



2021 / *Agrify Whitepaper*

How Micro-Climate Control Benefits Cannabis Production

Cannabis is not easy to cultivate. The phytocannabinoid and terpene profile of each plant, as well as how much of each compound the plant develops, is dependent on its growing environment. Atmospheric variability (changes to temperature, light, humidity, and more) can drastically alter which phytocannabinoids and terpenes develop, and in which amounts. Those small changes can make a noticeable difference to a cannabis consumer.

As the cannabis industry matures, the ability to scale while producing consistent, high yield and high quality product is critical. Incorporating microclimates into cultivation operations gives cultivators a much higher opportunity for success.

How cannabis is shaped by its growing environment

While the science behind a grow environment's impact on phytocannabinoid and terpene content is still evolving, anecdotal evidence from the legal adult-use and medical markets in the United States clearly illustrates the key role environment plays in a harvest's chemical profile.

For a baseline, turn to [The Grow Off](#), an annual cultivation competition that judges cultivators on several milestones, including maximizing phytocannabinoid and terpene production. [A commercial competition](#), featuring 24 growers cultivating Caramel Cream clones sourced from the same mother plant, resulted in phytocannabinoid content ranging from 15.37% to 28.57%, and terpene content ranging from 0.86% to 5.32%. A similar pattern emerged the year before, from the [competition in Northern California](#): There was a 507% difference between the lowest and highest limonene content in that year's cultivar, White Tahoe Cookies.

Even though the cultivars were the same, the clones were sourced from the same mother plant, and the contestants were in the same geographic area, the chemical profile was still wildly different. Each master grower brings their own facility infrastructure and layout, tried and true techniques, and environmental control methods to the table. This small-scale competition may be a microcosm of the larger issues facing cannabis cultivators in a budding legal industry, but it's a precise illustration of the challenges cultivators everywhere are hoping to solve.



Micro-climates At Work: How One Cultivator Achieved 0.08%

Temperature has a particularly strong effect on terpene production. As a volatile organic compound, terpenes are particularly sensitive to temperature fluctuations, and particularly to heat, when terpenes can evaporate off the plant and affect total yield. Careful monitoring and tight control of daytime and nighttime temperatures are essential to ensuring consistent terpene yields.

Regarding phytocannabinoid production, some cultivators advocate for adjusting temperature during the flowering stage to help boost trichome production. Studies have yet to uncover if phytocannabinoid production increases at a certain temperature, but cultivators must keep a careful eye on particularly warm temps. This is because a too-hot grow room can usher in less-than-ideal environmental conditions that can cause plant death or play a role, along with relative humidity, in facilitating the growth of mold and mildew.

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How the cultivation environment influences the cannabis chemical profile

To understand how to achieve consistent yields, it's important to know which factors can influence plant composition, and how they do so.

Core to this principle is stress response in cannabis. Cultivators have long believed that stress responses lead to improved phytocannabinoid and terpene development, specifically THC. This guiding light underscores many of the methods cultivators stick to today for high yields. Examples include:

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Temperature is more of concern for overall plant health as opposed to phytocannabinoid production, although some cultivators advocate for adjusting temperature during the flowering stage to help boost trichome production. Studies have yet to uncover if phytocannabinoid production increases at a certain temperature, but cultivators must keep a careful eye on particularly warm temps. This is because a too-hot grow room can usher in less-than-ideal environmental conditions that can cause plant death or play a role, along with relative humidity, in facilitating the growth of mold and mildew.

RELATIVE HUMIDITY

Too low relative humidity levels can slow phytocannabinoid and terpene development, resulting in less potent flower overall. Optimal relative humidity levels vary depending on grow stage and desired results. Similar to temperature's role in cultivation, relative humidity plays a greater role in overall plant health than it does in chemical profile. Too high level of moisture in the air, and the plants run the risk of developing mold, mildew, and other contaminants.

LIGHT

Light plays a critical role in the development of phytocannabinoids and terpenes. There are multiple factors to consider when discussing the impact of light beyond simply how many hours the plants are subjected to during each stage of cultivation. Light placement, intensity, source, and spectrum all play a role in phytocannabinoid and terpene development in the following ways:

- **Placement:** Studies have found that light intensity decreases as a plant grows because leaves absorb this light, plus shade increases as the plant grows. While the lights themselves may be on the correct settings and cycling, the photosynthetic photon flux density (PPFD), or the amount of light that truly reaches the plant canopy, can be significantly different from the intended settings. That directly impacts phytocannabinoid and terpene development.

- **Light intensity:** Studies have found that light intensity per watt can have an impact on phytocannabinoid yield. Increasing light intensity reduces the yield of THC per WM2 (watt per meter squared), with some cultivars experiencing this at greater rates than others. Conversely, in some cultivars, CBD yields increased at higher light intensities. This suggests to researchers that cannabis produces phytocannabinoid as a stress response to counteract the effects of increased light intensity. Other studies have found differing results; a 2021 study conducted at the University of Guelph found marginal impact of light intensity on phytocannabinoid development and a small impact on terpene development.
- **Light source:** LED lighting, HPS lighting, and metal halide (MH) lamps all produce different results. Studies have found that WM2 increased when HPS lighting was used in place of MH lighting. However, using HPS lights comes with its own set of challenges, including increasing room temperature. That's one of the many reasons why LED lighting is now a more commonplace option for cultivation.
- **Light spectrum:** All plants, including cannabis, are sensitive to light. Plants respond differently to varying light wavelengths and colors. Each has its own unique effect on photosynthesis and photomorphogenesis, among other plant development stages. This is vitally important for each cultivation stage, as the wrong light spectrum can speed up or delay flowering, adversely affecting the plant's chemical profile.

FERTILIZATION

No matter the cultivar, fertilization is a significant factor in phytocannabinoid development and fertilizer type is a topic of much debate and passion in the cannabis community, as cultivators tend to have their own preferred brands and methodologies that they have successfully implemented in past grows.

Some studies conducted on industrial hemp have noted the impact of certain fertilizers on phytocannabinoid development, and particularly on THC development. For example, a study conducted on low-THC industrial hemp found that THC levels decreased when a nitrogen-based fertilizer was administered; notably, nitrogen is essential during the vegetation stage, not during the flowering stage. It's important to note that findings from studies conducted on low-THC industrial hemp may not be transferable to high-THC cannabis in terms of commercial cannabis cultivation.

Create a Micro-climate with Agrify's Vertical Farming Units

Designed from the inside-out for cannabis, our fully enclosed and compartmentalized VFUs offer automated high-fidelity irrigation, fertigation, and CO2 control. Outfitted with full spectrum LED grow lights, every aspect of our VFUs can be fully set, controlled, and adjusted to deliver consistent phytocannabinoid and terpene development, no matter which cultivar you're growing. VFUs are also stackable up to three high, maximizing vertical height while saving square footage.

- Compartmentalized micro-climates for growing
- Total enclosure with blackout curtains
- Up to 6x yield per square foot compared to traditional grow
- Grow different cultivars next to one another

[Learn More](#)

What does proper environmental control mean to customers?

Cultivators and brands work hard to earn a consumer's trust. One more hour of light, a drop in humidity, or a tiny tweak to nutrients can result in a product so different that a customer may switch brands altogether. As a cultivator, the power to ensure each harvest is as consistent in chemical profile as possible is quite literally in your hands.

While the average customer may not know the many ways atmospheric variability impacts the product they're buying, they will become familiar through experience. If changes in a cultivation facility resulted in cannabis with a different phytocannabinoid and terpene profile – even though the brand or cultivar name didn't change – it can greatly alter the customer's experience.

This commitment to consistency becomes even more important as the cannabis market matures. According to New Frontier Data, a significant percentage of consumers in states with legal medical or adult-use programs are unlikely to migrate away from cannabis flower, even as manufactured products like edibles continue to rise in popularity and market dominance for cannabis flower shrinks. Cannabis flower is familiar to many consumers, particularly those transitioning to buying from a licensed dispensary, and they are unlikely to switch from a product they know and love. This creates an opportunity to build a dependable core consumer base that will be attracted to a brand's quality and consistency. A happy customer keeps your customers – the dispensary – happy as well. And as any cultivator knows, a consistent, quality product begins from the moment the seed is planted.

Data At Your Fingertips with Agrify Insights

Improve your results with each harvest with Agrify Insights. Our proprietary software is included with each VFU, ready to roll upon installation. From crop status at a glance to a precise record of historical and current data, Agrify Insights supplies the information your facility needs to produce consistent yields time and again. Use our pre-programmed grow plans for best-selling cultivars that comes with Agrify Insights, or create your own "recipe" for proprietary cultivars.

- Precision monitoring and controls from the dashboard
- Collect up to 1.5 million data points annually
- Use data to perfect results with each harvest
- Comes pre-installed with Agrify Vertical Farming Units

[Learn More](#)



What does proper environmental control mean to customers?

Considering just how many factors are at play, it can seem like a never-ending, exhausting task to maintain total control over the grow environment. And in some ways, you may be right: environmental control is so essential that it shapes every element of a facility buildout or expansion. Even within those calculated buildouts, issues do occur. For cultivators, environmental control is an issue of minimizing risk, not of prevention. Not only is there a massive amount of ground to cover in a large cultivation facility, but the sheer number of components involved from HVAC systems to lights to irrigation systems, increases the possibility that something malfunctions or breaks down. One issue could have a profound impact facility-wide.

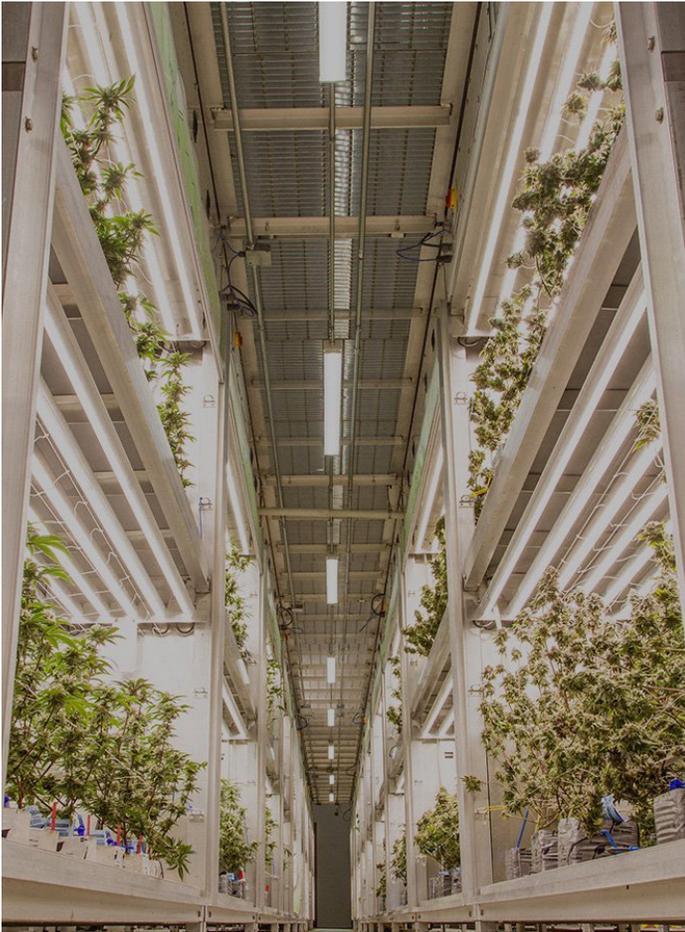
The best way to combat these issues is not to tackle the entirety of a massive grow facility, but to break down these components into smaller areas you can control reliably and with minimal risk to the rest of your harvest. Here's where the concept of a microclimate comes into play. These small, restricted areas allow for precise control over all the factors that shape phytocannabinoid and terpene development on a scale that's much more realistic to manage fully.

Often limited to only a few plants in each area, microclimates can be carefully managed to a degree that a large room cannot. With just a few square feet to work with, tight control is a reality that can be extremely difficult to master in a facility that's several times the size. Microclimates with built-in software allow for precision controls and adjustments. If something goes awry, only a handful of plants are affected, and the issue can be remedied quickly without affecting a whole harvest. This also allows for multiple cultivars within the same grow room placed next to one another, without affecting the cultivar in the unit next door. This eliminates the need to run multiple grow operations for difficult cultivars simultaneously, simplifying management and growth cycles.

The ability to create microclimates supported with expert environmental control and the ability to repeat and scale those microclimates is critical for success in such a competitive industry. Adding [data and analytics results](#) in the ability to craft

"recipes" of precise environmental needs for specific cultivars, ensuring the same settings are applied to future harvests. The result is a product harnessing outcomes within a fraction of a percentage of difference between yields – a game-changing result that can bring buyers, dispensaries, and customers back for your product repeatedly.





**Get in touch with Agrify
to learn more about the
solutions that can help you
optimize your grow.**



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