

# 2019 Global CEA Census

---

*Autogrow* ®

 AGRITECTURE  
CONSULTING



The vision for the Food and Agriculture Organization (FAO) of the United Nations is “a world free from hunger and malnutrition, where food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner”.

Autogrow and Agritecture support FAO’s vision and see Controlled Environment Agriculture (CEA) as a key component in achieving that ideal.



## Disclaimer

The 2019 Global CEA Census is a joint project of Agritecture LLC and Autogrow. Both parties have done their best effort to encourage participation in the Census among CEA farm operators globally. That said, all participation in the Census was voluntary and none of the information submitted by Census respondents has been verified by any independent sources.

We (Autogrow & Agritecture) are not responsible for the accuracy of the data in the report since it has not been independently verified. We encourage any organization to conduct proper due diligence before making any critical decisions for you or your business.

# Contents.

Thank you and takeaways .....	5
About the Census .....	7
The Definitions .....	8
The Farmers .....	11
The Farms .....	20
Funding & Financials .....	35
Adoption of Technology .....	46
Conclusion .....	50
Acknowledgements .....	52

# Thank you & takeaways.

We would like to thank all those who took part in the Global CEA Census and those taking the time to read this report. We would also like to thank the media and industry partners that helped promote participation in the Census.

It was a great learning experience for both Agritecture and Autogrow and while we consider the Census to have been a huge success for the first year, there are certainly improvements to be made for the future.

The goal of the Census was to get a pulse of what is happening in the CEA industry around the world today. We hear the constant buzz about the newest technologies being developed and the latest farms that are rolling out, but there is very little actual documentation of what is happening. The main goal of the Census was to address this issue.

The following are important takeaways that we hope all readers will consider when interpreting the results in this report.

---

## Takeaway #1: Value in trends.

The participation in the first Global CEA Census was amazing. 316 responses were received from CEA operators in more than 50 countries. With this huge variety of operations and locations, extracting and interpreting data points across international boundaries and different economies, is more challenging and less meaningful. For that reason we designed the Census Report to be more about subjects and trends and less about specific data points. Additionally, participation in the Census was voluntary and without full participation, a data set is not fully representative. Thus, this report highlights the trends that the authors feel are particularly relevant to the industry now and moving forward.

---

## Takeaway #2: We could have done better.

While we believe that the Global CEA Census was a smashing success, we realize that we could have done better. Some of the improvements could have been in the design/wording of the questions and the answer options. One specific question where this is relevant was regarding the gender of the operations founder. The results showed an overwhelmingly high percentage of male founders in the CEA industry. While this may be true, the design of our question left out the opportunity for operations with multiple founders to answer this question and the authors hypothesize that offering this option might have registered a higher level of participation based on female co-founders that might not have been mentioned. The Census was also influenced by the channels used to promote engagement with social media playing a strong role. While we know there are more greenhouse growers in the market, this has not been reflected in the results.

---

## Takeaway #3: A snapshot in time.

The Census was conducted June 4 - July 22, 2019. Operators answered the Census based on their feelings and situation at the particular moment in time. As industry members know and as you will see in the results, the industry is almost “brand new” and a huge percentage of CEA operations that participated in the Census were started in the last few years. Businesses are almost guaranteed to not make a profit during their first few years while they reinvest or set up their structure. Some of these businesses may fail, but many will likely succeed and opinions expressed in the Census may be significantly different 6, 12 or 18 months from now.

# About the Census.

## 7 WEEKS

---

The Census ran from 4 June to 22 July 2019. It was promoted through Twitter, LinkedIn, Facebook, Instagram and various online media and industry channels.

## 45 QUESTIONS

---

The Census asked questions about the farms, farm management, operations, marketing, pain points and more. Any questions where the sample size was too small, we have not included in this report.

## 54 COUNTRIES

---

Respondents were from all over the world with the largest percentage from the United States, India, Belgium and South Africa.

## 316 RESPONDENTS

---

Operations ranged from small businesses with revenue under USD10,000 to large with more than 100 employees with annual revenue exceeding USD10,000,000.

## The Definitions

The Controlled Environment Agriculture (CEA) industry is still refining its own identity. For the purposes of this report we are using the following definitions:

**CEA** is the growing of crops while controlling certain aspects of the environment including lighting, temperature, humidity, irrigation, fertigation and other factors that influence plant physiological responses.

**GREENHOUSE** refers to a climate-regulated structure with walls and roof made out of a transparent material in which crops are grown.

**ROOFTOP GREENHOUSE** refers to greenhouse located on top of another building.

**SHIPPING CONTAINER** refers to a climate-regulated shipping container using only supplemental lighting (no sunlight) for crop production.

**HIGH TUNNEL** refers to crops covered with a canopy for protection against the elements and sometimes referred to as hoop houses or tunnel houses (not small backyard hobby tunnels).

**INDOOR FARM** refers to crop production that utilizes artificial lighting instead of sunlight. This can include rooms, warehouses, factories and other converted indoor spaces.

**VERTICAL FARMING** is crop production that uses the vertical space. Plants can be stacked horizontally or in tall towers.

## The Report

For this report we have chosen to incorporate other research undertaken by external sources that can give further context to what is a complex industry. All additional sources have been cited at the end of the report.

# Snapshot 2019.

316 people responded to the survey. Of those **43** started their business this year, these are their numbers:



**19% received funding** (50% from corporate investors). 16% applied but were not successful. 65% did not pursue funding.



**65% of companies are currently pre-revenue stage** (the maximum revenue for this group is USD\$250-500K).



**16% are currently pre-profit.** 19% are breaking even, 26% profitable, 39% declined to state.



**46% of the founders had no experience at all in agriculture.** 44% of those founders were between 21-30 years of age.



**77% male founders** 23% female founders.



**21% of those companies based in the United States.**



**65% grow salad greens and microgreens.**



**61% in indoor vertical farms.**  
**32% in greenhouses.**



**90% plan to increase their production area.**

## Top Three Challenges Were:

1

Raising capital funds

2

Maximising profit & sales

3

Automation to increase efficiency

# Snapshot 2014.

316 people responded to the survey. Of those **17** started their business five years ago, these are their numbers:



**28% received funding** (50% from corporate investors). 28% applied but were not successful. 44% did not pursue funding.



**16% of companies are currently pre-revenue stage** (the maximum revenue for this group is USD\$250-500K).



**8% are currently pre-profit** 25% are breaking even, 42% profitable, 25% declined to state.



**29% of the founders had no experience at all in agriculture.** 20% of those founders were between 21-30 years of age.



**>95% male founders.**



**47% of those companies based in the United States.**



**80% grow salad greens and microgreens.**



**30% in indoor vertical farms.  
50% in greenhouses.**



**75% plan to increase their production area.**

## Top Three Challenges Were:

1

Finding the right customer base

2

Raising capital funds

3

Maximizing efficiency in small farming spaces

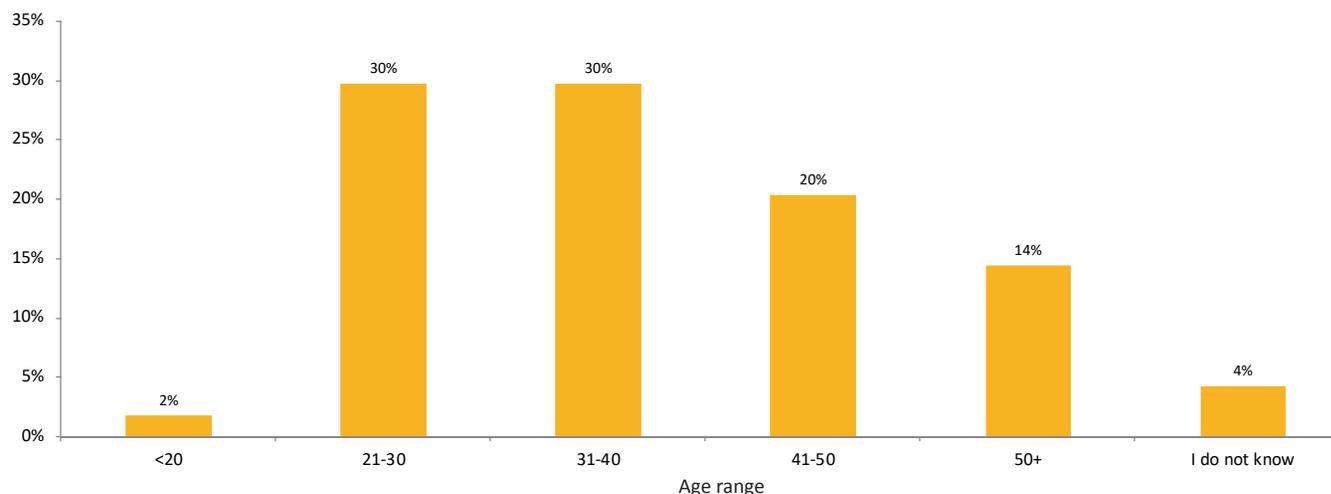


# The Farmers.

PHOTO: Maungatapere Berries,  
New Zealand

# CEA is bucking the aging trend.

Age of the founder when starting the company



CEA operations, across all types, reported that 60% of founders were under 40 years old at the time of starting their business. This is in conjunction with approximately 70% of respondents starting their business in the last five years.

Industry research shows there is a global problem with the aging of farmers. In the U.S. specifically, the percentage of older farmers has increased over the past 30 years. As of 2012, farmers over the age of 55 accounted for approximately 60% of the farming population. Younger farmers, those under 44 years old, accounted for less than 20% of the farming population.<sup>1</sup>

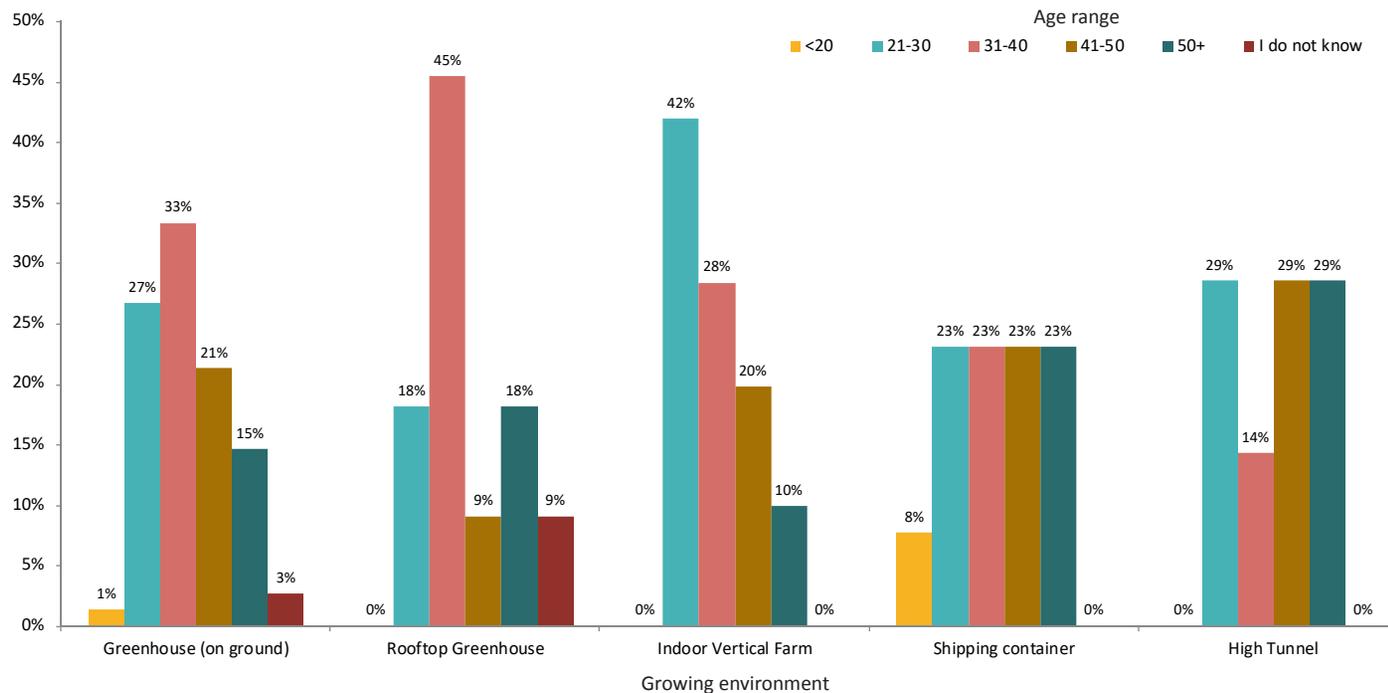
The same phenomenon is seen in countries like Canada. In 2016, the average age of the Canadian farmer was 55 years old, while farmers under 35 years of age accounted for only 9.1% of total farm operators.<sup>2</sup> This increase in average farming age becomes even more apparent when taking into account other regions- Japan: 67.<sup>3</sup> Australia: 56.<sup>4</sup> China: 51.<sup>5</sup> Brazil: 50.<sup>6</sup> Africa as a whole: 60.<sup>7</sup>

Founders of Indoor Vertical Farms, on the other hand, show a higher rate of representation by individuals

under the age of 30. There's no conclusive reason for this; however, anecdotal evidence suggests that vertical farms are considered to be the easiest to monitor and control and technology is easier to integrate. Studies have shown that younger individuals across the world have a much higher exposure rate to technology than older individuals and this is likely one reason younger growers are more tied to vertical farming.

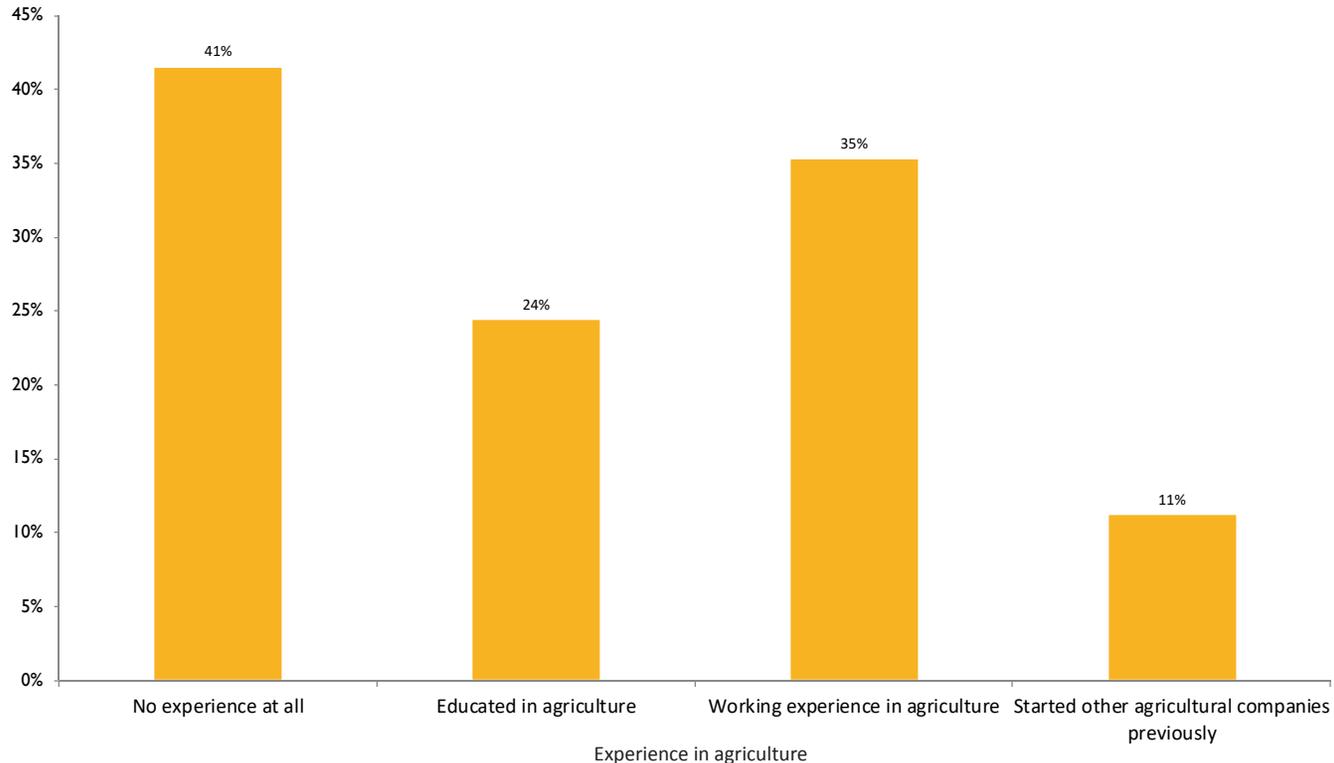
In addition, the majority of the world's population, especially young people, have moved to cities. The United Nations reports that 55% of the global population currently lives in urban areas. This is expected to increase to 68% in 30 years.<sup>8</sup> Due to generally higher land and property expenses in cities, vertical farming is often the most viable option in urban environments, making it the logical choice for young urban dwellers interested in agriculture.

### The founder's age when starting the company — by growing environment



# No experience necessary?

The founder's experience in agriculture before starting the company



*NOTE: Respondents could select multiple answers.*

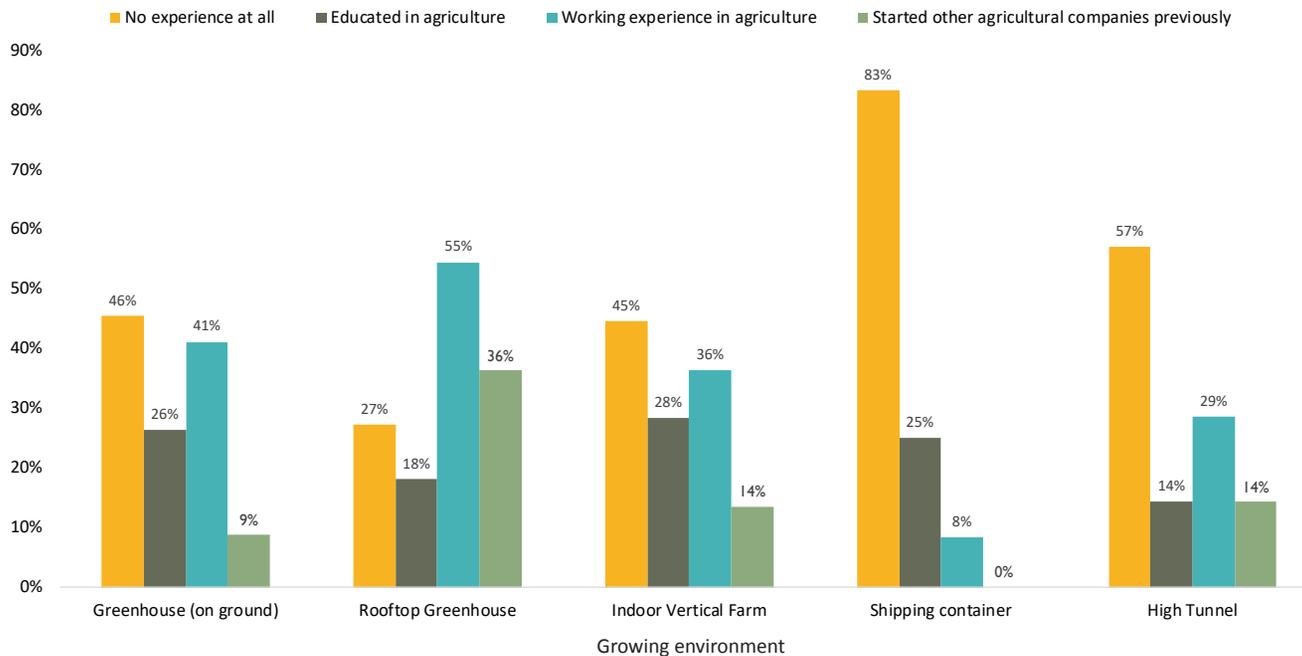
One surprising result of the Census is that 41% of respondents had no experience in agriculture prior to starting their current CEA operation.

When looking at the different types of CEA operations, container farms and high tunnels stand out as being largely begun by founders without experience. This could be due to the fact that these two environments

are the two lowest cost entry points for a CEA operation. Additionally, many container farms are advertised as being easy to use, plug and play systems, which is a quality that would appeal to those without agricultural experience.

However, studies show that the relationship between education and profitability is strongly positive, particularly in modernizing agricultural systems.<sup>9</sup> Education has been known to influence openness to adapting to new market opportunities, the size and influence of networks,<sup>10</sup> and ultimate success of the company.

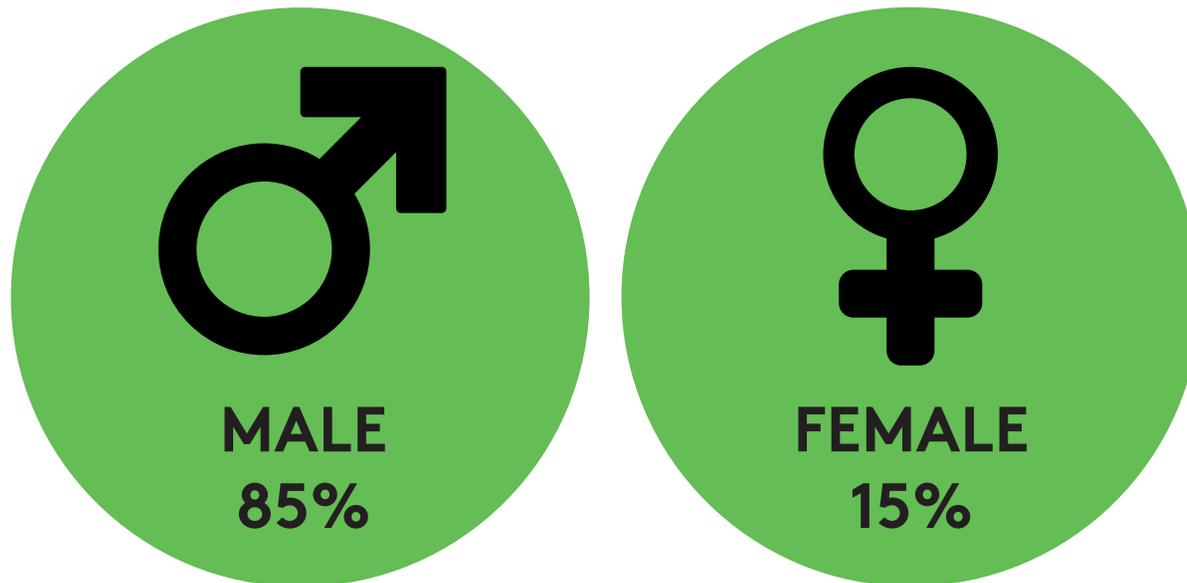
### The founder's experience in agriculture before starting the company — by growing environment



# Significant opportunities exist for women in agriculture.

Unsurprisingly, the Census reported that an overwhelming majority, 85% of founders, are male. However, despite low female representation among CEA operations, women-founded operations were located in all regions of the world.

The implications of this gender gap in agriculture has been discussed through various studies. One recent study, however, showed that men who are the sole decision makers tend to take greater risks, including adopting new technologies, changing land use, and intensity or experimentation. This effect is also heightened when paired with exposure to higher levels of education.<sup>11</sup>





## Joyce Hunter

CEO Vulcan Enterprises and  
previous Deputy CIO, Policy and Planning USDA.

---

**The global Census showed that 85% of CEA operations are founded by men and only 15% founded by women. What do you feel could be done to encourage more women to be involved in the industry in your country?**

“There exists an underlying issue that is keeping women from being even more impactful — difficulty finding funding. Women-owned businesses receive just 7 percent of venture capital investment money, which is highly disproportionate to their role in the economy. Additionally, loan approval rates for female entrepreneurs is 15 to 20 percent less than it is for men. Access to capital is crucial to any small business’s growth trajectory.”



## Namita Gurudas

Business Development Manager, AgroTIE  
Bangalore, India

---

“Controlled environment agriculture is a growing concept in India. In order to support this growth, there is a higher need for knowledge transfer from experts in this industry to entrepreneurs. I have noticed that a large percentage of farms have women running operations. However, there is a lack of training provided directly to these women. It is usually the men who serve as their supervisor and hence, receive training. Therefore, training programs on operational aspects as well as management skills that are women oriented will encourage the involvement of women in this sector.

As a young female entrepreneur, although there is a lot of appreciation and support, there are instances when potential partners and consultants don't welcome innovative ideas and keep an open mind to non-traditional methods. With that said, communications over time and a collaborative mindset paves the way for a solutions-oriented discussion.

Despite these challenges, our organization has a young and enthusiastic team led by highly talented women who are striving to break barriers and develop new norms for the industry.”

# The current top three challenges noted by growers.

---

## 1. Labor

This includes skills, the ability to work with new technology, the availability of workers and the overall cost of labor.

Some growers have undertaken the following solutions:

- Workshops to spread awareness of hydroponics and potential training courses ranging from a week to three months
  - Consumer marketing to generate interest in farming
  - Reducing costs to offset the high labor expenditure
  - Looking at new software solutions to balance out lack of skilled workers
  - Introducing automation to bring down the cost of labor.
- 

## 2. Funding

Some growers have undertaken the following solutions:

- Scaling projects down to fit existing financial availability
  - Partnering with research institutes or universities
  - Approaching other businesses to assist with set up and development.
  - Considering private investment for equity.
- 

## 3. Scaling or expanding the business

This included availability of land, finance to scale, technology

Some growers have undertaken the following solutions:

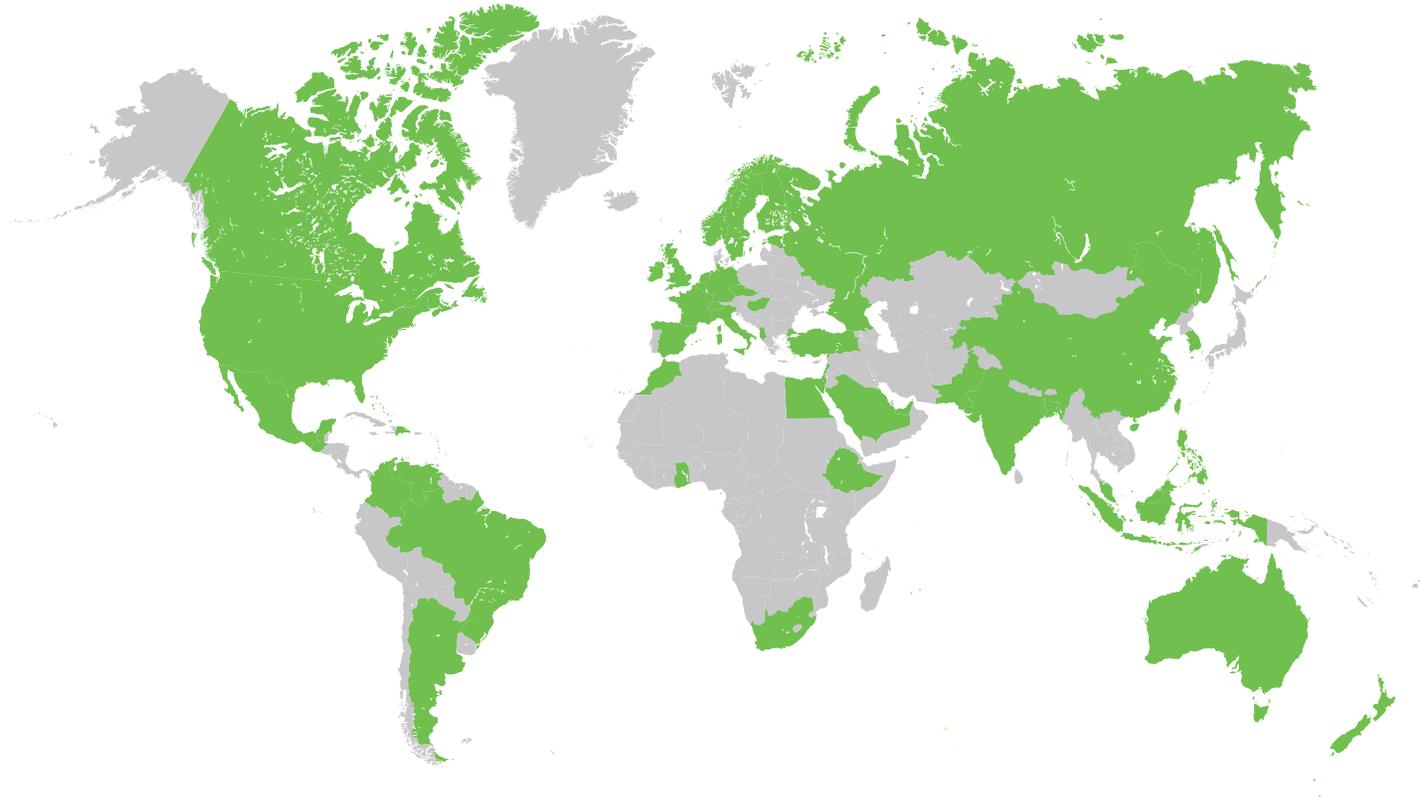
- Managing steadier and more controlled growth rates for greater appeal to investors
- Partnering with restaurants or suppliers
- Direct sales to consumers
- Increasing advertising.



# The Farms.

PHOTO: Schuyler Greens,  
Virginia, U.S.A.

# Where in the world are our farms?



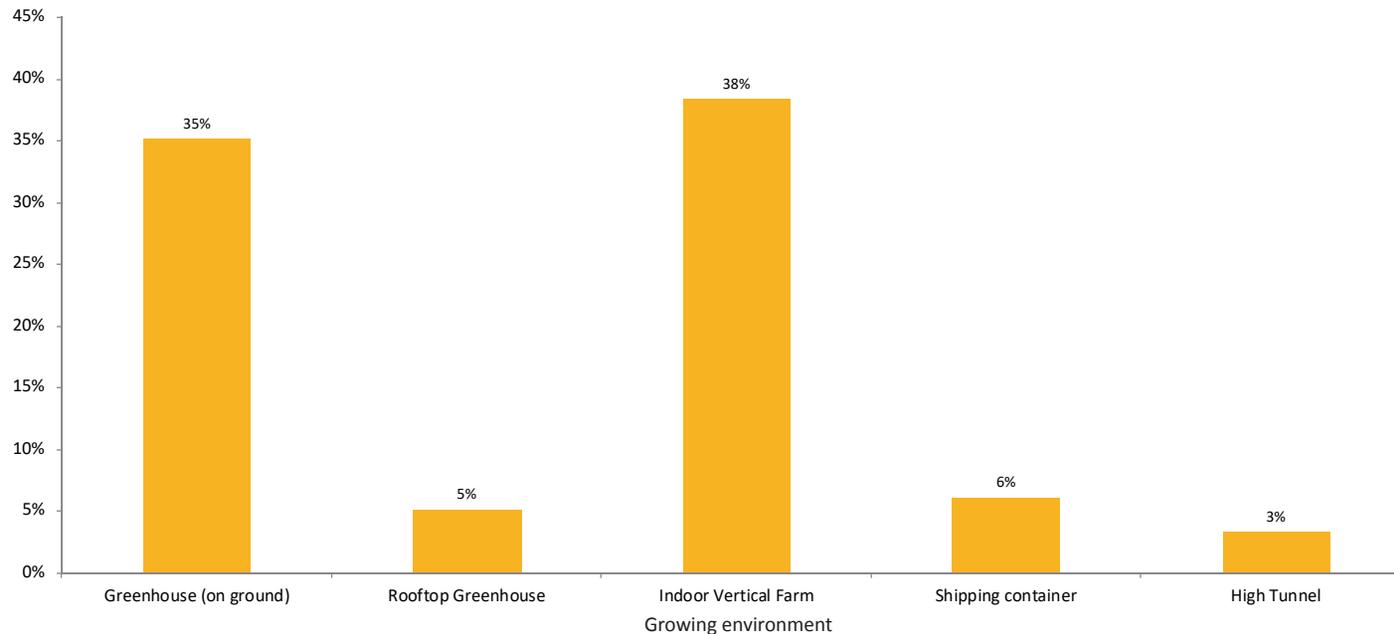
Respondents from 54 countries took part in the Census with the majority coming from the United States, India, Belgium and South Africa.

Globally, there is little consistent data available on growers regarding farm size, crops and facility type.

These differences make it almost impossible to get accurate data regarding the nature of the industry on a global scale. Those countries where a census is undertaken by government departments have the most accurate figures, however the information is not always made available.

# What type of facility is used for cultivation?

Growing environment used for cultivation



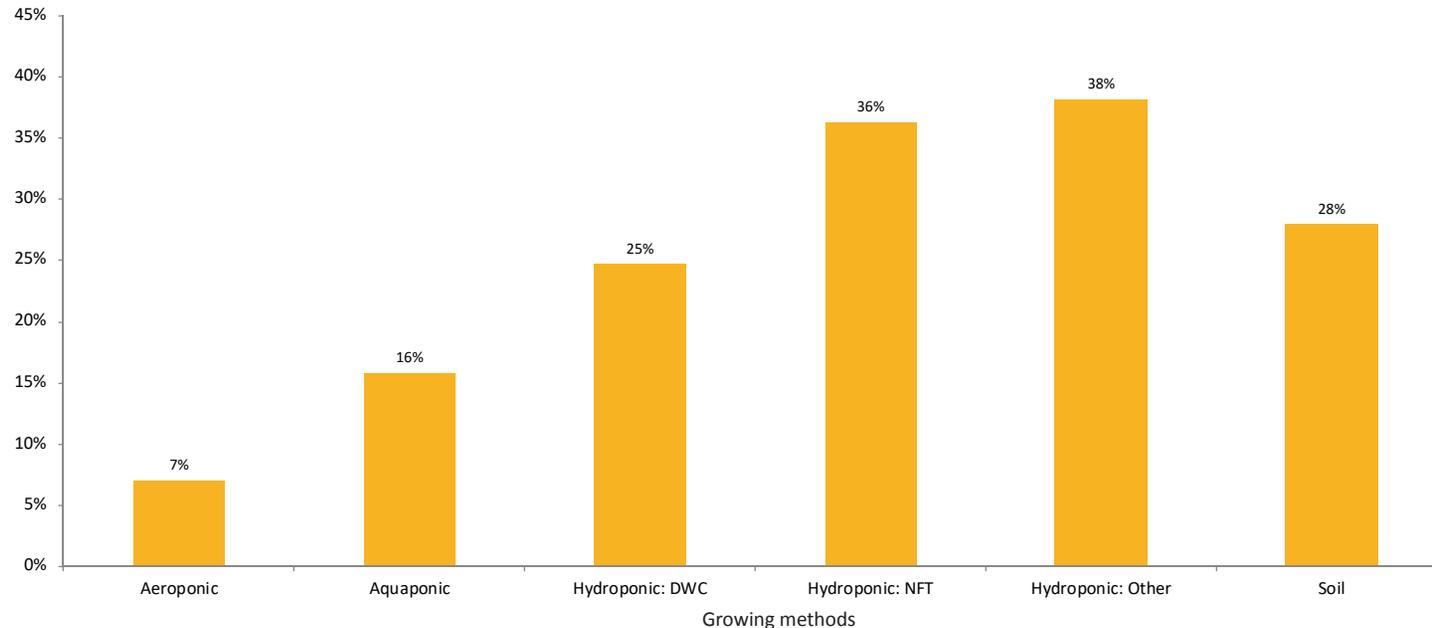
The most common facility types among Census participants were vertical farms, closely followed by on ground greenhouses. While outside sources show that on ground greenhouses greatly outnumber indoor farms globally, these results suggest that indoor growers are more likely to utilize digital communication channels. For this reason, they appear to be more aligned with the goals of the CEA Census.

Another point to note is that there is no common definition across the industry for the term “greenhouse”. In the Netherlands, it is defined as a “glass enclosed structure”. In Canada, it is referred to as a structure “under glass, plastic or other protection”. Under the latest government definition in the United States, it is “any production under cover”. Even lath, shade cloth or temporary high tunnels fall under this definition.<sup>12</sup>

# What growing methods are used?

When analyzing the growing methods used in different CEA environments, we saw some interesting results.

Overall, growers used the following methods:



*NOTE: There is some overlap above as 44% of farmers indicated they use multiple growing methods.*

The Census revealed that while almost 56% of operators use a single cultivation method, 44% use more than one cultivation system. What explains this high rate of choosing to operate multiple system types? CEA operators often realize that some crops perform better in one cultivation system than another. Or, some growers will simply want to experiment to see how a particular crop performs in a different system - and with so much new equipment and technology entering the CEA market, farmers have never had more optionality to do so. Previously, farm operators only had one option- soil. Now, operators have all the options shown above as well as a myriad of hybrid systems that many are developing.

**Aeroponics:** This is the least common system in all CEA environments. There are several factors that could be behind this. First, aeroponic systems are more fragile and require the strongest “backup infrastructure” among all cultivation types. Second, aeroponic systems are the most expensive to set up; because many Census respondents signaled that “access to capital” was one of their main challenges, this is likely one factor that pushed founders to choose a lower cost system. Finally, Census respondents show a strong indication that their customer base is interested in organic products. Due to the fact that aeroponic systems are generally not permitted in organic production systems, operators may have been driven away from using them.

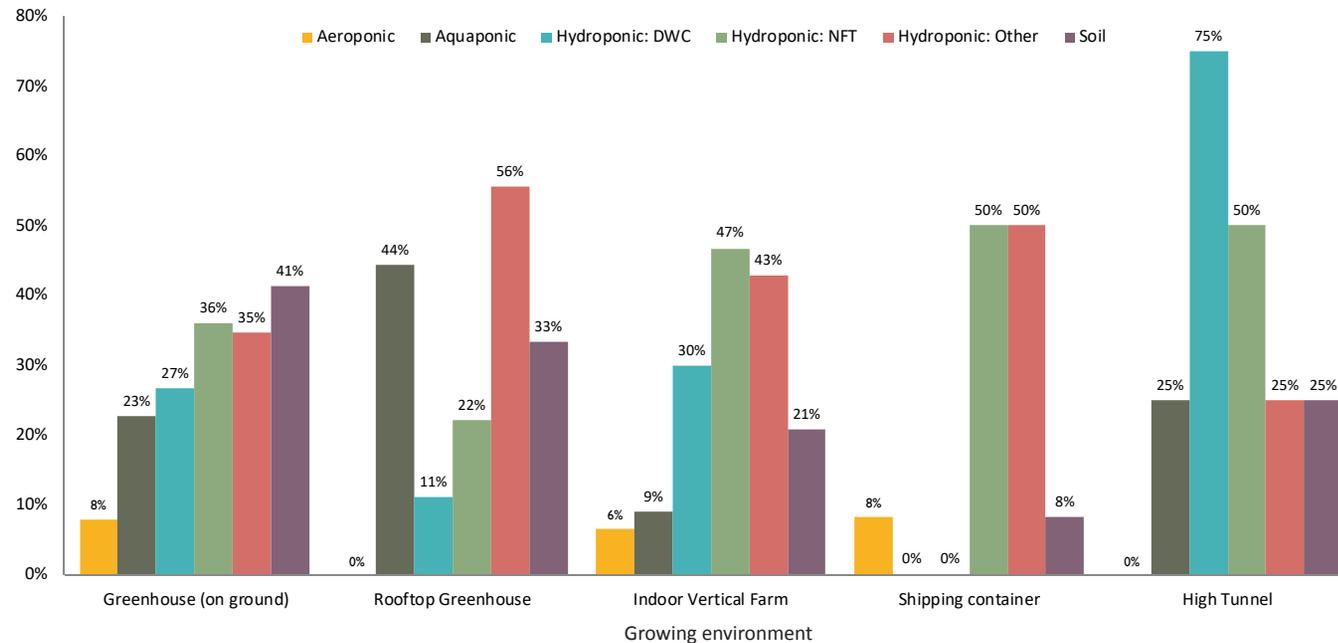
*NOTE: Aeroponic systems and organic production varies by country. Additionally, aeroponic systems have compatibility issues with organic nutrients and substrate which also make the marriage of these two systems more challenging.*

**Soil:** The Census showed that 28% of respondents grow in soil. Additionally, it is a common medium in greenhouses and high tunnels. It is the “least fragile” method of cultivation, in the sense that soil provides the largest buffer to change and allows plants to survive the longest without attention. Soil was largely absent as a cultivation media in Vertical Farms and Shipping Containers. This makes sense, since traditional soil would be extremely difficult to manage in the warm, humid environments found in these operations. Engineered soil would be a more appropriate choice if a soil-like system was preferred.

**Aquaponics:** This method of production is growing in popularity as wild fish stocks continue to be depleted worldwide and farmed fish becomes a larger percentage of the world market. According to a 2010 UN Report, “80 percent of the world’s fish stocks for which assessment information is available are reported as fully exploited or overexploited.”<sup>13</sup>

**Hydroponic:** Hydroponics was split into 3 categories- DWC (deep water culture), NFT (nutrient film technique) and “other”. Based on comments received by Census respondents, “other” consisted of ebb & flow (flood & drain) systems and numerous hybrid system types.

### Growing method used by operation



*NOTE: There is some overlap above as 44% of farmers indicated they use multiple growing methods.*

# What crops are being grown.

The respondents from the Census produce a range of crops including:

**61%**

**Salad greens**  
(Lettuce, salad mix, spring mix, arugula, etc)

**51%**

**Microgreens**

**49%**

**Herbs**  
(Cut or live: mint, oregano, rosemary, etc)

**45%**

**Other leafy greens**  
(Chard, kale, cabbage, etc)

**25%**

**Vine vegetables**  
(Tomatoes, cucumbers, peppers, etc)

**17%**

**Berries**  
(Raspberries, Blueberries, Strawberries, etc)

**12%**

**Root vegetables**  
(Carrots, radishes, beets, kohlrabi, etc)

**12%**

**Ornamental plants**

**10%**

**Nursery starts**

**10%**

**Broccoli or Cauliflower**

**9%**

**Cannabis**

**8%**

**Squashes or gourds**  
(Zucchini, pumpkin, etc)

**7%**

**Mushrooms**

**7%**

**Tree Fruits**  
(Apples, pears, peaches, nectarines, cherries, etc)

**6%**

**Root Starch vegetables**  
(Potatoes, yams, sweet potatoes, etc)

**6%**

**Melons**  
(Cantaloupe, watermelon, etc)

**3%**

**Tree nuts**  
(Almonds, pistachios, walnuts, etc)

## Diverse crop types in CEA

Surprisingly, the diversity of crops being grown in CEA facilities is almost as broad as that of outdoor agriculture. A majority of growers are still focusing on leafy greens (herbs, salad greens & microgreens) due to their quick crop cycles and high percentage of harvestable biomass. The Census did, however, bring awareness to many “unusual” crops being grown in CEA environments such as tree crops.

While tree crops are almost entirely grown outdoors throughout the world, operators are beginning to cultivate dwarf varieties in CEA environments. Greenhouses are the most common location for these crops but Vertical Farms are also being used for certain stages of growth. Indoor farms are being used as tissue culture facilities to clone fruit trees before their transfer to greenhouses. Greenhouse tree production is mostly focused on container production and is ideal for hydroponic cultivation methods. This allows for the development of a tree with a smaller root area, providing more space efficiency for the operation as well as the ability to move the trees outdoors for periods of time.

## Microgreens

Lastly, we couldn't help but mention microgreens and note their spread around the world. With beginnings in Southern California in the mid 1990's,<sup>14</sup> microgreens cultivation and consumption has spread throughout the globe in the last 20 years.

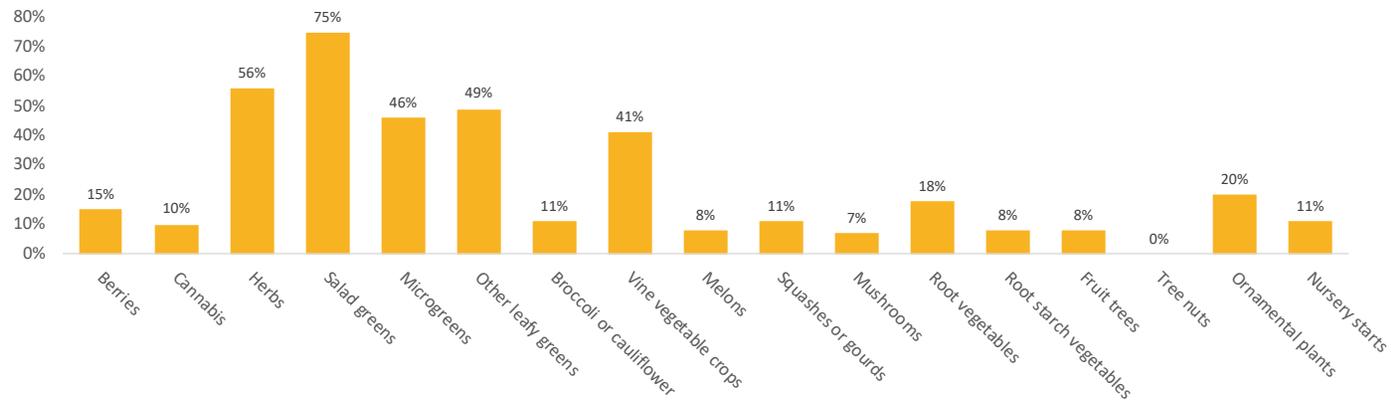
The rise in popularity of microgreens should be seen as positive for a couple reasons:

1. Microgreens are a high-priced, high-quality commodity. If there is a demand for this crop in a certain region, then there is likely demand for other, more affordable CEA crops such as herbs or cherry tomatoes as well.
2. Demand for microgreens generally demonstrates a consumer base concerned with healthy and clean eating, which is one of the main target markets for CEA crops. The fact that these markets are spreading globally is good sign for CEA production.

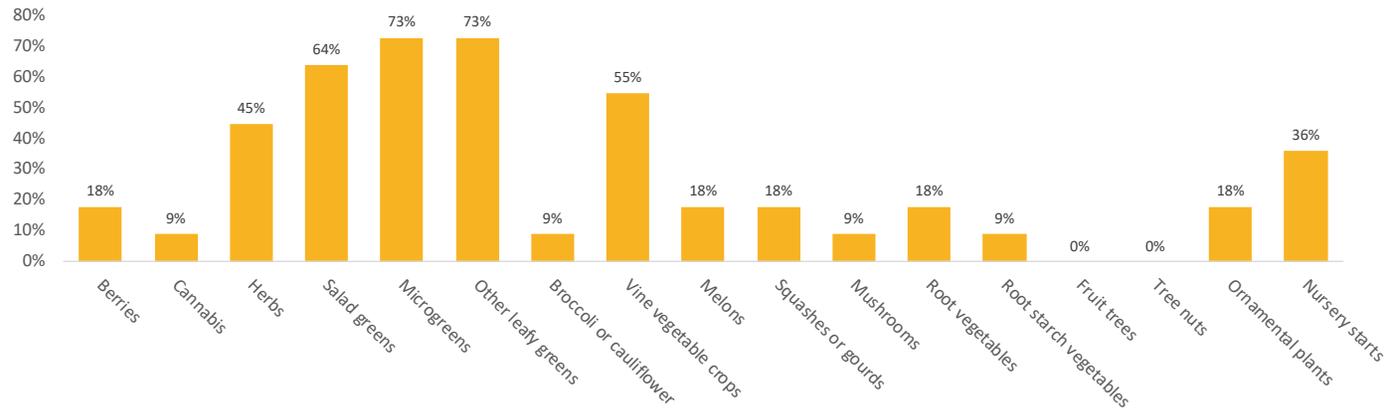
## Other products that were mentioned by respondents include the following:

- Hemp
- Edible Flowers
- Grapes
- Moringa
- Figs
- Olives
- Kiwifruit
- Hops
- Insects
- Snails (Escargot)

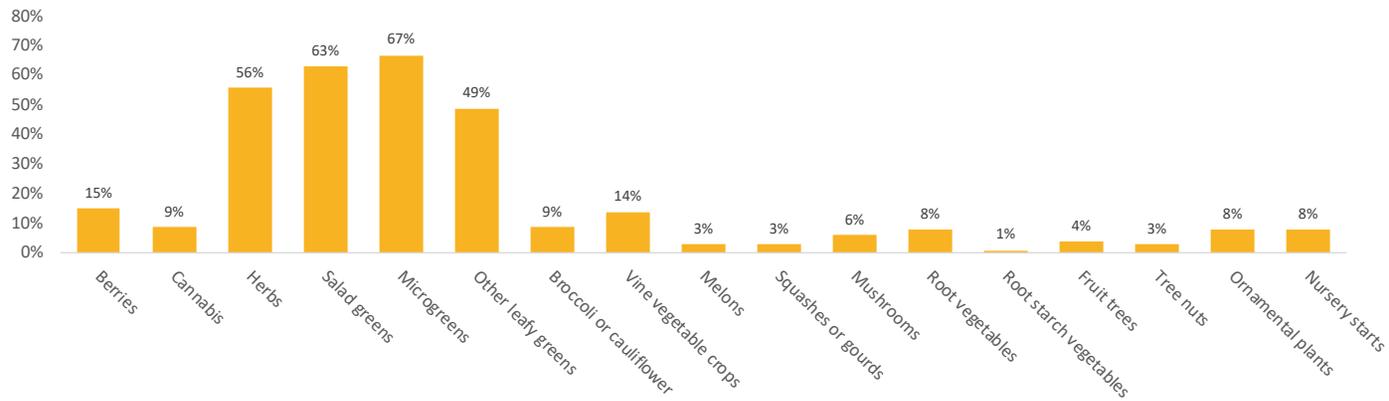
### Crops grown by operation — Greenhouse



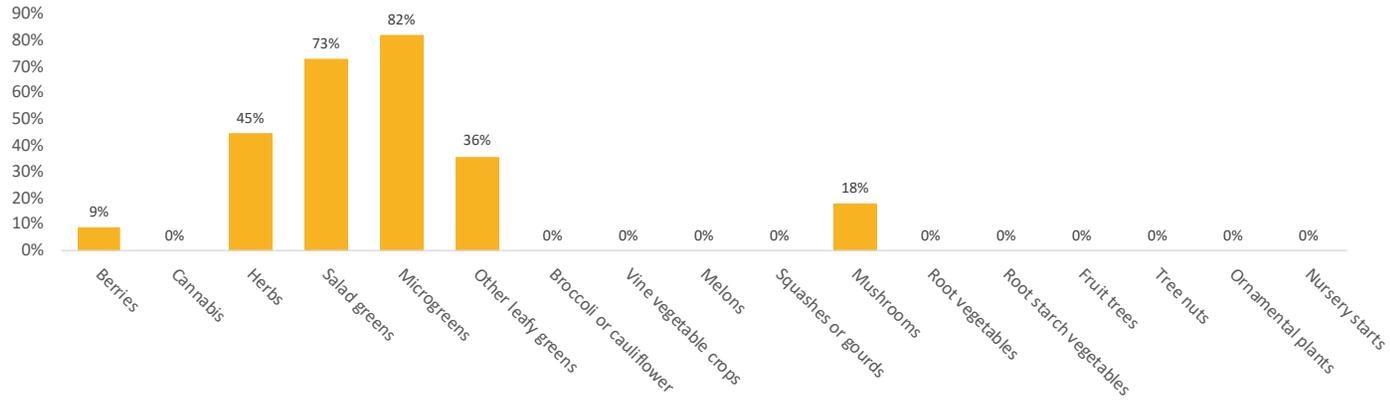
### Crops grown by operation — Rooftop Greenhouse



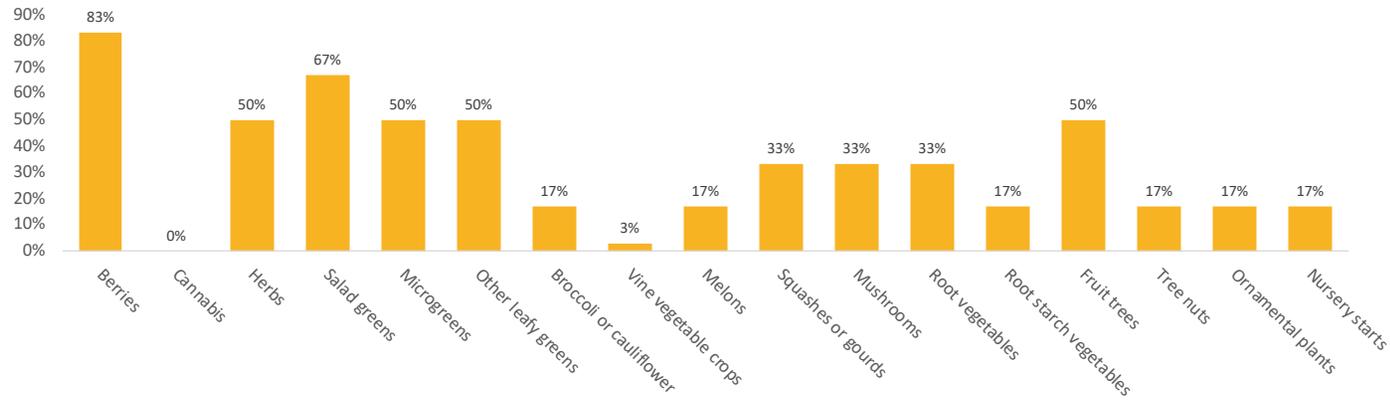
### Crops grown by operation — Indoor Vertical Farming



### Crops grown by operation — Shipping Container

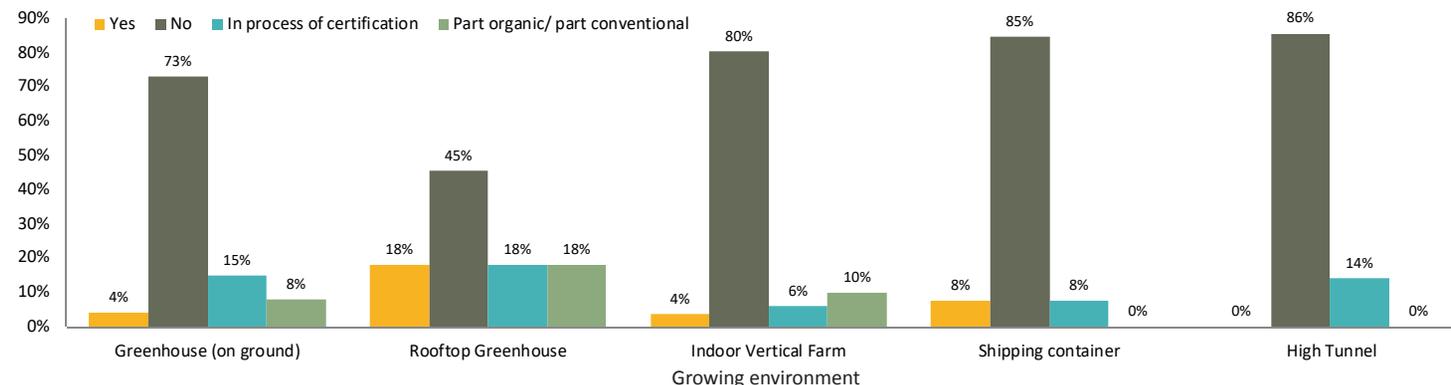


### Crops grown by operation — High Tunnel



# Is your operation certified organic?

## Are you organic?



In this report, one of the goals would be to give a definitive, industry-wide, globally-accepted definition of organic production. Unfortunately no such thing exists today.

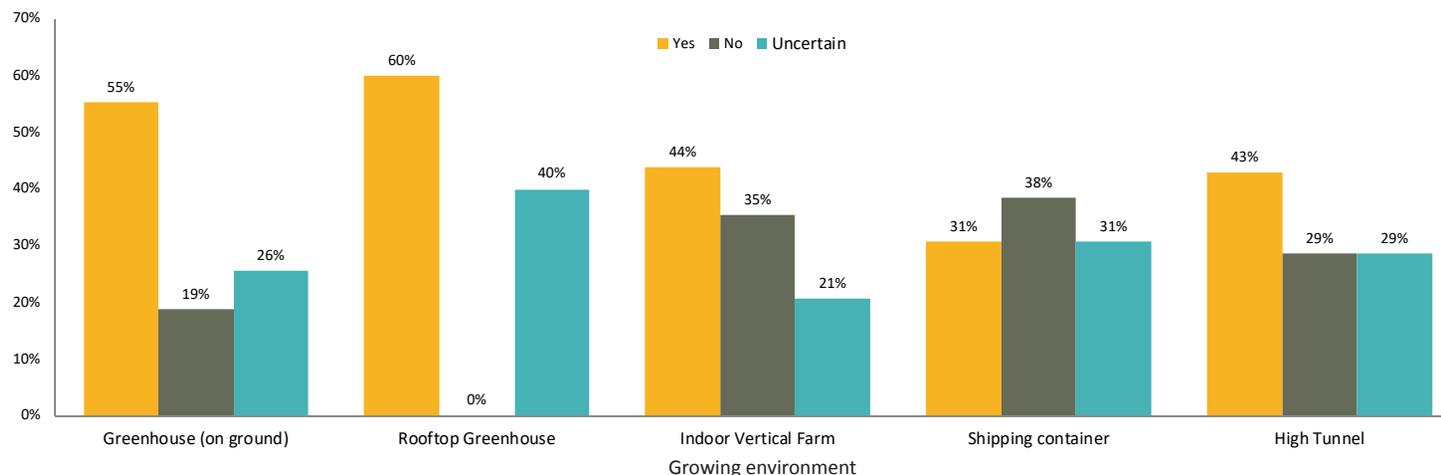
According to IFOAM (International Federation of Organic Agriculture Movements), there were 549 organic certifiers and 87 countries with organic regulations, with another 17 in the process of drafting regulations during the 2016 period.

Countries have different organic standards, but international trade of organic products is possible under the Trade Requirements. This, of course, becomes complex when a product grown hydroponically and certified as organic in one country is exported to another that does not consider it to be organic under their own regulations.

Hydroponic, aeroponic and aquaponic production is largely ineligible for organic certification around the globe. The main reasons for the exclusion are 1) a soil-less environment does not present direct environmental and ecosystem benefits, especially those related to soil; 2) the sample needed for certification evaluation are hard to achieve or lack an established method; 3) they simply do not meet the regulation entity's definition of "organic".

# Do you plan to begin or expand organic production in the coming years?

Intention to begin or expand organic production



As noted previously, different countries have different definitions of organic. We asked respondents whether they intended to begin or expand existing organic production and the majority said yes. With this in mind, growers need to be aware of the legal implications and what constitutes organic in their own country.

As of October 2019, the U.S. is one of the few countries to give 'organic' status to produce grown using hydroponic, aeroponic and aquaponic methods. This certification is currently being disputed by soil-based organic farmers.

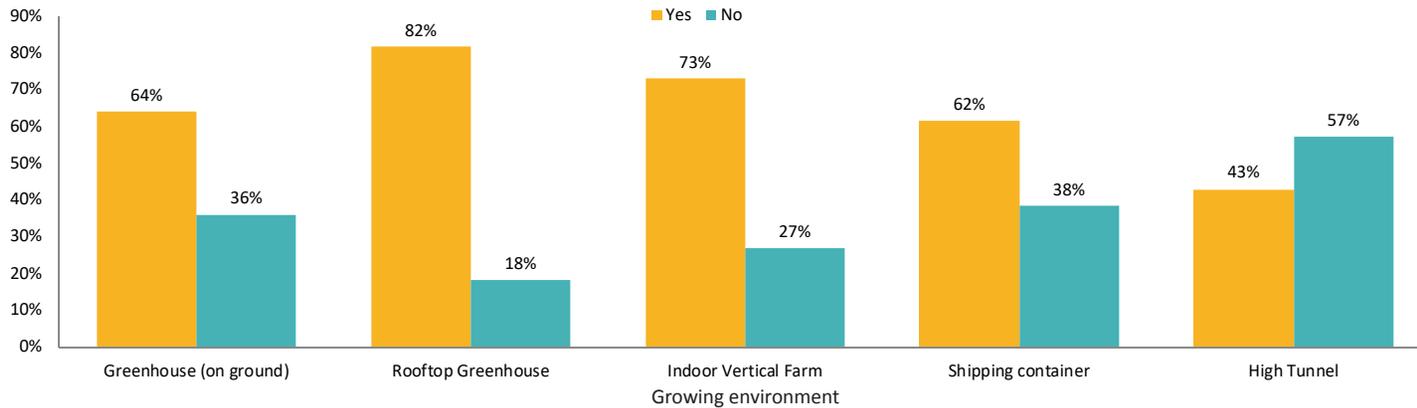
Mexico, Canada, Japan, New Zealand, and 24 European countries (including Holland, England, Germany, Italy, France, and Spain) all prohibit hydroponic vegetable products from being sold as organic in their own countries.<sup>15</sup>

## Marketing of "local" produce around the world

The Census asked respondents 3 questions regarding their use of the term "local" in product marketing and on product packaging.

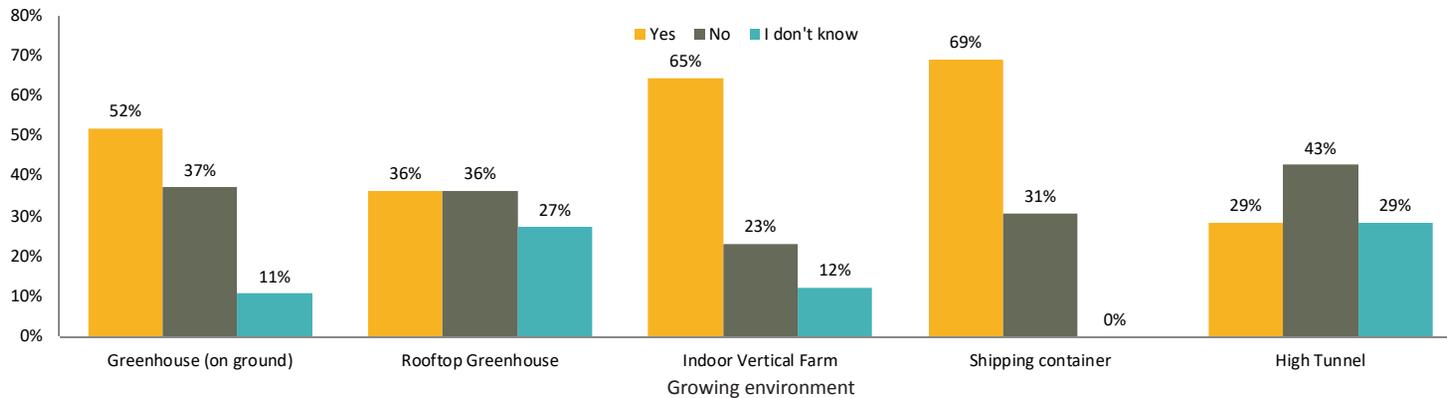
# Does your company use the term 'local' in your marketing or on your product packaging?

Use of the term 'local'



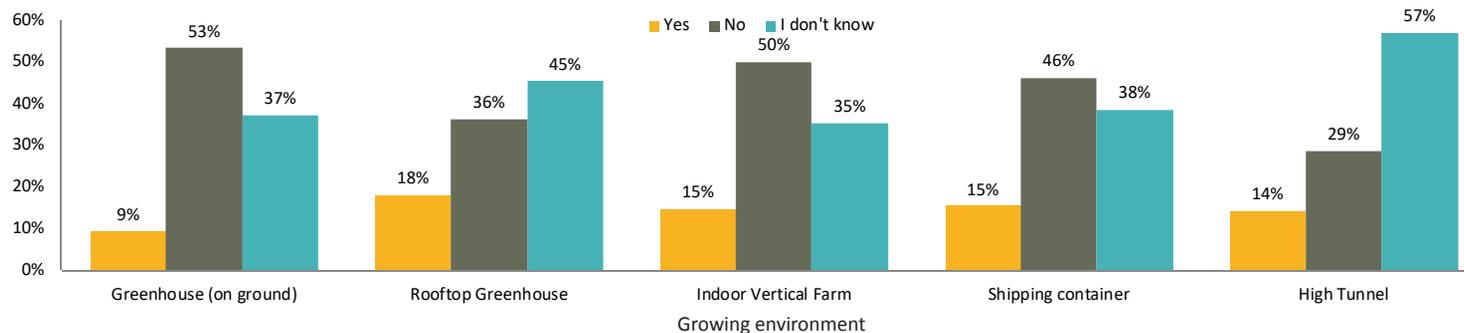
# Is there a premium paid for produce marketed as 'local' in your location?

Premium paid for product marketed as 'local'



# Are there government regulations regarding the use of the term 'local' on packaging or in marketing?

Government regulations regarding the use of the term 'local'



Responses to the 3 questions above point to the fact that CEA operations are overwhelmingly (65%) using the term 'local' on their packaging and marketing for one of three reasons. First, because there is a premium paid for produce labeled as local. 55% of respondents noted that this was the case in their location while 31% said that this was not true. 14% were uncertain if there was a premium paid for produce marketed as local. A second reason that CEA producers likely use the term 'local' on their packaging and marketing is that it often implies a fresher product that will have higher nutritional value and longer shelf life. Finally, most consumers want to see their 'local' economy grow. Local products can translate to local job creation, which is likely to be viewed positively by most consumers.

While CEA operations are using the term 'local' to market their products, there is very little understanding of what the term means and how it can or should be used. Only 13% of Census respondents noted that there are government regulations on the use of the term in their location. 48% responded that there are no regulations and 39% of CEA operations are uncertain if there exist regulations in their specific location.

Worldwide, where regulations do exist, their definition varies greatly. Each country and its systems are different so that 'local' will have a different meaning in each location. With that said, the industry needs to be careful that the term is not overused or misused. It could unintentionally erode the value for CEA operations, which are using the term to legitimately market their product in that way.



# Funding & Financials.



## Henry Gordon-Smith

Founder,  
Agritecture

---

“As a novel form of agriculture in many parts of the world, most CEA operators are struggling to raise the funding they need. In order for this to change, best practices that boost the confidence of investors need to be more accessible so that they can identify the winning models with confidence and keep investment deal flow. Furthermore, the recognition of CEA equipment as an asset class for banks would help with debt financing. Other strategies including equipment leasing models that could drastically reduce upfront capital costs would benefit many new vertical farmers that are struggling to raise capital to build their first farms. Finally, cities need to develop incentive structures to help new CEA operators set up in their city through better lease terms, economic development money, and subsidies for locally grown produce.”

# Policy and government to support CEA operations.

## According to Census respondents, the top three areas of support needed are:

1. Access to affordable land or indoor spaces for farming
2. Availability of technical experts/support
3. Educating local government about urban farming

While government support of traditional agriculture is a big item in many countries, there are few examples of CEA being supported by the government.

A few examples of government CEA support around the world are:

- U.S.: the 2018 farm bill created the USDA Office of Urban Agriculture and Innovative Production
- Paris, France: the Parisculteurs project is a government-supported project to greatly increase the area of roof space dedicated to agriculture.
- Singapore: development of an Agri-Food Innovation Park is underway which will feature indoor ag research and development.<sup>16</sup>

### **Access to affordable land or indoor spaces for farming**

Access to affordable land and indoor spaces is a huge challenge, especially in urban areas. Traditional farming areas near big cities are also having affordability issues due to development pressures. The cost of acquiring space for indoor farming in large cities is so high that it often forces growers to produce exclusively for markets that will pay a premium price. This reinforces a perception problem, in which consumers see CEA as being a premium industry or only for producing high-value niche crops such as microgreens or cannabis.

The truth is that CEA is currently a viable solution in many areas of the world for the production of crops like lettuce, strawberries, herbs, tomatoes, cucumbers and peppers. Over time, CEA will become a viable production method for other crops. While it may not be as viable to produce these in cities with traditional economic metrics, underused urban spaces as well as peri-urban and rural areas are economically viable and will continue to be so in the future. It is important for the industry to educate consumers that CEA produce is widespread and is already an important part of the food system.

Policy suggestion: Encourage cities to make underused urban spaces available to farmers at low costs to increase local production, provide jobs and make use of vacant spaces.

### **Availability of technical experts / support**

Almost 46% of Census respondents noted the lack of availability of technical experts as a significant problem. This is understandable, as the industry is relatively new, lacks standardization and is evolving so rapidly.

In-person technical support for agriculture generally comes in 3 forms- university extension agents, private consultants and peer to peer support. Unfortunately, university extension agencies are generally overworked and understaffed and many have little to no knowledge of CEA. Private consultants can be a great fit but they can also be expensive. Peer to peer support can be an amazing resource, but in this industry, there is a high level of concern regarding intellectual property and many growers are hesitant to share information about their practices.

Fortunately, the number of internet-based resources are increasing as CEA becomes more mainstream. Numerous universities worldwide have developed programs that focus on CEA. These universities offer both online and in person learning opportunities.

### **Leading universities offering CEA training are:**

- Wageningen University (Holland)
- Chiba University (Japan)
- University of Guelph (Canada)
- University of Florida (USA)
- University of Arizona - CEAC (USA)
- Cornell University (USA)
- Iowa State University (USA)
- Colorado State University (USA)
- Texas A & M (USA)
- Ohio State University (USA)
- Purdue University (USA)
- Michigan State University (USA)

Policy suggestion: Encourage more universities around the world to include CEA training as part of their agriculture programs. Encourage technical schools to have CEA training courses.

### **Educating local government about urban farming**

45% of Census respondents noted educating local government about urban farming as a critical need. Local governments must understand the benefits and implications of CEA projects in their communities so that they can be incorporated in appropriate ways.

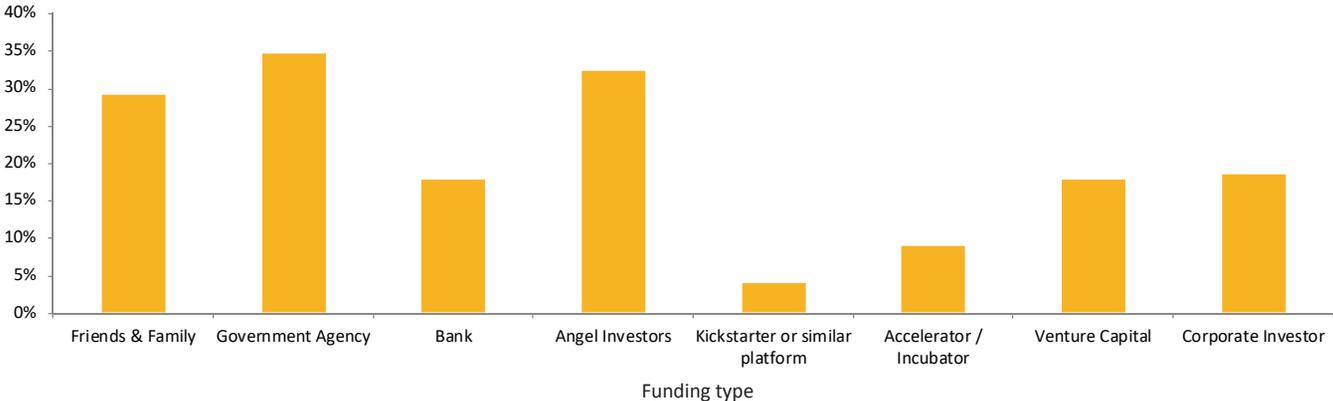
These include:

- As a job creation strategy.
- Planning for co-location of businesses to make CEA more efficient, reduce input costs, and increase overall sustainability of projects - i.e. locating a greenhouse adjacent to a CO2 producing facility or using district heating to distribute excess energy from the CEA facility to adjacent buildings.
- Disaster recovery- CEA facilities are often able to resume food production much faster than field agriculture especially after hurricane/ flood related events. They can help to insure a supply of fresh vegetables is reaching local populations.
- Crop diversity- many local governments may be opposed to CEA based on a perceived association with cannabis production, which is still illegal in many parts of the world. It is important that local governments understand the breadth of crops that can be produced in CEA facilities.

# Friends & family rate high on the scale.

As the graphic shows, funding for CEA operations comes from a wide variety of sources and varies greatly based on operation size. For larger operations with more than 100 employees, funding was spread out among banks, venture capital, government agencies, friends and family and angel investors.

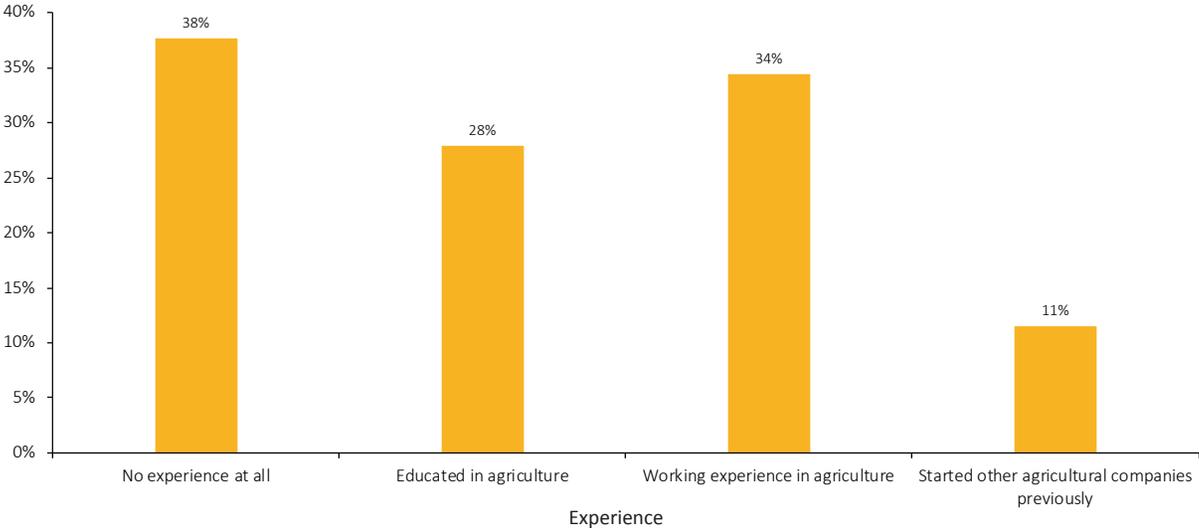
Type of funding received



# No experience necessary - For funding.

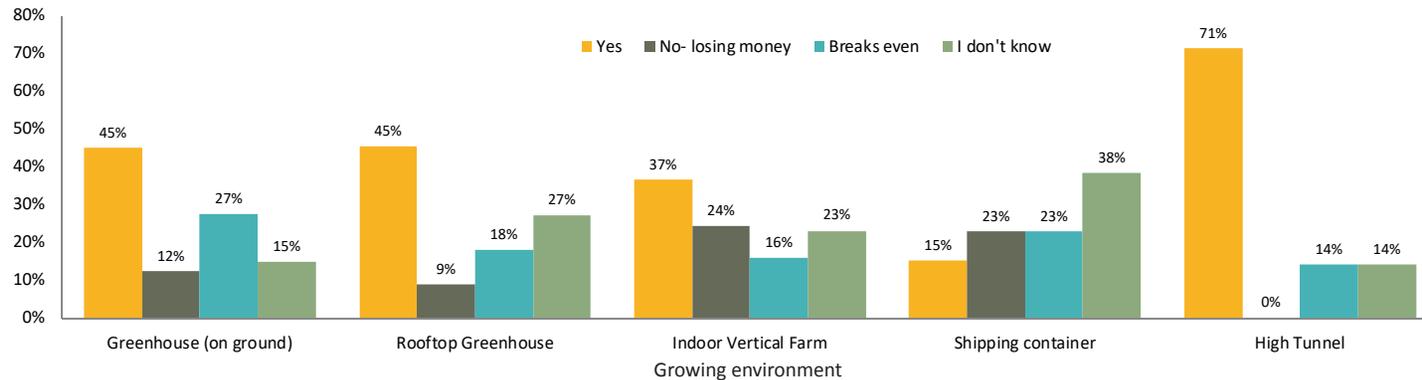
Surprisingly, funding doesn't appear to be significantly correlated to a founder having prior experience in agriculture. Of the operations that were successful in obtaining funding, 37% of founders had no experience at all in agriculture, compared to an overall rate of 45% of founders without experience. While experience is important, assembling the right team and understand the market are often more important to convince funders that an operation will be successful.

**Founders prior experience in agriculture**



# Is your operation currently profitable?

## Operation Profitability



Profitability among Census respondents varied greatly based on operation type. Respondents operating high tunnels had the highest percentage of profitable enterprises (>70%), followed by Rooftop Greenhouse and on ground Greenhouse operators (45%). Vertical farm operators were profitable at a rate of 38% and shipping container operators at 15%.

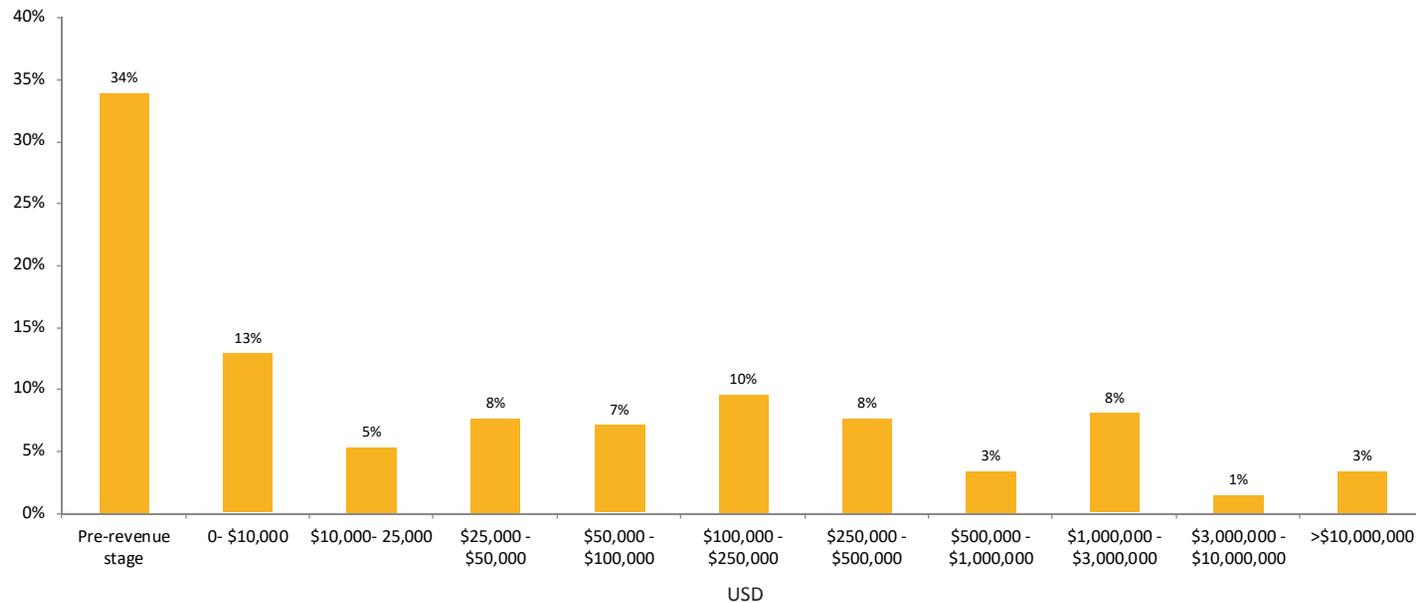
In this case, profitability generally inversely mirrors the capital costs of starting each operation type. For example, the capital expense for setting up a high tunnel is by far the least of all the operation types listed and, according to respondents, has the highest rate of profitable operations. On the opposite extreme, shipping container based farms are usually the most expensive per square foot of bedspace, and these were shown to have the lowest rate of profitability.

The capital cost of establishing both rooftop and on ground greenhouses falls somewhere in between the extremes of the high tunnel and the shipping container models. Rooftop greenhouses are generally more expensive to establish and operate than on ground greenhouses due to increased structural demands and higher labor and power rates in cities. On the other hand, these operations may be slightly more profitable because they can be established with a pre-existing customer base. One example of this is a rooftop greenhouse supplying produce for a supermarket located right below it.

# Operation Revenue

Census respondents represented a wide variety of operations. Just as the operation size varied greatly, so did the annual revenue.

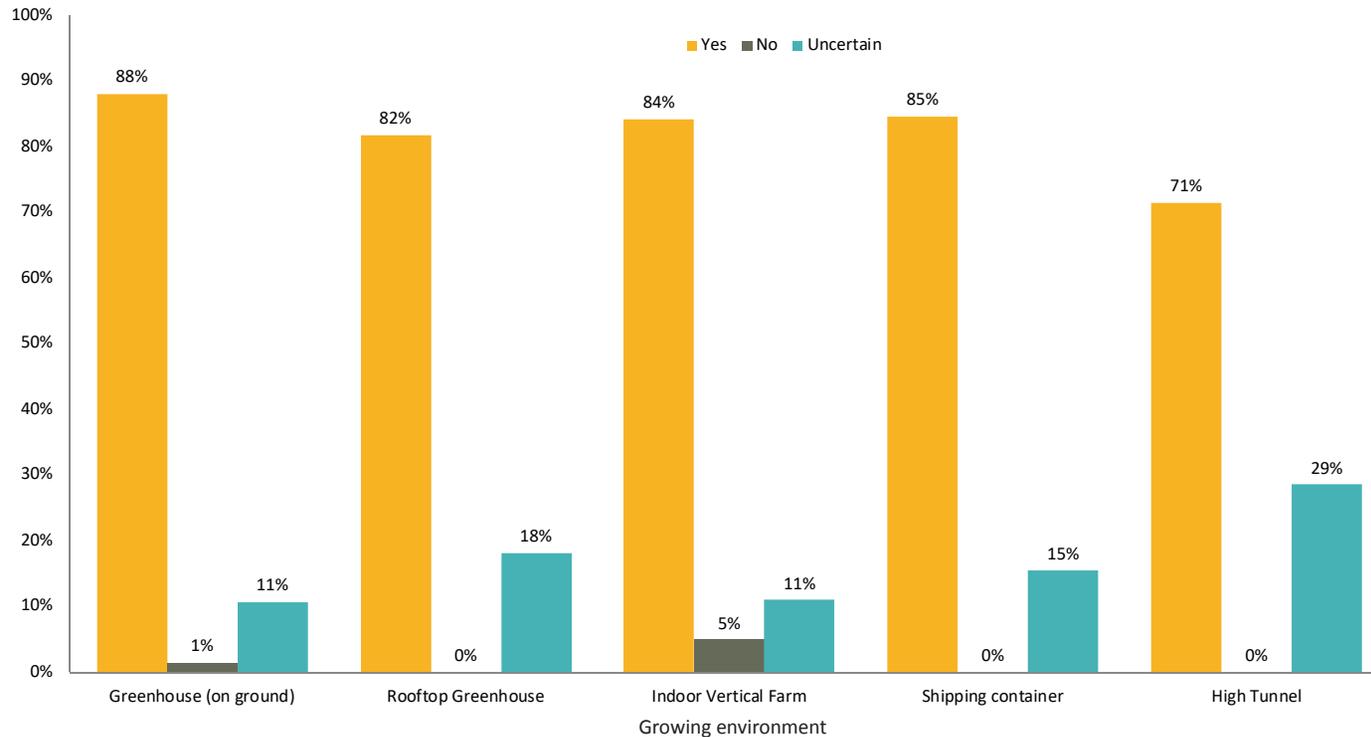
## Approximate annual sales revenue in USD



The highest percentage of Census respondents (34%) are in pre-revenue stage of operations. This reflects the young age of the industry. Additionally, there was a large number of small revenue companies (<\$10,000). While it would be difficult to sustain a company with this type of revenue in the United States, many of these companies are located in countries such as Malaysia, Guatemala, Colombia, Estonia and India where it may, in fact, represent a sustainable business. In other countries, this level of revenue may also represent a pilot operation, which is always recommended as the first step to enter in this industry.

# Do you plan to increase your production area in the future?

Intention to increase future production area



Regardless of operation type, respondents had an extremely positive outlook towards the future. Across the board, greater than 70% of all respondents are planning to increase production area in the future. This is a good sign not only for these operations, but all related businesses such as equipment and input suppliers. At the same time, lack of access to funding was noted as a major challenge by Census respondents. Developing more funding opportunities for CEA across the world will be extremely important for the industry to truly blossom.

## Ranking the operational costs.

The Census asked respondents to rank their operational costs with 1 being the highest and 7 being the lowest. Labor was the largest operational expense among the respondents, followed by energy and cost of goods. Since labor was the largest expense, we can likely expect automation to increase in the future as a way to drive down the labor expense.

- 1. Labor**
- 2. Energy**
- 3. Cost of goods (seed, nutrients, grow media)**
- 4. Rent**
- 5. Packaging**
- 6. Distribution / transportation**
- 7. Water**



# Adoption of Technology.



## Darryn Keiller

CEO,  
Autogrow

---

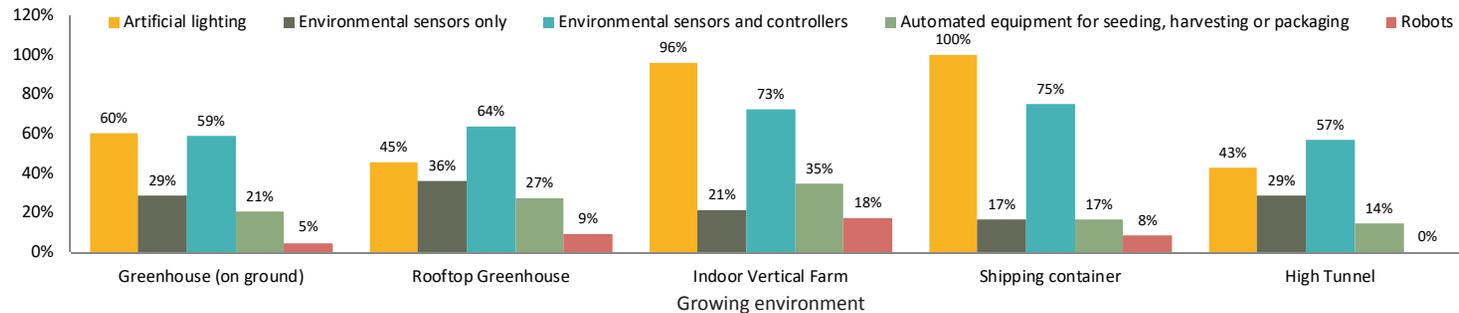
“New technology is the biggest game-changer in our industry. Not just from the new ways it will impact the crops and the growing environment, but the way the farmer will change the way they do business.

The amount of variables farmers need to navigate in order to bring a crop to market are substantial, and understanding how technology can improve (or save) your business is paramount.

The best farmers are those open to trying new things and getting involved in the process. It’s better to be at the front of the wave than left behind.”

# Technology adoption slow but steady.

## Technology used — by growing environment



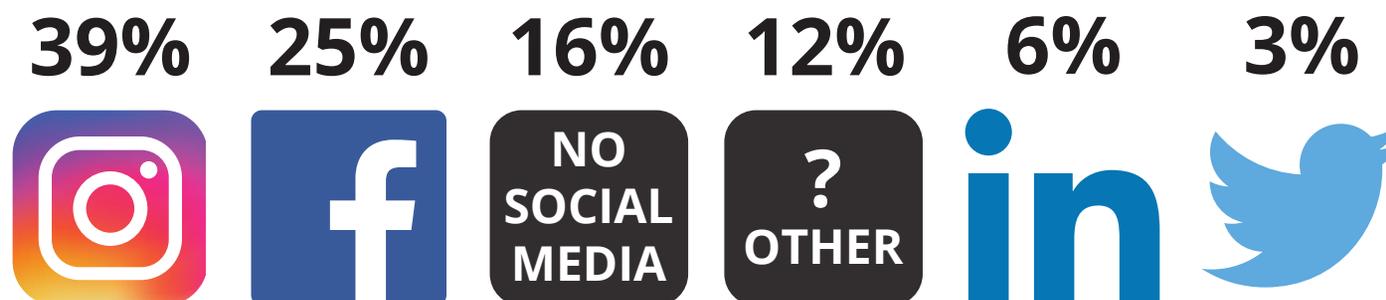
Penetration of technology into CEA operations is relatively widespread, according to respondents of the Census. The most common type of technology integration in CEA is artificial lighting, which was reported in 72% of the operations. It is predicted that this percentage will continue to increase as LED lights become more affordable and efficient. Artificial lighting is generally a requirement for high quality, year-round operations. The only exception is in greenhouse operations where DLI is above the crop needs on a year-round basis.

Regarding sensors and controllers, 23% of operations use only sensors while 62% use sensors in conjunction with controllers. This means that there is also 15% of operations who are using neither and controlling their lights, pumps, fans, etc manually or with timers. Because this is still a new industry, an issue that continues to be prevalent is the lack of communication between sensors and data made by different companies. Hopefully as the industry matures, more time will be spent addressing this challenge so that efficiency and data analysis are much more tangible to achieve.

Lastly, responses on automation for seeding, transplanting and harvesting processes were given. Respondents reported that approximately 25% used automated practices for seeding, transplanting and harvesting, while 10% of operations currently incorporate robots. This means that at least 65% of the responding operations do not use any automation for seeding, transplanting or harvesting. Earlier, it was noted that labor was the number one operating expense of the reporting operations; this is another area where our industry can become much more efficient.

# Social media usage

What social media tools do you use for marketing?



Instagram is shown to be the principal social media channel for a majority of CEA respondents. Instagram being the platform of choice can be due to a variety of reasons:

1. Age demographic of emerging CEA farmers: The age distribution for CEA farmers is primarily between the ages of 21-40. This range is defined as being part of the categorization of “millennials”, which, according to the Pew Research Center, is anyone between 23-38 years of age.<sup>17</sup> Of the 500 million people who check their Instagram daily, 34% of them fall within this age group of millennials.<sup>18</sup>
2. Attractive Visuals: Urban farming is a very visual field, both in its intricate use of technology and in what it produces. Many promotional and marketing materials that come from urban farms are attractive visuals of their operations. This, combined with the young age demographic of urban farmers mentioned above, is precisely what Instagram attracts. Instagram is a visual platform that attracts younger users, and urban farmers often take advantage of that benefit.

Regardless, Instagram seems to be the growing platform for urban farmers to promote their operations. Facebook, while still popular among CEA operators, does not have that same visual component that seems to pull young growers to Instagram.

# Conclusion.

The purpose of the Census was to get a pulse of the CEA industry around the world today. The data collected shows many reasons for a positive outlook but also areas that require improvement if CEA is going to continue to grow and develop.

The following three signs best demonstrate the developing strength of this industry:

- CEA in the form of both vertical farming and greenhouse production is spreading throughout the world. That it is occurring in countries with drastically different economic and natural resource profiles means that CEA is providing value and interest across various cultures, climates, and other local contexts.
- CEA is a method of producing an increasingly wider diversity of crops, in addition to other farm products. The diversification of use cases for CEA will continue to strengthen the industry.
- CEA is attracting younger professionals to the agriculture industry. This is extremely important with the aging populations associated with traditional farming in most areas of the world.

Key areas that require improvement for the industry to continue to grow are:

- Education of consumers and government. Consumers are unaware that CEA is a critical component of our existing food chain. Government officials don't understand the needs of our industry and how to best support and develop it.
- Lack of data. People involved in the CEA industry know that there is a lot of potential for improvement, but don't often know where to turn for help. The CEA Census is an attempt to start quantifying and tracking where data, support, and improvements can be most impactful. There are also other industry and government efforts to accomplish this goal, and we encourage coordination of these efforts along with full participation by CEA operations to facilitate this process.
- Lack of funding. There is a lack of funding options for operators looking to start or scale their CEA

businesses. Traditional agriculture has historically been supported by government funding programs but these entities are generally unfamiliar with CEA operations and their economics. This excludes the CEA industry from crucial funding mechanisms.

Thank you for taking the time to read this report. The excitement surrounding a new and growing industry like CEA is contagious and we hope our readers, no matter their role,, will feel driven to get more involved. Together, there is much more we can discover as the CEA industry experiences rapid and vast improvements.

## Acknowledgements

We'd like to again thank all the farmers who shared their knowledge and expertise to take part in this Census. From our perspective it is an incredibly valuable process that has garnered information we will all be able to learn from.

We also recognize the additional research we have cited through our report which has helped to give context to our Census.

We'd also like to acknowledge the work of the Autogrow team - Kylie Horomia and Debs Abraham, and Agritecture team - David Ceaser, Oksana Bihun, Briana Zagami and Joyce Liu.

Our industry is on the precipice of significant change which makes for an exciting place to be.

Any queries or comments regarding the Census please contact [david@agritecture.com](mailto:david@agritecture.com)

[www.autogrow.com](http://www.autogrow.com)

[www.agritecture.com](http://www.agritecture.com)

## Endnotes

- <sup>1</sup> <https://www.ers.usda.gov/webdocs/charts/56734/agedistributionofprincipaloperators.png?v=9084.7>
- <sup>2</sup> <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210044201>
- <sup>3</sup> <https://www.nippon.com/en/features/h00227/japan%E2%80%99s-farming-population-rapidly-aging-and-decreasing.html>
- <sup>4</sup> <https://www.abc.net.au/news/rural/2017-07-07/whos-farming-australia-abs-agricultural-census-2015-16/8686750>
- <sup>5</sup> <http://www.igsnr.ac.cn/xwzx/jxltwj/201609/P020160929403217366534.pdf>
- <sup>6</sup> <https://agfundernews.com/technology-is-closing-the-generational-gap-in-agriculture.html>
- <sup>7</sup> <https://gro-intelligence.com/insights/articles/agriculture-demographics-challenges>
- <sup>8</sup> <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>
- <sup>9</sup> Lockheed, M.E.; Jamison, T.; Lau, L.J. Farmer education and farm efficiency: A survey. *Econ. Dev. Cult. Chang.* 1980, 29, 37–76. [Google Scholar] [CrossRef]
- <sup>10</sup> Defrancesco, E.; Gatto, P.; Runge, F.; Trestini, S. Factors affecting farmers' participation in Agri-environmental measures: A Northern Italian perspective. *J. Agric. Econ.* 2008, 59, 114–131. [Google Scholar] [CrossRef]
- <sup>11</sup> Brown, P. Gender, Educational Attainment, and Farm Outcomes in New Zealand. 2019.
- <sup>12</sup> <https://www.freshplaza.com/article/2137854/global-vegetable-greenhouse-statistics-released/>
- <sup>13</sup> [https://www.un.org/depts/los/convention\\_agreements/reviewconf/FishStocks\\_EN\\_A.pdf](https://www.un.org/depts/los/convention_agreements/reviewconf/FishStocks_EN_A.pdf)
- <sup>14</sup> <http://www.freshorigins.com/microgreens-facts/>
- <sup>15</sup> <https://www.cornucopia.org/2015/03/hydroponics-organic/>
- <sup>16</sup> <https://www.straitstimes.com/politics/parliament-agri-food-innovation-park-in-sungei-kadut-to-open-from-early-2021-koh-poh-koon>
- <sup>17</sup> <https://www.pewresearch.org/fact-tank/2019/01/17/where-millennials-end-and-generation-z-begins/>
- <sup>18</sup> <https://www.business.com/articles/10-reasons-to-use-instagram-for-business/>

