

Cannabis Cultivator Phenotype and Attribute Preferences in Legal Recreational and Medical Cannabis Cultivation Operations in Oregon and Colorado

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Research Article

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Abstract

Background

As recreational and medicinal *Cannabis sativa* production increases across the United States, concerns have arisen regarding declines in cannabis biodiversity. Studies have suggested genetic bottlenecks have occurred primarily because of breeder and cultivator preferences and practices which over-emphasize the selection of strains with high contents of the psychoactive cannabinoid, Δ -9-tetrahydrocannabinol (THC). No study to-date, however, has sought to systematically assess grower and breeder knowledge, preferences, and practices within legal operations within the United States.

Methods

Twenty-one licensed recreational and medical cannabis growers in the states of Colorado and Oregon were provided with free lists to ascertain cultural domains of knowledge regarding cannabis phenotypes and attributes within commercial cannabis production operations. Semi-structured interviews were also conducted with participants to provide more nuanced explanations of free-list responses, and to clarify responses where necessary. Free-list results were initially ungrouped excepting those variables whose meanings had been triangulated utilizing interview data. Free list data was assessed utilizing Smith's S formula to ascertain cultural salience for listed attributes and phenotypes. A second analysis was then conducted for grouped terpene-related data.

Results

Results from the ungrouped free list identified *Yield* as the most culturally salient category (.29) followed by *High THC Content* (.26) and *Smell* (.25). Overall, horticultural characteristics such as yield, plant structure, and morphology garnered were the most frequently listed, followed by chemometrics, economics, and phenology, with some overlap between these categorizations. Though THC content was described as important within commercial operations by most growers both within free-list responses and interviews, growers also expressed that this preference was due to state testing regulations and a misinformed consumer base, rather than grower partialities. Respondents also noted that they believed consumer preferences were changing as consumer demographics were beginning to trend towards "older" consumers. When terpene-related attributes within free-listed results were combined utilizing triangulation from semi-structured interviews to verify the free list data, terpenes became the most cultural-salient attribute listed by growers (.42).

Conclusions

The results from this study suggest that cannabis biodiversity may indeed be declining due to breeder practices that emphasize THC content, but that these practices are informed by state policies and consumer purchasing metrics rather than grower preferences.

Introduction

Over the course of the last decade, an increasing number of states have ratified legislation legalizing the production, sales, and consumption of *Cannabis sativa*, creating one of the most lucrative agricultural industries within the United States. Amidst this rise in cannabis production and consumption, scholars from a wide range of disciplines have commenced in conducting research which offers a more comprehensive understanding of the circumstances and implications of these emerging cannabis markets. While research from the social sciences has indeed made inroads into the socio-cultural and political contexts and consequences of state-level cannabis legalization, most of this research has continued to focus almost exclusively on the criminology of cannabis-related activities (DeVylder et al., 2021; Polson, 2015; Sandberg, 2008;), as well as cannabis consumption cultures (Holm et al., 2014; Parnes et al., 2018; Pawson & Kelly, 2014).

Studies outside of the social sciences have highlighted however, that cannabis biodiversity has been steadily declining over the course of the last few decades, with some researchers suggesting that these deteriorations are due to cannabis grower and breeder practices (Clarke & Merlin, 2013; Clarke & Merlin, 2016; Mudge et al., 2018). As an increasingly large body of literature has identified the potential medicinal benefits of a wide range of cannabinoids and terpenes found in the cannabis plant, the implications of those losses in terms of both agrobiodiversity (ABD) and pharmacology (Bridgeman & Abazia, 2017; Costa, 2007) indicate an increasing need for research which positions cannabis production within an agricultural, rather than solely economic or legal, framework.

The Ethnobiology of Agricultural Biodiversity

While certain practices and management decisions amongst farmers are necessarily ubiquitous (i.e., irrigation, weed and pest management, and nutrient management) farmer knowledge and how this knowledge is applied within agricultural practice varies amongst agricultural practitioners and can have divergent outcomes in terms of agrobiodiversity (ABD) for the broader landscape within which they are implemented (FAO, 2006; Nautiyal et al., 2008; Nazarea, 1998). A subset of overall biodiversity, ABD is defined by the Convention on Biological Diversity, (2011) as “the outcome of the interactions among genetic resources, the environment, and the management systems and practices used by farmers” and is the foundation on which the crops that sustain human life are produced. Because of the wide breadth of factors that influence ABD, pursuit of its preservation requires interdisciplinary approaches which include ethnobiological studies on how groups of people “interpret, conceptualize, represent, cope with, utilize, and generally manage their knowledge of those domains of environmental experience which encompass living organisms” (Ellen, 2006).

Clarke and Merlin (2013, 2016) offer the most comprehensive ethnobotanical assessment of desirable traits for cannabis cultivators in both traditional societies and within more recent decades. According to their research, the authors suggest without human intervention most cannabis populations contain approximately equal amounts of the psychoactive compound Δ^9 -tetrahydrocannabinol (THC) [1] and

Cannabidiol (CBD), but that selection and breeding practices throughout the history of the human-cannabis relationship has resulted in the preponderance of strains that include high THC and low CBD (Type I), or low CBD and high THC (Type III). Without testing technology, pre-modern cannabis farmers relied upon the effects of cannabis when consumed as well as traits such as color, smell, trichome development, and resin content (stickiness) when selecting strains to breed and cultivate, as they believed these attributes indicated high contents of psychoactive cannabinoids (i.e., High THC) which would intensify or increase the plants potential effects when consumed.

Alternatively, the authors note that while modern farmers continue to use similar traits to their cannabis cultivating and breeding forebearers such as large trichomes and “desirable” aromatic terpenes, the advent of cannabinoid quantification methods such as gas chromatography and high-performance liquid chromatography have resulted in an uptick in growers cultivating strains with reproducible profiles of target cannabinoids and an overall high total cannabinoid content (Clarke & Merlin, 2016; Lazarjani et al., 2020). Though modern testing methods permit growers to assess non-THC and non-CBD cannabinoid contents [Cannabinol (CBN), Cannabigerol (CBG), Cannabichromene (CBC)] within cannabis which have also been found to have medicinal properties (Appendino et al., 2008; DeLong et al., 2010; Weydt et al., 2005), Clarke & Merlin (2016) propose that the pursuit of “high cannabinoid content” continues to predominantly refer to High THC and High CBD contents which are obtained by growers through a mixture of the “heritability of cannabinoid profiles, hybrid vigor between genetically distinct gene pools and the highly focused, human artificial selection for potency (p. 302).”

The proposed hypothesis that THC content has increased in cannabis over the years at least in part because of breeder practices was substantiated in a 2018 study by Mudge et al. (2018) which found that cannabis biodiversity within Canada has been decreasing over the past few decades due to breeder and grower practices that emphasize(d) increasing the average content of THC. Mudge and colleagues specify that biodiversity declines are most pronounced amongst strains rich in the non-psychoactive cannabinoid CBD, even amidst the increasing popularity of CBD products within mainstream markets (Lamers, 2019). Research conducted in the United States on cannabis seized from illegal ‘grows’ suggests similar trends of cannabis growers cultivating for increasing THC content, with average THC content rising from ~4% in 1995 to ~12% in 2014 (EISohly et al., 2016; Mehmedic et al., 2010).

Despite these illuminating findings, the fact remains that most studies on cannabis biodiversity and breeding practices have relied upon chemometric and metabolomic analyses of the cannabis plant itself rather than on data procured from cannabis breeders and growers as to their actual preferences and practices in relation to cannabis production. For example, while Mudge et al. (2019) explore the desirability of varying scent profiles (i.e., terpene contents) by growers in cannabis breeding and cultivation, and suggest that growers utilize scent profiles as “benchmarks” for determining which strains of cannabis contains high concentrations of cannabinoids, they also note that the assumed association growers make between terpene and cannabinoid content is “anecdotal” in nature, rather than based on scientific inquiry (p. 787).

As state-legal cannabis production continues to expand within the United States, shifting legal, economic, and technological frameworks dictate the need for contemporary ethnobiological studies on cannabis cultivator preferences, practices, and knowledge in relation cannabis production. Utilizing a qualitative approach, this study seeks to begin the process of ameliorating the dearth of research available on cannabis producers by investigating the knowledge and preferences of cannabis cultivators in commercial recreational and medical cannabis operations in the states of Colorado and Oregon. In identifying the culturally informed values, beliefs, and knowledge which influence cannabis production, this study contributes to the emerging areas of scholarship concerned with the impacts of the integration of cannabis production into the broader environmental and social landscapes within which it is occurring.

[1] Δ^9 -tetrahydrocannabinolic acid (THCA) is the naturally occurring cannabinoid within the cannabis plants which acts as the precursor for the psychoactive Δ^9 -tetrahydrocannabinolic (THC). While most state regulations dictate that total THC content reported on packaging must be calculated using the following formula: $\text{THC}_{\text{total}} = (\% \text{THCA}) \times 0.877 + (\% \text{THC})$ [OAR 845-026-0100 (15)] THC, rather than THCA or THC total, is the colloquial term utilized by cannabis growers and will be utilized here.

Methods

To ascertain cannabis cultivator knowledge and preferences in commercial operations, this study utilized a qualitative approach consisting of semi-structured interviews (N=21), and a phenotype free-listing exercise (N=21) with state-legal cannabis growers in the states of Colorado and Oregon. Research participants were recruited utilizing cannabis-focused pages on social media platforms including Instagram, CannaBuzz, and Facebook, as well as snowball sampling.

Sample

Of the interview/free list participants included in this study (N=21), fourteen (67%) worked for licensed cannabis facilities in Oregon, and 7 (33%) were licensed to cultivate cannabis in Colorado. Of the respondents 6 (29%) reported working for facilities licensed for recreational cannabis production, 5 (24%) reported working for exclusively medical facilities, 5 (24%) reported working for mixed recreational and medical facilities, and 1 (5%) reported a mixed hemp and recreational cannabis facility. Participants predominantly identified as white, between the ages of twenty six and forty four, and were approximately equally split in terms of gender-identity (Figure 1).

Figure 1: Interview Participant Demographics (N=21)

	Frequency	Percent (%)
Gender-Identity		
Male	10	47
Female	11	53
Race		
White	14	67
Latino/Latina/Latinx	1	5
American Indian or Alaskan Native ^[1]	2	10
Black or African American	1	5
East Asian/Asian	1	5
Other (Jewish)	1	5
Other (Armenian)	1	5
Age		
21-25	3	14
26-34	8	38
35-44	7	33
45-54	2	10
54+	1	5

Though respondents were requested to be currently working for a legally licensed recreational and/or medical cannabis production facility in either Colorado or Oregon, upon starting their interviews, 4 participants located in Oregon reported that they were not currently employed by a licensed company. All 4 respondents, however, were personally licensed to grow cannabis in their state and had worked for commercial, non-hemp, cannabis facilities in the past. These respondents were asked to answer interview questions using their most recent legally licensed non-hemp employer or operation as a basis for their responses and are listed under “not currently licensed” in Figure 2.

Figure 2: Grow Types, Locations, and Licensing

	Frequency (N=21)	Percent
Location		
Oregon	14	67%
Colorado	7	33%
License Type		
Recreational	7	33%
Medical	5	24%
Recreational and Medical	5	24%
Not currently working at a rec/med licensed facility	4	19%
Grow Type		
Indoor Only	6	29%
Outdoor Only	5	24%
Indoor and Outdoor	9	43%

Key Informants

Utilizing Faifua's (2014) parameters of status and wide-ranging communications, one respondent [#18] was identified as a key informant for this study. At the time of their interview, this respondent had a following of over 10k on the social media platform Instagram and was also identified by other growers as a well-respected and knowledgeable breeder and grower. For example, one participant who had no personal connection to the key informant referred to them by name within their own interview as someone who *"is not just out there growing the strains that yield the fastest or the thing that's going to just make the biggest buck. [They're] going to take the time to make good medicine and good genetics,"* indicating that this participant is well known within Pacific Northwest cannabis cultivation culture.

Free Listing and Semi-Structured Interviews

For centuries, ethnobiological and ethnobotanical scholars have collected and reported on Indigenous people's knowledge of plants and their medicinal benefits, often with the purpose of exploiting this knowledge for pharmacological purposes (Ford *in* Anderson et al, 2011; Hunn, 2007). In recent years, the scope of ethnobiological study has expanded to include Western cultures and systems of knowledge in relation to plants, and methods for conducting ethnobiological studies have been standardized in such a way as to generate scientifically rigorous results (Borgatti, 1998; Heinrich et al., 2009; Quave et al., 2012; Weller & Romney, 1988). Free listing is one such method which has gained ascendancy amongst ethnobotanical scholars, as it offers a quick and relatively easy method for determining participants'

cultural knowledge of the significance of plants or their attributes within a cultural domain (M. Quinlan, 2005; Zambrana et al., 2018). Within the free listing process, participants are asked to record or list all entities or attributes that they can think of within the domain that is of interest to the researcher. The data produced by participants is then analyzed to assess the frequency with which listed variables are included, as well as the positioning of the variable within lists with the expectation that those items that are listed first and more frequently are more culturally salient than those that are listed less frequently or later in the list (Borgatti, 1998; Miranda et al., 2007).

Free lists differ from open-ended surveys as they require participants to recall information about a cultural domain, rather than about their subjective feelings or experiences. Within this study, participants were asked about their preferences in cannabis cultivation which according to Quinlan (2019), could potentially fall within the domain of open-ended surveying rather than true free listing. The parameter of selecting preferences within *commercial operations* specifically, however, engaged participants to think outside of their personal preferences to what is desirable for market-bound cannabis products.

Interview participants (N=21) were provided with Phenotype Free-Listing Forms at the time of their interviews and were asked to record preferred phenotypic attributes for cannabis plants included in their commercial grow operations. Free-listing data was collected prior to interviews to avoid the possibility of the contamination of data by the researcher during the interviews, which occurs when researchers inadvertently lead interviewees in their responses by priming participants with suggestions or mentions of possible responses (Quinlan 2019). Interviewees whose interviews were conducted either over the phone or via Zoom were asked to verbally list desired cannabis phenotypes and/or attributes which were then recorded by the interviewer. Interviewees whose interviews were conducted in-person were provided with the forms directly, which they then filled out by hand. Participants were provided with no other instructions than to “list the cannabis attributes or phenotypes that are most important or desirable to you when selecting which strains to include in your commercial operations”. Though there was the potential for data contamination by providing examples of phenotypes or attributes, after conducting the first few interviews, the examples of Color, Smell, THC Content, and CBD content were provided in the instructions as examples based on the responses provided by the first few participants. The inclusion of these examples was required as participants were often unsure what was being asked of them when they were requested to list “phenotypes or attributes” of cannabis plants.

The distinction between the nature of the free-listing exercise and an open-ended survey was substantiated by participants involved in the exercise as many interviewees following the distribution of the free-list instructions asked for clarification as to whether the variables being listed should fall under their own personal preferences for cannabis or those that they looked for in the course of their job. Though personal preferences were not included here, respondents would often specify that if they owned the grow or the cannabis being produced was for personal use, they would select different phenotypes or attributes.

Free List Analysis

Thompson and Juan (2006) working from Borgatti (1998), note that the frequency of mention of an item or variable is the simplest way to determine the salience of a variable within a knowledge domain as the most cited terms “tend to denote more locally prominent or salient items” (Silva et al. 2014: p. 23). To create a more comprehensive salience analysis however, the position of the variable within a list may also be included utilizing the Smith’s S formula (Figure 3) which combines frequency of mention with the rank of the variable (Thompson and Juan 2006). The positioning of a variable within a list is of importance in addition to frequency of mention, as participants are most likely to list first the terms or variables that are most familiar to them thus indicating salience (Quinlan 2005).

Free list responses were analyzed using ANTHROPAC 1.0-Freelists which applies Smith’s S formula to assess salience. In cases where respondents listed two variables on a single line (e.g., Taste and Smell), responses were separated with the first listed variable placed at a higher rank (i.e., 1- Taste, 2-Smell). According to Quinlan (2005) and Borgatti (1998) selecting which items are salient within a free list is often complicated by the fact that most lists result in “a huge number of items that are each mentioned by just one person” (Borgatti, 1998), and suggest that the most effective method for selecting salient items is to utilize natural “breaks” in the data in terms of frequency of mention using a scree plot. Based on the outcomes of the free list-analysis (see Figure 6) which resulted in a natural break at the 10% mark, this cut-off was utilized to determine which items were culturally salient and should be included in the final analysis.

The analysis of free list data provided by respondents produced some unique challenges considering the interrelationship between cannabis phenotypes and chemometrics, particularly in relation to terpene-related attributes. Terpenes or “all natural compounds built up from isoprene subunits that predominantly originate from plants” (Breitmaier, 2006: p.1) influence the effects and medicinal benefits experienced by cannabis consumers (Cox-Georgian et al., 2019; Kamal et al., 2018; Sommano et al., 2020) as well as the sensory (smell and taste) cues which growers use to determine what types of strains to grow (Booth & Bohlmann, 2019; Mudge et al., 2019; Roell, 2020). When creating their free-lists, grower’s responses both directly referenced, and tangentially alluded to, terpene contents. For example, while some growers listed *Unique Terpene Profiles* and *Wide-Ranging Terpenes*, others referred to terpene-related attributes such as *Smell Spectrum* or more specific flavor/scent attributes such as *Fruity* or *Gassy* plant.

Borgatti (1998) argues that within free lists, subdomain items and like-concepts may be treated as synonymous when clarifying information is provided by respondents. Semi-structured interviews were thus conducted following the free listing portion of the data collection which offered the opportunity to collect a “more exhaustive and contextualized” set of responses from participants regarding phenotype and strain preferences within commercial operations (Zambrana et al., 2018: p. 201). Free list response meanings that were verified using the interview data before being combined with “like” responses have been marked as such within the results (see **Appendix A**).

Interview Analysis

Interviews were conducted following the free-listing activity, in person, over the phone, or over Zoom. Interviews lasted between one to two and a half hours during which cannabis growers were asked questions regarding their preferences and practices in relation to cannabis strain selection and cultivation. Interviews were recorded, transcribed, and then coded for data related to cultivator preferences and practices utilizing the NVIVO qualitative data software program.

^[1] Both respondents in this category identified as mixed race Native American, American Indian, or Pacific Islander & white.

Results

The free list analysis resulted in fifty-two unique attributes or phenotypes of interest to growers in their commercial operations with nineteen items producing frequency scores greater than 10%. When items were ranked by salience score rather than frequency, 4 additional items (*Temperature Resilience, High Terpene Content, and Unique Terpene Profile*) with frequency scores of 9.5% emerged as being more culturally salient than other attributes with a >10% frequency. As these items were approximately within the 10% cut-off and exhibited higher salience scores, they have also been included within this analysis. The results of the free list portion of this study are pictured in Figure 4, with listed attributes organized by highest (left) to lowest (right) salience scores.

The top twenty-three attributes by frequency of mention and salience were sorted into the broader categories of *Horticultural, Phenology, Chemometrics, and Economic* (Figure 5). Most listed attributes by participants fell within the horticultural domain, followed by Chemometric, Economic, and Phenology.

Figure 5: Free List Responses by Category and by Salience

Category	Items
Horticultural	Yield, Smell, Disease Resistance, Morphology (Short), Large Buds, Vigor, Bushiness, Pest Resistance, Flavor/Taste, Dense Buds, Trichome development, Easy/Low Inputs, Temperature Resilience, Stable Genetics, Bud Density, Unique/Vibrant Color
Phenology	Short Flowering Time
Chemometric	High THC, High CBD, High Terpene Content, Unique Terpene Profile
Economic	Market Demand, Different than other strains in the grow

The following analysis presents the free listing data by category and highest to lowest salience scores. Some items have been combined within the analysis however, based on similarity of the items or the relationship between the items described by participants (e.g., *Bud Size* and *Bud Density, Smell* and *Taste*). The results presented here are supported by findings from the interviews which expand grower's rationale for selecting attributes their importance to commercial cannabis production. Interviews were also employed to clarify broad or unclear terminology utilized by growers and assisted with the grouping

of items, where appropriate. For example, while one grower noted that “THC Content” was of importance in their free list, it was unclear what type of THC content was preferable (high or low). Interview data with this grower revealed that High THC content was of interest to the consumer (“*since the consumer is chasing this first high, growers have been like well then I’m going to fucking give it to you*” [#5]) and caused the participant to adjust their strain selection processes accordingly indicating that the item *THC Content* could reasonably be grouped within the category of *High THC*. Items whose meanings were clarified using the interview data and were subsequently grouped with other like terms within the free list analysis are denoted as such within **Appendix A**.

Horticultural

Yield: Frequency (43%), Salience (.29)

Yield resulted in both the highest frequency and salience scores within the free listing analysis. *Yield* was also emphasized within interviews with twelve (57%) of the twenty-one respondents explicitly mentioning it as an important attribute when considering what to grow in a commercial operation (Figure 6). Growers who discussed yield expressed consensus that maximizing production was desirable within commercial contexts as this resulted in greater financial returns, indicating a single versus multi-directional approach in grower preferences and practices.

Figure 6: Horticultural Attributes- Yield

Respondent	License	Grow Type	State	Sample Data
5	Rec and Med	I	OR	<i>How much crop can I yield from this because it means like, the more crop you can yield the more money you can make. So we want to be as efficient as possible</i>
9	Rec and Med	O	OR	<i>You know I have indoor friends that grow indoors, and it's just based on calculations. If the strain doesn't yield enough and something else does, they're going to go with the other strain</i>
10	Rec	I/O	CO	<i>We grow with living soil, and we feel like that really brings out the terpenes in cannabis, so that's something that we definitely try to pinpoint, but yields are definitely a huge factor.</i>
12	Rec and Med	I	CO	<i>When you get your license it's not how many pounds you can grow. You can grow a million pounds. There's no limit on the amount you can produce but the limit is on the number of plants, so if you're a businessperson, you're not going to pick all tiny plants that are the best because you're not going to make any money</i>

Key: Rec=recreational, Med=Medical, I=Indoor, O=Outdoor, I/O= Indoor and Outdoor

Smell, Flavor/Taste: Frequency- Smell (43%), Salience-Smell (.25), Frequency-Taste (24%), Salience- Taste (.106).

Smell garnered the third highest salience score out of free-listed attributes with seventeen (81%) respondents also directly discussing the importance of smell, fragrance, or aromas within the course of their interviews. Likewise, while only 24% of respondents included flavor/taste within their free lists thirteen (62%) growers specifically noted the importance of flavor and taste within the interview data. As the sample data in Figure 7 illustrates, the smaller frequency of responses that specified smell and/or taste/flavor in the free lists is likely due to the interconnectedness of these variables and the tendency of some growers to use these terms interchangeably [#1, #9, #12]. Growers were also aware that taste and smell were a result of terpene content which was potentially inferred through the inclusion of items such as *Fruity Terpenes*, *Gassy Terpenes*, or *Exotic Fruit Terpenes*. The lack of specification as to the preferred outcome (smell, taste, or both) associated with these terpenes however, required that these attributes remain as standalone items within the free list analysis.

Figure 7: Horticultural Attributes- Smell

Respondent	License	Type	Location	Sample Data
1	None	I	OR	<i>I know they [consumers] like some specific fragrance like blueberry strain so there's a large market. You can always see something is blue or berry, it's somehow related to blueberry so they want a fruity flavor.</i>
5	Rec and Med	I	OR	<i>"The nose knows" that's what he [the mentor] told me a long time ago so that's what I tell people when I'm showing people weed. I'm like here's this and if I see their nose light up and I'm like that's the one. Because it's like your body... what we know now through science is that it's intuitive, people are studying aromatherapy and stuff and that's your body responding to the terpenes so it's that linalool or myrcene or pinene or what the fuck ever and your nose is lit on fire like that your bodies like I want that</i>
9	Rec and Med	O	OR	<i>When I plant, I really plant a taste of the rainbow I want different kinds of terpenes across the board, so every row has its own smell.</i>
10	Rec	I/O	CO	<i>Those are the two [terpenes] that you'll see a lot so then you'll have similar smells, and tastes and effects, you know?</i>
11	Medical	I/O	CO	<i>I don't know I just like growing the Indicas. It's something in my nose</i>
12	Medical	I	CO	<i>It's not so much about what the effect is as the potencies and the flavoring, the smells and all. Ester is what is making that fruity taste and smell and those are really unrelated to cannabinoids, the grape other sugary kind of smells or whatever.</i>
13	Medical	O	OR	<i>I think it [patient preference] was mostly effects. It was always a bonus if it smelled or tasted good.</i>
16	Rec	O	OR	<i>People are really starting to go off of how things smell. In Oregon it's a lot easier because it's the only state that allows customers to smell their weed before they buy it, like it's all prepackaged in every other state so you just have to kind of trust that whatever is in the package you're going to like. But in Oregon you can go up and actually smell all of the jars and then you can use your own intuition, and just let your body guide the way a little bit.</i>
17	None	O	OR	<i>People in the rec industry it depends on what they're looking for so like the different terpenes which is like the smells, or the majority of people I think are really going for those high percentage plants or strains.</i>
18*	Rec	I/O	OR	<i>Personally, I'm all about flavors and smells and the experience of cannabis. I could breed cannabis for different CBD levels and THCa levels, and that would be in theory pointless since we all have different cannabinoid systems. Cannabis affects everybody differently.</i>

				<i>That's what our customer bases are doing they're just looking for the chef where they agree with the palette, and they like what they see and taste</i>
19	None	I/O	OR	<i>If you've got good stuff that smells well, your body is trying to tell you to pick that terpene profile because it knows it like it and it will enjoy it</i>
20	None	I/O	OR	<i>Why would you smoke anything you don't like that doesn't taste good, that doesn't smell good, that doesn't medicate you right, so that's definitely part of the search of everything, is finding ones that smell and taste good or the best.</i>

*Key Informant

Interestingly, while *Effects* and *Medicinal Spectrum* only garnered a frequency response rate of 5% each, interview data suggests that participants associated smell and taste with the medicinal and psychoactive effects experienced by cannabis consumers [#5, #10, #11, #12, #16, #18, #19, #20]. For example, participants [#5, #16, and #19] specified that strains that smell or taste good to a cannabis consumer are those that contain chemical components that are compatible with one's endocannabinoid system, with one grower summarizing the association by stating that *"the nose knows"*. Participant [#18] who is a well-known breeder within the Pacific Northwest echoed this sentiment by explaining that they tended to breed for *"flavors, smells and experiences"* rather than cannabinoids, as everyone's cannabinoid system is different and so breeding for THC and CBD would be *"useless"*.

Disease Resistance: Frequency (29%), Saliency (.20)

Within free listed responses, 3 participants specifically listed resistance to the fungal plant pathogen Powdery Mildew (*Golovinomyces cichoracearum*), and 2 respondents specified that they sought strains that exhibited mold resistance. Powdery Mildew Resistance was also the most frequently mentioned disease-related trait within interviews with 8 (38%) of growers suggesting that they seek out plants with higher levels of resistance to this common fungal infection. 2 growers discussed difficulties in contending with the fungus botrytis (*boytrytis cinerea*); however only 1 grower specified that they selected for strains with botrytis resistance, while the other grower simply noted that the fungal pathogen was a problem. Similarly, while 11 (52%) of growers expressed concerns about contending with mold in their grows, only 2 respondents within the free list exercise specified that they selected for mold-resistant strains though 4 (19%) growers noted that mold-resistance was a desired attributes within the interview process.

Height: Frequency (33%), Saliency (.19)

Preferences regarding height were also itemized both within the free listing exercise and interview data, though levels of specificity in responses varied with 1 grower noting that "Height" was of interest, and 1 grower suggesting that "Bigger" plants were desirable, specifically in outdoor production. Because interview data was not able to substantiate the more nuanced meaning associated with these terms,

these responses were analyzed individually within the free list analysis. 33% of respondent's however, explicitly listed *Short(ness)* as a desirable trait. The import of the short stature of cannabis for growers was elaborated upon by interview participants who explained that shorter plants were preferable as indoor growers are limited by the height of the ceilings of the buildings in which they are producing [#7, #14] while outdoor growers in Oregon in particular, expressed a need for shorter plants (under 8 feet) as these were more likely to be able to withstand inclement weather and were easier to manage [#4, #9] (Figure 8).

Figure 8: Horticultural Attributes- Height

Respondent	License	Type	Location	Sample Data
4	Rec	I/O	OR	<i>If a plant was very tall and topped heavy, it would be a poor candidate for production in most places because of its likelihood to lodge and fall over [in] rains and wind, and so looking at plants....trying to find the happy medium of something that's vigorous growing but that can also withstand environmental pressures.</i>
7	Rec and Med	I/O	CO	<i>Height and bushiness. The way we have our plants growing, we bend them and top them so that they grow long and sideways versus height.</i>
9	Rec and Med	O	OR	<i>As outdoor sun growers, structure of the plant is really important, especially in Oregon they need to be able to make it through the Eugene weather. We don't go for anything that's too tall because it's unmanageable when you get to the scale that we're at, so we've definitely kept the plants so they're under 8 feet or we top the plant if it's a plant that tends to get higher than that.</i>
14	Medical	I/O	OR	<i>We definitely had to choose strains that would be productive in the space that was there because there was a shorter ceiling height, primarily being the biggest limit</i>

Large Buds and Dense Buds: Frequency- LB (29%), Saliency- LB (.17), Frequency-DB (24%), Saliency-DB (.10).

While large and dense flowers could arguably be grouped within the larger umbrella of *Yield* considering the flower is the commercially valuable part of the plant, the separation of these attributes within some grower's lists indicated a preference for *Large* or *Dense Buds* for reasons separate from overall production. Interview data confirmed the validity of this approach with growers explaining that, while large buds were commercially desirable ("*No one wants to get a bag of little popcorn stuff, it's like here's an 8th of your BIG bud*"[#14]), strains with larger buds were also preferable because "*big buds are obviously cheaper to harvest* [#13]," as they required "*less trimming and maintenance overall...and drying space*" [#14]. *Dense Buds* were described as of importance in terms of assisting with moisture content

though some growers reported that less dense buds were more appropriate in damper climates such as Oregon, where the development of mold was a concern.

Vigor: Frequency (29%), Saliency (.14)

Vigor was indicated as being desirable by almost a third of producers, however what was meant by the term *Vigor* varied amongst interviewees, with some growers describing vigor as speed of growth [#13, #18], and others describing vigor as pest and disease resistance [#13] (Figure 9). One respondent associated vigor with branching patterns [#3] explaining that the spacing of branches and how many leaves were being produced could indicate “how vigorous” the plant would ultimately be.

Figure 9: Horticultural Attributes- Vigor

Respondent	Type	Location	Data
3	O	OR	<i>How many branches are coming off, what is the spacing in-between each branch between the internodal space, those, and you know how many leaves are coming off at what stages in its life will be a good indication of how vigorous it's going to grow</i>
4	I/O	OR	<i>[I'm] trying to find the happy medium of something that's vigorous growing but that can also withstand um, environmental pressures.</i>
13	O	OR	<i>Participant: Well vigor, how vigorous the plant is. Interviewer: Speed of growth? Participant: Speed but also if they are disease resistant.</i>
18*	I/O	OR	<i>So as a breeder and as a grower I'm pretty focused on a few things, I stay hyper focused on them. Vigor is one, I don't like plants that are not going to grow and in cannabis there are a lot of mutations on a genetic level that will stifle and slow down growth, so I definitely look for vigor in rooting and in cellular division. I don't like to see things that go slow.</i>

Bushiness/Branching Patterns: Frequency (19%), Saliency (.13)

Though *Bushiness* and *Branching* were at times listed separately by growers, these responses were ultimately grouped within the analysis as branching patterns determine overall plant growth patterns and structure, dictating the overall bushiness of the plant (Danziger & Bernstein, 2021). Though one respondent listed “Bushy” as a desirable attribute, this data point was kept separate from the category of *Bushiness* as interviews with growers revealed that distinctions in the terminology were rooted in divergent preferences in relation to overall plant size. For example, while an indoor grower specified that increased bushiness was preferable for filling the lattice over the plants and maximizing production in a small space [#14], 2 outdoor growers indicated that plants that were too bushy tended to attract pests [#21] and diseases [#9], and so were less desirable than plants that grew more sparsely (Figure 10).

Figure 10: Horticultural Attributes- Bushiness and Branching

Respondent	Type	Location	Data
3	O	OR	<i>How many branches are coming off, what is the spacing in-between each branch between the internodal space, those, and you know how many leaves are coming off at what stages in its life will be a good indication of how vigorous it's going to grow</i>
7	I/O	CO	<i>Height and bushiness. The way we have our plants growing, we bend them and top them so that they grow long and sideways versus height.</i>
9	O	OR	<i>We took out strains that were too dense and too bushy and were just going to mold out in our weather.</i>
14	I/O	OR	<i>Since it was one plant per light, we really wanted [the plants] to fill up its entire lattice that was over the plants. We ideally wanted to have about 16 bud sites, just so they were substantial enough in size but it wasn't so many shoots where it was taking energy away from other stalks. Because there comes a point, say you started with like 30 little top colas, they're going to be a lot smaller than if you had 16 just because the energy doesn't have to be shared as much.</i>
21	O	CO	<i>Keeping moms alive is a thing in itself, keeping them small and clean, and not too bushy because they get spider mites easily like that</i>

Pest Resistance: Frequency (19%), Saliency (.126)

Similar to the reporting style exhibited in relation to disease resistance, growers who discussed pest resistance were more likely to generally discuss common pest pressures rather than indicate that they selected strains that exhibited pest resistance. For example, while 6 (29%) growers noted that contending with pests was a central responsibility within their grows, only 2 of these respondents revealed that they selected strains that were genetically adapted to contend with pest pressures. Common pests identified by growers included russet mites, aphids, spider mites, and thrips with spider mites being mentioned by the largest percentage of growers (29%).

Trichome Development: Frequency (19%), Saliency (.1)

Though most traits were addressed at a higher frequency within interviews than in free list responses, trichome development was included by only 4 (19%) of respondents within their interviews. Of these references, 3 addressed the quantity of trichomes with growers indicating that higher quantities of trichomes were desirable as trichomes are associated with cannabinoid and terpene content, and 1 grower proposing that the color (milky) of the trichomes was the most important component of this attribute.

Easy/Low Inputs: Frequency (19%), Saliency (.086)

Strains that performed well in low input environments or that were not heavy “feeders” were described as desirable to growers as a lower need for inputs also meant less labor in feeding the plants and reduced cost when purchasing nutrients. 1 grower also expressed that they felt that the utilization of lower inputs resulted in a better product that “*processed better and smoked better* [#19]” in addition to being cheaper to produce.

Temperature Resilience: Frequency 9.5%, Saliency (.082)

Temperature (heat) resilience was listed by only 2 respondents within the free listing portion of the exercise, both of whom were outdoor growers. Though many respondents discussed temperature and climate within their interviews, only 1 outdoor grower suggested that they selected strains that were specifically acclimated to high heat. The lack of attention to temperature resilience may at least be in part due to the preponderance of indoor growers involved within the study as indoor growers have greater control over the humidity, air flow, and temperature of their grow environments.

Stable Genetics: Frequency (14.3%), Saliency (.076)

References to stable genetics in cannabis plants were much lower than other attributes with mention by only 3 (14%) growers. According to the interview data, stability in the genetic profile of the plant was indicated by low levels of mutations which “*stifle and slow down the growth of the plant*” or which can result in the production of undesirable traits such as low cannabinoid content.

Unique/Vibrant Color: Frequency (24%), Saliency (.063)

Though unique or vibrant color was mentioned by 24% of respondents in their free lists, this attribute received a low overall saliency score indicating it’s positioning further down most growers’ lists. Out of all the respondents, only one grower indicated that he specifically selected for more “pure” or “extravagant” colors such as purples, violets, or blues. Other growers however, generally specified that color was of importance, but without elaboration.

Phenology

Flowering Time: Time to flower/harvest was also noted within the free listing portion of the data collection process with 29% of respondents including this variable. In interviews, *Short Flowering Time* was specifically expressed as being desirable for outdoor growers in Oregon because it assisted in ensuring that product was harvested before the end of the growing season (Figure 11).

Figure 11: Phenology- Flowering Time

Respondent	Type	Location	Data
3	O	OR	<i>[I'm] looking for strains that suit my amount of sun that I get and that for me is my sun stops around October, so I need 8 maximum 9 week flowering time</i>
13	O	OR	<i>Outdoors you want something that has a shorter cycle, at least in Oregon. We have a pretty short grow season, so I do say I look for ones that could produce a lot and that were very easy to grow basically.</i>
14	I/O	OR	<i>With our humidity here, if it [the harvest] comes early, just this last year we saw so many people lost their fields because of botrytis and powdery mildew and it's because they left it out long enough so they would finish developing all the way but it's really to have that good, dry end product that's done on time before winter comes. Because we have a very short growing season here compared to California. Not only do we get our plants out way later but we have to finish them earlier so we need strains that can develop to their full potential in that shorter growing window.</i>
16	O	OR	<i>Our farm because it's central, south-ish Willamette Valley it's not the greatest place to grow outdoor weed, so we look for things that have a really short flower time, because ideally, we'd like to have most of our harvest wrapped up by early October which is very early for a lot of people.</i>
20	I/O	OR	<i>Especially around Portland [flowering time] is a big deal because the end of September gets kind of rainy and bad weather so you need strains that finish early and what that means is that they start flowering earlier at the beginning of July or beginning of August, because then you have a whole nother group of strains that won't start flowering until the end of August....So people who are growing the longer term things, it's okay if you have a whole greenhouse set up or something, but just people who have a few out in the sun, you have to early finishing plants to have a good success</i>

Chemometrics

THC Content: Frequency (76%), Salience (.23)

Of the chemometric responses from the free lists, High THC content was the most frequently mentioned attribute and culturally salient item behind yield (.23). 90% of interview respondents discussed THC content within their interviews however, opinions on the import of High THC were diverse in terms of rationales for why THC was of import in commercial grows. Of the respondents who discussed High THC in their interviews for example, only 3 [#9, #15, #19] specifically noted that they *personally* preferred, or selected for, High THC strains in their grows (Figure 12). Of these 3 respondents 2 specified that though they liked THC and selected for it, other attributes such as terpenes [#9, #19] and a wide variety of other cannabinoids [#9] were of equal or more importance.

Figure 12: Chemometrics- High THC

Respondent	License	Grow Type	State	Sample Data
9	Rec and Med	0	OR	<i>When I plant the field and we pick out our strains it's very important that we have cannabinoid profiles that go across so high-CBD, high-THC, terpenes. So, when I plant, I really plant a taste of the rainbow I want different kinds of terpenes across the board.</i>
15	Med	1	CO	<i>Interviewer: If you had the power to make all of the decisions about what you were going to put in that grow, would you still do it the same way do you think? Mostly high THC plants?</i> <i>Participant: Yeah definitely.</i>
19	None	I/O	OR	<i>Well, I'm definitely a fan of THC content you know, because I like THC [laughs]. It's a difficult question. I guess terpenes are more what I'm concerned about than anything.</i>

A common narrative expressed by growers regarding High THC was that the drive to produce High THC strains was a result of consumer, rather than grower, preferences and was the result of the miseducation or a lack of education on the part of the consumer and cannabis sales representatives (i.e., “budtenders”) (Figure 13). Interestingly, while some growers acknowledged catering to consumer demands and selecting and propagating High THC strains [#2, #14, #16] others were more likely to speak about the push for Higher THC strains more generally or as a practice applied by *other* growers [#5, #6, #13, #17, #18, #20] rather than something that they themselves engaged in.

Figure 13: Chemometrics- High THC and Consumer Preferences

Respondent	License	Grow Type	State	Sample Data
2	Rec	I	OR	<i>Since I didn't actually talk to the consumer as much, I would have to go with what the dispensary owners would say and sadly like the vast majority of the time all they care about is THC content</i>
5	Rec and Med	I	OR	<p><i>Participant: I hate the pushing of the THC thing because I think we've lost good genetics of some other things that are present in the plant that we're never going to get back.</i></p> <p><i>Interviewer: Do you think something under 18 [% THC] would sell?</i></p> <p><i>Participant: Um it sells if you have it at a cheap price point and if it just like smells really good.</i></p> <p><i>We're still in a world where testing labs are getting death threats because somebody sent samples there that they were sure was 30% THC and it came back as like 22%.</i></p>
6	Rec	I	OR	<p><i>Now I feel like more people are just caring about how much they can sell rather than the quality of it, and how much percentage of THC they can get into it so they're pumping all this random stuff into it and crossing these random crosses that don't go together that give people that experience.</i></p> <p><i>It sucks to have to alter you know, where the THC percentage is just because a lot of the general public just looks at that number and says "well that's what I want because that's what's going to get me high" and not understanding how the plants work and the cannabinoids and how they effect you..... and like somebody that wants to go to sleep, they're being misinformed.....or not even being misinformed they just want something because of the THC level but it's not what they actually want</i></p>
7	Rec and Med	I/O	CO	<p><i>Participant: there's ways to manipulate test results.</i></p> <p><i>Interviewer: And do you think that.... How do you think that people are manipulating them? What do you think that they're changing?</i></p> <p><i>Participant: I think it's just to advertise a higher THC to make more money.</i></p>

Interviewer: They think that if it's higher THC they can charge more?

Participant: Yeah.

13 Med 0 OR *Participant: A lot of my patients liked the ones that were a little lower in THC. The high THC can sometimes make you feel worse. And a lot of them wanted it to help with their medical issues but they still wanted to be able to function*

Interviewer: Do you think there is an overproduction or overbreeding of high THC strains happening either in the rec or medical market? Did you ever notice that?

Participant: I think yes, that seems to be what people are going for

14 Med I/O OR *Even though it was the medical market, surprisingly the high THC was in big demand.*

16 Rec 0 OR *Participant: Yeah, so when we were doing medical, we were growing what our patients wanted which was really high THC*

17 None 0 OR *Participant: people in the rec industry it depends on what they're looking for so like the different terpenes which is like the smells, or the majority of people I think are really going for those high percentage plants or strains.*

Interviewer: high percentage?

Participant: high percentage of THC.

Interviewer: Specifically THC.

Participant: Yeah.

18* Rec I/O OR *The consumer base has been somehow tricked though, and it's horrible, for the consumer base, you have to literally use counterintelligence and put up posters and shit to tell people about their endocannabinoid system and how THC just doesn't matter. It's about terpenes.*

20 None I/O OR *If you're dealing with the shops, they're going to value things that are higher THC or just even higher total cannabinoids more than something that has lower [THC and other cannabinoids]*

21 Rec 0 CO *Interviewer: Did you find that the numbers really mattered to the dispensaries? Like how high the THC was?*

Participant: I don't think so, no. People seem to think that but no, I don't really think so. All our stuff tested at the last fall harvest, at 20% or above. Between 20 and 25%.

As a key informant, respondent #18's opinion regarding the lack of import of High THC content in producing a high-quality end cannabis product, but the import of THC to consumers, was of particular interest, particularly as this sentiment was echoed by all other growers who directly addressed the value of High THC excepting one participant [#15] indicating a cultural consensus.

Narratives regarding trends in increasing the production of lower THC strains also emerged that addressed the widening of the cannabis consumer base to include "older" clientele, who were less likely to be interested in strains with high THC content (Figure 14).

Figure 14: Chemometrics- Age-Related Trends in Cannabis Production

Respondent	License	Grow Type	State	Sample Data
2	Rec	I	OR	<i>I think there needs to be some marketing to older people because I know so many old people that don't like to smoke because they've always been given the wrong product and those low-THC strains would probably be really good for people</i>
5	Rec and Med	I	OR	<i>Like they'll [customers over the age of 70] come in and be like oh I heard about CBD and you tell them about CBD and they're so afraid of THC and then a couple of weeks later they're buying like the 1:1 because it makes them feel better and then a few weeks later they're buying just like straight up like 5mg THC gummies and stuff like that you know?</i>
13	Med	O	OR	<i>Yeah because you know you go in there, we [older cannabis consumers] go in there [dispensaries] with our aches and pains and it's like....my friends came to me because they knew I could relate. I think if they had more diversity in the dispensaries too, and I don't know if this is a very good statement or not but promoting the medicinal qualities of cannabis rather than just getting high.</i>

Though most growers indicated that High THC was of import, predominantly to the consumer base, one participant [#21] suggested that although growers *thought* consumers wanted High THC, this was not their experience of the markets. Interestingly this participant specified that their cannabis sales had been successful the year prior and had tested at between 20 and 25% THC indicating that they believed this range to be "low THC". Respondent #5 also designated beliefs what constituted "High" THC levels by specifying that testing labs would get death threats if their product came back with a 22% THC rate as opposed to 30% and noting that cannabis under 18% THC would only sell if "*it was at a low price point and smelled really good.*"

High CBD and Non-CBD Cannabinoids: Frequency (14.3%), Saliency (.116)

While THC content was noted as being important by most growers, 17 (81%) of respondents also directly discussed CBD within the course of their interviews though all producers were engaged in the non-hemp recreational or medical markets. Of these respondents, 4 noted that they were specifically engaged in producing cannabis strains that were higher in CBD content. As one grower explained [#16] (Figure 15), low CBD strains have increased in popularity due to the inability of hemp growers to produce strains for recreational markets.

Figure 15: Chemometrics- High CBD/Non-THC Cannabinoids

Of the respondents who discussed alternative cannabinoids to THC, only 3 respondents (14%) noted that they personally were actively involved in producing cannabis that contained non-THC or non-CBD cannabinoids (i.e., CBN and CBG) and only 1 grower [#10] revealed that they were engaged in growing cannabis strains with alternative THC cannabinoids (i.e., THCv).

High Terpene Content and Unique Terpene Profile: Frequency-HTC (9.5%), Saliency-HTC (.071), Frequency-UTP (9.5%), Saliency-UTP (.068).

Though high or unique terpene content resulted in relatively low frequency and saliency scores, these results are misleading considering the prevalence of attributes that are directly associated with terpene content within the cannabis plant. For example, when all terpene related attributes were grouped within the broader category of *Terpene Content*, both the frequency (71%) and saliency (.42) of this category outranked all other listed attributes (See **Appendix B**).

Figure 16: Terpene-Specific Interview Responses

Terpene	Frequency of Mention	Respondents
Myrcene	5	#2, #5, #6, #10, #19
Linalool	2	#5, #6
Caryophyllene	1	#6
Limonene	1	#9
Beta-Caryophyllene	1	#10

Nevertheless, only 13 (62%) of growers mentioned the importance of terpenes directly within their interviews as opposed to 76% who directly discussed or referenced THC. Also, while the cannabinoids THC and CBD were frequently discussed by name within interviews, only 6 (29%) interview participants named specific terpenes within the interview data, and of these responses 3 participants [#5, #6, #10] were responsible for 70% of the total frequencies (See Figure 16). Of these mentions, no respondents specifically associated aromas or tastes with a particular terpene but rather spoke of the terpenes more generally as components of the plant (Figure 17).

Respondent	License	Grow Type	State	Sample Data
4	Rec	I/O	OR	<i>We are CBD focused right now and also focused on looking into other cannabinoids, so less of an emphasis than a lot of folks on THC</i>
5	Rec and Med	I	OR	<i>There're a few growers that are kind of starting to resist that [high THC] now, because growers have always known.... Like when someone comes in and tells me like, I want the high THC shit, I can't get high on anything less like, "what we're you smoking ten years ago? Because there wasn't 30% weed"</i>
9	Rec and Med	O	OR	<i>I think that [high THC] came out of the black-market days, it was all about THC because all anyone really knew was THC. Now everyone knows about CBD, next they'll know about CBG and you know until there's more research or education, people aren't going to know.</i>
10	Rec	I/O	CO	<i>We do have one strain that we grow that is about a 1:1 so it will test around 7% THC and 7% CBD and there's a strong market for that, and we've just started a new strain that's like 17% CBD and a little over 1% THC and then it does have some CBG and CBN in it so we're going to hopefully start trying to cross that with some of our other strains</i>
11	Med	I/O	CO	<i>We grow...the 1:1 is really where it's at, especially because of the market in Oklahoma, that's what people are craving right now. They want the 1:1 THC to CBD strains so I've been experimenting with that just for those people.</i>
12	Rec and Med	I	CO	<i>Like there's this hype if you wish but it's actually real science, but there's THCV which they are calling skinny THC or skinny weed because THCV supposedly, apparently, suppresses your appetite, but on a mental level. So you're just not hungry, it's not that anything chemical happens to you it's just that your human need to put food in your mouth goes away basically. And so they're....they being money interests [at his company] are looking at this as the next health, diet, craze because it's cannabis and it's weight loss at the same time.</i>
16	Rec	O	OR	<i>There's a lot of money to be made in the rec market if we can grow very high CBD strains because hemp farmers aren't allowed to sell to dispensaries. So we've been doing that as well, growing some strains that are basically hemp</i>
21	Rec	O	CO	<i>Participant: For some reason the high elevation weed tests higher in CBG which is new and people are kind of getting into. I don't know a whole lot about it.</i> <i>Interviewer: Are you finding that people are starting to request different cannabinoids more frequently now?</i>

Participant: Yeah, I think so. Once people go into the dispensary. And he's starting to advertise that too [her boss] or putting that [cannabinoids] on the label. I don't think that's required, but he adds it and tests for it.

Figure 17: Chemometrics- High Terpene Content and Terpene Profiles

Respondent	License	Grow Type	State	Sample Data
2	Rec	I	OR	<i>Number one thing is, is it going to sell and after that I'd look at basically terpenes.. smell and how it stands in terms of testing</i>
9	Rec and Med	O	OR	<i>We just want the widest profile, so if I can get a lot of limonene, so I grow lemon OG because lemon OG has a lot of limonene in it. I grow shishkaberry because it has a lot of sweet aromas, it brings a different kind of terpene to the profiles</i>
10	Rec	I/O	CO	<i>There's like 9 dominant terpenes and we try to grow a strain that is dominant in each terpene.</i>
16	Rec	O	OR	<i>Right now, it's been like a terpene revolution. So THC is sort of cancelled.</i> <i>This [Oregon] is the only place where people can smell around and decide what they want and that has been really steering people's interest in different strains way more than the THC or CBD or sativa or indica or whatever. People are almost just going in with a blindfold and just buying stuff of what they think smells good.</i>
17	None	O	OR	<i>People in the rec industry it depends on what they're looking for so like the different terpenes which is like the smells, or the majority of people I think are really going for those high percentage [THC and CBD] plants or strains.</i>
18	Rec	I/O	OR	<i>[Cannabis quality] is about terpenes.... It's kind of crazy how it happens but there's a chemical reaction between THC and terpenes, and without one or the other, you're going to get way less high. And every person is going to receive different terpene profiles and THC in their endocannabinoid system differently.</i>
19	None	I/O	OR	<i>The taste and the smells and the flavors are all there [in terpenes] but as far as efficacy, the terpenes are where all of your modulation is coming from so if you have straight THC and you smoke it, versus THC with some terpenes you're just going to have a much different effect. So I definitely like to have something with a nice rich terpene profile that's not too dominant one thing or another.</i>
20	None	I/O	OR	<i>I think too it's hard to come up with "the best" [cannabis attributes] there's different niche types all tied in with the terpenes and everything. Niches of different types of weed so that's the goal of being a grower is to have half a dozen strains that are kind of different from each other but that fill different parts of that smell spectrum and have slightly different effects so throughout the day or week, if you have different ailments you can choose the strain that's going to benefit you the most.</i>

Market Demands: Frequency (19%), Saliency (.091)

As in the case of terpene-related data, the relatively low saliency score produced for *Market Demand* was complicated by the integration of discussions on consumer preferences situated within the data on cannabinoid and terpene content. THC content specifically for example, was associated by growers with consumer preferences. As THC content was the second most culturally salient category, *Market Demand* may be assumed to have a more significant weight than what is indicated by the free list responses.

Uniqueness in Grows: Frequency (14.3%), Saliency (.053)

The desire for strains or genetics that varied from what growers currently had in cultivation in their grows, spoke to attempts to meet the demands of a wider consumer base. Growers were aware that variations in terpene and cannabinoid profiles are of interest to different consumers within the market with one grower noting that:

“Breeders are essentially just chefs and we have different palettes and stuff that we like so you know if you go to a big city there’s a bunch of steak restaurants but they’re definitely cooked differently at different restaurants. And you can find a chef that cooks steaks just the way you like it. That’s what our customer bases are doing, they’re just looking for the chef where they agree with the palette, and they like what they see and taste.”

Interestingly, while some growers had suggested that the advent of testing had limited biodiversity by placing THC content at the front and center of the consumer’s consciousness, a different participant suggested that testing had increased biodiversity as growers had to be conscientious that the cannabinoid and terpene content of the plant were going to be made publicly available:

“Some people really enjoy just growing a couple like the black market grows that I’ve helped with or worked at, we’ve grown just two or three just because the flower isn’t being tested at all through a lab. So really the black market grower is looking for a really pungent smell and the weight of the nug and the size of it versus....for example Jager is a high-yielding plant and a lot of black market growers love to grow this plant. It has a little bit of the possibility for mold, and the numbers are a little average when you get it tested, but because the yields are so much, most growers opt for that strain in the black-market industry. I think generally the farms that I’ve worked on in the rec market, the farms have really wanted to get variety in their strains because they want to keep it exciting for the market so if someone doesn’t like a strain they have many others to choose from.”

Discussion

The results of the research presented here support the hypothesis proposed by Clarke and Merlin (2013, 2016) that cannabis growers are most familiar with the cannabinoids CBD and THC, and that strain selection and breeding practices within state-legal commercial cannabis operations tend to favor the

maximization of these compounds, and in particular THC. The results of this study also suggest however, that the desirability of these attributes, rather than stemming from grower preferences, has predominantly originated from the consumer and market trends. Participants suggested that consumer preferences for THC were the result of a lack of knowledge within the consumer base regarding non-THC and non-CBD cannabinoids, combined with state-mandated testing regulations which require the reporting of these major cannabinoids on cannabis packaging. Regulations which prevent consumers from smelling cannabis products prior to purchase were also indicated as being responsible for an emphasis on THC content as opposed to terpene content within cannabis markets, as scent was associated with a consumer's ability to "intuit" which strains contained appropriate chemical compounds for their unique endocannabinoid systems.

Data which addressed terpene content within the cannabis plant produced some unique challenges considering the interrelationship between cannabis phenotypes and chemometrics, and specifically how growers chose to express preferences for various terpene-related attributes. Terpenes or "all natural compounds built up from isoprene subunits that predominantly originate from plants" (Breitmaier, 2006: p.1) influence the effects and medicinal benefits experienced by cannabis consumers (Cox-Georgian et al., 2019; Kamal et al., 2018; Sommano et al., 2020) as well as the sensory (smell and taste) cues which growers use in the strain selection process (Mudge, Brown, and Murch 2019). When creating their free-lists, grower's responses both directly referenced, and tangentially alluded to, terpene contents. For example, while some growers listed *Unique Terpene Profiles* and *Wide-Ranging Terpenes*, others referred to terpene-related attributes such as *Smell Spectrum* or more specific flavor/scent attributes such as *Fruity* or *Gassy*. When results were combined to reflect all terpene-related attributes however (**Appendix B**), *Terpene Content* became the most culturally salient category within this analysis. Growers, furthermore, did not indicate that they consciously associated terpene-related attributes such as aroma with cannabinoid content as suggested by Mudge, Murch, and Brown (2019), rather, the terpenes were valued for their aromatic and taste outputs.

Conclusions

The cannabis plant has over one hundred and fifty terpenes and one hundred cannabinoids whose form and function are still little understood (Booth & Bohlmann, 2019). Though participants in this study indicated that terpene content was of considerable importance when selecting for desirable cannabis phenotypes and attributes, most were also unlikely to describe or identify associations between specific terpenes (e.g., linalool, myrcene, pinene, etc.) and aromas, flavors, or effects. The omission of this association does not necessarily mean that cannabis growers are ignorant of the value of terpenes or that their understanding of how the chemometric components of *Cannabis sativa* interact. Cannabis producers hold knowledge that is most often based on experience and experimentation. Reliance on the domain of knowledge embedded in practice by cannabis growers then, make them key actors and partners in preventing the loss of valuable cannabis genetics and biodiversity until science can catch up to the claims of the plants pharmacological value.

Abbreviations

ABD: Agrobiodiversity

CBD: Cannabidiol

CBC: Cannabichromene

CBG: Cannabigerol

CBN: Cannabinol

THC: Δ -9-tetrahydrocannabinol

Declarations

Availability of Data and Materials

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

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Ethics Declaration

Ethics Approval and Consent to Participate

This project was reviewed and accepted by the Oregon State University Institutional Review Board. Consent was acquired from all participants before the data collection process.

Consent for Publication

Participants in the study were informed that the information they provided would be utilized within public publications with identifying information removed.

Competing Interests

The author declares that they have no competing interests.

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Figures

$$S = \left\{ \sum [(L_i - R_j + 1) / L_i] \right\} / N$$

Figure 1

Smith's S Formula

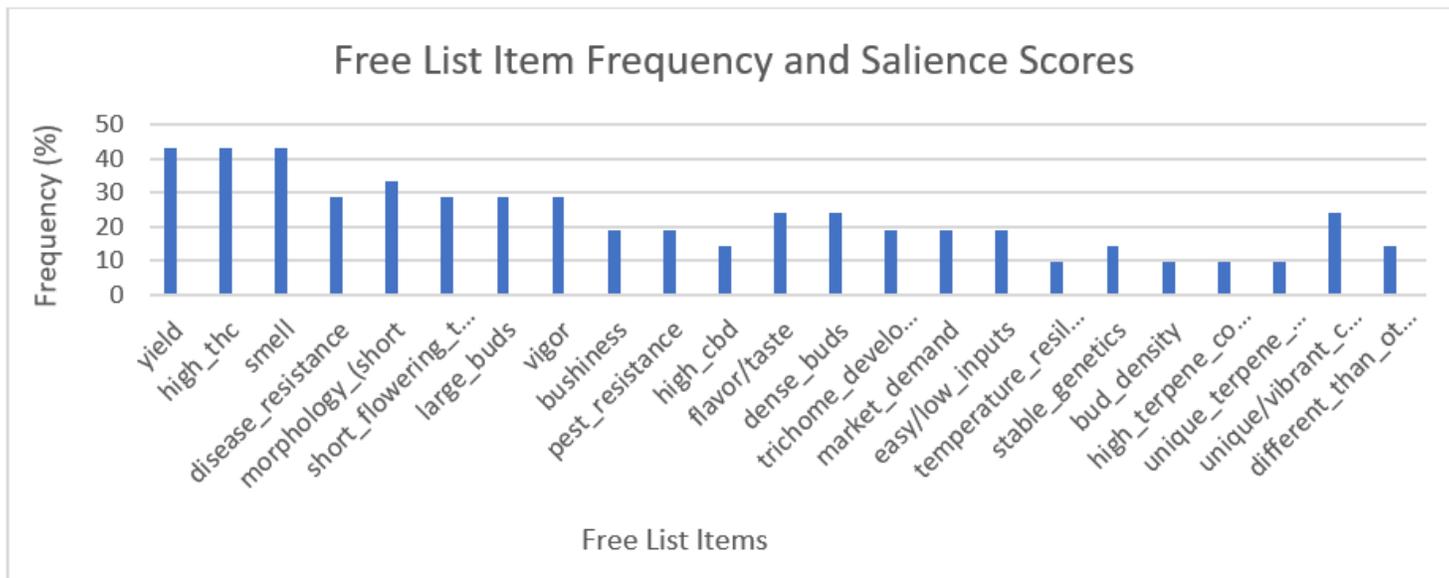


Figure 2

Free List Item Frequency and Salience Scores

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