

State of Indoor Farming 2020



ARTEMIS

About the Authors



ARTEMIS

Artemis® is determined to create a more profitable, more sustainable, traceable agricultural supply chain. We work to strengthen health and safety standards and practices across countries and continents. We believe that no one should ever get sick from consuming plants, farmers should make a good living, farmworkers should be treated with dignity, and profitability is the key to scaling our agriculture system. Data informs us, but people inspire us.

For questions or comments, please reach out to:

info@artemisag.com

www.artemisag.com

With support from  **Startle**

Startle Innovation, LLC is a venture catalyst. We turn cutting-edge technology and science into ventures that reimagine, reinvent, and ultimately fuel a healthier food system. With this in mind, our areas of interest are broad and interconnected, including: increasing supply chain safety, sustainability, and transparency; systems and dynamics that determine how people consume their food; and improving the nutritional value of the food we eat.

For questions or comments, please reach out to:

info@startleinnovation.com

www.startleinnovation.com

Introduction

The purpose of this report is to look at where the indoor farming industry is today as well as where we think it is going in the near future. This year, we conducted a survey of over 40 in-depth questions with 133 respondents, both online and via telephone. In addition, we compiled two supplemental surveys, one focused on cannabis and one mid-year. These surveys were conducted by a total of 72 respondents, both online and via telephone. Wherever possible, our analyses include all participating farms—exceptions were only made if and when there weren't enough data points to comfortably draw a conclusion or where outlier data points were excluded.

Despite the impact of COVID on our industry, we gathered a robust data set for discussing the state of this industry and for thinking about its future. The resulting report is based on quantitative inputs, but is highly qualitative in nature, focusing on indicators, questions, and potential trajectories.

Table of Contents

Who We Surveyed

- Facility Types..... 5
- Crops Grown..... 6

2020 Business Snapshot

- Crop Yields..... 7
- Revenue..... 9

Expenses

- Labor..... 10
- Inputs..... 12
- Suppliers..... 13
- Lighting..... 14

Sales Channels

- Distribution..... 15
- Contracts..... 16

Growth

- Technology and Hardware..... 17
- Software..... 19
- Expansion Plans..... 20
- Capital Needs..... 21

- Cannabis..... 22

- 2021 And Beyond..... 23





- Appendix..... 26






Who We Surveyed

Facility Types




The facility types we reached out to for this year's State of Indoor Farming survey included the following:

-  Sun
-  Artificial light
-  High tech
-  Low tech



High tech glass greenhouse

-  Transparent, enclosed structure made of glass.
-  Highly dependent on automation and technology systems.
- 



Mid-tech glass/poly greenhouse

-  Transparent, enclosed structure made of glass or polycarbonate. Has more automation than high tunnel production but not to the full extent possible.
- 
- 



Low tech high tunnel

-  Semi-circular, tunnel-shaped structure made of steel and polythene. Little to no automation.
- 

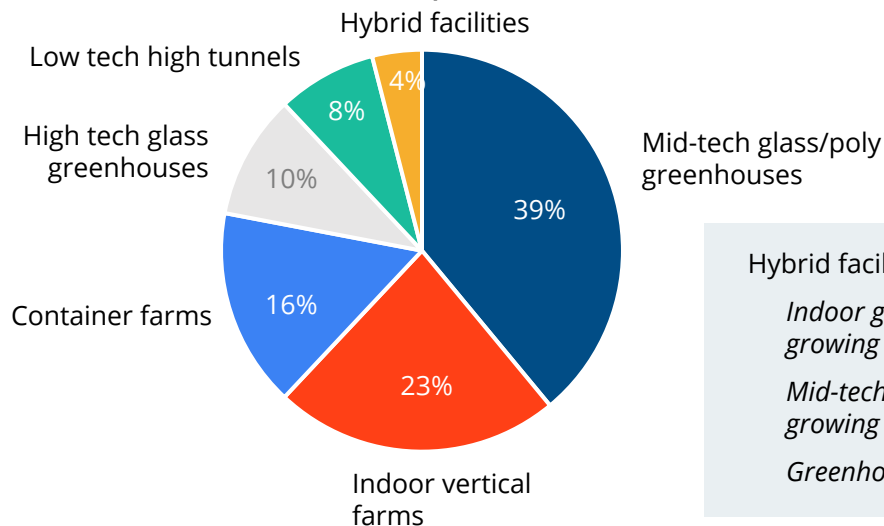
Indoor vertical farm

-  Any fully enclosed and opaque room with a vertical hydroponic, aeroponic, and/or aquaponic system. Artificial lights are used.
- 

Container farm

-  Self-contained growing units that use vertical farming and artificial lighting. In contrast to custom-designed warehouses, container farms strive for standardization.
- 

Our Respondents

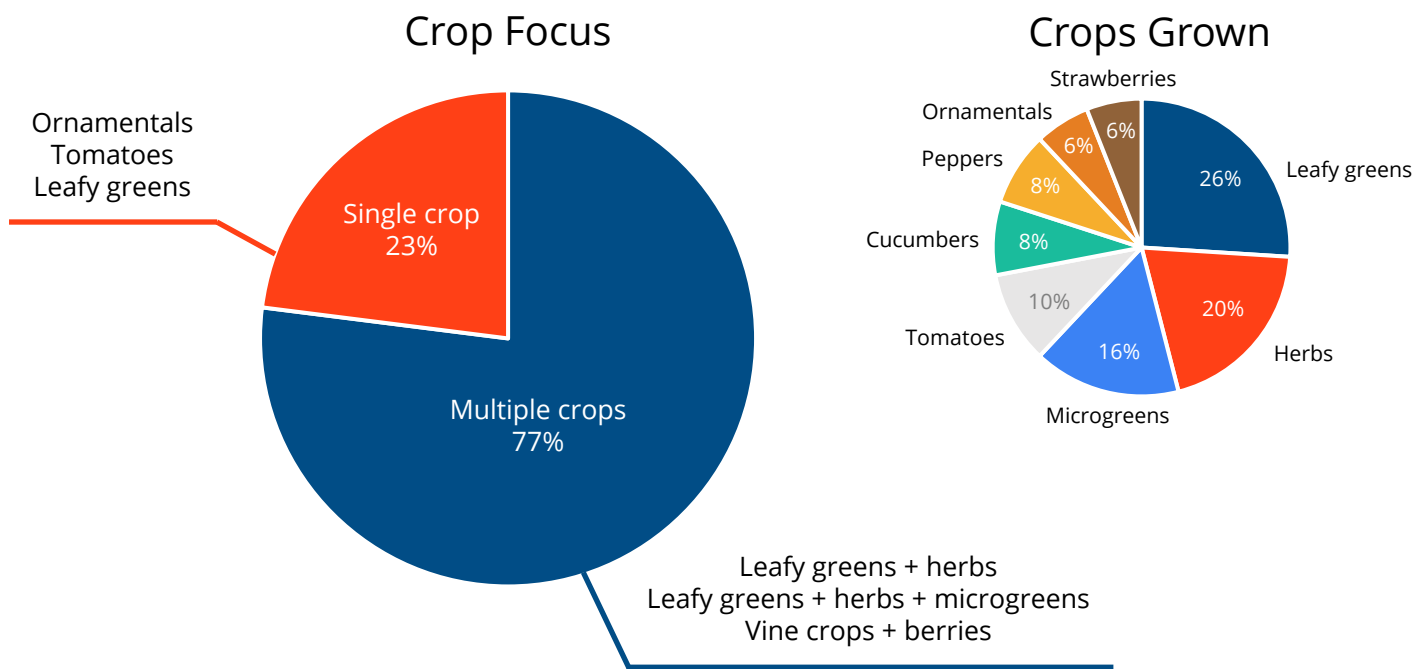


Hybrid facilities include:

- Indoor growing operation without vertical growing systems*
- Mid-tech glass/poly greenhouse with vertical growing systems*
- Greenhouse with outdoor operations*

Crops Grown

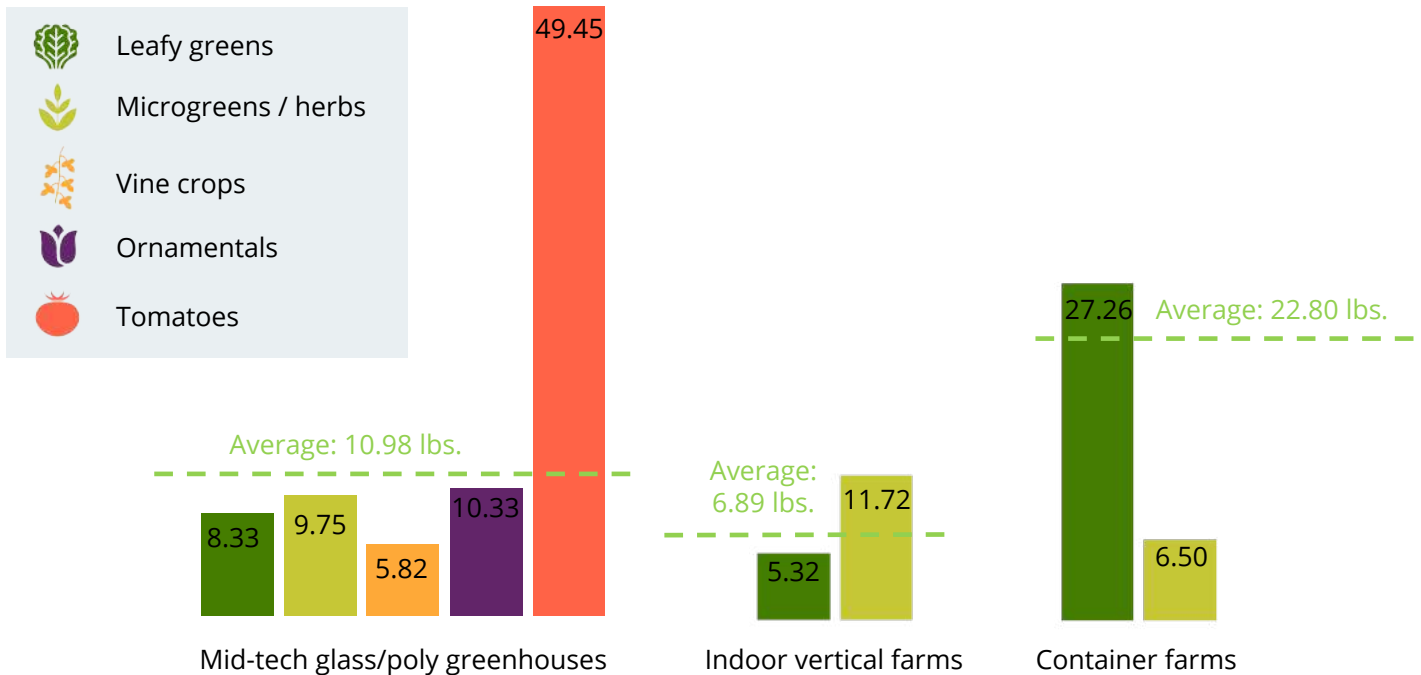
Our respondents fell into two different categories: those who grow a single crop and those who grow multiple crops.



2020 Business Snapshot

Crop Yields

Crop yields in pounds per square foot



As a point of comparison for the yields above, a small number of outdoor growers also took this survey, and their average yield was 0.77 pounds per square foot.

As we have seen in past years, the average yield of mid-tech glass/poly greenhouses outperformed that of vertical farms. This is likely due to:

Heavy crops like tomatoes skewing mid-tech glass/poly greenhouse numbers upwards as you can see in the graph above.

AND

Vertical farms generally growing varieties that are used to higher ambient light environments than indoor farms can provide. This mismatch between genetics and environment generally leads to lower productivity, which may be the case here.

The yield responses we received from container farms were higher than those published in other external data sources:

Yield range, according to public industry data:

9–20 pounds
per square foot

Average yield, according to public industry data:

14.5 pounds
per square foot

Average yield reported by container farm survey respondents:

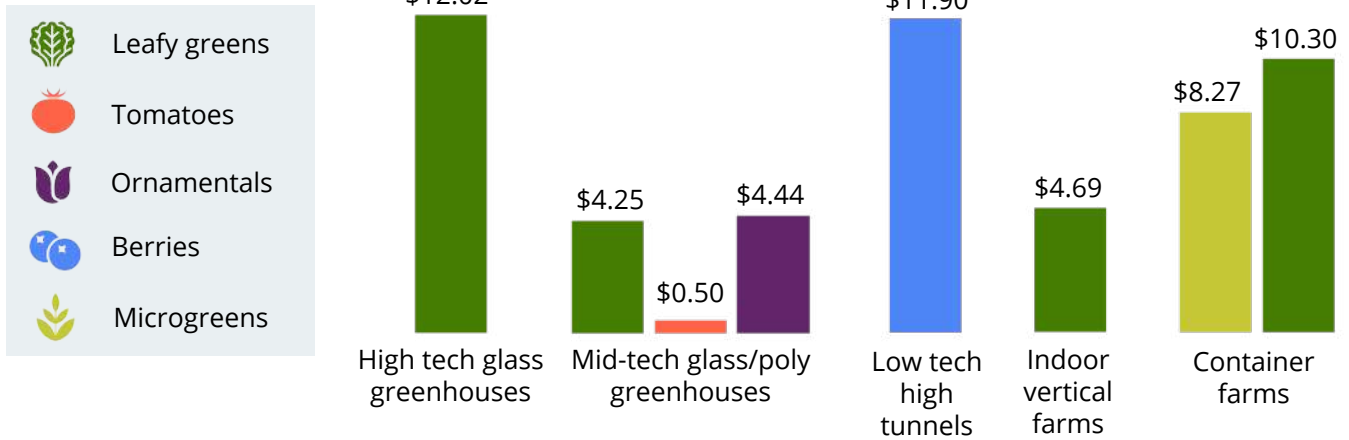
22.8 pounds
per square foot

What accounts for this discrepancy? These numbers are self-reported, so it is possible that respondents in our survey over-reported yields. It is also possible that respondents in our survey are disproportionately newer operations who experience highly fluctuating yields while they settle into their operations.



Revenue

Selected crop revenue per pound



Indoor agriculture commands more revenue per pound compared to their conventional field counterparts.

\$7.82

revenue per pound

Average revenue reported by indoor growers selling leafy greens

\$0.50

revenue per pound

Average leafy greens revenue reported by the handful of outdoor growers that responded to our survey

\$0.44

price per pound

Average lettuce price (head, leaf, and romaine) for outdoor lettuce growers in 2019, per [this USDA report](#)

This observed difference in revenue per pound may be due to the type of leafy greens being sold. Field grown greens tend to be head lettuce or high-volume bagged leafy greens, which command lower prices than the specialty, clamshell-packaged leafy greens more commonly grown by indoor producers.

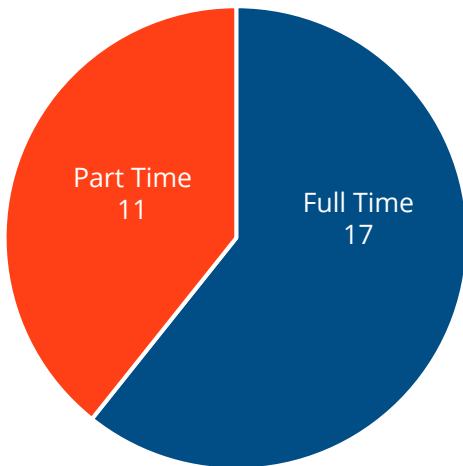
The expected revenue, of course, varies greatly not only by facility type, but also by sales channel and geography. Container farms, for example, tend to produce less volume than other facilities, and therefore choose different channels—like restaurants and retail—where they can command a higher price than by selling to wholesalers or distributors.

Expenses

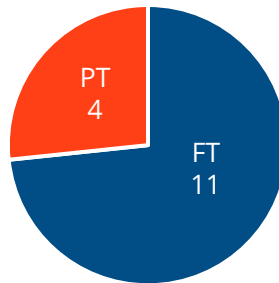
Labor

Number of employees by facility type

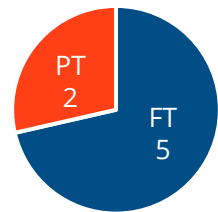
Mid-tech glass/poly greenhouses
Average # of employees: 28



Indoor vertical farms
Average # of employees: 15

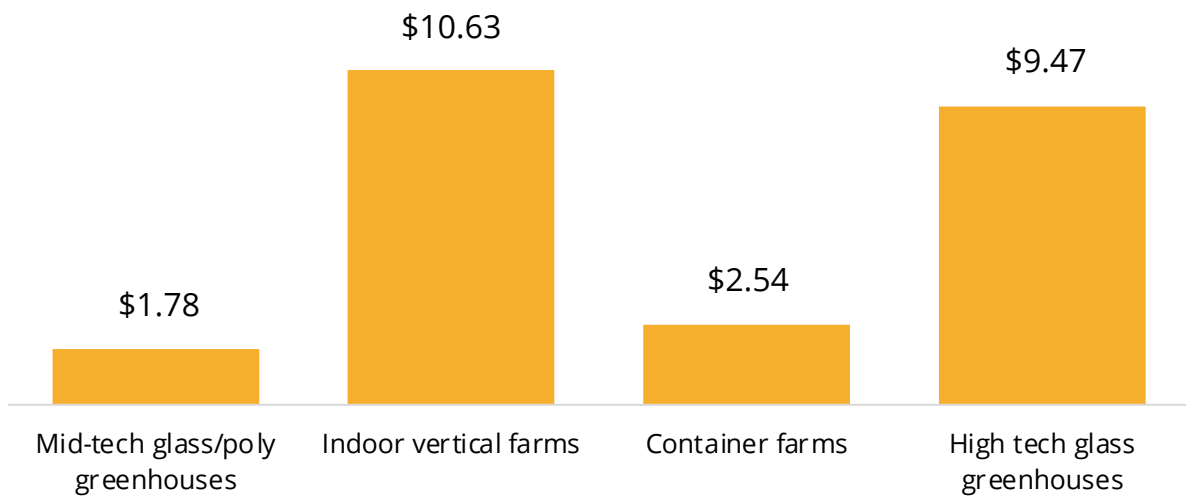


Low tech high tunnels
Average # of employees: 7



NOTE: We defined full time as >30 hours per week, which may have led some respondents to include seasonal workers in the full-time category.

Dollars per pound spent on labor



NOTE: We removed outlier data for indoor vertical farms and container farms that captured their labor costs as >\$400/lb. These operations likely added corporate overhead (for large venture-backed style organizations) to farm labor costs.

Some container farms included all employees in their labor costs, accounting for sales and marketing teams, whereas farms with a more traditional business model (likely not venture-backed) only calculated farm workers in their labor costs.

\$2.35

labor cost per pound

The average figure reported by container farms that only accounted for farm labor within this expense category, which is still higher than most other facilities

\$457

labor cost per pound

The average figure reported by container farms that included all employees in their response

\$453

labor cost per pound

The average figure reported by indoor vertical farms that similarly included all employees in their labor costs

FUTURE CONSIDERATIONS

Though we could dismiss these high labor cost numbers as outliers, it is possible that we're seeing the beginnings of a shift in business model and mindset. Could a subset of this industry be approaching their agricultural operations more in line with other businesses vs. the traditional farming model, with a focus on marketing and improving overall operations as opposed to focusing on harvesting and packing processes to drive margins? Is the venture-backed approach to indoor agriculture driving these considerations?

An interesting note about the labor force is how many different languages are spoken on indoor farms in the US and Canada:

English
64%

Spanish
12%

4%

Arabic

4%

French

4%

Thai

2%

Afrikaans

2%

Punjabi

1%

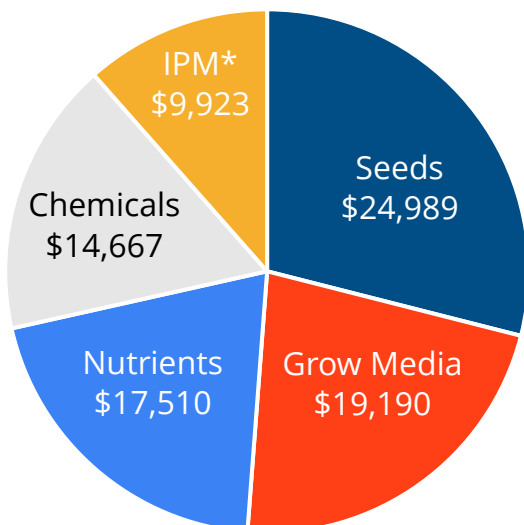
Vietnamese



Inputs

Inputs for indoor growers are one of the most significant drivers of operational cost. Unlike field agriculture, where a big spend is on chemicals and fertilizer, indoor growers have a high spend on seed, growing media, and nutrients. Like field agriculture, chemicals are also a big component of input costs at 17% of the annual input spend.

Average Annual Input Costs



Input cost per pound, by crop:

Microgreens	\$1.38
Leafy greens	\$0.47
Tomatoes	\$0.06

*IPM=Integrated Pest Management

Suppliers

There is no dominant vendor for inputs in the indoor agriculture industry yet. These inputs tend to come from smaller regional sources, or they are imported in bulk from international sources. The regional model has both pros and cons:

Con: because buyers are piecing together their purchases from a variety of systems and sources, prices may be higher without economies of scale.

Pro: the lack of a single source for inputs, and specifically for seeds, might be healthy for the agriculture ecosystem as a whole.

External innovation related to inputs for indoor agriculture operations is limited, though that is changing. [Unfold Agriculture, for example, recently spun out of Bayer](#) to focus on plant breeding specifically for indoor agriculture. [AeroFarms just announced a partnership with Hortifruit](#) to optimize blueberry and caneberry plants for indoor growing environments. [Plenty also recently announced a partnership with Driscoll's](#) to work toward indoor strawberry production.

A sampling of the places from which our respondents are buying inputs:



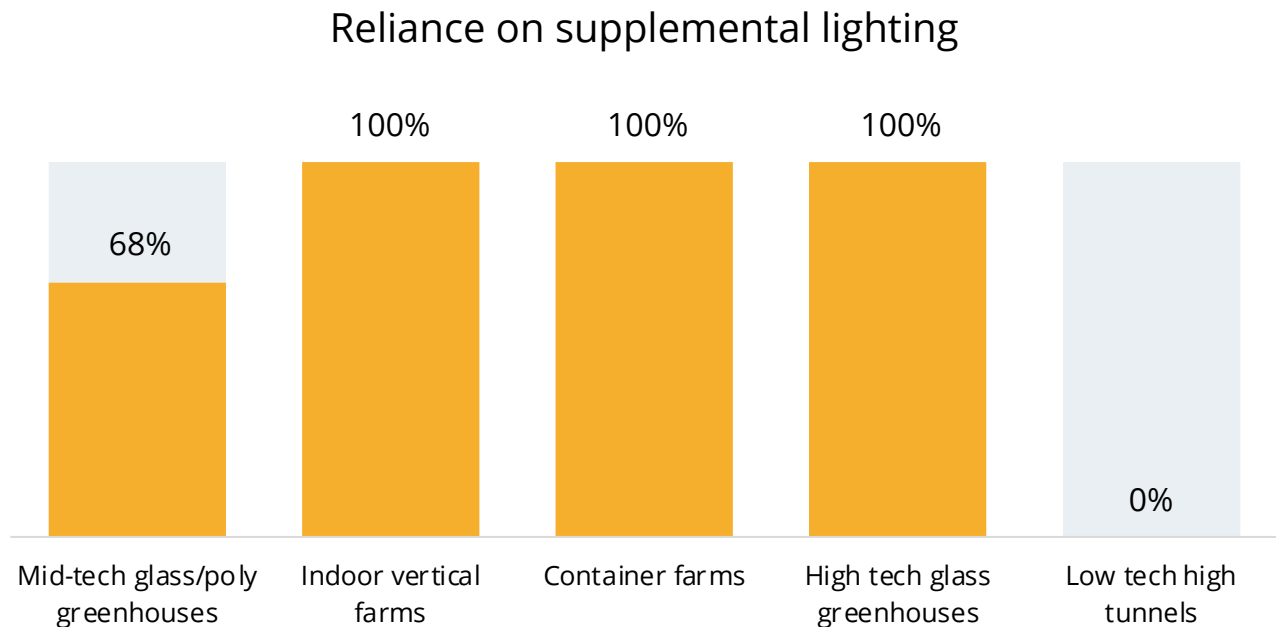
Some growers purchase in bulk from international wholesale suppliers, primarily in Portugal and Spain

FUTURE CONSIDERATIONS FOR INDOOR AG INPUTS

Will we see the same type of massive ownership consolidation in indoor agriculture sources as we've seen in conventional field agriculture? Check out [this chart](#) from Michigan State University to see just how consolidated ownership is for conventional agriculture. Or will we see innovation speed up due to startups in the space, like Farmer's Business Network, Unfold Agriculture, Indigo Agriculture, and Benson Hill? There might be an opportunity for smaller players to dominate this lucrative market.

Lighting

Supplemental lighting makes up a significant and predictable expense for most indoor agriculture facility types—though low tech high tunnels are the outlier as they rely on sunlight alone.



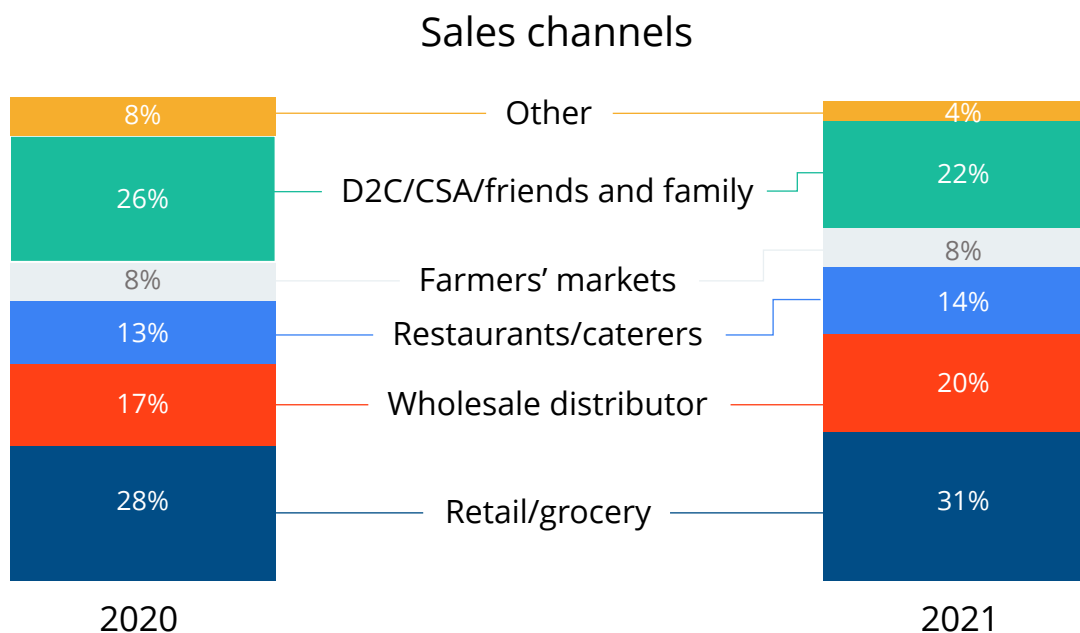
Supplemental lighting is an area of opportunity for indoor farms to make their operations more sustainable, given their heavy reliance on lighting and the amount of energy it requires. LEDs are generally seen as the greener lighting technology, given their energy efficiency and relatively long lifespan. Although LEDs are pricier up front, they cost less to operate over time.

Sales Channels

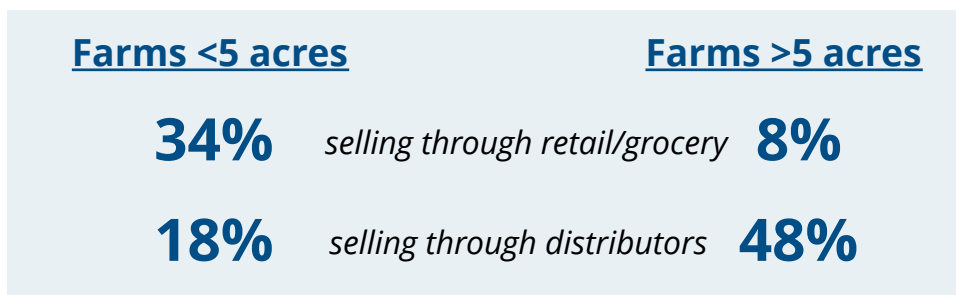
In 2020, sales channels were more heavily weighted to direct-to-consumer opportunities than they have been in years past. Our respondents indicated that the COVID-19 pandemic was the reason for this shift.

Distribution

Growers expect a percentage of sales to revert to grocery and wholesale distributors, although few respondents think sales channels in 2021 will look significantly different than 2020.

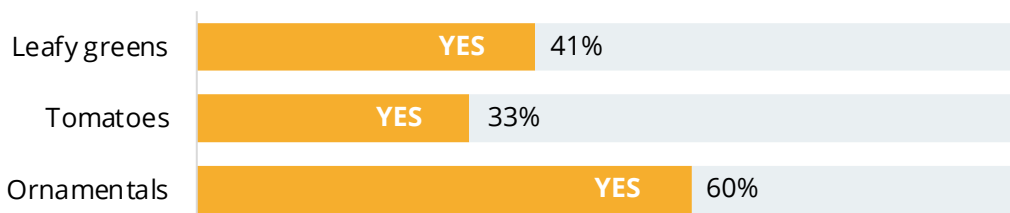


Beyond the impact of COVID-19, the size of farms also dictated their sales channel breakdown. Larger farms relied much more heavily on distributors than did smaller farms:

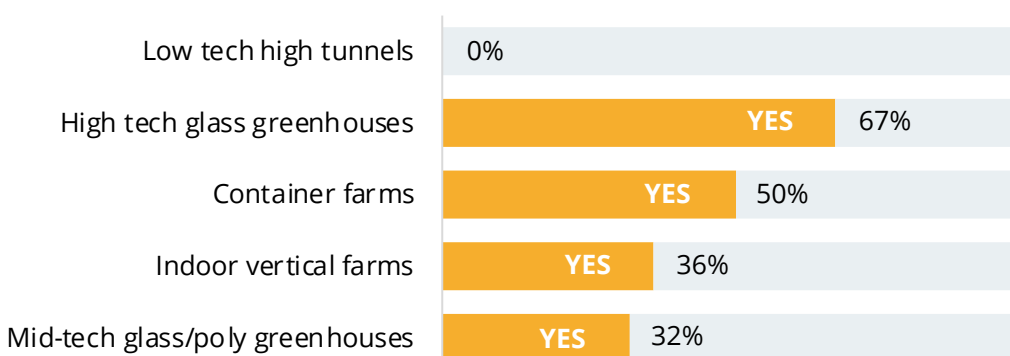


Contracts

Use of contracts by crop



Use of contracts by facility



Among farms selling to wholesale accounts, most (62%) do not work with set contracts. Contracts are controversial within the agriculture industry, since perishables must be sold quickly before they spoil, rendering farms unable to hold inventory indefinitely while looking for a buyer. In addition, prices for produce change throughout the year, so it is often to the grower's advantage to sell for the highest spot price possible without locking themselves into a lower price earlier on.

There are also advantages to contracts. Having guaranteed buyers reduces operating risk, which makes it easier for facilities to access traditional debt offerings as they look to expand. We are starting to see more producers use contracts as a result.

FUTURE CONSIDERATIONS

How will sales channels continue to evolve as new business models emerge post-pandemic? Will the direct-to-consumer trend continue, and if so, can we expect to see even fewer set contracts in the world of indoor agriculture? Or will there be an opportunity for partnerships with larger buyers as they focus on traceability and sustainability in their supply chains, leading to more contracts for growers?

Growth

Technology and Hardware

Indoor agriculture generally requires more technology than conventional field operations, and the baseline of minimum technology used has also increased over the years. This is due to the ability of indoor growers to physically control their environment and climate to produce optimal results.

Only **1%** are using pen and paper with no other devices

For daily operations, mobile devices surprisingly beat out desktops:

35% are using tablets and mobile phones

24% are using desktop computers

On the other hand, indoor agriculture seems to be lagging on the adoption of barcode scanners:

6% are using barcode scanners

When we asked respondents about their goals for implementing new technology, the clear frontrunner was to manage operations more efficiently. Lowering cost of production and increasing yield came in a distant second and third, with only half as many respondents choosing them.

1	Managing operations more efficiently	39%
2	Lowering cost of production	20%
3	Increasing yield	19%
4	Achieving better quality crops	13%
5	Interacting with customers better	6%
6	Food safety and compliance	3%

In order to accomplish these goals, our respondents are planning to implement the following technologies in the coming year:

1	Data and analytics	19%
2	Climate control system	18%
3	Labor tracking	14%
4	Cultivation management software	14%
5	Adding LEDs	14%
6	Post-harvest automation equipment	12%
7	Organic nutrients	10%

Of the technologies above, only LEDs and organic nutrients live outside the realm of managing operations more efficiently (or “automation”).

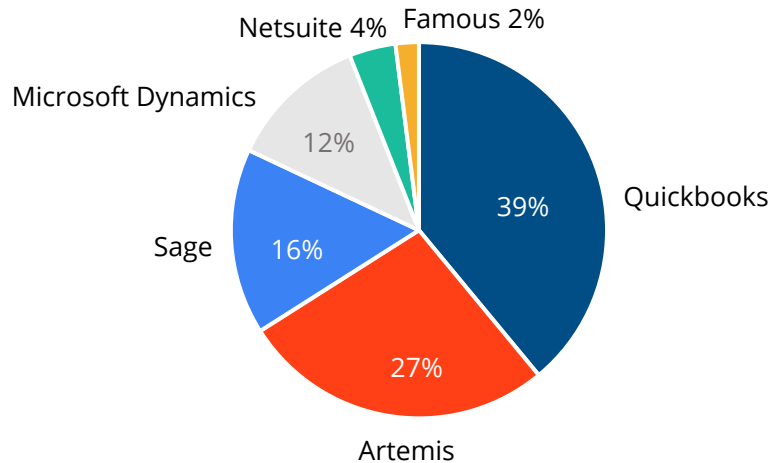
Other improvements that were mentioned but didn’t make the top 7 listed above included better growing systems, remote monitoring, and automated scales for weight measurements.

There were also some technologies that were considered overhyped or polarizing. Vertical growing systems topped that list, followed by LED lights, and container farms. Some respondents also questioned the benefits of new growing media and customer-facing QR codes, and voiced trepidation around the dangers of scaled-up indoor agriculture operations becoming the new “big ag.”



Software

We asked respondents what type of software they are currently using:



Quickbooks, Artemis, and Sage were the top three choices. There were also a handful of software platforms that we listed as a choice but that received zero selections, such as Agriware, Conservis, Granular, SBI, and Fishbowl. Note that these platforms tend to be geared towards conventional field agriculture.

We also asked respondents what the ideal fee structure is for software services. While there was a pretty even split between paid and free, the majority of respondents wanted some sort of free offering with low-touch support models, but with the option to pay for better support and training as needed.



FUTURE CONSIDERATIONS

Are we seeing an opportunity for less siloed software platforms between indoor and outdoor farming operations? Are there opportunities for collaboration between platforms or will we see consolidation in this space as well?

Expansion Plans

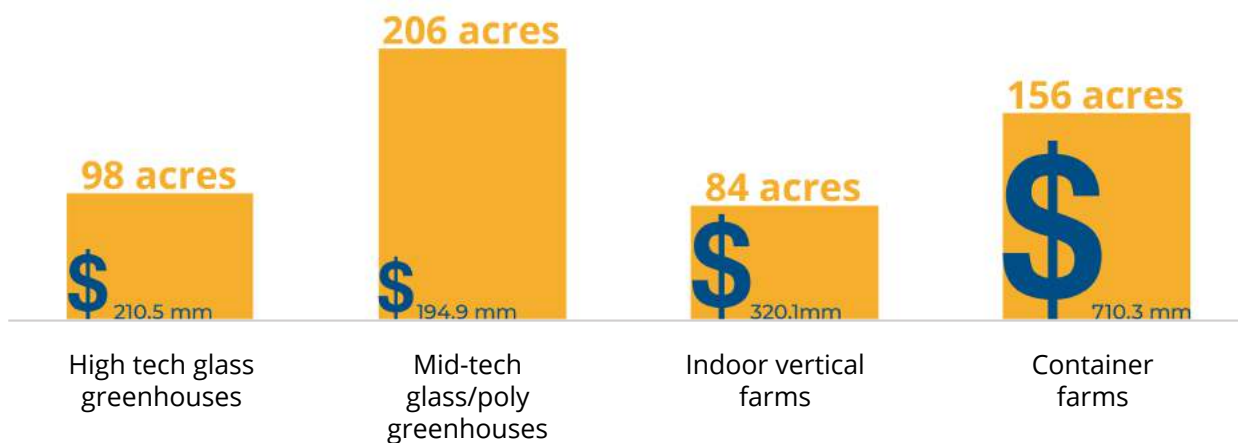
There are big expansion plans afoot for indoor farms in the next 5 years:

73% have plans to expand

The combined intended expansion is **544** total acres

Only **14%** of respondents do not plan to expand further

Planned 5-year expansion in acreage and cost



A handful of respondents indicated that part of their expansion will include packing operations, which is new from past surveys:

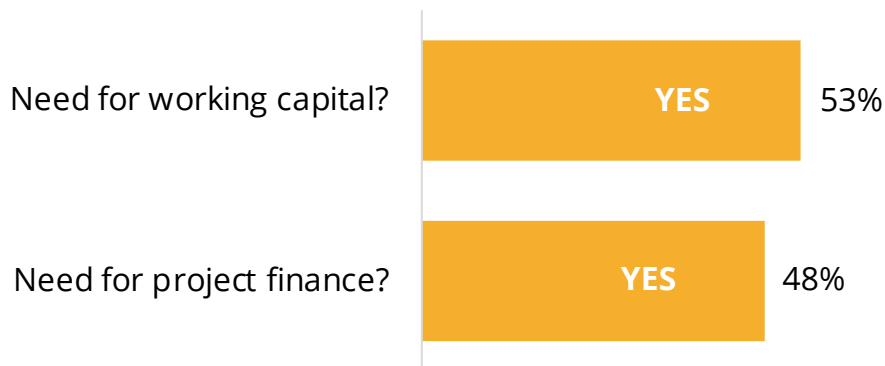
This could be due to COVID illuminating holes in the supply chain and a desire to reduce dependence on other businesses in uncertain times.



It could also be tied into respondents' aggressive growth plans—as volume picks up, the need to pack and distribute on site may become more necessary for growers.

Capital Needs

Both growth and day-to-day operations require capital. We asked respondents what their ongoing needs are for working capital, and if they have a need for project finance:



Most respondents have been turning to banks or private lending (private equity, venture capital, or private investors) for capital. There was a noticeable geographical difference in satisfaction with banks as a lending source:

Canadian growers reported going to larger banks and being happy with the rates.

Our US respondents, on the other hand, use local banks and are not happy with rates offered.

The top-rated banks included: BMO, Scotiabank, Farm Credit, Truist, ATB, and the USDA and FSA. The lower-rated lenders were RBC, rural investment funds, and local banks.

FUTURE CONSIDERATIONS

There is a big need for more debt capital in this space and an opportunity for differentiation among banks and other lenders who haven't yet won the hearts of indoor growers.

Cannabis

Cannabis is an exciting growth area— especially since more US states made recreational marijuana use legal in 2020. This heavily regulated but evolving crop is an area that will be interesting to watch.

Reported Average Yields and Revenues

0.16 pounds per sq. ft.

\$152 revenue per sq. ft.

\$739 revenue per lb.

The yield reported by cannabis facilities is much lower than indoor and outdoor non-cannabis farms, but the revenue is significantly higher. Comparatively, cannabis is an extremely high value crop.

Expansion and Capital Deployment

77% have plans to expand growing facilities in next 5 years

\$82mm slated for expansion

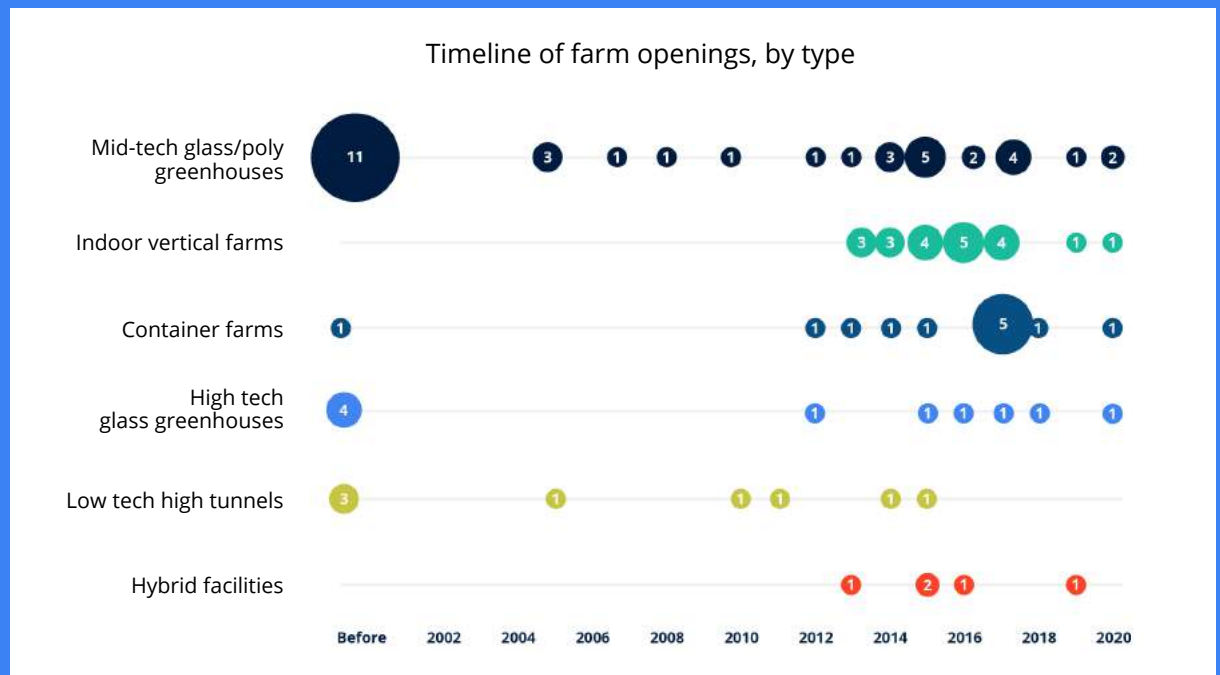
\$1.13mm cost of expansion per acre

Contracts

33% produce with set contracts

Strict regulations may be one reason for more cannabis growers to have contracts in place with their end buyers compared to non-cannabis growers.

The pace at which technology-enabled indoor growing facilities (including high tech glass and mid-tech glass/poly greenhouses, indoor vertical farms, and container farms) are opening has been consistent for the last 8 years. We expect to see this trend continue as technology to optimize indoor farming operations grows more sophisticated.



2021 and Beyond

In 2020, we learned that leaders in indoor agriculture have lofty goals for the future, as well as some big hurdles to overcome.

When we asked what growers' number one goal was for 2021, every answer fell into one of four buckets:

Financial optimization: achieve profitability, increase sales, decrease costs

Expansion: open new locations, increase on-site capacity, raise capital for expansion

Grow high quality products

COVID-related recovery: healthy staff, return to normal sales channels

We also asked about the biggest challenge growers face when operating their farms. The responses below are ranked from most to least challenging based on the number of respondents who chose each one as their top priority:

Indoor Farms

- *Access to working capital*
- *Sales*
- *Managing and hiring labor*
- *Reducing operating costs*
- *Food safety and compliance*
- *Lack of technology*

Cannabis Growers

- *Managing and hiring labor*
- *Access to working capital*
- *Reducing operating costs*
- *Food safety or regulatory concerns*
- *Sales*
- *Lack of technology*

There are a lot of similarities between these two groups and what they consider their biggest operational challenges. It is interesting to note, however, that sales is significantly less of a concern to cannabis growers.

The spread among respondents was wide when we asked about annual budgets for on-farm innovation. Answers for non-cannabis indoor farms ranged from \$100 to \$250,000, with the average budget landing at \$31,208. With the types of technology needed for indoor growing and general operational management, that budget won't stretch very far.

Cannabis, on the other hand, appears to be more tech-heavy and more inclined to spend on technology needs. The average annual budget for on-farm innovation for this group was \$341,667, which amounts to \$2.38 per square foot.



FINAL CONSIDERATIONS

Indoor farming as a concept is an inherently novel approach to growing food and feeding communities. Can the industry tap into its innovative roots to re-evaluate the importance of investing today in technology and software that will carry the industry into tomorrow? Do some of our outlier respondents represent the beginnings of a reinvented business model that focuses on the company or business as a whole—from field to office—as contributing to crop output? Technology is not an end in itself, but a means to achieve other goals.

If you have any questions or wish to continue the conversation, feel free to reach out to Artemis and/or Startle. Your enthusiasm for indoor farming, where it stands today, how it may evolve, and how it may impact our larger food system motivates all of us to do the best work possible in our respective fields.

Appendix



Anonymous

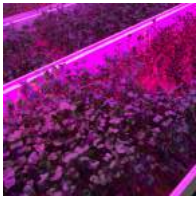
Page 3



Nebullam, Inc.

<https://www.nebullam.com>

Page 6



Sweet Peas Urban Gardens, LLC

www.sweetpeasurbangardens.com

Page 8



Swanky Roots, Inc.

www.swankyroots.com

Page 12



GROWx

www.growx.co

Page 18



Gull Valley Greenhouses Ltd

www.gullvalley.ca

Page 24



Polar Permaculture Solutions, AS

<http://www.polarpermaculture.com>

Page 25

With heartfelt thanks to all of the respondents who shared photographs and/or took time out of their busy schedules to participate in this survey.

