other cultivars. If not for the effort of one individual, Carolina Gold would likely have been lost to our palettes forever.

Dr. Richard Schulze, an Oxford-educated eye surgeon from Savannah, Georgia, took an interest in the history of the Southeast Coast's rice production after he began planting rice to attract ducks to his property in Hardeeville, South Carolina (Taylor, 1988). His research uncovered numerous sources highlighting Carolina Gold rice's past

economic, cultural, and gastronomical importance (Taylor, 1988). Naturally, Dr. Schulze wanted to grow the cultivar.

Dr. Schulze discovered that a seed bank run by the USDA Rice Institute in Beaumont, Texas, housed a small quantity of Carolina Gold seed (Taylor, 1988). He convinced USDA scientists to propagate some of the seeds, and in 1986, they sent him 14 pounds of Carolina Gold seed (Taylor, 1988). In the spring of that year, Dr. Schulze sowed the rice and, later that fall, harvested 64 pounds (Taylor, 1988). His harvest increased to 500 pounds the following year, and by 1988, Dr. Schulze collected 10,000 pounds of Carolina Gold (Taylor, 1988). The news spread quickly—Carolina Gold was back and was delicious as ever.

Today, there are a handful of South Carolina farmers producing Carolina Gold commercially. Their product can be found in grocery stores and restaurants across the Carolinas and beyond. By growing Carolina Gold, these growers are not only preserving the Lowcountry's rich history and cuisine but may also be advancing the agricultural future of the region.

1.4 Sea Level Rise and The Future Importance of Rice Production

Researchers at Clemson University, with support from the Carolina Gold Rice Foundation, have been seeking to revive the cultivation of heirloom grains[20] (which includes Carolina Gold rice) in South Carolina (Attaway, 2019). These crops hold

[20] Heirlooms are varieties of crops with uniqueness and uncommon characteristics of value that have been selected for by growers over generations (Attaway, 2019).

significant cultural and culinary importance and can also aid farmers as they adapt to changing environmental conditions (Attaway, 2019). Rising sea levels associated with climate change are expected to impact coastal communities worldwide, and South Carolina is no exception. Much of the state's land area along its coastline has an elevation just above historic sea level, increasing its risk of future flooding and saltwater intrusion. Saltwater inundation into freshwater aquifers has already occurred in Beaufort, South Carolina, and across the state line in Savannah, Georgia (Bradley, 2021). Increasing salt concentrations in freshwater resources will have serious implications for agricultural producers across the Lowcountry, as many crops are highly salt-sensitive. Up to 200,000 acres of arable land in South Carolina are at risk of becoming unfit for agricultural purposes if the current trend continues (Bradley, 2021).

Carolina Gold offers hope amid this dim outlook. The cultivar has proven uniquely resistant to high salt concentrations. Widespread adoption of the crop could prevent the collapse of the Lowcountry's agricultural industry, which would help ensure the region's future economic viability.

Economic factors associated with rice production specific to South Carolina need to be considered if the transition to rice production is to occur, as the cultivation of Carolina Gold by private producers can only be replicable at a large scale if production of the commodity is profitable. An enterprise budget was developed to assist producers in estimating costs and revenues associated with rice production in South Carolina. Breakeven price and sensitivity analyses were also performed to further examine profitability.

1.5 Enterprise Budget and Price Premiums

Enterprise budgets itemize all the potential revenue sources and expenses associated with a given type of agricultural production (CSU Extension, 2022), and are used to examine crop profitability (Wei, et al., 2020; Singerman, et al., 2017). These budgets aid farmers in making production decisions, as they inform whether a given production method is expected to be profitable. The more specified an enterprise budget is to a growing region and production method, the more accurate, and therefore useful, the budget's projections will be. Agricultural extension programs in other rice-producing states have published rice enterprise budgets, but these fail to capture the unique aspects of South Carolina's rice production and market. As mentioned, South Carolina's rice growers face different growing conditions than other rice-producing regions. To be profitable, South Carolina's rice growers must charge higher prices than growers in California or Arkansas, for example, which is a major cause of the industry's prior collapse in the state.

However, consumers have demonstrated increasing demand for local foods and heirloom crops (Day-Farnsworth, et al., 2009; Dwivedi, et al., 2019). Agricultural products with these qualities often have higher production costs than other commercially grown commodities. To be profitable, producers of these specialized commodities often charge a price premium. The literature suggests that many consumers are willing to pay this price premium for local and heirloom foods (Day-Farnsworth, et al., 2009; Dwivedi, et al., 2019).

We create an enterprise budget specific to South Carolina rice production by modifying a rice enterprise budget published by the University of Arkansas Division of Research and Extension (Watkins, 2024). Data on South Carolina's price premiums, production costs, and expected yield were provided by a local rice grower. This budget allows researchers and producers to evaluate profitability and determine the feasibility of expanding rice production in South Carolina.

2. Empirical analysis

Microsoft excel was used to formulate the enterprise budget as follows:

1. Yield in bushels per acre was multiplied by price per bushel to generate expected gross revenue per acre.
2. Seven variable costs and average crop losses were summed to calculate variable operating expenses.
3. Fixed costs were added to operating expenses to calculate total specified expenses.
4. Total specified expenses were subtracted from expected revenue to formulate expected net returns.
5. Cash land rent and lease agreements can also be included as potential earning/cost sources.

Through the implementation of the enterprise budget, the breakeven price for a singular growing season (one year) was determined, which, given costs, expected yield, and expected sale price, is the minimum price point a rice farm will not incur a loss.

Additionally, a sensitivity analysis on expected annual net returns was performed. Six price and three yield scenarios are evaluated for their effect on profitability. The enterprise budget was used to perform this analysis.

3. Results

The enterprise budget reports an average yield of 50 bushels of rice per acre and a sale price of $46.00 per bushel for a gross revenue of $2300.00 per acre[21]. Seven variable costs are reported: seed at $75.12/acre, chemical inputs at $374.44/acre, fuel at $66.00/acre, water removal (pumps) at $50.00/acre, drying at $10.00/acre, CO_2 storage at $12.00/acre, and storage totes at $20.00/acre. Field labor costs per acre specific to South Carolina were unable to be captured; thus, we used data provided by the University of Arkansas' rice enterprise budget to account for this cost, which is estimated to be $9.33/acre (Watkins, 2024). Additionally, an average crop loss of 30% per acre, primarily from bird predation and saltwater intrusion, is included in the enterprise budget. This represents a $690 per acre loss.

Three fixed costs are included in the enterprise budget: machinery & equipment at a 10-year amortization at $350.00/acre, water removal equipment at $35.00/acre, and farm overhead at $200.00/acre. After summing variable costs, estimated losses, and fixed costs, and subtracting total cost from gross revenue, at the provided price point and yield, annual net return per acre is $408.12.

[21] Information on yield, sale price, and costs were provided by a local rice grower.

The cost of cash land rent and lease agreements are ignored in this analysis. If growers rent fields, then the cash land rent is an additional cost that should be accounted for when developing the enterprise budget. Likewise, if the grower owns the land on which he or she produces rice, there is an opportunity to lease fields for recreational purposes, namely waterfowl hunting. Lease agreements should be accounted for as an additional revenue source if applicable to a given grower.

The Arkansas enterprise budget and the South Carolina enterprise budget are included in appendix two.

In calculating the breakeven price, it is important to note the size of the price premium captured by the South Carolina enterprise budget. The rice enterprise budget published by the University of Arkansas estimated an average price point of $6.75 per bushel for the states' rice growers. This price is 6.8 times less than the $46 price per bushel in our analysis. If South Carolina's rice growers received the same per bushel price as Arkansas's growers, the annual per acre net loss is $965.64. This is clearly far from profitable and magnifies the importance of the local and heirloom price premiums. The South Carolina breakeven price was determined to be $34.34 dollars per bushel. This price is 5.1 times higher per bushel than the price received by Arkansas's growers.

The sensitivity analysis accounts for how variances in price and/or yield effect profitability. The timeframe selected in this analysis was a single growing season. Yield was decreased in three 5% increments from the 50 Bu/acre reported in the enterprise budget. Sale price was decreased by $4 increments for a total of six different price

scenarios, beginning with the $46.00/Bu reported in the enterprise budget. The values reported in table 2.1 are expected net revenue per acre under the given scenarios.

Table 2.1 Sensitivity analysis of expected annual net returns: varying yield and price scenarios

Price/ Yield Scenario	1 (50 Bu)	2 (47.5 Bu)	3 (45 Bu)	4 (42.5 Bu)
$46	$408.12	$329.72	$251.32	$172.92
$42	$268.12	$196.72	$125.32	$53.92
$38	$128.12	$63.72	$-0.69	$-65.09
$34	$-11.89	$-69.29	$-126.69	$-184.09
$30	$-151.89	$-202.29	$-252.69	$-303.09
$26	$-291.89	$-335.29	$-378.69	$-422.09

Profitability is not achieved under all yield scenarios when price is $34 or less. This finding is consistent with the results of the breakeven analysis, which determined the breakeven price to be $34.34. Profitability is also not achieved at a price of $38 under yield scenarios 3 (45 Bu/acre) and 4 (42.5 Bu/acre).

4. Conclusion

The enterprise budget and sensitivity analysis indicate that rice production in South Carolina can be profitable at high price points and/or yields. The breakeven price was determined to be $34.34/Bu, which is $11.66 less than the South Carolina sale price reported in the enterprise budget. As a result, there is potential for some expansion of rice production in the state. The enterprise budget can facilitate this expansion as individual

producers can apply their personalized costs and revenue sources into the budget, allowing them to predict future gains.

Industry expansion could impact South Carolina's agricultural economy. With sea level rise and saltwater intrusion threatening agricultural production across the Lowcountry region, it may become imperative for growers to transition to saltwater-resistant crops like Carolina Gold rice. If widespread adoption of Carolina Gold cultivation were to take place, it would allow growers to remain operable in the face of these changing conditions. However, if South Carolina's rice industry continues to grow, the impact of increasing supply on sale price must be evaluated. The empirical analyses revealed that profitability cannot be achieved at other growing regions' sale prices, and rice production can only be profitable in South Carolina given the local and heirloom price premiums. If the supply of rice with these qualities were to increase significantly, under the law of demand, the sale price would decrease. This would endanger profitability. Additional research on the price elasticities of demand is needed. Thus, future work should examine consumer demand elasticities for local and heirloom rice in South Carolina to predict what impact increasing supply will have on sale price.

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APPENDICES

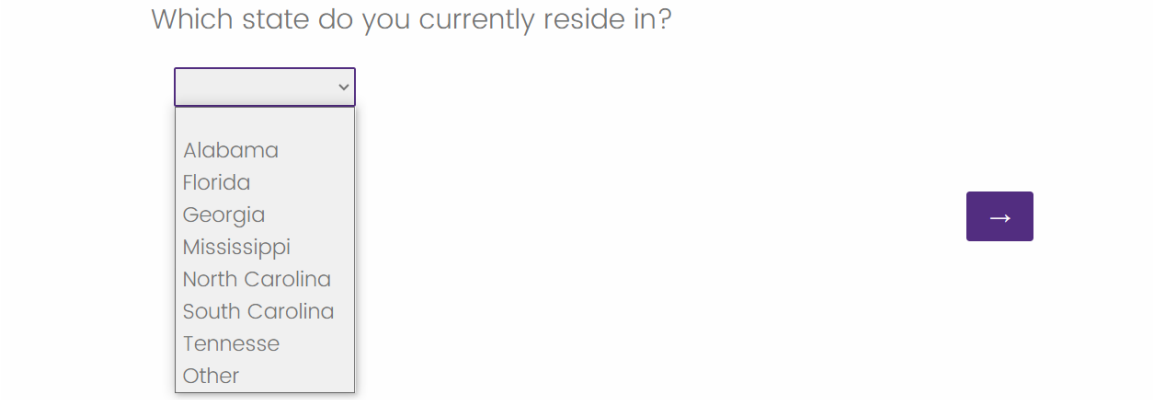
Appendix A
Chapter One Appendix

AP Table 1. Price selected by payment card, 10% imperfection level

Price Selected	WOA	WOAS	WOAL	WOASL	WA	WAS	WAL	WASL
0.96	17.83%	21.45%	18.86%	21.45%	22.89%	21.20%	21.93%	19.52%
1.01	11.11%	12.66%	13.44%	9.56%	12.29%	13.49%	11.08%	12.05%
1.06	12.14%	10.59%	11.63%	12.14%	9.16%	9.88%	11.33%	11.08%
1.12	9.82%	9.04%	9.56%	8.01%	11.57%	9.40%	9.16%	8.92%
1.17	5.94%	5.94%	8.01%	6.46%	5.30%	6.99%	6.75%	6.99%
1.22	3.88%	5.43%	5.68%	5.68%	5.06%	6.99%	5.78%	6.27%
1.28	4.65%	3.88%	2.07%	3.36%	3.37%	2.17%	3.86 %	3.37%
1.33	13.18%	11.37%	11.63%	13.44%	10.60%	10.12%	10.60%	10.12%
WNB	21.45%	19.64%	19.12%	19.90%	19.76%	19.76%	19.52%	21.69%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Table note: Total respondent number for the WOA response block (columns 2-5) is 387. Total respondent number for the WA response block (columns 6-9) is 415.

Survey questions from which variables were derived.



Have you bought any produce (vegetable or fruit) that had a discount because it had visual imperfections (yellow or black spots)?

- ◯ Yes
- ◯ No

How likely is it that you would eat vegetables with imperfections if it was served to you at following occasions?

	Very unlikely	Unlikely	Maybe	Likely	Very likely
At a restaurant	◯	◯	◯	◯	◯
At your house	◯	◯	◯	◯	◯
At a friend's house	◯	◯	◯	◯	◯
At an event (for example, work gathering)	◯	◯	◯	◯	◯

What are the varieties of kale that you typically eat? (please check all that apply)

- [ ] 
  Red kale
- [ ] 
  Green kale
- [ ] 
  Kale Lacinato/ Tuscan
- [ ] Other (please specify)

- [ ] I do not eat kale

Where do you typically purchase your groceries?

	Do you typically purchase your groceries here?		Driving time to store from your primary residence					
	Yes	No	Less than 5	5-10 mins	10-15 mins	15-25 mins	25 mins and more	Not applicable (I do not shop here)
Walmart	○	○	○	○	○	○	○	○
Grocery Store (Bi-Lo, Publix, Piggly Wiggly, Harris Teeter, Aldi)	○	○	○	○	○	○	○	○
Super Centers (Sam's Club, Costco)	○	○	○	○	○	○	○	○
Farmers' Market	○	○	○	○	○	○	○	○
Health Food Store (Whole Foods, Earth Fare, Trader Joes)	○	○	○	○	○	○	○	○
Online (Amazon Prime, Blue Apron, Hello Fresh)	○	○	○	○	○	○	○	○
Others (please specify)	○	○	○	○	○	○	○	○

Have you heard of the term 'organic food products'?

○ Yes

○ No

Do you prefer to eat locally-sourced kale (from Southeastern US)?

- ◯ Yes
- ◯ No
- ◯ Source of kale does not matter to me

Would you be willing to pay a **premium** for organic kale grown in the Southeastern US?

- ◯ Yes
- ◯ No

What is your gender?

What ethnicity do you most identify with?

- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or Pacific Islander
- Hispanic or Latino or Spanish Origin of any race
- Other

What is the highest level of education you have completed?

- ◯ Some high school or less
- ◯ High school diploma or GED
- ◯ Some college, but no degree
- ◯ Associates or technical degree
- ◯ Bachelor's degree
- ◯ Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.)
- ◯ Prefer not to say

Which of the following categories best describes your employment status?

- ◯ Employed full time
- ◯ Employed part time
- ◯ Unemployed
- ◯ Retired
- ◯ Student
- ◯ Disabled

What was your total household income before taxes during the past 12 months?

- ◯ Less than $25,000
- ◯ $25,000-$49,999
- ◯ $50,000-$74,999
- ◯ $75,000-$99,999
- ◯ $100,000-$149,999
- ◯ $150,000 or more
- ◯ Prefer not to say

Lifestyle questions

	Yes	No
Do you recycle?	○	○
Are you vegan or vegetarian?	○	○
Do you exercise at least once a week? (gym, yoga, Pilates, etc.)	○	○
Have you done agro-tourism in the last year?	○	○
Do you cook dinner at home more than 3 times a week?	○	○
Do you buy Genetically Modified Organism (GMO) products or any product with a partially engineered ingredient?	○	○

Appendix B
Chapter Two Appendix

South Carolina Rice Enterprise Budget

2024 Rice Enterprise Budget, Conventional Seed					
CROP VALUE	**Grower %**	**Unit**	**[1]Yield**	**Price/Unit**	**Revenue**
Crop Value, Enter Expected Farm Yield & Price	100%	Bu.	50.00	46.00	2,300.00
OPERATING EXPENSES			**Quantity**	**[2]Price/Unit**	**Costs**
Seed, per acre	100%			75.12	75.12
Chemicals and Application				374.44	374.44
Fuel				66	66
Water Removal (Pumps)	100%				50.00
Crop Loss				30% LOSS	690.00
CO2 Storage	100%		0.24		12.00
Labor, Field Activities	100%		0.749	12.45	9.33
Totes	100%		0.400		20.00
Post-Harvest Expense	100%				
Drying			0.20		10.00
Lease Costs	100%				0.00
Cash Land Rent				0.00	0.00
Total Operating Expenses					0.00
Returns to Operating Expenses					**$1,306.89**
CAPITAL RECOVERY & FIXED COSTS					**$993.11**
Machinery and Equipment					350
Irrigation Equipment					35.00
Farm Overhead					200.00
TOTAL CAPITAL RECOVERY AND FIXED COSTS					**$585.00**
TOTAL EXPENSES					**$1,891.89**
NET RETURNS					**$408.11**

Arkansas Rice Enterprise Budget

Table 23. 2023 Rice Enterprise Budget, Conventional Seed

CROP VALUE	**Grower %**	**Unit**	**[1]Yield**	**Price/Unit**	**Revenue**
Crop Value, Enter Expected Farm Yield & Price	100%	Bu.	170.00	6.75	1,147.50
OPERATING EXPENSES		**Unit**	**Quantity**	**[2]Price/Unit**	**Costs**
Seed, per acre	100%	Lbs/ac	72.0	0.61	43.92
Nitrogen (Urea, 46-0-0)	100%	Lbs/ac	330.00	0.290	95.70
Phosphate (0-46-0)	100%	Lbs/ac	87.00	0.380	33.06
Potash (0-0-60)	100%	Lbs/ac	100.00	0.293	29.25
Ammonium Sulfate (21-0-0-24)	100%	Lbs/ac	0.00	0.263	0.00
Boron 15%	100%	Lbs/ac	0.00	1.280	0.00
Agrotain (treatment for urea)	100%	Qts	0.46	41.98	19.31
Herbicide	100%	Acre	1	147.78	147.78
Insecticide	100%	Acre	1	3.01	3.01
Fungicide	100%	Acre	1	24.10	24.10
Other Chemical	100%	Acre	1	0.00	0.00
Other Chemical	100%	Acre	1	0.00	0.00
Custom Chemical & Fertlizer Applications					
Ground Application: Fertilizer & Chemical	100%	Acre	1	8.00	8.00
Air Application: Fertilizer & Chemical	100%	Acre	5	8.00	40.00
Air Application: Lbs	100%	Lbs/ac	330	0.080	26.40
Other Custom Hire, Air Seeding	100%	Acre	0	8.00	0.00
Machinery and Equipment					
Diesel Fuel, Pre-Post Harvest	100%	Gallons	3.811	3.85	14.67
Repairs and Maintenance, Pre-Post Harvest	100%	Acre	1	7.65	7.65
Diesel Fuel, Harvest	100%	Gallons	2.027	3.85	7.81
Repairs and Maintenance, Harvest	100%	Acre	1	10.79	10.79
Irrigation Energy Cost	100%	Ac-In	30	4.55	136.42
Irrigation System Repairs & Maintenance		Ac-In	30	0.24	7.20
Supplies (ex. polypipe)	100%	Acre	1	0.00	0.00
Levee Gates	100%	Acre	1	0.70	0.70
Labor, Field Activities	100%	Hrs	0.749	12.45	9.32
Scouting/Consultant Fee	100%	Acre	1	8.00	8.00
Labor, Irrigation	100%	Hrs	3.500	12.45	43.58
Crop Insurance	100%	Acre	1	10.29	10.29
Interest, Annual Rate Applied for 6 Months	100%	Rate %	8.00	794.67	29.08
Custom Harvest	100%	Acre	0.00	0.00	0.00
Post-Harvest Expense					
Drying	100%	Bu.	170.00	0.40	68.00
Hauling	100%	Bu.	170.00	0.19	32.30
Check Off, Boards	100%	Bu.	170.00	0.0135	2.30
Cash Land Rent		Acre	1	0.00	0.00
Total Operating Expenses					**$858.63**
Returns to Operating Expenses					**$288.87**
CAPITAL RECOVERY & FIXED COSTS					
Machinery and Equipment		Acre	1	82.65	82.65
Irrigation Equipment		Acre	1	50.75	50.75
Farm Overhead; see Note 3		Acre	1	4.13	4.13
Total Capital Recovery & Fixed Costs					**$137.53**
TOTAL SPECIFIED EXPENSES					**$996.16**
NET RETURNS					**$151.34**

Note 1: Yield and inputs are based on Extension research data. Enter expected farm yield and inputs.
Note 2: All price estimates do not include rebates, bulk deals, or discounts available through suppliers.
Note 3: Estimate based on machinery and equipment.