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GMO Turfgrass Introduction to the Market: Acceptance and Market Simulations for Connecticut Consumers

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Abstract. **Using conjoint analysis and market simulations, the impact of the introduction of certified genetically modified organism (GMO)-free; GMO-free, not certified; and non-labeled turfgrass was examined for Connecticut consumers. We categorized consumers into five distinct segments according to their preferences. The largest segment consisted of 38% of respondents (multifaceted), whereas the smallest consisted of 8% of respondents (extremely price sensitive). For most consumers GMO labeling was not a major driver for purchasing decisions, accounting for only 11% of purchasing decisions. However, holding all factors constant except GMO labeling and price, 66% of the market preferred a noncertified GMO-free label, with a significant number of consumers willing to pay for the certified GMO-free label. Based on market simulations, the noncertified GMO-free-labeled seed would maximize revenue at a 60% premium whereas the certified GMO-free label maximizes revenue when there is no premium.**

According to the U.S. Department of Agriculture (USDA) (2019b), there is no legal definition of GMO that is used universally within the United States. However, the USDA (2019a) gives a general definition of GMO as "an organism produced through genetic modification." Furthermore, genetic modification is defined as "[t]he production of heritable improvements in plants or animals for specific uses, via either genetic engineering or other more traditional methods . . . ." Diaz (2019) gives a more specific definition:

> *[O]rganism whose genome has been engineered in the laboratory in order to favour the expression of desired physiological traits or the generation of desired biological products. In conventional livestock production, crop farming, and even pet breeding, it has long been the practice to breed select individuals of a species in order to produce offspring that have desirable traits. In genetic modification, however, recombinant genetic technologies are employed to produce organisms whose genomes have been precisely altered at the molecular level, usually by the inclusion of genes from unrelated species of organisms that code for traits that would not be obtained easily through conventional selective breeding.*

Although general and specific GMO definitions exist, consumers continually report a lack of understanding of what constitutes a GMO. Numerous studies have examined perceptions of and/or awareness of U.S. consumers with respect to GMOs (Hallman et al., 2004, 2013; Lefebvre et al., 2019; McFadden and Lusk, 2016; Wolfe et al., 2012). According to a 2016 Pew Research Center report, 19% of U.S. adults had heard nothing about GMO foods; another 52% had heard only a little. Furthermore, the Pew Research Center found that 51% of U.S. adults care some to a great deal about GMO food issues, with 39% perceiving GMO foods as worse for your health (Funk and Kennedy, 2016). In a 2018 Pew Research Center report, the percentage of U.S. adults perceiving GMO foods as worse for your health had increased by 10% to 49% of U.S. adults (Funk et al., 2018). With respect to plants, Klingeman and Hall (2006) and Klingeman et al. (2006) noted similar concerns for GMO plants as there are for GMO foods.

As of 2015, a number of GMO crops have been approved by the USDA for production in the United States. Although the majority of these are used for food or feed, the USDA has approved several GMO turfgrasses for production and sale in the United States as well. Notably, Scotts' Miracle Gro (Marysville, OH) has developed a GMO grass that requires less fertilizer, grows at a slower rate, and is resistant to Roundup (Bayer Corp., Whippany, NJ) (Alexander, 2016). GMO varieties of tall fescue (*Festuca arundinacea*), kentucky bluegrass (*Poa pratensis*), and St. Augustine grass (*Stenotaphrum secundatum*) have been cleared for cultivation by the USDA (Perkowski, 2015). As GMO turfgrasses enter the market, firms must determine how best to market and position their products based on their consumer base and relative to their competitors. As a result, a variety of GMO labels are likely to be seen, including GMO-free labels appearing on turfgrasses that are not GMO. To date, no research has examined how GMO turfgrass labeling might impact consumer demand. An argument could be made that consumers will be more amenable to GMO turfgrasses, given turfgrass is not consumed. Findings by Klingeman et al. (2006) support this finding in that Tennessee Master Gardeners anticipated a slight benefit of introducing GMO plants to a landscape. However, a counterargument is that the GMO food stigma will translate to turfgrass as well, or that consumers may associate a GMO turfgrass with increased pesticide use.

Our work fills the gap in the literature by examining the impact of GMO-free labeling on turfgrass labeling introductions—notably, on market share, demand, and revenue. We hypothesize that a large percentage of the market will prefer a non-GMO-labeled turfgrass. At the same time, we expect that drivers of consumer's turfgrass purchase decisions to be heterogeneous across market segments. This latter hypothesis is in line with Curtis and Cowee (2010), Ghimire et al. (2016, 2019), Hugie et al. (2012), and Yue et al. (2017), who found that varying attributes drive the purchase decisions of turfgrass.

Materials and Methods

We implemented an online survey in Summer 2016. The survey examined consumer preference, awareness, and preference for several products. We obtained survey respondents from the database of Global Market Insight, Inc. (Lightspeed Research, Warren, NJ). Panelists meeting two criteria (>18 years of age and residents of Connecticut) were invited to participate in the survey. We selected Connecticut as the study site as a result of funding agency requirements, although Connecticut makes a good case study

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Table 1. Demographics of Connecticut respondents from a genetically modified organism turfgrass acceptance survey.

Characteristic	Total Mean	Total SD	Census estimates[z]
Age (median y)	43.0	—	40.0
Millennial and younger	25%	43%	
Generation X	38%	49%	
Baby Boomer and older	38%	48%	
Caucasian	81%	40%	80%
Male	28%	45%	
Political Affiliation			
Republican	18%	39%	
Democrat	43%	50%	
Other affiliation	39%	49%	
Urbanicity			
Rural	21%	41%	
Suburban	70%	46%	
Urban	9%	29%	
Household income (median $)	$68,939	—	$76,1406
Home characteristics			
Detached home	57%	50%	
Attached home	25%	44%	
Apartment	12%	33%	
Other home type	5%	23%	
No. of adults in household	2.4	1.0	
No. of children (<18 years) in household	0.47	0.92	
Education			
High school or less	16%	36%	
Associates degree/some college	49%	50%	
Bachelor's degree	20%	40%	
Graduate degree	16%	37%	
Purchased turfgrass seed or sod (% yes)	43%	50%	
Observations	374		

[z]U.S. Census Bureau (2015, 2019).

for GMO labeling because it has been progressive in trying to require GMO labeling. Notably, in 2013 Connecticut became the first state to pass a GMO labeling bill (H.B. No. 6519) that mandated GMO labeling under certain conditions (Connecticut General Assembly, 2013). Although the Connecticut bill was later invalidated by a 2016 USDA rule (RIN 0581-AD54), it set the stage for Connecticut as progressive in wanting GMO labeling of products. Furthermore, USDA rule RIN 0581-AD54 established the National Bioengineered Food Disclosure Standard Law, which established GMO labeling mandates (USDA-Agricultural Marketing Service, 2018). A caveat to using residents of Connecticut only is that the results are generalizable outside the sample in so much as the demographics and behaviors of the sample are representative of the overall population.

Upon entering the survey, we assigned respondents randomly to a conjoint analysis experiment for a single product. For the purposes of this study, the focus was on turfgrass only. A total of 374 respondents who were assigned to the turfgrass experiment completed the survey. As a part of the survey, respondents completed the turfgrass conjoint section as well as demographic and purchasing questions. The median age of the sample was 43 years, with a median income of ≈$69,000 (Table 1). In comparison, the median age and household income level for Connecticut was 40 years and $76,106, respectively (U.S. Census Bureau, 2015, 2019). The sample was 81% Caucasian which is in line with the population makeup of Connecticut (80% Caucasian) (U.S. Census Bureau, 2019). For the survey, women were oversampled because it has been shown that women are more likely to be the primary shopper in households (Flagg et al., 2013; Wolfe, 2013; Zepeda, 2009). Given age, household income, and race, the sample appears to be representative of the Connecticut population. Although limited to a Connecticut sample, findings are generalizable outside of the sample as long as the data are representative of other states. At the very least, the findings offer insights into the consumer market for GMO labeling of turfgrass as well as how a non-GMO price premium will impact the market.

To examine consumer preferences for GMO turfgrass, we use conjoint analysis. Conjoint analysis is a well-established technique to understand preferences for products and product attributes. Notably, conjoint analysis has been used extensively to analyze specialty crops (Behe, 2006; Campbell et al., 2010, 2013, 2016; Darby et al., 2008; Ekelund et al., 2007; Frank et al., 2001; Onozaka and McFadden, 2011) and plants (Behe et al., 2014; Hall et al., 2010; Mason et al., 2008; Zagaden et al., 2008).

The first step of conjoint analysis is to identify the product, attributes, and attribute levels to be included in the experiment. We used a 1-lb bag of grass seed for the product. Attributes included variety, price, product origin, production practice, GMO label, and retail outlet where sold (Table 2). Grass variety is an important factor in purchasing grass seeds; therefore, four commonly purchased varieties were included: perennial ryegrass (*Lolium perenne*), kentucky bluegrass, fine fescue (*Festuca* spp.), and sun/shade (mix of grass types). Price per pound had five attribute levels: $0.79, $1.59, $2.39, $3.59, and $4.69/lb. Product origin included New England, Canada, Connecticut, and California, along with no label. Although most consumers would not be able to identify a Connecticut-grown turfgrass from turfgrass from another origin, origin has been shown to influence purchasing decisions. For instance, Yue et al. (2011), Khachatryan et al. (2014), and Rihn et al. (2015) showed that locally produced plants generate preference and/or premiums compared with their nonlocal counterparts. Production practice attribute levels included no label, organic practices (but not certified organic), certified organic, environmentally friendly, and sustainability grown. GMO labeling attribute levels included no label, certified GMO free, and noncertified GMO free. Retail outlet was included, because this attribute has been found to be important for a variety of specialty crops, such as Christmas trees (Zaffou and Campbell, 2017), berries (Hoke et al., 2017), and vegetables (Campbell et al., 2016). Attribute levels for retail outlet included mass merchandiser (e.g., Walmart, Target), home improvement center (e.g., Home Depot, Lowes), and nursery/greenhouse garden center.

Given the number of attributes and levels, a full design would have resulted in a respondent evaluating an impractical number of profiles ($5^3 \times 4 \times 3^2$). Therefore, an orthogonal fractional factorial design was used to generate 25 product profiles that had one attribute level from each attribute. Using the orthogonal fractional factorial design allowed a reduction in respondent fatigue and improved response rate while also allowing for the estimation of the main effects. Upon entering the conjoint section of the survey, respondents were told to assume they were in a real purchase situation and they were shopping for a grass seed for their home lawn. They were also reminded to consider their past purchasing decisions and current income budget restraints in making their decision. Respondents were then asked to rate each of the 25 product profiles on how likely they would be to purchase 1 lb of the grass seed shown in the profile. Ratings were on a 0 to 100 continuous scale, where 0 was "Extremely Unlikely," 50 was "Neither Likely/Unlikely," and 100 was "Extremely Likely," and values in between were representative of varying likely and unlikely levels. For the product profiles, all attributes were in text form, with the variety also being shown as a picture.

Conjoint analysis is based on a random utility framework in which utility is based on the individual utilities associated with the attributes and attribute levels of each product (Wirth et al., 2011). According to Lusk and Schroeder (2004), the rating scale represents a buyer's utility in that the choice j can be thought of as

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad [1]$$

where U_{ij} represents a product's total utility for respondent i to product j, V_{ij} is the sum of individual attribute utility levels (i.e., the utility generated by each attribute level), and ε_{ij}

Table 2. Grass seed (1 lb) attributes and levels for a conjoint analysis experiment based on responses from Connecticut residents about genetically modified organism (GMO) turfgrass acceptance.

Variety	Price	Retail location	Product origin	Production Practice	GMO
Perennial ryegrass	$0.79	Mass merchandiser	No label	No label	No label
Kentucky bluegrass	$1.59	Nursery/greenhouse garden center	New England	Organic practices, not certified	Certified GMO free
Fine fescue	$2.39	Home improvement store	Canada	Certified organic	Noncertified GMO free
Mix (shade/shade)	$3.59		Connecticut	Environmentally friendly	
	$4.69		California	Sustainably grown	

is a stochastic error term. Parameter values (i.e., part-worth utilities) were estimated using ordinary least squares,

$$Y_{ij} = \beta_0 + \beta_i X_{ij} + \varepsilon_{ij} \qquad [2]$$

where ε_{ij} is an independent and identically distributed error term, X_{ij} represents a vector of product attributes, Y_{ij} represents the product ratings, β_0 is an intercept, and β_i is a part-worth utility vector. The independent variables are effects coding, which makes them deviations from the mean (Hair et al., 1998). The β_i part-worth utilities can be thought of as increases/decreases on the rating point scale or a change in the percentage on the rating point scale given the purchase scale's range is from 0 to 100. After obtaining the part-worth utilities for each attribute level, relative importance values were calculated as

$$RI_i = \frac{\text{Range}_i \times 100}{\sum \text{range}_i};\ i = 1,...,6\ , \qquad [3]$$

where RI_i is the relative importance of attribute i and range is the range (i.e., Highest part-worth utility for attribute i – Lowest part-worth utility for attribute i) for a consumer's coefficients for attribute i.

After calculating the part-worth utilities and relative importance values, we identified consumer segments using cluster analysis. With cluster analysis, similar part-worth utilities are grouped together to form clusters (market segments) (Green and Helsen, 1989). There is a myriad of clustering techniques. For this analysis, Ward was used as the primary technique, although the robustness of the results was checked with complete linkage and centroid linkage. The final clusters were identified using a combination of max pseudo-J and min pseudo t^2-criteria as well as subjective evaluation. Subjective evaluations were used to ensure the market segments were measurable, actionable, accessible, substantial, and differentiable (Kotler and Keller, 2009).

Multinomial logit analysis (MNL) was used to estimate the effect of demographic and past purchasing on the probability of segment membership. The MNL model used was (Greene, 2003)

$$\text{Prob}(R_i = j) = \frac{e^{\beta_j' x_i}}{\sum_{j=1}^{5} e^{\beta_v' x_i}},\ \text{where } j = 1,2,3,4,5, \qquad [4]$$

where Prob($R_i = j$) is the probability that the ith respondent will be in the jth market segment, x represents respondent demographics, and β is a vector of parameters. We calculated the marginal effects to evaluate how the explanatory variables impact the probability of being in a specific market segment. Continuous marginal effects are interpreted as the change in the probability of segment membership given a 1-unit change in the explanatory variable (e.g., household income). Categorical marginal effects are interpreted as the change in the probability of segment membership given a change from a base variable (e.g., female compared with male).

Next, we simulated how the market would change given new product introductions. We first simulated the introduction of a GMO-free grass seed into the market using a first-choice model. The first-choice model has been used widely to simulate the market of several products, such as ethnic vegetables (Campbell et al., 2016), citrus (Campbell et al., 2006), peaches (Campbell et al., 2013), and peanuts (Nelson et al., 2005). A fundamental premise of economics is that a consumer purchases the product that has the highest utility. Using this premise, a base market is established that is made up of various products. New products are then introduced into the market according to their product attribute levels. The product is then evaluated based on which products are chosen (i.e., has the highest utility as represented by summation of the part-worth utilities for all attribute levels for a product).

We examined market shares, quantity demanded, and revenues for buyers and nonbuyers with respect to market outcome indicators for the first-choice model simulations. We calculated market shares as the number of respondents choosing a product divided by the number of consumers in the market. We calculated quantity demanded for buyers using the amount of grass seed purchased by each individual consumer and assigning that quantity to the product chosen. For nonbuyers, we assumed that nonbuyers would enter the market and purchase the average amount purchased by buyers. Although they are not buyers, the nonbuyer simulation gives an idea of what would happen if these consumers entered the market. Revenues are calculated by multiplying the quantity demanded by price.

The first step in setting up the market simulation was to establish an initial market. In this case, we defined the initial market as unlabeled seed priced at $2.39/lb, holding all other attribute levels constant. We then introduced a noncertified GMO-free-labeled product into the market. Last, we introduced a certified GMO-free-labeled product into the market. We varied systematically the price premium for GMO-free and certified GMO-free products to assess how consumers would respond to paying a premium for a turfgrass seed that was labeled GMO free. We assessed market shares, quantity demanded, and revenues after each price change.

Results and Discussion

Overall market

Price was the most important attribute, making up an average of 26% of the consumers' buying decisions (Table 3). Grass origin (18%), production practices (18%), and grass variety (17%) were in the next tier of importance. GMO labeling (11%) and location of purchase (10%) were in the lowest tier of relative importance. Although GMO labeling is one of the lowest factors in a consumer's decision to purchase, it becomes more important when products are similar across other attributes. For instance, GMO plays a larger role if the grass variety, production practices, and grass variety are the same.

Examining the part-worth utilities, the overall sample preferred a lower price to a higher price. This can be seen by the 9.5 increase in the likelihood-to-purchase rating for the $0.79/lb price compared with a 9.3 rating decrease for the $4.69/lb price point (Table 3). The sun/shade mix was preferred (1.3 rating increase), whereas perennial ryegrass had a negative utility (2.3 rating decrease). The preference for the sun/shade mix fits with the findings of Ghimire et al. (2016) and Hugie et al. (2012). For the other attributes (and levels), nursery/greenhouse garden center was the most preferred, as was grass seed originating in Connecticut and grass seed certified organic. Interestingly, the overall sample preferred no production label to the organic (not certified) label, and preferred the environmentally friendly and sustainable labels more than the organic (not certified) label. With respect to GMO labeling, the noncertified GMO was preferred to the no label and the certified GMO label.

Market segmentation

Based on Ward's method and qualitative assessment, we identified five market segments categorized as multifaceted, fuzzy, market origin, price sensitive, and extremely price sensitive. The market size of the segments ranged from 8% (extremely price sensitive) to 39% (multifaceted) of the market (Table 3).

Multifaceted. The multifaceted segment accounted for 39% of the consumers in the sample (Table 3). Grass variety (20%), price (20%), and production practice (20%) were the

Table 3. Relative importance and part-worth utilities obtained from a conjoint analysis experiment based on responses from Connecticut residents about genetically modified organism (GMO) turfgrass acceptance.

	Market segments[z]					
	Multifaceted	Fuzzy	Origin	Price sensitive	Extremely price sensitive	Total
Relative importance (%)						
Grass variety	**20**	**19**	13	15	10	**17**
Price	**20**	**19**	15	33	**54**	**26**
Location of purchase	11	12	9	9	7	10
Grass origin	17	**18**	**33**	18	11	**18**
Production practices	**20**	**20**	18	16	11	**18**
GMO	12	11	11	10	7	11
Part-worth utility (intercept)[y]	42.83	52.98	53.43	48.05	43.50	46.96
Grass variety						
Perennial ryegrass	–3.31	1.15	–0.11	–3.34	–3.96	–2.34
Kentucky bluegrass	1.41	–2.95	–1.75	2.66	–1.17	0.54
Sun/shade mix	–1.88	7.30	1.57	2.08	1.67	1.32
Fine fescue	3.78	–5.50	0.30	–1.39	3.46	0.48
Price of seed						
$0.79/lb	1.70	–0.82	–1.27	20.91	43.48	9.51
$1.59/lb	1.04	2.33	0.88	8.77	18.89	4.74
$2.39/lb	0.63	0.11	–0.35	0.03	–1.75	0.10
$3.59/lb	–0.97	–0.83	2.24	–10.20	–25.11	–5.06
$4.69/lb	–2.40	–0.78	–1.51	–19.50	–35.50	–9.30
Home improvement center	0.03	–3.54	0.74	–0.09	–0.24	–0.55
Mass merchandiser	0.04	4.42	–1.43	–1.80	–1.39	0.02
Nursery/greenhouse garden center	–0.07	–0.88	0.69	1.88	1.63	0.53
Grass origin						
No label	0.49	–2.97	–6.57	–0.96	–1.62	–1.29
New England	–0.15	2.27	10.73	2.63	0.40	2.05
Canada	0.26	–1.48	–8.18	–3.31	0.60	–1.75
Connecticut	0.12	2.01	15.93	6.04	0.31	3.51
California	–0.72	0.17	–11.90	–4.40	0.31	–2.52
Production practices						
No label	–1.18	0.30	–4.58	–0.15	–1.15	–0.96
Organic (not certified)	–0.22	–6.04	0.38	–1.68	0.39	–1.49
Certified organic	1.26	–0.04	5.81	0.11	0.45	1.08
Environmentally friendly	–0.08	2.90	0.04	1.79	0.57	0.99
Sustainable	0.22	2.89	–1.65	–0.07	–0.26	0.38
GMO						
No label	–1.11	–0.53	–2.21	–1.82	0.59	–1.18
Certified GMO free	0.11	1.64	2.12	–0.75	1.61	0.43
Noncertified GMO free	1.00	–1.12	0.09	2.56	–2.20	0.74
R^2 (%)	84	85	90	89	95	87
Adjusted R^2 (%)	21	26	52	48	76	36
No. of consumers in each segment	146	62	34	102	29	373
Market share (%)	39	17	9	27	8	100

[z]Bold type indicates significance at the 0.10 significance level.

[y]Part-worth utilities can be interpreted as percentage increase/decrease or as magnitude changes on the 0 to 100 rating scale.

main purchase drivers for the multifaceted segment. Notably, this segment preferred fine fescue (3.8) over kentucky bluegrass (1.4); there were negative values for the sun/shade mix (–1.9) and perennial ryegrass (–3.3). There was little to no preference difference for location of purchase. The no label was the most preferred origin label, followed by Canada and Connecticut. Certified organic was the most preferred production label, with no production label being the least preferred. With respect to GMO labeling, the noncertified GMO free resulted in a 1% increase in the likelihood-to-purchase rating, with the certified GMO label only having a small (0.11) impact on rating.

Examining the MNL marginal effects, younger consumers (millennials and younger) were 18.2% less likely to be in the multifaceted segment. However, Republicans and respondents denoting "other" political party affiliation were 16.7% and 15.5%, respectively, more likely to be in this segment compared with a respondent that indicated Democrat. As household income increased by $1000, the probability of being in the multifaceted segment increased by 0.1%. A respondent who had purchased sod or grass seed in the past year was 12.6% less likely to be in this segment.

Fuzzy. The fuzzy segment had several attributes that were similar in importance: production practices (20%), grass variety (19%), price (19%), and origin (18%) (Table 3). With respect to production practices, environmentally friendly and sustainable were the most preferred. An environmentally friendly and sustainable label raised a respondent's purchase likelihood by 2.9 and 2.9, respectively. However, the noncertified organic resulted in a 6-point rating decrease in likelihood of purchase. For grass variety, the sun/shade mix was preferred the most, followed by perennial ryegrass. This segment did not prefer the cheapest price; they valued the $1.59/lb price the most. Although theory would tell us that the lowest price should be preferred, it could be that the lowest price might be seen as a lower quality grass seed. The New England and Connecticut origin labels were the most preferred, with the no label decreasing a respondent's purchase likelihood. Although making up only 11% (relative importance) of the decision to purchase, this segment preferred the certified GMO-free label and had a negative view of the noncertified GMO-free label.

Several studies have found a fuzzy segment (e.g., Campbell et al., 2006, 2013; Hall et al., 2010), with this segment generally being an eclectic mix of consumers. Given the mix of consumers, it was not unexpected that this segment had few significant marginal effects. The only significant marginal effect was for the Republican variable (Table 4). Respondents indicating they were Republican were 11% less likely to be in the fuzzy segment.

Origin. The origin segment placed one-third (33%) of their decision to purchase on the origin attribute (Table 3). A Connecticut grass seed generated a 15.9 increase in the likelihood of purchase, followed by a New

Table 4. Multinomial logit marginal effects based on responses from Connecticut residents about genetically modified organism turfgrass acceptance.

	Marginal effects[z]									
	Multifaceted		Fuzzy		Origin		Price sensitive		Extremely price sensitive	
	Coeff.	*P* value	Coeff.	*P* value	Coeff.	*P* value	Coeff.	*P* value	Coeff.	*P* value
Millennial and younger	**–0.182**	**0.010**	0.112	0.111	0.035	0.461	0.058	0.427	–0.022	0.369
Generation X	–0.080	0.222	0.008	0.883	–0.013	0.722	0.075	0.261	0.009	0.704
Caucasian	–0.046	0.557	0.001	0.982	0.032	0.329	–0.044	0.532	**0.056**	**0.020**
Male	–0.045	0.471	0.051	0.330	0.009	0.817	0.020	0.738	**–0.034**	**0.089**
Political affiliation										
Republican	**0.167**	**0.045**	**–0.111**	**0.013**	–0.043	0.239	–0.046	0.490	0.033	0.385
Other affiliation	**0.155**	**0.012**	–0.064	0.112	–0.023	0.452	–0.080	0.142	0.012	0.638
Urbanicity										
Rural	0.002	0.984	–0.019	0.799	–0.024	0.675	0.033	0.750	0.008	0.873
Suburban	–0.138	0.144	0.019	0.772	0.043	0.367	0.059	0.474	0.017	0.646
Household income[y]	**0.001**	**0.084**	0.000	0.605	–0.001	0.175	0.000	0.591	**–0.001**	**0.064**
Home characteristics										
Attached home	0.025	0.737	0.051	0.395	0.006	0.863	–0.055	0.372	–0.027	0.251
Apartment	–0.050	0.570	0.097	0.242	–0.002	0.969	0.012	0.889	**–0.058**	**0.001**
Other home type	0.066	0.611	0.082	0.485	0.021	0.797	–0.132	0.171	–0.036	0.117
No. of adults in household	–0.035	0.209	0.013	0.502	0.002	0.897	0.030	0.225	–0.009	0.442
No. of children (<18 yr) in household	–0.008	0.796	0.011	0.707	0.013	0.410	–0.004	0.897	–0.011	0.363
Education										
Bachelor's degree	**–0.117**	**0.090**	0.031	0.620	**0.115**	**0.049**	0.003	0.964	**–0.032**	**0.066**
Graduate degree	–0.009	0.914	0.032	0.663	0.037	0.472	–0.061	0.401	0.001	0.979
Purchased turfgrass seed or sod	**–0.128**	**0.024**	0.039	0.382	0.027	0.419	0.059	0.251	0.002	0.911
Wald χ^2-square	88.160									
Probability > χ^2	0.051									
Log pseudolikelihood	–499.776									
Pseudo-R^2	0.068									
Total no. of observations	373									

[z]Bold type indicates significance at the 0.10 significance level.

[y]Income is based on a \$1000 change. The interpretation for household income is that for a \$1000 increase in income, there is a *x*-percent increase/decrease in the probability of being in the segment.

England–labeled grass seed, which increased the likelihood of purchase by 10.7. When the California label, Canada label, and no label were shown, respondents in this segment had a negative preference, and their likelihood to purchase decreased by 11.9, 8.2, and 6.6, respectively. Regarding the other attributes, this segment preferred the sun/shade mix, home improvement centers, certified organic grass, and certified non-GMO. The main demographic characteristic that described members of this segment was education. Respondents with a bachelor's degree were 11.5% more likely to be in this segment than respondents with an education level less than a bachelor's degree (Table 4).

Price sensitive. One-third (33%) of the purchase decision for consumers in this segment was a result of price. The \$0.79/lb price resulted in a 20.9 rating increase in likelihood of purchase (Table 3). The \$4.69/lb price caused a 19.5 rating decrease in likelihood to purchase. Other than price, consumers in this segment preferred kentucky bluegrass, nursery/greenhouse garden center, Connecticut origin, labeled environmentally friendly, and noncertified GMO free. There were no demographics that were significant for this segment.

Extremely price sensitive. Consumers in this segment relied heavily on price, with 54% of their buying decision a result of price (Table 3). A \$0.79/lb price resulted in a 43.5 increase in their likeliness to purchase rating, whereas a \$4.69/lb price resulted in a 35.5 decrease in their purchase rating. In comparison, the extremely price-sensitive segment part-worth utility was 108% (43.5 utiles vs. 21 utiles) greater than the price-sensitive segment at the \$0.79/lb price. For the other attributes, this segment preferred fine fescue, nursery/greenhouse garden center, Canadian origin, environmentally friendly labeled, and the certified GMO label.

With respect to demographic characteristics, Caucasians were 5.6% more likely to be in this segment compared with non-Caucasians (Table 4). Males, higher household incomes, and consumers with a bachelor's degree were 3.4%, 0.1% per \$1000 increase in income, and 3.2% less likely to be in this segment, respectively.

Market simulations

Buyer market. In the base scenario that currently exists in the market (no GMO certification in the grass seed market), the no label would have 100% market share, sold 191 lb of grass seed, with \$457 in revenue (Table 5). Note that the amount sold is based on the numbers provided by respondents in the survey. With the entry of a noncertified GMO-free grass seed into the market at the same \$2.39/lb price, the no label would have a 44% market share whereas the noncertified GMO-free-labeled grass seed would gain a 56% market share. The noncertified GMO-free-labeled grass seed would sell 106 lb and make \$254 in revenue based on our sample.

The introduction of a certified GMO-free option into the market (at the same \$2.39/lb price as no label and noncertified GMO free) would take a 45% market share, with most of the market share coming from the no-label option (44% to 10%) (Table 5). The no-label grass seed would be the biggest loser with the introduction of the certified GMO free option because its market share would be only 10% with revenues falling more than 80% from the no-label/noncertified GMO levels.

As the GMO introductions enter the market, they are most likely going to be marketed at premiums, given the added benefit of a GMO label. Simulating price premiums at 10% intervals, market share, demand, and revenues increase for the no-label seeds but decrease for the GMO-labeled seed. Given most retailers will want to maximize revenues, the noncertified GMO-free-labeled seed would maximize revenue at a 70% premium (\$239.72), whereas the certified GMO-free label maximizes revenue when there is no premium (\$191.20). However, depending on costs, such as obtaining a GMO-free certification, a producer/retailer may have to charge a premium. For the no-label grass seed, the greater the GMO-free premium, the more revenue received.

Given these findings, an interesting dichotomy is observed. For GMO-free producers/retailers wanting to differentiate themselves, a potential means to accomplish differentiation is to put a GMO-free label on their product. For producers/retailers wanting to differentiate themselves further, seeking GMO-free certification may be a way to accomplish this goal. However, the noncertified GMO-free seed should enter the market with

Table 5. Market simulation results based on responses from Connecticut residents about genetically modified organism (GMO) turfgrass acceptance.[z]

	Market share (%)			Quantity sold (lbs)[y]			Revenue ($)[x]		
	No label[w]	Noncertified GMO free[w]	Certified GMO free[w]	No label[w]	Noncertified GMO free[w]	Certified GMO free[w]	No label[w]	Noncertified GMO free[w]	Certified GMO free[w]
Buyer market									
Base	100	—	—	191	—	—	456.49	—	—
GMO-free introduction	44	56	—	85	106	—	202.41	254.08	—
GMO-free premium									
0%	10	45	45	14	97	80	33.46	231.83	191.20
10%	22	40	38	33	89	69	78.87	233.98	181.40
20%	34	36	30	60	76	55	143.40	217.97	157.74
30%	43	32	24	80	67	44	191.20	208.17	136.71
40%	45	30	24	83	65	44	198.37	217.49	147.22
47%	48	29	22	89	61	42	212.71	218.69	150.57
50%	48	29	22	89	61	42	212.71	233.26	160.61
60%	52	27	21	93	59	40	222.27	239.72	162.52
70%	52	27	20	95	59	38	227.05	253.82	163.48
Nonbuyer market[v]									
Base	100	—	—	252	—	—	602.28	—	—
GMO-free introduction	42	58	—	105	147	—	250.64	351.64	—
GMO-free premium									
0%	11	45	44	27	113	112	64.53	270.07	267.68
10%	24	41	35	61	102	89	145.79	268.16	233.98
20%	32	39	30	80	98	75	191.20	281.06	215.10
30%	36	35	28	92	89	71	219.88	276.52	220.60
40%	43	31	25	109	78	64	260.51	260.99	214.14
47%	45	30	25	113	76	63	270.07	272.46	225.86
50%	45	30	25	114	76	62	272.46	290.62	237.09
60%	49	27	24	124	69	59	296.36	280.35	239.72
70%	51	25	24	130	63	59	310.70	271.03	253.82

[z]The total market is the sum of the buyer and nonbuyer markets. The base market assumes no GMO labeling in the market, GMO-free introduction assumes a noncertified GMO seed enters the market. The price premiums are higher prices that could be charged for noncertified GMO and certified GMO free seed.

[y]Quantity sold for the nonbuyers is assumed to be the average number of pounds purchased by the buyers. This assumes that nonbuyers enter the market.

[x]Revenue is calculated by as the quantity sold × price. In the nonpremium cases, the price is $2.39/lb.

[w]No label means no GMO label was provided to indicate whether the turf was a GMO; GMO free (not certified) means a GMO label was provided but no certification was indicated; and certified GMO free means a GMO label was provided that indicated it was certified as GMO free.

[v]Quantity sold for nonbuyers assumes the nonbuyers enter the market and purchase the average amount purchased by buyers.

a 60% premium. The certified GMO-free grass seed would most likely be expected to have an equal or greater price compared with a noncertified GMO-free grass seed, but the optimal strategy for the certified GMO-free grass seed would be to have a zero premium. This finding is the result of 66% (the multifaceted and price-sensitive segments from Table 3) of the market valuing a noncertified GMO-free product. If a retailer is targeting the other marketing segments in Table 3, then a premium could be warranted, especially for the fuzzy and origin segments.

Nonbuyer market. To test how the market would respond to new consumers entering the market, we assumed new consumers would purchase the average quantity purchased by grass seed buyers. Results of the nonbuyer simulations were similar to the findings from the buyer simulation. Notably, revenues for no labeling were greater with increased GMO-free premiums, noncertified GMO-free labeling revenues are maximized at a 50% premium, and the certified GMO label is maximized at no premium.

Conclusion

As GMO grass seed enter the market, there will be a transformation in labeling. Some firms that produce/retail GMO-free seed will look to differentiate their product. These firms will either seek GMO-free certification or simply label their seed as GMO free. To make the decision on whether and how to differentiate, grass seed producers/retailers need information on market segmentation and how the market will change with new entrants.

GMO labeling was not a major driver in most consumers' purchasing decisions. However, it did account for ≈11% of the decision, which is important if other attributes are similar (e.g., two grass seed products with similar prices). Examining GMO preferences in detail, 66% of the market (Multifaceted market share + Price-sensitive market share) preferred a noncertified GMO-free label and not the certified GMO-free label. This finding is important because two-thirds of the market prefer a firm not paying to be certified. However, 34% of the market prefers a certified GMO-free label, although it could be hard to target the extremely price-sensitive segment because this segment demands a low price, which may not compensate the producer/retailer for the added cost of certification.

Another conundrum arises for producers/retailers when pricing their products. Noncertified GMO-free products would maximize revenue at a 60% price premium, although certified GMO-free producers maximize revenue at a 0% premium. Pricing at a 0% premium will most likely not cover their costs to certify. For noncertified GMO-free products, if a certified GMO-free grass seed does not have a price premium, then it may be hard to charge a 60% premium.

Based on our research, it is clear that grass seed producers/retailers need to examine the market thoroughly when making labeling and product introductions. Failure to understand the heterogenous nature of the market and how pricing/labeling decisions will impact the market will result in lower product profitability.

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