A RESOURCE GUIDE FOR

Starting a SPECIALTY MUSHROOM FARM

FUNGI ALLY AND CORNELL MUSHROOMS

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INTRODUCTION

Mushroom farming is a beautiful thing. Not only are high quality medicinal foods produced but many of the by-products can be used to feed a community. When done in a conscientious way, mushroom farming will grow community, build soil matter, improve human health, and provide economic opportunities. This booklet touches on the nitty gritties of creating a lab, a fruiting room, and financial opportunities in mushroom farming. This is the third booklet in a series. For more context, it may help to go back and read the other two booklets.

In mushroom farming, the methods used and the specific products sold will dictate what equipment and space is needed. One can buy ready-to-fruit blocks, make their own, or do a combination of both. We will start by looking at the process of creating infrastructure for farms to produce blocks in house. We will then look at data from five mushroom farms—the costs and income from buying blocks and creating them on the farm. We hope this booklet brings beginning growers more clarity about how to create a farm that meets their desires.

The authors are deeply grateful to SARE for the opportunity to conduct this research, to the farmers who grew mushrooms and recorded data through a crazy 2020, and of course to the beautiful mushrooms that we serve. Thank YOU for your interest in growing mushrooms. Please continue down this path and bring them more deeply into your life, we promise you won't regret it!

SETTING UP A MUSHROOM FARM

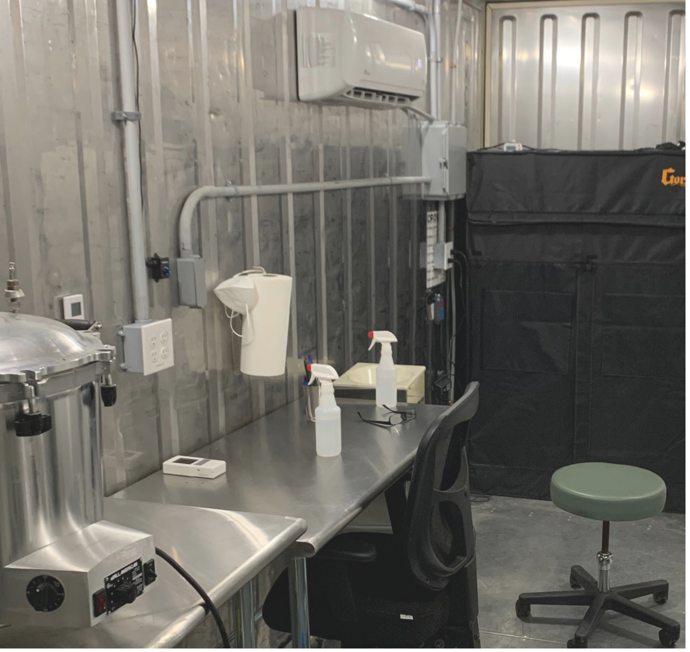
A) Building a Mushroom Lab

The lab, a meticulous area, is one of the most important parts of a mushroom farm. Everything starts in the lab. It is of the utmost importance to keep it extremely clean. When building a lab, use materials that are easy to clean. Use cleanable surfaces for the walls—coroplast or thick contractor plastic are both good materials to use. A concrete floor is ideal but tile or linoleum will also work. Avoid wood floors or floors that have cracks in them. Plastic tables can be used but metal tables are ideal. A smaller space is much easier to keep clean, so keeping the lab size down is very helpful. However, there should be sufficient space to allow the bulk substrate to cool in the lab. One of the important features of a mushroom lab is that it has positive pressure. This means there is more air entering the room than the room can hold, forcing air out through any cracks. A HEPA filter should be used to create this positive pressure so all the air in the room has been filtered before entering.

Sterilizing Material

There are several different setups that are commonly used for treating substrates. On a small scale, table-top pressure cookers work great for treating agar and grain. These may have internal heaters or, if not, an external hot plate can be added for heating the water. The pressure cookers should be run between 15-20 PSI, bringing the internal temperature up to 250+° fahrenheit. For agar it is good to run for 1 hour at temperature and for grain 2-3 hours at temperature, depending on the size of the jar/bag. Using bags is much easier but jars are a good reusable material for masters. For treating bulk substrates, steam sterilization is the norm for supplemented sawdust materials. This can be done in a variety of different containers.

The general idea is to pump steam into a container, reach a temperature around 208° and maintain that temperature for 16 hours. There are currently two common setups used in small-scale cultivation. One is to use a sauna steamer, 6 or 9 kw depending on the quantity of substrate being steamed, and pump that into a cattle trough, barrel, or other metal container that can withstand the high temperatures. It is important with this method to have a drain for condensate to drip out of or to elevate the bags 9-12 inches from the bottom so they do not fill with water. The other common method is to use a heating element at the bottom of a 55 or 80 gallon barrel with a false bottom, in which the steam is generated at the bottom while the substrate sits above. These can be retrofitted with a float valve and intake so that they automatically refill over time. You can purchase high quality units from Bubba's Barrels. If you are making your own, it is best to use stainless steel, a lower quality metal will not last for more than 6-12 months. These units, whether cattle troughs or barrels, should be placed on wheels. The cooking of the substrate can happen outside of the lab but once complete should be wheeled into the lab to cool. During the cooling process air is sucked into the bags so the flow hoods should be on.



HEPA filters

A note on HEPA filters. Any size will work but 2x2 is the most common as an intake filter, although a 2x4 4x4 or 4x8 is great to work in front of, depending on the quantity of your production. Four feet starts to get a little bit short if 2 people are working in front of the flow hood. When producing 10 lb bags, the 2 foot height can be short as you pour spawn into the bag. For filter specifications you want to be sure to get a filter rated at 99.99% at .3 micron. There are many 99.97% efficiency filters available but these filters failed the 99.99% test and should be avoided if possible. The increase in possible contamination is much more costly than the initial cost of the filter.

Lab Technique

It is important to understand the ways contamination can get into an operation so that when it occurs there can be a diagnosis of what to change moving forward. It is a constant dance with contamination to find out what is going on and to eliminate it. Many factors are in play, meaning that contamination is bound to pop up and go away and pop up—it is the reality of growing mushrooms. Contamination is unacceptable while transferring between spawn. A small amount of contamination while you are going to a bulk substrate is okay but contaminated spawn needs to be thrown away. If fruiting bags contain contamination, wait to see if the mushroom mycelium will overgrow it and maintain a certain portion of territory. Bags can be fruited if they are 40% or less contaminated. Initiate as far away from the contam as possible and hopefully some mushrooms will still emerge. An easy way to go through lab technique is to introduce the 7 vectors of contamination.

THE 7 VECTORS OF CONTAMINATION:

1) Air: Air is the reason why it is important to put so much energy into proper lab design and building. In every breath we take we inhale fungal spores, they are everywhere! To combat that it is always important to work in front of the flow hood. When working in front of the hood, imagine a stream of water running from the flow hood towards the end of the table where work is being done. Never pass hands or dirty material upstream of the clean substrate as things can blow downstream into the bag. Move slowly and with intention, causing as few ripples in the water as possible. If anything is being brought into the clean stream area, spray it down with 70% isopropyl alcohol. Talking or singing while working can transmit or push contamination into your clean substrate. After sterilization, cooling your bags inside the lab is important. As the bags cool, air is sucked into the sterilizer and bag, ensuring this air is already filtered will help decrease opportunities for contamination. When air is an issue, contamination usually shows up inconsistently and very spotty, popping up in one or two places in the substrate.

2) Substrate: When contamination shows up in the substrate, it is usually from improper treatment before sterilization or from improper sterilization itself. This can mean either that the correct temperature was never reached or that it didn't run for the correct amount of time. Substrate contamination can also result from using a dirty substrate to begin with. If fungal spores or bacteria are already present in the substrate it is much more difficult to get rid of them through treatment. When the substrate is the issue, contamination will be widespread throughout an entire batch. Rather than jumping off from a singular point, it will be all over the bag.

3) Spawn: Spawn can be a source of contamination as well. It is possible to use contaminated spawn to inoculate certain low nutrient bulk substrates like straw or coco coir but it will decrease yield. Before using a bag of spawn it is important to inspect it for any visual contamination, especially in the corners and top of the bag. Smelling the bag is also a good way to detect if there is any bacterial contamination. Small cuts or holes in a bag of spawn can lead to contamination getting in and expanding onto the spawn. Spawn should be sprayed down with alcohol before being used, coming into the clean air flow. If contamination is from the spawn, typically one can see the contaminant jumping off of the grains or pieces of spawn into the new substrate.

4) Surfaces: Surfaces have bacteria and fungal spores on them. These contaminants constantly settle from the air onto the surface. Because of this, it is important to clean the surface while working in the lab. Before placing anything onto the surface in front of the flow hood, remove any debris from the table, then spray it down with 70% isopropyl alcohol. Allow the alcohol to evaporate, do not wipe the alcohol away. It is during the evaporation process that the alcohol kills microorganisms. It is good to spray the surface down every 10 minutes or after finishing a bag of spawn. Clear the table and spray it down to give a reset. Surface contamination will show up as sporadic in the spawn bag.

5) Tools: Common tools used in the lab are scalpels, bag sealers, scissors, parafilm, petri plates, jars, filters, and bags. All of these tools should be cleaned and sprayed with alcohol repeatedly during the inoculation process. When using scissors, be sure to spray them before cutting any bags of spawn open. If tools aren't kept in the clean air flow they should be sprayed before they come into it each time. Flame scalpels in order to sterilize them before cutting agar. For this purpose, the cheapest and least effective tool is a lighter, next is an alcohol lamp, and finally for extremely effective sterilizing, a bacti cinerator. If parafilm is left out in a dry area after being applied to a petri plate it can dry and crack. If the parafilm starts to crack on an actively growing petri plate or if the lab area is dry, place the plates into a sealed plastic bag to grow out. This will ensure that the parafilm doesn't crack and let in contaminants. Tool contamination will show up in the substrate as spotty inconsistent contamination.

6) Cultivator: The technique and cleanliness of the cultivator plays a huge part in whether inoculation is successful or not. Everyone has their own little quirks while working in the lab–stick with what works for you! If trying to change anything, change things one thing at a time and very slowly in order to watch if there is any impact over the course of 3-4 weeks. It is a good practice to start lab days at the beginning of the day after showering and wearing freshly laundered clothing. Do not go into the lab after picking mushrooms or being in the fruiting room. The fruiting room is full of spores, bacteria, and other funky stuff that you don't want in the freshly cleaned substrate.

7) Mobile Contamination Units: Mobile contamination units are mice, people, flies, gnats, or any other unwanted creatures that could chew, fly, or open things in unwanted ways. Mice can cause a lot of damage by chewing through bags to go for the recently inoculated grain. Roaming, curious people should not be allowed into the lab, and if visitors are allowed be sure it is before cleaning and they know not to touch things unless they ask. Sometimes a random fly can enter a bag during inoculation. Typically these aren't a huge problem (unless you have a serious mice problem) and it is easy to tell if they cause contamination.

Mid-range budget for a new mushroom lab

(it is possible to do it for closer to $4,000 depending on your knowledge, skill level, and time):

Item	Cost
Wall construction 12x12	$1000
2x4 flow hood	$1100
2x2 flow hood	$600
Steel table	$500
Bulk sterilization unit	$3200
41.5 quart pressure cooker	$1100
Impulse sealer 405-HIM	$240
Petri plates	$60
Scalpel	$40
Agar	$30
Bags	$200
Jars	$60
Filters	$30
Parafilm	$30
Total:	$8190

B) Creating an Incubation Room

The incubation room is the easiest part of creating a mushroom growing facility. The point of this room is to provide a consistent temperature, adequate space and ventilation for the mycelium to healthily grow through the substrate. There are several considerations for the incubation room, which will each be addressed individually: ease of access, shelving, lighting, temperature and air movement.

Temperature

Ideally temperatures should be kept between 65-75°. As the bags grow, they generate heat. Internal bag temperatures tend to be 7 or 8° higher than the ambient room temperature. As room temps get into the 80's, internal bag temperatures will approach the 90's, which can cause suffocation and contamination to grow. If insulated, this room can generally produce sufficient heat so that no additional heating is needed during the winter. Air conditioning is likely needed for the incubation room. Air does not need to be actively exchanged with the outdoors so a regular sized AC should be sufficient.

Air Movement

During the incubation period it is helpful to have oscillating fans in the room. The fans help to keep the air from becoming stagnant. Fans help to decrease incubation time and can sometimes lead to higher yields.

Lighting

During incubation, lighting is not required. The mycelium grows in the dark in natural settings and can grow sufficiently with no light. Install sufficient lighting to work and be able to monitor mycelial growth throughout the incubation period.

Shelving

Many different shelving types are used in incubation. Ready-to-assemble chrome wire shelving is an expensive but fast and readily available option. Building shelving is also doable with the right skill set. A simple construction of 2x4's and PVC piping can be used to create cheap reliable shelving. It is important to allow ventilation on the bottoms of the bags and not use a material like plywood that could splinter and poke a hole. Having wheels on the shelving units is helpful but not necessary. It is best to keep incubation shelves in the incubation room and not use them for fruiting, as they will get extremely dirty, especially with shiitake mushrooms. Shelving can go as high as allowed by the building but bags will need to be lifted and placed onto the shelves. When placing bags on the shelf they should be a palms-width apart—if they are tightly packed against each other they can overheat and get contaminated.

Layout

As bags will constantly be moving in and out of this room it is important to have adequate space for working. 3' aisles and carts with wheels to move the bags from the lab into the incubation room are extremely helpful.

C) Creating a Fruiting Room

The most exciting and visually stimulating part of mushroom cultivation is the fruiting. Once the mycelium reaches full colonization, meaning that it has grown over the available substrate, the bag is moved into the fruiting room. A basement where temperatures are stable is the ideal place for a fruiting room. Barns, warehouses, tunnels, greenhouses, and other structures can also work well. Not much space is needed to fruit a large amount of mushrooms. An 8x16' space can easily grow 150 lb per week. A simple greenhouse-like structure can be erected to act as a fruiting room. Use 2x4's to create a frame, stapling 6 mil plastic around the inside of the frame. This creates a durable, cheap, easy-to-clean room for growing mushrooms in. Corrugated plastic can also be a great building material for the walls of a fruiting room. The floor should ideally be concrete with a drain in it. Linoleum also works as flooring that is easy to clean. Once the structure is complete there are four environmental conditions that need to be monitored and controlled. These four conditions are humidity, light, CO2 and temperature.

Lighting should be similar to lighting found in a house–LED or fluorescent lights work well. Mushrooms do not photosynthesize so do not require a certain spectrum of lighting. A cycle of 18 hours on and 6 hours off works great for healthy growth. If the lighting is too dim the mushrooms will have long stems and little caps as though they are growing taller looking for the light, similar to what plants do in response to insufficient light. Lights can get covered in spores and need to be cleaned occasionally. Even though there is a high humidity, having lights directly in the room seems to be okay. Alternatively, the lights can be kept outside the room with a piece of plexiglass or other transparent material in the ceiling. An 8x16' room is extremely well lit by four 4' foot light fixtures.

Humidity: In order to fruit, mushrooms must have a moist environment. Humidity should be kept between 80-90% depending on their stage of development. A higher humidity–close to 90%–is necessary to initiate fruiting. During fruit body development a lower humidity can be tolerated. Shiitake mushrooms do extremely well when sprayed directly with water for the first 4 days. Other mushrooms can also be sprayed pre-pinning but it is not as impactful or necessary. While creating humidity, the mushrooms should not get water directly on them. Mushrooms act as

sponges sucking up any liquid they touch. If water is constantly being sprayed onto them they will easily get disease like blotch or in the case of lion's mane become waterlogged.

There are many different options for misters depending on budget. Several good options with varying costs are: home humidifiers, ultrasonic misters, carbonator pumps and atomizing nozzles, or watering the floor and walls several times a day. Ultrasonic humidifiers from House of Hydro and pressurized pumps from Aeromist are both good systems. The ultrasonic humidifiers are considerably cheaper and sufficient for rooms up to 400 square feet. Larger rectangular rooms do well with the aeromist equipment.

Temperature: The third environmental condition to be aware of is temperature. Most mushrooms fruit best in the mid 60's. To maximize yields, the temperature should be maintained between 62-68°, but anywhere from 55-75° will give good results. It is wise to rotate what species are being cultivated based on outdoor temperatures. Yellow, pink, and phoenix oysters are all good for high temperature situations. King oyster, enoki, and chestnuts all prefer colder temperatures. Cultivating warm- or cold-loving species based on the season can help to minimize heating or cooling requirements.

CO2: The last parameter to modify is CO2. Like people, mushrooms breathe in oxygen and emit CO2. If the mushrooms are in an enclosed room it only takes about 10 minutes before the CO2 levels become too high for proper fruiting. To address the buildup of CO2, it is recommended that all of the air in the grow room is exchanged at least every 10 minutes. With oysters, the more fresh air the better. If CO2 is too high the mushrooms will have long stems and little caps, and at levels above 1200 PPM fruiting can be inhibited. Shiitakes, Lion's Mane, King Oyster and others are tolerant of CO2 levels in the range of 1000-1300 PPM. Oyster mushrooms have a lower tolerance, with CO2 levels above 800 PPM causing deformations. Some mushrooms like Maitake and Enoki can fruit in high CO2 environments and still be a high quality mushroom.

D) Packing and Cold Storage

Once the mushrooms are harvested, the last step before selling is packing and storing them. A packing area can be as simple as a table or two, scales, markers, tape, and other miscellaneous materials. It is best to harvest directly into the package that the mushrooms are sold in but bulk storage crates work as well. Bulb crates with a towel on top are a great way to store mushrooms in a walk-in cooler. Some growers get plastic totes and drill holes into them. It is important to have something on top of the mushrooms to absorb any excess moisture that forms, so that sitting water doesn't get absorbed or cause disease on the mushrooms. Typically mushrooms are sold in 3.5 oz containers and 3 lb or 5 lb cases. Mushrooms should be stored in a cooler between 36-40°. The most affordable way to achieve this on a commercial scale is through the use of an A.C. and a Coolbot. The Coolbot tricks the A.C. into thinking it is warmer and brings the room temperature down to the high 30's. Using an old walk-in cooler, reefer trailer, or a custom built insulated room, the A.C and coolbot combination can meet refrigeration needs for $1,000. If purchasing ready-to-fruit blocks it is good to have enough refrigerated storage for twice the amount of mushrooms cultivated plus 3-4 weeks of ready-to-fruit blocks.

FARM ANALYSIS

A) Choosing Ready-to-Fruit vs Making Blocks in House

There is not just one way to grow mushrooms, nor the perfect place. A successful operation requires that the environmental conditions are maintained to a level that is achievable and reliable, while matching the mushroom species, strains, and substrates to the environment. The environment largely depends on the grower's climate, location, seasonal temperature variation, and integrity of the building insulation to buffer temperature swings.

In addition to the environmental conditions, a grower's work flow can have a major effect on the outcome. One of the larger junctions in the many decisions a grower needs to make is: **will I produce my own blocks on site or buy them in?**

The answer to this question may change over time, and it could be both. For instance, a grower might start with buying blocks while getting a handle on production protocols. Or, one might buy pre-made blocks in order to try a new species for markets or to determine whether their environment is conducive before committing to making the blocks on site.

The focus of this article is on the block portion of production, with the assumption that the reader is considering fruiting mushrooms indoors from blocks and is considering whether to make their own blocks or buy them in. Before we consider the pros and cons of this important decision, let's define what a "block" is. In the mushroom production life cycle, there are three important steps:

1) Spawn production from mushroom cultures (liquid, petri dish, live or dried specimen) is where a culture is grown initially on grain or sawdust. No mushrooms are produced from this material, rather it is used to inoculate other materials. This must be done with skilled techniques and in a sterile space.

2) Block production from spawn (above) that is inoculated into a mixture of substrate (sawdust, straw, coffee grounds, grain hulls, etc) with the goal of the block or bag fruiting mushrooms. These are typically done in 5 or 10 lb blocks—but some growers also use other containers, such as straw in five gallon buckets when growing oysters.

3) Fruiting, sales and other distribution of the mushrooms.

Blocks can either be purchased from a supplier and then put into a fruiting space OR Blocks can be inoculated onsite, after the substrate is cleaned of contaminants, and then incubated (for most species, 3-4 weeks) before being put into the fruiting space.

Let's first consider some of the pros and cons of each approach, as neither is 'right' in all situations but given the farm context, one might be more favorable:

Buy Ready-to-Fruit Blocks		Make Blocks "In House"	
Pro	**Con**	**Pro**	**Con**
- Eliminates the need for an incubation room, can focus on fruiting and sales - Can significantly reduce contamination in blocks - Eliminates or reduces substantial labor, material, and infrastructure costs - Reduces the need to maintain sterile conditions within the growing space (less cleaning!) - Possible lower cost per block - Can trial new strains for markets and grow environments without committing to them entirely	- Additional shipping costs if supplier is not nearby - Possible higher cost per block - Issues can arise when relying on supplier schedule and stock - Shipping and freight logistics:timing, lost items, unloading, etc - May need cooler storage if ordering in bulk - Currently there are limited suppliers of blocks within the U.S. - High cash flow; need to pay upfront before selling - Scheduling and commiting to a volume weeks or months ahead of time - Substrate materials not necessarily local or sustainable	- Complete control over scheduling, from production to fruiting - Can scale up or down in production volume as needed - Able to source and utilize local and waste materials as substrate, and to build sustainable connections - Control over the cost per block and ability to reduce that cost over time	- Depending on methods, significant infrastructure is needed (tanks, pasteurization or sterilization equipment) - - Need incubation space - Labor availability will greatly affect the volume of production possible - Take on responsibility for contamination issues as they arise

A summary of the table might read:

Buying in blocks reduces labor and infrastructure while increasing the need for cash flow, shipping costs and logistics, and increases reliance on a supplier with the possible supply issues they may have.

Making blocks in house will increase labor and infrastructure costs but allow more control over substrate materials, timing, logistics, and the ability to reduce the cost per block over time.

Considering these factors, let's look at grower scenarios from our research to see how these decisions can play out.

B) Grower Scenario Summaries

In 2020, we engaged potential growers in a number of educational efforts. These growers were starting up production in their first or second year and ready to jump into a commercial enterprise. They applied for consulting support and assistance, in exchange for collecting and sharing data on their production figures, sales, labor costs and material costs.

We are grateful for the fourteen growers who initially signed up and the five farms who were able to produce data sets we could analyze. Of course, 2020 was a challenging year given the COVID-19 pandemic, some growers could not complete datasets because they decided to stop or delay production, or other life circumstances arose.

Table 1 summarizes the datasets we received from five farms as well as from the Cornell block studies also conducted in 2020, which to some degree can be thought of as a "control" comparison to the more dynamic nature of actual on-farm production.

Of these seven examples, three sites purchased blocks and three sites made their own blocks on the farm. Some farms utilized 10 lb blocks and others 5 lb blocks, so for the purposes of comparison, we converted all the farms to utilize 5 lb block equivalents in our calculations.

The unique circumstances of each farm mean that there is a wide range in some of the elements, limiting the value of comparison. There is a large range in the timeframe that data was collected from each of the farms, from 16 to 69 weeks. We ended up eliminating infrastructure costs (capital and fixed costs) in the analysis below because the range was too variable to compare farms. Instead, we focused on the operational costs (labor + materials) to give a snapshot of average weekly costs, to assess the realities in production systems.

The table below is ranked by the number of blocks initiated per week. Interestingly, the Cornell trials fell to the middle of the group and appears to be an indicator of a potential "break even" point, suggesting that farms doing 60 blocks a week should be able to realize profit. However, this does not guarantee that a smaller operation couldn't find profitability, or that 60 blocks a week is sufficient. One factor in this is the residency of blocks in a grow room; for the Cornell research, blocks were left in the fruiting space for 8 full weeks to capture the entire potential yield and this is reflected in the higher average pounds per block value.

Most farms cycle blocks faster, often removing them after the first major harvest to make room for more new blocks. Given all the variability and difference between these seven examples, it's important not to directly compare one farm to another or make any conclusions about the right scale of enterprise. The farmers who participated all indicated that the data they collected was not perfect, but the best they could achieve while busy with production.

The next section below uses a strategy of averaging values per block in order to create some reasonable projections for others to use. Perhaps the most important takeaway from the Table 1 summary is the wide variability of operations and their potential to be efficient in labor and material costs, production, and ultimately profit or loss.

One might be tempted to infer that based on dividing sales by pounds the price received per pound could be determined. We specifically did not include a $/lb figure because that can be misleading. Several of these farms have value-added products, spawn kits, supplies, workshops, and other sales as part of the total. The sales in the overall enterprises are not a direct result of pounds of mushrooms.

Farm	Weeks of Data	Blocks Initiated per Week	Pounds Harvested / Week	Average Pounds/ Block	Sales/ Week	Costs/ Week	Profit & Loss/ Week
Farm A	20	16.15	15.03	0.93	$112.45	$410.19	-$297.74
Farm B	30	24.03	28.00	1.17	$138.98	$233.74	-$94.76
CORNELL A	16	60.00	40.85	1.36	$490.20	$488.13	$2.07
CORNELL B	16	60.00	48.8	1.63	$585.60	$488.13	$97.47
Farm C	27	90.22	59.39	0.66	$791.10	$624.50	$166.60
Farm D	69	117.41	88.05	0.75	$969.40	$296.94	$672.46
Farm E	18	313.33	284.06	0.91	$3,389.37	$2,044.67	$1,344.70

TABLE 1: Average Weekly Values for seven mushroom production scenarios.

Farm A is producing in West Virginia and initiated an average of 16 blocks per week, produced on site. This yielded an average of 15.03 lb of mushrooms and generated $112.45 in income each week. Labor costs represented 80% of overall costs and were notably higher than the other operations, with 34% of time spent harvesting, 22% inoculating, 28% in delivery and sales, and 14% in packing and processing. At this pace and scale, the farm is operating at a loss. Increasing the number of blocks produced weekly and reducing labor costs would most improve profit and loss.

Farm B is producing in Massachusetts using ready-to-fruit blocks. It is notable that blocks were not added weekly but one or two times per month, which resulted in weeks of no labor/yield and then weeks where there was much higher activity, with some weeks with 50-90 lb produced. An average of 24 blocks initiated each week produced 28 lb, which generated $138.98 in sales. Labor costs were 52% of overall costs, with 82% of the material cost being the purchase of ready-to-fruit blocks. Labor was 60% in harvesting, 0% inoculation, 21% sales, 17% packing and processing, and 2% other. At this pace the farm is operating at a loss. Increasing the scale of production would most improve profit and loss.

Farm E is initiating an average of 313 ready-to-fruit blocks a week in New York. This yielded 284 lb for $3389.37 sales per week. The material costs represent 67% of the overall costs and are almost entirely ready-to-fruit block purchases, which cost $1,402.50 per week. Labor breakdown is 20% on harvesting, 0% inoculating, 33% delivery and sales, 22% packing processing, 6% cleaning, and 17% other. At this pace and scale, the enterprise is making a profit.

Farm C is producing an average of 90 blocks per week, made on site in Vermont. This yielded 59.39 lb per week generating $791.10 in sales. Labor represented 67% of the operating costs and was spent on 12% harvesting, 29% inoculation, 30% delivery and sales, 14% packing and processing, 6% cleaning, and 7% other. At this scale the farm is operating at a profit of $166.60 per week. Improvements in inoculation and delivery and sales efficiency would likely most improve the profit and loss for this enterprise.

Farm D is producing on blocks the farm made on site, in Eastern New York. The average blocks initiated per week was 117.4 and this yielded 88.5 lb and generated $969.40 revenue per week. Labor represented 68% of the operating costs and was spent on 9.9% harvesting, 34% inoculation, 46% delivery and sales, and 9.8% packing and processing. It is important to note the wide range of value-added products that enhance weekly sales, including mushroom kits, tinctures, workshops, and spawn for purchase. At this scale the farm was generating a profit of $517.89 per week. Improvements to this enterprise would most effectively focus on increasing the pounds yielded per block, which was the lowest of all the farms.

C) Average Numbers Per Block

Given all the variables of production on various farms, it is most accurate to compare their production systems based on five lb blocks. Table 2 summarizes the per block values for each farm.

It is important to consider the **average pounds harvested per block**, which across all 5 participating farms was .88 lbs. (We left out Cornell blocks because of the excessive residency noted above.) **The costs per block** value is also important, which accounts for both the material and labor inputs combined. The **labor per block** values give a sense of how much labor factors into the overall cost.

Farm	Average Pounds/ lock	Sales/ Block	Costs/ Block	Profit & Loss/ block	Labor (hr)/ block
Farm A	0.93	$6.96	$25.40	-$18.44	1.52
Farm B	1.17	$5.78	$9.73	-$3.94	0.34
Farm C	0.66	$8.77	$6.92	$1.85	0.14
Farm D	0.75	$8.26	$2.53	$5.73	0.27
Farm E	0.91	$10.82	$6.53	$4.29	0.27

TABLE 2: Per block values for each farm

One goal in facilitating and sharing this data is to provide some metrics for others to use in their planning, as they consider what production could look like. In order to do this, we first looked at the average of all five farms (two which showed a loss, three that showed a profit). The average generated a loss and a very exceptional value for the labor per block.

Averaging the top four producing farms (one with a loss, three with a profit) yielded a good set of values to consider as the “low” end of a continuum. Averaging the three profitable ventures offered a good set of “high” values for scenario models. Averaging farms across a spectrum of profit/loss does dilute some of the details, but provides a more realistic picture for growers as they begin production. Table 3 shows the averaged values for these various groupings.

	Weeks of Data	5# Blocks Initiated/ Week	Pounds/ Week	Average Pounds/ lock	Sales/ Block	Costs/ Block	Profit & Loss/ block	Labor (hr)/ Block
All 5 Farms	32.8	112.23	94.90	0.88	$8.12	$10.22	-$2.10	0.51
Top 4 Farms (LOW)	36	136.25	114.87	0.87	$8.41	$6.43	$1.98	0.25
Top 3 Farms, all Profitable (HIGH)	38	173.65	143.83	0.77	$9.28	$5.33	$3.96	0.22

TABLE 3: Averaged per block values for various groupings of farms

This average helps us compensate for variability, such as the high labor costs with some operations vs others, but it also hides the reality that each of these operations works very differently. These average values offer a starting point for some projections. Keep in mind that any enterprise should use values as a projection while also keeping their own records in order to compare results over time.

Note that this summary accounts for only the "operating costs" which include the materials and labor to produce blocks and/or mushrooms. Absent are the wide range of capital, equipment, infrastructure, and other fixed costs like rent or utilities. There was simply too much variability in these, with a total average of $4,751.12, with highest $10,665.00 and lowest $694.85. In exit interviews, the growers observed that these values were not as accurately reported as operating costs. For instance, some enterprises may have started with a building or equipment on hand while others did not. Some reported rent and utilities and others did not. Thus anyone using the above values in projections should keep in mind this data summary covers only the base operating costs and should factor other indirect costs into their overall budgets.

The operating costs were broken into labor and material costs. All of the farms except one were owner-operated. The labor cost was calculated by the amount of hours worked times $15 per hour. In the four owner operated farms these would be added into overall farm profit. The table below shows the breakdown of operating costs into labor and material costs.

	Labor Cost/ Week	Material Cost/ Week	TOTAL Costs/ Week	Method
Farm A	$369.38	$40.82	$410.19	Blocks On Site
Farm B	$123.75	$109.99	$233.74	RTF Blocks
Farm C	$416.94	$207.56	$624.50	Blocks On Site
Farm D	$203.04	$93.90	$296.94	Blocks On Site
Farm E	$675.00	$1,369.67	$2,044.67	RTF Blocks
CORNELL A	$238.75	$249.38	$488.13	RTF Blocks
CORNELL B	$238.75	$249.38	$488.13	RTF Blocks

Breakdown of weekly costs

D) Projecting the Potential

Based on these values in Table 3, we can project the potential values for operating a mushroom operation on a wide range of scales. Farms tend to produce seasonally or year round, so one could consider multiplying these by the number of weeks they might consider growing to consider what a whole operation could yield.

For these scenarios, we kept the yield per block at the global average across all the farms (.88 lbs/block). Note that the values for labor, sales, and costs on a per block basis only vary to a small degree, yet result in values that almost double profitability. Table 4 shows the "low" production scenario and Table 5 shows the "high" production scenario, with modest changes in sales and costs reflecting a substantial increase in profitability.

Values Used:	0.88 lbs	0.25 hrs	$8.41	$6.42	$1.98
blocks per week	**yield (lbs)**	**labor (hrs)**	**sales ($)**	**costs ($)**	**profit / loss**
20	17.60	5.00	$168.20	$128.40	$39.80
40	35.20	10.00	$336.40	$256.80	$79.60
60	52.80	15.00	$504.60	$385.20	$119.40
80	70.40	20.00	$672.80	$513.60	$159.20
100	88.00	25.00	$841.00	$642.00	$199.00
120	105.60	30.00	$1,009.20	$770.40	$238.80
140	123.20	35.00	$1,177.40	$898.80	$278.60
160	140.80	40.00	$1,345.60	$1,027.20	$318.40
180	158.40	45.00	$1,513.80	$1,155.60	$358.20
200	176.00	50.00	$1,682.00	$1,284.00	$398.00

TABLE 4: "Low" Scenario for Production based on Blocks Initiated

Values Used:	0.88 lbs	0.22 hrs	$9.28	$5.33	$3.96
blocks per week	**yield (lbs)**	**labor (hrs)**	**sales ($)**	**costs ($)**	**profit / loss**
20	17.60	4.40	$185.60	$106.60	$79.00
40	35.20	8.80	$371.20	$213.20	$158.00
60	52.80	13.20	$556.80	$319.80	$237.00
80	70.40	17.60	$742.40	$426.40	$316.00
100	88.00	22.00	$928.00	$533.00	$395.00
120	105.60	26.40	$1,113.60	$639.60	$474.00
140	123.20	30.80	$1,299.20	$746.20	$553.00
160	140.80	35.20	$1,484.80	$852.80	$632.00
180	158.40	39.60	$1,670.40	$959.40	$711.00
200	176.00	44.00	$1,856.00	$1,066.00	$790.00

TABLE 5: "High" Scenario for Production based on Blocks Initiated

Keep in mind these projections are based on the original averages, so there is no accounting for the potential efficiencies of various scales. That said, we can see in the "low scenario" that at around 160 blocks a week the enterprise becomes a full time job for one person, while generating a surplus profit of $318.40 to cover other indirect and investment costs. In the "high scenario" 180 blocks a week becomes a full time job for one person, while generating a surplus profit of $711.

We are thankful for the participating farms and their data, which we can use to help others plan for successful enterprises via our online Indoor Crop Decision Tool. The initial data in this tool was an estimated projection from conversations with growers, but this grower data along with results from Cornell trials will be integrated into this tool in the Winter of 2022 and we expect to offer a second release using this data in Spring 2022. This will offer users a more realistic tool for projections in the future.

E) Lessons Learned

1) Ready-to-Fruit and BOS (Blocks on site) can both be profitable, or not. Based on the data, there was not a clear "winner" in terms of overall profitability when thinking about the two approaches (more on this below). Not surprisingly, what does seem clear is that within operating costs, labor is much more substantial when blocks are made on site, while materials costs are higher for those operations buying in ready-to-fruit blocks. One consideration is that labor is a cost that can theoretically be improved or reduced by a grower, while the material costs of buying blocks are likely out of their hands.

2) Scale matters for profitability. The farms producing at the lower end of scale (16-24 blocks/week) did not report profitable numbers, while those at 90 blocks per week and above saw positive gains. The chart above suggests profitability at each scale, but remember that this is operating costs only. The fixed and capital costs, along with the number of weeks in production will greatly affect the potential profit or loss of a specific operation. The farms producing 50 lbs or more per week were consistently profitable while the ones below were typically not profitable.

3) It is important to analyze the yield per block. The range farms reported was .66 to 1.36 lb per block. This means the proper selection of strains, substrate, and methods could cut potential yields in half, or double them, depending on the choices made. It is recommended that farms track production yields periodically and use these measures to determine changes that can improve their operation over time.

4) Calculate hours per pound by tracking labor. Growers reported a wide range of values for labor in relation to their yields. The average was .56 hours per pound, with .14 hours being lowest and 1.52 hours being highest. In most farm enterprises, labor is the highest cost and also has the highest potential for improvement. Improving the flow of workers and materials, the skills and abilities of the workforce, and the way spaces are set up can all have dramatic effects. As a starting point, it's critical to track the labor and develop a system to make this record-keeping simple so that it does not detract from production work.

Table 6 offers the breakdown of various tasks within operations and the rough percentage of the overall labor cost it represents. Some farms expressed that due to the challenges of labor tracking, their total hours were likely greater. Some farms accounted for time cleaning while for others it was wrapped into other categories. In retrospect, it would have been best to define cleaning as a separate category, since growers report this is a substantial portion of their time.

Labor accounts for 67% of operating costs, and materials 32%—an average for all of the farms. When we look at farms making blocks on site (orange) vs buying in blocks (blue), the breakdown is quite different. Farms making blocks on site arrive at 20% materials and 80% labor while ready-to-fruit block farms have a higher material cost of 58% and labor at 42%.

	Farm A	Farm B	Farm C	Farm D	Farm E
Type	Blocks on Farm	Blocks Bought In	Blocks on Farm	Blocks on Farm	Blocks Bought In
Harvesting	34%	60%	12%	10%	20%
Inoculation	22%	0%	29%	34%	0%
Delivery/Sales	29%	21%	30%	46%	33%
Packing / Processing	14%	17%	14%	10%	22%
other /cleaning	1%	2%	15%	0	25%

TABLE 6: Breakdown of labor allocation

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