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RESEARCH ARTICLE

Exploring Consumer Preferences for Potting Mix Characteristics Using Best-Worst Scaling

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Abstract
Little is known about the preferences of US at-home gardeners for potting mix characteristics. This study uses a Best-Worst Scaling approach to evaluate consumer preferences for eleven characteristics of potting mix. The most important characteristics identified are formulated for specific plant or garden types, pre-mixed ingredients, and price. The least important are the brand, packaging, and home delivery. There is some variation in the relative importance of these potting mix characteristics depending on consumer demographics. This study guides Industry stakeholders and policymakers on product development while enhancing environmental sustainability.

Keywords: Best-Worst Scaling; gardening; master gardener; peat moss; potting mix

JEL classifications: Q10; Q15

Introduction

Within horticulture, the US potting soil and mix is a multi-billion industry with expected continued growth (Arizton, 2022).[1] This is driven by a 30% increase in urban gardeners over the past three decades, especially in the wake of COVID-19, amounting to over 18 million new gardeners in the US (San Fratello et al., 2022). Moreover, potting soil's growth may, in part, stem from changing patterns in population density and green space availability making container gardening more attractive (Nagase and Lundholm., 2021).

The industry faces several challenges amidst changing conditions in its supply chain. For example, several state and international organizations are advocating for and instituting protections for peatlands (Dept. for Environmental Food & Rural Affairs and The Rt Hon Lord Benyon (2022), altering the availability of peat moss, a historically major component found in potting mix. Researchers are exploring alternative substrates that are inexpensive or readily available (Abad et al., 2005; Adamczewska-Sowińska et al., 2022; Trejo-Téllez et al., 2022). Changing consumer preferences may also affect future product development and sales of horticultural products including potting mix. Following the global pandemic began in 2020, consumers seem to enjoy the convenience of home-delivered grocery and other products (e.g., Belcore et al. (2024)). Gardeners are increasingly interested in and purchasing characteristics perceived as more environmentally friendly such as peat-free or with biochar (Herbes et al., 2020; Silwal et al., 2023; Thomas et al., 2021; Waliczek et al., 2020) or other alternatives that support wildlife such as birds, bees, and butterflies (Fallon, 2022; Wollaeger et al., 2015). This matches a

[1]The two terms are used interchangeably throughout the paper.

broader pattern across all consumer products for increased sustainability-oriented characteristics (Kronthal-Sacco and Whelan, 2023). Other recent changes in consumer preferences include increased spending in organic gardening products as well as for indoor houseplant gardening (Fallon, 2022; Starbuck, 2022).

These studies demonstrate that multiple factors may be important to gardeners to varying degrees. For instance, in addition to price, product customization can be important, such as potting mix specific to garden types and plants, potting mix protecting against over and under watering, and convenience of product such as pre-mixed ingredients, including plant food or fertilizer. Variation exists in consumer preferences for the product's brand, whether it is local or organic, and its sustainability implications (Behe et al., 2013; Hawkins et al., 2012; Mason et al., 2008). For instance, German household preferences for potting mix characteristics demonstrate that price, the sustainability of the components in the potting mix, and peat-free to be the three most important characteristics (Dahlin et al., 2019; Herbes et al., 2020). Yet such work to understand consumer preferences or knowledge of potting mix in such a similar, comprehensive manner does not exist in the US.

The purpose of this study is to understand consumer preferences by analyzing the relative importance of potting mix characteristics. To accomplish this, we use the Best-Worst Scaling (BWS) approach as part of a survey of Louisiana gardeners. In our sample, we find that gardeners most prefer potting mix specific to a plant or garden type, followed by a general mix with all components pre-mixed, then by price. The rank of potting mix characteristics is the same for several sub-groups such as those who are master gardeners, where they buy their potting mix from, and their views on climate change, with the important exception of those who state they most frequently buy general potting mix without any specific garden/plant designation. The information can help producers and retailers to best formulate products and marketing strategies to respond to consumer preferences. Our findings may also be useful to policymakers as to how they may promote the use of more sustainable materials for potting mix.

Methods

BWS and survey design

To measure the relative importance of potting mix characteristics among consumers, we implement a BWS approach, also known as maximum difference scaling. Developed by Finn and Louviere (1992), BWS presents respondents with a list of three or more items and asks them to select the best (or most important) and the worst (or least important) of the items listed. The items can be product attributes, options of stores, or even opinions. Respondents' attention span is limited, and they usually cannot effectively evaluate more than several items at a time. As a result, when there are too many items to include into a single list, the BWS exercise is usually repeated several times, each only includes a fraction of all the items to consider. Each of these lists is also referred to as a choice set. A statistical experimental design is often used to determine which items appear together in one choice set and how many times each item appears over all choice sets. For each choice set, the respondent provides their most and least preferred item, which identifies the maximum difference in their underlying value between the best and worst item, providing more accurate results of relative preferences than a standard Likert style question.

BWS is advantageous because it eliminates the bias of different interpretations of terms like "very important" or "somewhat agree" in rating scales (Aizaki and Fogarty, 2023). It also forces tradeoffs in that a person cannot select "very important" for all items. As well, BWS has better predictive validity compared to several other rating techniques (Chrzan and Golovashkina, 2006; Mielby et al., 2012). We implement the BWS object case (known as Case 1), which measures preference intensity for a list of objects, meaning a list of attributes, characteristics, traits, or issues to be measured. Hereafter we refer to the items in a list as characteristics.

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Table 1. List of BWS objects and its description shown in the survey

Object: Description
1. **Contains fertilizer:** mix includes a type of plant food or fertilizer
2. **Packaging:** size and material of potting mix packaging
3. **Moisture control:** protects against over and under watering
4. **Organic:** produced without the use of chemicals or artificial components
5. **Contains peat moss:** potting mix uses peat moss as an ingredient
6. **Plant/Garden-specific formulation:** designed for specific garden types (in-ground, raised beds, etc.) or for specific plants (acid-loving, succulents, etc.)
7. **Home delivery:** potting mix can be delivered directly to your home
8. **Locally owned retailer:** a locally owned plant nursery (rather than a big-box store)
9. **Brand:** a specific brand
10. **Price:** the cost of purchasing the potting mix
11. **Pre-mixed:** all ingredients are combined and purchased together

Two other cases of BWS exist. Case 2 is known as profile BWS in which multiple levels exist for each attribute (e.g. the size of the bag of potting mix (attribute) can be small, medium, or large (levels)), with the respondents selecting their most and least preferred of the attribute level of those shown. While more flexible, its validity is questionable if attributes shown increase or decrease consumer values (Soekhai et al., 2021). Case 3 is the multi-profile BWS in which the respondent selects among several profiles of items, each containing its own combination of attributes and levels, also known as Discrete Choice Experiments, are commonly used in consumer preferences for food and horticultural products (Chavez et al., 2020; Hu et al., 2009). While DCEs allow for the calculation of economic value, such as Willingness to Pay, they face several challenges. First, their complexity makes them less intuitive to understand and answer compared to Case 1 and 2 BWS. Further, when calculating Willingness to Pay, DCEs are known to suffer from hypothetical bias, despite methods to ameliorate this issue (Penn and Hu, 2018, 2023). Further, their increased complexity reduces the likelihood of respondent comprehension (Pearce et al., 2021) and/or requires additional instructions to facilitate comprehension, thus increasing survey length and cost of data collection.

We consider eleven potting mix characteristics. Table 1 lists these characteristics and the descriptions of each shown to respondents, which are: *Contains fertilizer*, *Packaging*, *Moisture control*, *Organic*, *Contains peat moss*, *Plant/Garden-specific formulation*, *Home delivery*, *Locally owned retailer*, *Brand*, *Price*, and *Pre-mixed*. These characteristics were selected through several rounds of discussions with potting mix producers, retailers, and consumers. Some of these characteristics were chosen because they are common labels on potting mix bags or have been examined, though in a more piecemeal fashion, in previous research (Campbell et al., 2020; Dahlin et al., 2019; Herbes et al., 2020; Thomas et al., 2021; Thomas, 2019). *Home delivery* and whether the potting mix is purchased from a *Locally owned retailer* are two characteristics which have not been previously examined. The former describes a recently available method for consumers to acquire potting mix (whether as loose, bulk material or bagged) and is included as a characteristic to see how convenience of delivery is preferred to other characteristics. The localness of a retail business has been viewed favorably in other product segments such as food (Printezis et al., 2019; Soley et al., 2019), and it may have a similar appeal among gardeners who prefer to purchase from locally owned stores.

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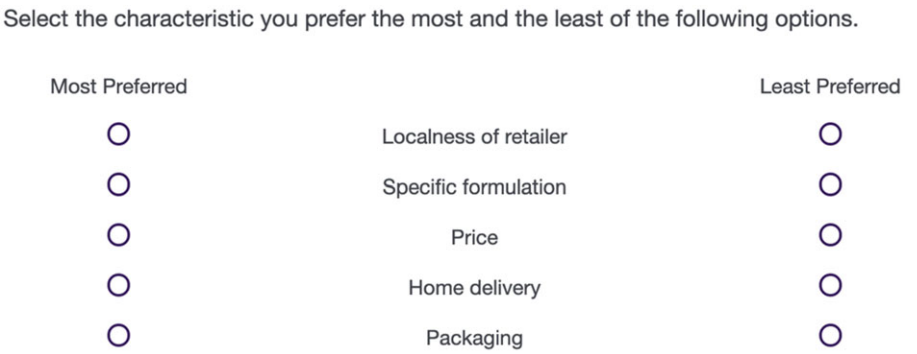

Figure 1. Example BWS choice set.

Several characteristics were considered but ultimately combined into another characteristic to reduce the number of characteristics in the BWS (and therefore the number of choice sets) answered by respondents. Compost is a type of organically sourced fertilizer or plant food, characteristics already included in this study, so compost is excluded, and "no artificial or synthetic components" is in the definition of *Organic*, therefore it is eliminated as well. Formulated for specific plants and types of gardens was consolidated into *Plant/Garden-specific formulation*, which encompasses both characteristics.[2]

The BWS was designed in R using support. BWS (Aizaki and Fogarty, 2023). We employed a Balanced Incomplete Block Design (BIBD), which requires each object to appear the same number of times, and the probability of joint appearance of two objects is equal across all objects, meaning that there is balance and orthogonality between each object (Flynn and Marley, 2014). By construct, the BIBD has a 100% D-efficiency. We verified that our BWS design of eleven characteristics is a BIBD, with each person answering eleven choice sets of five characteristics per choice set. The order of choice sets and order of characteristics within each choice set was randomized.

Each respondent was asked to select the most important and least important potting mix characteristic of the five options within each choice set. At the start of the BWS section, following Caputo and Lusk (2020), respondents received the following instructions: "The following 11 questions are about your preferences regarding potting mix characteristics and availability. Each question is composed of five characteristics that apply to potting mixes available in the US, and we would like to know which characteristic you prefer most and which characteristic you prefer least of the options available in each question." The respondents also saw a short description of each characteristic. An example choice set appears in Figure 1.

The BWS was embedded as part of a larger survey of gardeners within the US, which contained six sections. The design of the survey is based on questions and elements seen in related works (Campbell et al., 2020; Dahlin et al., 2019). The first section contained two screening questions: "do you currently have any plants or garden space you take care of?" and "have you purchased potting mix or soil within the past year?" Only those who answered "Yes" to both questions took the full survey, ensuring that the respondent was part of the target population of gardeners/users of potting mix with some recent knowledge of gardening and potting mix.

Section 2 focused on basic characteristics of the respondent's participation and experience in gardening in terms of the size of their garden, types of plants, and participation in gardening related organizations/clubs. Questions include: "how long have you participated in gardening of any type," "which resources have you used in the past year to learn about gardening," "what size is

[2]Admittedly, a consumer may interpret "Packaging", an attribute included in this study to also mean the weight of the product. However, this does not appear to be a dominant interpretation as none of our survey focus group participants indicated this inclination.

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your garden," "which plant hardiness/grow zone is your garden space located," "what is the 5-digit zip code of your gardening space," and "are you in any gardening related organizations?".

Section 3 focused on respondents' purchases and preferences for potting mix. Questions include the number of bags of potting mix purchased and type of retailer purchased from, preferred brand, bag size, formulation, or desirable potting mix features. These questions allow for an alternative gauge of consumer behavior to compare BWS results against and primes respondents to think about their preferences prior to answering the BWS. Section 4 contained the BWS questions.

Section 5 focused on peat moss and its connection to the environment. Respondents were asked about their familiarity with peat moss and if they had knowingly used potting mixes containing peat moss in the past. They then provided Likert-style responses on the environmental effects of their gardening products and plants, their willingness to switch to alternative products/practices, and their perceived harmfulness of using potting mix ingredients: perlite, peat moss, compost, and vermiculite. The last part of this section directed respondents to a small information treatment about potential issues of using peat moss, the focus of a separate study.

The final, sixth section asked for demographic information and other characteristics of the respondents such as whether they are master gardeners or master naturalists. These characteristics are useful in terms distinguishing how preferences for potting mix may vary across groups of gardeners. For example, master gardeners and master naturalists have more experience and skills in gardening and environmental/natural resource conservation than an average consumer. These two types of respondents may value potting mix characteristics differently from the average public. Definitions of gardening, attitudinal, and demographic characteristics used in the analysis appear in Table 2.

The survey was conducted online using the Qualtrics platform. Recruitment of participants occurred through convenience sampling via recruitment though social media (Facebook, Instagram, Twitter, and LinkedIn) of eleven related organizations and businesses,[3] with several sending out/posting reminders. Each organization's primary audience and members (though not exclusively) are in Louisiana. The formal survey was distributed from August to September 2023 and closed with 671 responses. The survey uses several data quality checks to remove bot responses, duplicate responses from the same individual, and inattentive responses,[4] all issues shown to affect survey data quality results (Gao et al., 2016; Goodrich et al., 2023).

Statistical analysis

To analyze the BWS results, we use the aggregated counting method from Aizaki et al. (2023), which provides a score for each item based on the number of times it was selected the best and worst across all respondents. Each potting mix characteristic (i) is tallied in terms of the number of times it is selected best or worst and the cumulative points allow the characteristics to be ranked. The frequency in which a characteristic is chosen as the best summing across all respondents is shown as B_i, and the frequency in which a characteristic is chosen as the worst summing across all respondents is shown as W_i. Subtracting W from B yields the Best-Worst score (BW_i),[5] the aggregated score for each characteristic from all respondents, as shown in Equation (1).

$$BW_i = B_i - W_i \tag{1}$$

The more positive (negative) BW_i, the more (less) preferred characteristic i is for respondents. Equation (2) shows the standardized score ($std.BW_i$), which divides BW_i by N, the total number of

[3]The eleven entities or groups that shared on social media are: Louisiana State University College of Agriculture and LSU Agricultural Center, Baton Rouge Green, Louisiana Department of Agriculture and Forestry, Clegg's Nursery, Louisiana Nursery, Louisiana Gardeners, Louisiana Native Plant Society, Louisiana Horticultural Professionals Network, Louisiana Plants, South Louisiana Gardening, and Louisiana Master Gardeners.

[4]We included a trap question in our survey and 96% of the sample analyzed in this study answered this question correctly.

[5]Also known as M-L score for "Most" and "Least" preferred.

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Table 2. Variable definitions and descriptive statistics ($n = 499$)*

Variable	Definition	%
Louisiana	1 if Louisiana resident, Else 0 (Outside LA)	86.5
Female	1 if Female, Else 0 (Male or Prefer not to answer)	71.3
Age	18–34	10.6
	35–44	23.1
	45–54	14.7
	55–64	21.8
	65+	29.8
Education	No college degree	6.4
	Some College	24.1
	College degree	34.1
	Graduate degree	35.4
Income	Less than $50,000	19.6
	$50,000 to $99,999	61.4
	$100,000+	19.1
Race	White	85.4
	Black or African American	3.6
	Asian	1.6
	Other	9.4
Master Gardener	1 if a Master Gardener, Else 0	41.6
Experience	3 years or less	9.8
	4–10 years	20.8
	More than 10 years	69.3
Garden Type	Containers/Pots	92.6
	Raised beds	62.9
	In ground	84.4
Retailer	Mass merchandizer/Club store (e.g., Walmart, Sam's)	10.4
	Home improvement store (e.g., Home Depot)	46.1
	Local garden center	41.3
	Online	2.2
Potting Mix Type	All-purpose/general potting mix	44.9
	Plant-specific potting mix	7.1
	Specific for a particular garden bed-type	34.3
	Individual ingredients to make custom mix	13.7
Climate Change	Those who disagree/strongly disagree with: "I don't believe that human-caused climate change is a real thing."	59.7
Peat Moss Use	Have used potting mixes that contain peat moss in the past	81.8
Environmental harm of Peat Moss removal	Somewhat or very harmful	26.9
	Not at all or a little harmful	50.3
	Not sure	22.2

(*Continued*)

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Table 2. (*Continued*)

Variable	Definition	%
Environmental effects of gardening products used	Those who strongly agree or agree with: "I've thought about the environmental effects of gardening products I use (potting soil, plants, fertilizers, etc.)."	74.2

*Based on those who answered the question and did not select "Prefer not to answer"

responses, times r, the number of times that characteristic occurs in the survey. Quantity $std.BW_i$ can range from −1 to 1 across all characteristics, facilitating comparison.

$$std.BW_i = BW_i/(N * r) \tag{2}$$

Let variable X be the indicator for a characteristic. It only equals one if the characteristic appears in a choice set. Let β be the associated coefficients of X. We define Equation (3) as an indicator function for respondent n choosing the j-th characteristic as the best or the most preferred characteristic and the k-th characteristic as the worst or least preferred characteristic plus a random, unobservable component (e), made among all characteristics J shown in the t-th choice set:

$$I_{njt} = X_{njt}\beta_j - X_{nkt}\beta_k + e_{njt} \tag{3}$$

For a potting mix characteristic not included in a choice set ($X = 0$), the characteristic and its associated coefficient will not appear in the indicator functions associated with that choice set; furthermore, indicator I is zero if either j or k are not present. As such, in the following discussion, dropping variable X will not affect the expressions. Equation (3) is maximized when the difference between the two chosen characteristics is the largest among all possible differences. Alternatively, the probability of observing these choices is the probability that the difference between characteristic j and k is greater than all other $J(J\text{-}1)\text{-}1$ possible differences in choice set t (Lusk and Briggeman, 2009).

Assuming that e_{nj} is distributed iid type I largest extreme value, then estimates β of the best and worst characteristic (j and k), relative to an omitted reference characteristic normalized to zero, can be estimated according to the conditional logit model. To allow for random taste heterogeneity across individuals n, we instead rely on a mixed logit model, as in Equation (4).

$$P_n(best = j, worst = k) = \int_{\beta} \frac{\exp(\beta_{nj} - \beta_{nk})}{\sum_{l,m=1 \text{ and } l \neq m}^{J} \exp(\beta_{nl} - \beta_{nm})} f(\beta_n) d\beta_n \tag{4}$$

We conduct a simulated maximum likelihood estimation based on 1000 Halton draws, assuming that preference variation follows a normal distribution for all characteristics. Relying on this approach also allows for the calculation of the share of preferences, which measures the relative importance of characteristic i (Lusk and Briggeman, 2009), as in Equation (5).

$$SP_i = \frac{\exp(\hat{\beta}_i)}{\sum_{j=1}^{11} \exp(\hat{\beta}_j)} \tag{5}$$

The share of preferences across all eleven attributes must sum to one. Comparing the ratio of SP across attributes portrays relative importance. For example, if $SP_i = 0.2$ and $SP_j = 0.1$, then attribute i is twice as important as attribute j (0.2/0.1 = 2.0). All estimation was completed in R 4.3.1 and using the "Support.BWS" package (Aizaki and Fogarty, 2023).

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Results

Of the 671 people who initially opened the survey, 153 were removed as incomplete, duplicate, fraudulent, or inattentive along with 19 unqualified to take the survey (those who had not purchased potting mix), yielding 499 responses used in the analysis. Table 2 provides descriptive statistics of the analyzed sample.

As expected, the vast majority (86.5%) are Louisiana residents. A large majority are females (71.3%) and white (85.4%). Over 51% are at least 55 years old, almost 69% have a 4-year college degree or more, and over 60% of the respondents have household income in the $50,000 to $99,999 range. As well, 42% are master gardeners and almost 70% have more than ten years of gardening experience. There is high participation in all three types of gardening (container, raised bed, and in-ground). With respect to the type of store they purchase their potting mix from most often, 46% purchase from home improvement stores, followed by local garden centers (41%), with the remainder buying from mass merchandisers, warehouse clubs, or online. These outcomes are dissimilar to national patterns among gardeners who are more balanced in terms of gender, less likely to be college graduates, and less wealthy (Bumgarner et al., 2024; Cohen and Baldwin, 2018).

While we are unaware of any previous surveys specific to Louisiana (using either representative or convenience samples) to compare against, an inspection of the sub-sample of the 203 master gardeners in our sample shows they largely female (73%), age 55 or older (75%), white (88%), and have received a bachelor's degree or more (76%). Encouragingly,, this matches trends of other master gardener surveys (Takle et al., 2017). Furthermore, Das and Ramaswami (2022) found that at-home gardeners tend to be wealthier, more educated, and white.

Nevertheless, self-selection in our sample seems likely. Specifically, only a few thousand people have become master gardeners in all of Louisiana over its 30-year history, but they represent a high percentage of our sampled respondents. Compared to national gardener surveys (Axiom, 2023; Statista, 2022), our sample is older, has more female and more gardening experience, and is more likely to purchase from local garden centers/nurseries.[6] This demonstrates an important caveat of the results and conclusions reached shown below; limiting implications of convenience sample to the broader population of Louisiana gardeners. However, although we caution against making inference to the general population of gardeners, we believe there is useful information to be learned, especially by exploring different consumer segments in the population. We accomplish this by conducting a series of sub-sample analyses to provide some indication of how preferences/rankings of attributes may change if a representative sample exists featuring more or less of the various types of consumer demographics investigated in our study.

BWS results

The aggregated results of the BWS appear in Table 3. It shows the ranking of how often the characteristics were ranked best, worst, and the overall ranking based on the BW and standardized BW score.

Collectively, the three most important characteristics are potting mix for a *Plant/Garden specific formulation*, followed by *Pre-mix*ed, then *Price*. This matches broader industry predictions of strong growth in both pre-mixed all-purpose potting mix and specialized plant-specific potting mix (Fortune Business Insights, 2023). While the high importance of price may distress local nurseries who do not have the economies of scale and so less competitive on price compared to national home improvement chains, they may still find some relief since purchasing from a locally owned nursery is the fourth most important characteristic in the sample.

[6]Axiom finds that, nationally, 59.1% of gardeners are 41+ years old, 38.8% have 10+ years of gardening experience, and 52.3% are female, whereas Statista finds that 62% of gardener purchase their lawn and garden supplies from home improvement stores, and 11% purchase from local garden centers/nurseries.

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Table 3. Result of B/W/BW rankings ($n = 499$)

	Best	Worst	BW	StdBW
Plant/Garden-specific formulation	938	194	744	0.298
Pre-mixed	765	147	618	0.248
Price	713	188	525	0.210
Locally owned retailer	642	265	377	0.151
Moisture control	590	350	240	0.096
Organic	607	388	219	0.088
Contains fertilizer	427	311	116	0.046
Contains peat moss	304	430	−126	−0.051
Brand	347	676	−329	−0.132
Packaging	89	1008	−919	−0.368
Home delivery	67	1532	−1465	−0.587

Listed in order of importance, the more positive, the more important, the more negative, the less important.

The middle three characteristics are *Moisture control*, *Organic*, and *Contains fertilizer*. Each of these relate to the particular features of the potting mix. The three least important characteristics of potting mix are its *Brand*, *Packaging*, and *Home delivery*. Collectively, this suggests that, on average, manufacturers and retailers should maintain strong depth (the number of product variants) within their potting mix product line and retailers should carry a diverse assortment to meet consumer needs. It may be easier for businesses to still obtain attractive pricing by buying in volume from the manufacturer/dealer of a single brand, which is relatively less of a factor of consideration for consumers, and not to prioritize packaging type or the availability of home delivery. Importantly though, our study shows the relative importance of the 11 characteristics considered, and it does not mean such characteristics are unimportant in absolute terms, with each demonstrating significance in past studies (Behe et al., 2016; Campbell et al., 2020; Silwal et al., 2023).

Potting mix that *Contains peat moss* has a BW score less than 0 indicates it is generally seen as unimportant and is the fourth least important characteristic. Companies considering a substitute substrate may find this reassuring in terms of creating less adverse reaction from consumers.

Conversely, *Moisture control* has a positive BW score and the fifth most important characteristic. While seemingly contradictory to the low importance of peat moss, which has strong moisture control properties, there are several potential explanations. First, consumers could care about moisture control but do not know that peat moss is the conventional ingredient used to provide this feature. Second, consumers may be willing to consider other types of substrates that can accomplish the same goal of moisture control. Third, providing moisture control means protecting against overwater or underwatering. Peat moss's ability to prevent underwatering may be of little value because the vast majority of respondents reside in Louisiana, which typically has annual precipitation over 60 inches. This means their selection of moisture control may instead be more focused on preventing overwatering, which is based on perlite.

Figure 2 shows the distribution of BW score per characteristic. It shows the number of times each characteristic was selected either as the best or worst characteristic. +5 (−5) indicates the number of people who selected a characteristic as the most (least) important in all five choice sets that it appeared. 0 indicates the number of people who selected it as neither the most nor least important characteristic in all four choice sets. Overall, it shows there is considerable heterogeneity for the most preferred characteristic. The dispersion of specific characteristics though still matches the overall ranking in Table 3; *Garden/Plant-specific formulation* and

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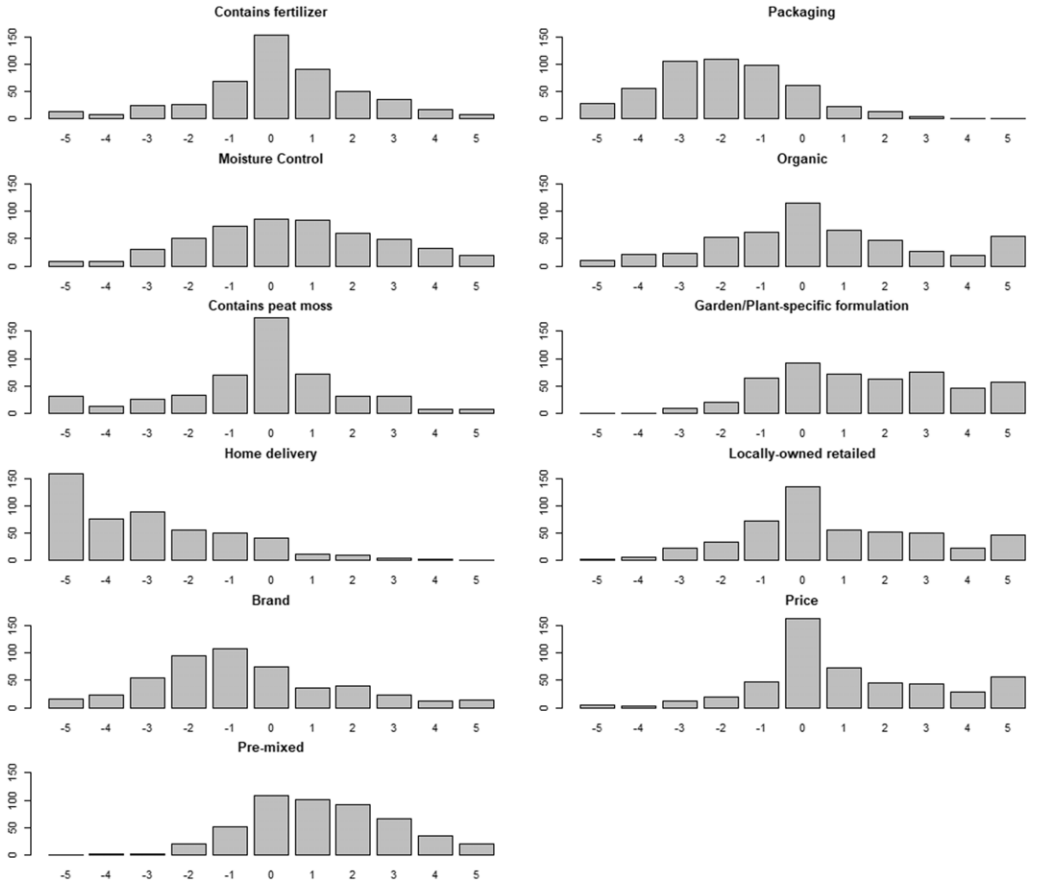

Figure 2. Distributions of simple BW scores by potting mix characteristics.

Pre-mixed are selected by most respondents as either neutral or preferred. *Price* is neutral for many respondents. Conversely, most respondents consistently selected *Packaging* and *Home delivery* as the least important in all five choice sets.

Table 4 shows the mixed logit model results to investigate whether preferences are significantly different across characteristics. These coefficients are relative to the *Price* characteristic, which is normalized to 0. These results reinforce outcomes of Table 3: every characteristic is significantly different from 0, meaning that relative importance of every characteristic is significantly different from Price, whether more (positive coefficient) or less (negative coefficient) important. We can use post-estimation Wald tests as well to test for differences between characteristics. Again, nearly all significantly different from each other except that *Moisture Control* is equivalent to *Organic* (p-value = 0.420). Also, the significance of each standard deviation demonstrates there is considerable heterogeneity across participants in how they chose the more and least important characteristics as would be expected.

Table 5 provides the relative importance across characteristics according to the share of preferences in Equation (5). Table 5 can be interpreted comparing the relative importance of the row element versus a corresponding column element. Numbers close to one indicate relative equivalence. For example, the last number on the first row 31.87 indicates that the *Plant/Garden-specific formulation* characteristic (the most important characteristic) is almost thirty-two times more important than *Home delivery* (the least important characteristic).

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Table 4. Mixed logit model results[1]

	Coef.	(Std. Err)	Std. Dev.	(Std. Err)
Plant/Garden-specific formulation	0.283***	(0.054)	1.286***	(0.057)
Pre-mixed	0.122**	(0.053)	0.728***	(0.053)
Locally owned retailer	−0.137**	(0.058)	1.501***	(0.060)
Moisture control	−0.516***	(0.060)	1.722***	(0.058)
Organic	−0.567***	(0.058)	1.415***	(0.056)
Contains fertilizer	−0.761***	(0.060)	1.259***	(0.056)
Contains peat moss	−1.157***	(0.058)	1.062***	(0.051)
Brand	−1.416***	(0.056)	1.477***	(0.053)
Packaging	−2.292***	(0.061)	0.985***	(0.058)
Home delivery	−3.178***	(0.069)	1.565***	(0.062)
LL-Model	−12156.7			
AIC	24353.3			

[1]All coefficients are relative to the "Price" characteristic. Post-estimation Wald tests of equality of characteristic coefficients show the preference between characteristics is significantly different (p-value <0.01) except for moisture control vs organic (p-value = 0.420).
Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Preferences across characteristics

Lastly, we explore whether preferences for potting mix characteristics change with consumer characteristics. This is accomplished by examining the standardized BW score and rankings of characteristics across several individual-specific characteristics. Numerous characteristics were considered but many generated the same rank of potting mix characteristics, though still with different magnitudes. Among gardening characteristics, this includes those who are Master Gardeners, who buy potting mix from home improvement stores, those who believe in human-caused climate change, those with 10 or more years of gardening experience, and those who knowingly use peat moss in their potting mix (Table A1). For demographic characteristics, females and those with graduate degrees have consistent characteristic ranks as the overall outcome (Table A2). Individual characteristics that exhibited a different rank than the overall outcome appear in Table 6 for gardening characteristics and Table 7 for demographic characteristics. Reflected by Table 6, those who primarily buy an all-purpose/general potting mix, who did not knowingly use peat moss, and the three groups of perceived harm of extracting peat moss (Not at all/A little harmful, Somewhat/Very harmful, and Unsure) all had different rankings. Importantly, those who said Not at all/A little harmful ranked *Pre-mix* first and *Organic* eighth, but fifth and third, respectively, among the Somewhat/Very harmful and Unsure respondents. *Plant/Garden-Specific* fell from first (overall) to fourth among general mix purchasers. For consumers who have not thought much about the environmental effects of gardening products they had purchased (the last column of Table 6), their ranking of potting mix containing fertilizer increased from seventh to fourth. All other changes in rank were by one or two levels.

In Table 7, among the changes in rankings for demographic variables, these changes are small for those 45–64 years old, 65 years or older, males, and those with either no/some college experience and those with a 4-year degree, both because few attributes switch and only changing one or two levels. Only those between age 18 and 44 exhibit considerable ranking changes, with six changes in rank, with *Price* as the most important the convenience of *Pre-mix* declining to fourth. Overall, these results show preferences for potting mix characteristics may or may not change

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Table 5. Relative importance across characteristics based on mixed logit results in Table 4

	Plant/Garden-specific formulation	Pre-mixed	Price	Locally owned retailer	Organic	Moisture control	Contains fertilizer	Contains peat moss	Brand	Packaging	Home delivery
Plant/Garden-specific formulation	1.00	1.18	1.33	1.52	2.22	2.34	2.84	4.22	5.47	13.13	31.87
Pre-mixed		1.00	1.13	1.30	1.89	1.99	2.42	3.59	4.66	11.17	27.12
Price			1.00	1.15	1.68	1.76	2.14	3.18	4.12	9.89	24.01
Locally owned retailer				1.00	1.46	1.54	1.87	2.77	3.59	8.62	20.93
Organic					1.00	1.05	1.28	1.90	2.46	5.90	14.33
Moisture control						1.00	1.21	1.80	2.34	5.61	13.61
Contains fertilizer							1.00	1.49	1.93	4.62	11.22
Contains peat moss								1.00	1.30	3.11	7.55
Brand									1.00	2.40	5.83
Packaging										1.00	2.43
Home delivery											1.00

Values close to 1 (as seen in several cells) show near equivalence in importance. Increasing values show increase difference in relative importance. For example, 1.99 for Pre-mix versus organic shows that the former is twice as important as the latter, calculated by Equation (5).

Table 6. Standardized best-worst scores (StdBW) by gardening characteristics

	Overall		General Mix		Peat Moss: Not Used		Peat Moss: Not at all/A little harmful		Peat Moss: Somewhat/Very harmful		Peat Moss: Unsure of harm		Enviro effects garden products: Neither/Disag./Strongly Disag.	
	N = 499		N = 222		N = 91		N = 251		N = 134		N = 111		N = 128	
	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank
Plant/Garden-Specific	0.298	1	0.146	***4***	0.268	***2***	0.272	***2***	0.337	1	0.306	1	0.322	1
Pre-mix	0.248	2	0.314	***1***	0.237	***3***	0.280	***1***	0.185	***5***	0.115	***5***	0.281	2
Price	0.210	3	0.294	***2***	0.338	***1***	0.167	3	0.216	***4***	0.133	***4***	0.195	3
Local	0.151	4	0.151	***3***	0.158	4	0.092	***5***	0.290	***2***	0.301	***2***	0.094	***6***
Moisture Control	0.096	5	0.023	***7***	0.108	5	0.138	***4***	0.004	***6***	0.101	***6***	0.111	***5***
Organic	0.088	6	0.086	***6***	0.103	6	0.017	***8***	0.260	***3***	0.252	***3***	−0.066	***8***
Contains Fertilizer	0.046	7	0.116	***5***	0.088	7	0.076	7	−0.087	7	0.049	7	0.156	***4***
Contains Peat Moss	−0.051	8	−0.076	***9***	−0.185	***9***	0.084	***6***	−0.288	***9***	−0.169	***9***	0.031	***7***
Brand	−0.132	9	−0.069	***8***	−0.127	***8***	−0.127	9	−0.109	***8***	−0.067	***8***	−0.102	9
Packaging	−0.368	10	−0.352	10	−0.338	10	−0.362	10	−0.333	10	−0.422	10	−0.372	10
Delivery	−0.587	11	−0.631	11	−0.651	11	−0.638	11	−0.476	11	−0.6	11	−0.652	11

Bold numbers denote the ranking of the attribute differs from the Overall outcome.
Peat Moss Use: Do you know if you have used potting mixes that contain peat moss in the past?
Peat Moss Harm: Based on your knowledge, how *harmful* are the following potting soil/mix ingredients to the *environment*?
Enviro Effect: I've thought about the environmental effects of gardening products I use (potting soil, plants, fertilizers, etc.)

Table 7. Standardized best-worst scores (StdBW) by demographic characteristics

	Overall		Age: 18-44		Age: 45-64		Age: 65+		Gender: Male		Edu: No/Some College		Edu: 4-year degree	
	N = 499		N = 135		N = 171		N = 184		N = 117		N = 143		N = 164	
	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank	StdBW	Rank
Plant/Garden-Specific	0.298	1	0.281	***2***	0.311	1	0.303	1	0.289	1	0.280	1	0.289	1
Pre-mix	0.248	2	0.209	***4***	0.257	2	0.282	2	0.246	2	0.250	2	0.244	***3***
Price	0.210	3	0.307	***1***	0.216	3	0.137	3	0.200	3	0.162	3	0.259	***2***
Local	0.151	4	0.258	***3***	0.105	***5***	0.117	4	0.137	4	0.140	***5***	0.134	4
Moisture Control	0.096	5	0.116	5	0.094	***6***	0.078	***6***	0.111	5	0.095	***6***	0.113	5
Organic	0.088	6	0.050	***7***	0.135	***4***	0.080	***5***	0.065	6	0.145	***4***	0.073	6
Contains Fertilizer	0.046	7	0.052	***6***	0.039	7	0.053	7	−0.010	***8***	0.069	7	0.041	7
Contains Peat Moss	−0.051	8	−0.132	8	−0.069	8	0.018	8	0.012	***7***	−0.070	8	−0.011	8
Brand	−0.132	9	−0.219	9	−0.143	9	−0.071	9	−0.096	9	−0.143	9	−0.152	9
Packaging	−0.368	10	−0.396	10	−0.368	10	−0.345	10	−0.344	10	−0.336	10	−0.354	10
Delivery	−0.587	11	−0.526	11	−0.577	11	−0.654	11	−0.610	11	−0.593	11	−0.637	11

Bold numbers denote the ranking of the attribute differs from the overall outcome.

substantially across sub-samples. So, even though the sample may not be representative of gardeners more broadly, the results could hold for the broader population since numerous individual characteristics generated the same rank. Even if the population is different, ranking may only change slightly, as occurred for educational attainment.

Conclusion/Discussion

The potting mix industry must adapt to changing conditions in its supply of materials as well as consumer taste. This study examines preferences of gardening consumers, concentrated primarily in Louisiana, for eleven potting mix characteristics. Collectively, our sample of gardeners ranks price as the third most important, with plant/garden specific potting mix and pre-mixed ingredients as more important. Others have found price to be the most important aspect of choice in gardening (Dahlin et al., 2019; Mason et al., 2008). We believe our sample explains this difference, with a disproportionately high percentage of master gardeners and graduate-educated participants. Characteristics of middle importance to consumer concentrate in the functions and ingredients of the potting mix, specifically whether it provides moisture control (ranked fifth), features organic ingredients, or contains fertilizer.

Interestingly, peat moss, the environmentally controversial item in many types of potting mix, is ranked eighth. This has several implications and explanations: consumers may not understand that peat moss is one of the means of providing moisture control. This also means that gardeners may be open to product reformulation without peat moss to address environmental concerns so long as the product still provides moisture control. Characteristics not directly related to the quality and functionality of potting mix, such as packaging and home delivery are ranked the lowest in their importance by consumers. Like Dahlin et al. (2019), brand name is also relatively unimportant.

The relative ranking of characteristics is consistent across several, but not all, consumer segments. Master gardeners, those who buy from home improvement stores, believers in human-caused climate change, and experienced gardeners all rank characteristics similarly to the overall sample. However, those who purchase all-purpose/general potting mix have significantly different preferences, placing less importance on moisture control and containing peat moss. This difference may be important on the actual potting mix market depending on the proportion of gardeners in this segment. Arizton (2022) provides some perspectives by estimating that the all-purpose potting mix accounted for 33.8% of global revenue, with expected continued growth in the 2020s.

Our results have several implications. For producers and retailers, while price is important, consumers seem to care more about the quality and usability of their potting mix than peripheral characteristics such as packaging and delivery method. In addition, while not all consumer characteristics play a role, some factors do affect consumer preferences. This information can guide producers and retailers on their product development and marketing. For example, continued development of mixes that match the expected growth in indoor edible gardening (Fortune Business Insights, 2023). Further, if the trend of increased awareness and concern for environment continues, then producers should reorient to match the markedly different rankings of those who are concerned about the environmental effects of peat moss extraction. It also means extension and education programming could change preferences, with many gardeners lacking knowledge (Bumgarner et al., 2024). Similarly, while there is growth in organic gardening materials, more opportunity may may exist with the substantial increase in preference for organic among those who have thought about environmental effects of peat moss and in gardening.

Our research has several limitations and opportunities for future research. First and most importantly, our sample is not representative, as evidenced by the summary statistics of the demographic outcomes, so no inference to the general population is made. Conversely, by

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examining numerous sub-populations and observing consistency in ranking of characteristics across many groups, we see that preferences may be similar even if a representative sample were collected. Nevertheless, future studies should rely on more representative samples such as through probability sampling to enhance external validity and population inference. Studies often desire to understand the precise economic value of each characteristic (i.e., Willingness to Pay), which this study did not elicit. Future studies could extend our framework to understand the potting mix industry in other geographic regions, where there are different challenges to gardening and consumer opinion may vary. Lastly, using observed consumer choices of potting mix purchases would be helpful to corroborate our findings. Even if revealed preference or non-hypothetical choices are infeasible, moving future surveys to an actual retail setting or approximating in virtual reality will likely improve ecological validity, generalizability to real-world outcomes (Fang et al., 2021; Shamay-Tsoory and Mendelsohn, 2019), by allowing the participant to make choices in a context that more closely matches real shopping settings (Bangcuyo et al., 2015), increasing external validity. Employing a DCE (in other words, BWS Case 3) that allows for more nuance in terms of consumer preferences may also provide additional insights. For example, while packaging was among the least important characteristic in our sample, a related aspect is the weight of the bag of potting mix, yet there is a noticeable gap in research regarding consumer preferences for the weight of potting mix bags, highlighting the need for more studies to better understand how weight influences purchasing decisions.

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