Mushroom Cultivation Project

Community Empowerment Project – Producing Food from Waste.

1/29/2013

Funguys Gourmet cc. (Co.Reg.2008/125793/23)
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FOREWORD

It is my intention with this document to outline a low budget formula, for the production of Oyster Mushrooms from Waste Barley Grain, Waste Paper and Grasses. The mushroom grow facility outlined in this paper is designed to be environmentally friendly, energy efficient and sustainable.

The Project is outlined in stages of growth:

- Phase 1 will deal with Planning, Site Location and Construction of the Grow Facility.
- Phase 2 will deal with Costing
- Phase 3 will deal with Production of Mushrooms.

Phase 1 - Planning, Site Location and Construction of the Grow Facility

Planning:

Planning the Project is by far the most time consuming activity in the process, but by taking care in weighing up all your options, the pros and the cons, the scope and intention we hope for decisive and consistent results. Planning for the economical tides that we locally and internationally may experience over the next couple of years as well as planning ahead for energy saving and efficiency is of utmost importance. Planning your project to be Green will have positive effects on your local economy. Planning ahead where you will find your substrates, what containers you will use to grow your mushrooms in and what waste products you yourself will produce is all part of this planning phase.

Scope:

1) What type of mushroom will grow well naturally in our environment and may very well be part of our local ecosystem?
2) Can I produce this mushroom through the year?
3) What does the mushroom need to thrive?
4) Planning the budget.
5) Weighing up the pros and cons of available substrate.
6) Consider financial increases of production cost.
7) Consider increases in energy charges.
8) Consider water usage and saving.
9) Consider what waste material you will produce and how you could recycle your own waste in a secondary productive process.
10) Negotiating with local businesses to supply you with substrate materials e.g. some types of garden refuse, waste barley grain from the local brewery, municipal grass clippings and paper from the paper recycling depot.
11) Negotiating with some local businesses or local government to sponsor or donate to the ongoing project e.g. shipping containers.
12) Consider the scope of expanding the project.
13) Planning a training schedule for all staff.
14) Health and safety procedures.
15) Pest control.

Site Location:

Ideally you would like a site in the mountains with a crystal water stream flowing past your grow facility. In our world today this is becoming further and further away a possibility, so we chose to look at what we have.

Scope:

1) We need access to clean de-chlorinated water;
2) Easy access to the substrates that will be used;
3) Relatively clean air – low contamination levels from external sources;
4) North facing roof structure for solar equipment;
5) Easy access to market your product locally;
6) Accessible to Workforce;
7) Access to space outdoors for composting and Vermicast production (Secondary process - mushroom production);
8) Access to Cleaning facilities, toilets, change room for staff;
9) Access to Clean – SABS049 Standard – Packing facility;
10) Accessibility of existing rain water tanks will be beneficial;
11) It is beneficial to the cultivator to separate the different phases of production. Ideally you want your grow facility away from spawn rooms and your laboratory. Waste substrates must be removed away from the premises to avoid proliferation of pests.

Construction of the Grow facility:

There is a large sum of work to consider as well as intense planning before building your mushroom grow-facility. As an example I will consider using an empty factory space in an Industrial area and that the entire grow facility will fit within this factory space. Three main Zones must be created within this factory. Zone 1 is a public space, for administration, reception, deliveries etc. Zone 2 is separated from Zone 1 and will be used for cleaning, showering, have toilets and a changing room. Zone 3 is separated from Zone 2 and will house the mushroom factory. The following section will focus on Zone 3.

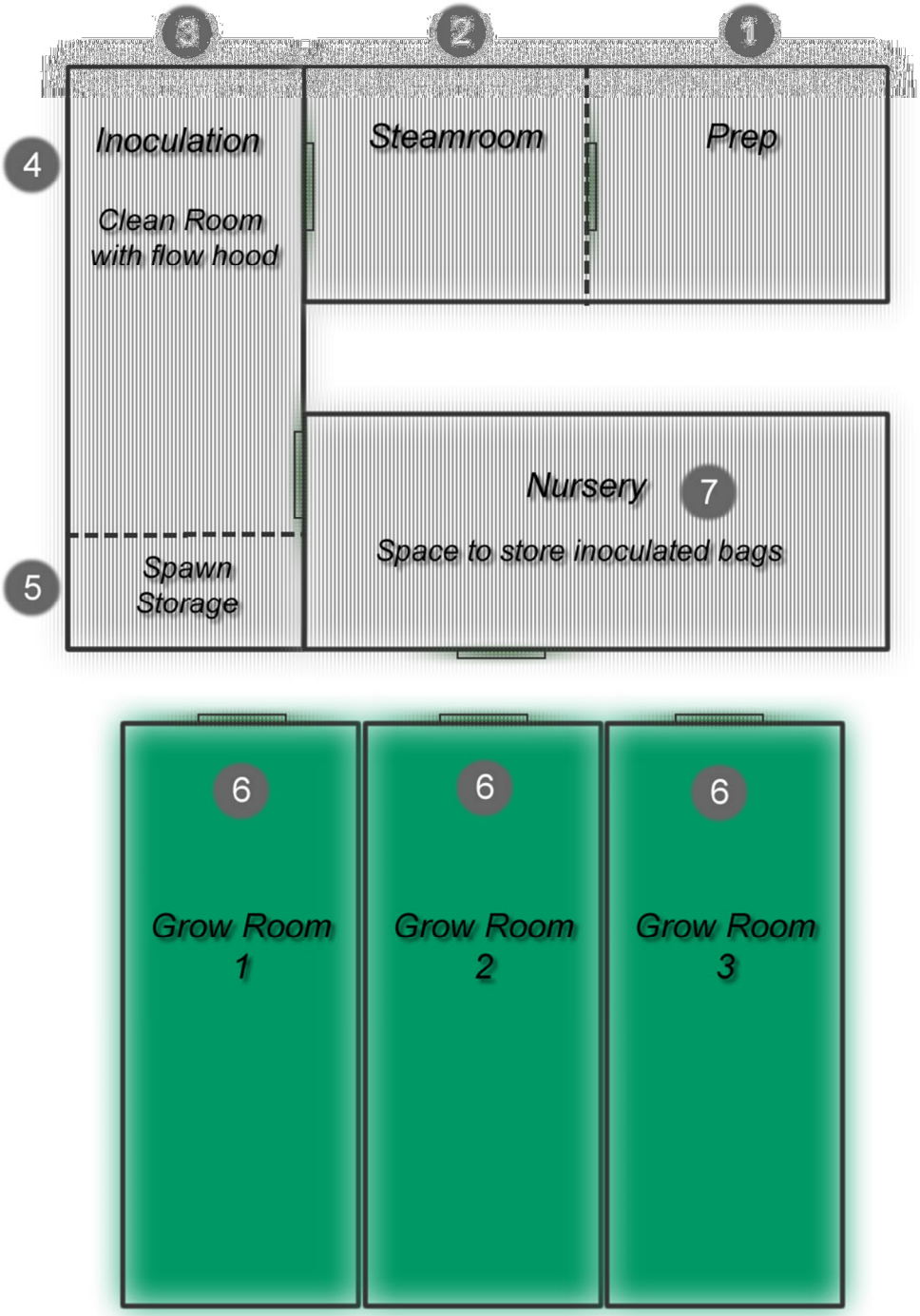
3
2
1
Inoculation
Clean Room
with flow hood
Steamroom
Prep
4
Nursery
7
Space to store inoculated bags
Spawn
Storage
5
6
6
6
Grow Room
1
Grow Room
2
Grow Room
3

Diagram 1

Step 1 A - Warm Water Pasteurization

a) Build the pasteurization chamber. Use a stainless steel pasteurizer, 210 Lt Drum or cement mixer. Depending on the method used you will need some way to extract the substrate after sterilization. The wet substrate could get quite heavy when soaked and you will need a mechanical chain lift to remove the substrate. This step must be considered and pre planned for in Phase 1.
b) The preparation and pasteurization area must have a concrete floor, and have a drain to easily dispose of excess water.
c) Natural Gas is used in part of the pasteurization process and must be kept away from flammable equipment.
d) Solar heated water will be ideal to use in the production facility for pasteurization and washing up.
e) A Suitable method must be found to allow your substrate to cool, away from insects and out of air draft. It is important to keep your sterilized substrate clean at this time to avoid later contamination that will spoil your harvest.
f) Easy access to the inoculation chambers.

Step 1 B - Cold Water Pasteurization

a) Another effective way to sterilize your substrate is using Calcium Hydroxide.
b) Use 56L black plastic tubs.
c) Soak the substrate for 16 – 18 hours in the cold water / calcium hydroxide solution.
d) Drain the water for 4 – 8 hours after.

Step 2

a) The Inoculation Chambers must be a semi-sterile space that is only used for the purpose of inoculating your mushroom bags. Before and after each inoculation session, the room must be pressure washed and sterilized using Des-O-Germ™. (This is an environmentally friendly product that can be used in Myco culture.) To accomplish this, the floor must be cemented and slanted slightly for easy drainage.
b) It is customary to use a laminar flow hood in your inoculation chambers, but for a startup project, it will be possible to go without (Pleurotus Ostreatus – Oyster Mushrooms is a very hardy and aggressive culture).
c) The inoculation chambers will need a fresh air inlet – sterilize the air using a 3-micron HEPA filter.
d) A large stainless steel surface is needed to handle your substrate.
e) The inoculation chambers must have a basin and water tap for hand washing.

f) The inoculation chambers must be fitted with a hand towel dispenser as well as equipped with a clean cupboard for sterile overalls.
g) It will be useful to have a door leading from the inoculation chambers to the Nursery for easy transfer of inoculated bags.

Step 3

a) The Nursery is the space where inoculated bags are left to mature before fruiting. Light is omitted completely during this stage.
b) A Cement well drained floor is preferable to aid easy cleaning.
c) The room must be air tight to keep out insects and contaminants.
d) The Nursery will need a fresh air inlet – sterilize the air using a 3-micron HEPA filter.
e) The room must be fitted with racks to keep the bags off the floor.
f) This room must be fitted with a thermostat and wall heating unit to automate temperature variations.

Step 4

a) The mushroom fruiting space will take the larger part of the factory.
b) For the purpose of this project I will consider an open plan grow space. (Diagram 1)
c) The floor will be constructed from cement for easy cleaning.
d) Humidification can be achieved using Ultrasonic humidifiers. It is important to create a fine mist and not have big drops of water settle or drip on the developing and adult mushrooms.
e) The wall separations can be constructed from a treated wood construction and "Nutec" boards and greenhouse plastic sheeting. The construction must me sturdy.
f) Oyster mushrooms need light, if the factory roof does not have sufficient sky lighting available, lighting will have to be provided.
g) Fresh air inlets must be provided to the grow space as developing mushrooms produce tremendous amounts of carbon dioxide, and this gas must be removed from the space.
h) Entry points to the grow space must be screened doorways to deter flying insects from entering. The cause of most of contamination in my experience is when fungus gnats make their appearance in my grow room. From observing these little flies, I noticed that they farm and reproduce molds the same way termites farm mushroom mycelium underground - termitomyces.
i) Easy access from the grow rooms to the exterior of the factory must be created, for removal of spent substrate and if any contaminated mushroom bags.

Step 5

a) The Sorting / Packing Room must be airtight and well screened from insects and other pests.
b) The room must be well ventilated and have a good light source.
c) There must be a basin and fresh water tap. (SABS049)
d) The floor must be tiled and have a proper drainage for easy cleaning. (SABS049)
e) The Sorting / Packing Room need be equipped with disposable hand toweling;
f) Off the floor storage of packaging containers; (SABS049)
g) Stainless steel working surface;
h) Harvesting and processing tools;
i) A Calibrated measuring scale.

Step 6

a) Post processing – Refrigerated chambers to keep spawn and mushrooms.
b) Drying facility to dry mushrooms.

Step 7

a) Spent substrate bags can be emptied outdoors in a designated area. Preferably away from your grow facility.
b) The spent substrate can be turned into rich compost using earthworms and beneficial soil bacteria.
c) A Shade netted area will be sufficient.

Phase 2 – Costing

There is some specialized equipment not included: Herewith the basic Costs Only. Note that these prices are as example only and may vary or scaled.

Basic Monthly Costs	
Rental - site specific	3500
Telephone	600
Electricity - availability	2000
Water - availability	300
Pest Control	150
Labor	5000
	11550
Labor - Basic	
2 People	5000
	5000
Grow Facility - Setup Cost	
Prep and Steam Room	4000
Inoculation Room	19500
Nursery	11200
Grow Room 1,2,3	47600
Solar Water System	9900
Air & Filtration	15000
Professional Services	3000
	110200
Prep and Steam Room	
Gas Equipment & Fittings	600
Pasteurization Equipment	1000
Buckets & Lids	2400
	4000
Inoculation Room	
Structure / If not available	5000
Laminar Flow Hood / recommended	10000

Fresh Air Inlet - Spigots and air pipes	1200
Stainless Steel Table	2000
Paper Toweling Dispenser	300
Consumables	1000
	19500

Nursery

Structure / If not available	6000
Shelving	4000
Air inlet & Spigots	1200
	11200

Grow Room 1,2,3

Structure X 3 / If not available	30000
Fresh Air inlets & Spigots	3600
Ultrasonic Humidifiers	4500
Lighting	6000
	44100

Professional Services

Electrical Costs - Wiring	1500
Plumbing Costs	1500
	3000

Solar Water Pump System (Optional)

1 Pump	1600
3 X 70W Solar Voltaic Panels	3000
2 X 105 ah Batteries	2400
1 X Controller	750
Wiring	1000
	8750

Production Costs per Cycle

Tubing	585
Calcium Sulphate	120
Gas	1832
Spawn	3520
Consumables	200
	6257

Returns per 50 Tubing bags

Amount of Bags	50	
Average Bag Weight	10	kg
Bio Efficiency	50%	
Yield expected - 6 weeks	250	kg
Kilogram Price Wholesale	90	
	22500	

Spawn Calculation - Rate 15%

Per every 10kg of wet weight substrate you can use 1.5kg Spawn

To produce 50 X 10kg Mushroom Bags you will need:

Wet weight	500
Spawn Rate	15%
Weight of Spawn Bag	3.5
Amount of Bags Needed	21.43
Cost of Spawn per Unit	160
Total Spawn Cost	3428.57

Phase 3 – Oyster Mushroom production

Substrate Selection:

Selection may consist of Grass clippings from both municipal source and garden services; Waste Barley grain from local breweries; Water Hyacinth can be sourced from local dams (tertiary cleanup project); wheat straw is by far the best substrate to produce Oyster Mushrooms and must be added at least at a 50% ratio when available; waste paper from local businesses and Knysna recycling depot can also be used. Substrates may have to be pre dried to some degree before use. Long grasses and straw can be chipped to 3- 4 cm pieces. Use only good looking uncontaminated substrates and remove any substrates that have been contaminated away from the facility. In my experience wheat straw is by far the best substrate to use in cultivating oyster mushrooms and is ideal for commercial cultivation of mushrooms as a tried and tested substrate.

Pasteurization:

You will need to keep your substrate submerged in 65˚C clean water for 1.5 - 2 hours. Ideally a stainless steel milk pasteurization tank would guarantee results, but using a 210L metal tank would also be sufficient. This process must take place in an area that is draft free and away from any contaminants. Drained water must be funneled to an exterior troth for further treatment or use. It is advisable to have this preparation area in close proximity to your inoculation chambers for easy access. The heated and now sterilized substrate will need to cool down in a clean space that is out of draft and away from insects. The substrate will take about 3 – 4 hours to cool down to below 25˚C before inoculation can take place.

Also read about cold water pasteurization here.

Spawning

Introducing mushroom mycelium to the sterilized substrate is referred to as spawning or inoculation. It is accomplished by adding seed kernels to the substrate that previously was impregnated by the fungi of your choice. The seed spawn kernels are well mixed into the still moist and warm spawn and the bagged in 300mm diameter plastic bags or tubs. These bags are then moved to your Mushroom Nursery. Ideal inoculation rates for oyster mushrooms are between 10 and 15%.

The Nursery

The inoculated bags will heed some time for vegetative growth. By keeping the temperature constant above 18˚C and below 22˚C, the bags will be ready for fruiting in 10 – 14 days. During this time light is completely omitted, fresh air is routinely introduced to expel the high amounts of carbon dioxide that will build up in the nursery during this time. The humidity can be kept between 60 and 70 RHM during this time. **Care must be taken to keep the nursery free of rodents and flying insects.** Any contaminated bags can be removed away from the premises and composted.

Since Trichoderma is a common fungal contaminant in the mushroom growing environment, trying to combat the fungi is impossible. The only way to win is by prevention. Trichoderma has economic value; as an additive in commercial Peat production and in compost making as well as being a natural pesticide. Trichoderma also seem to show mycorrhizal activity with plant roots and can improve the general health of plants by activating their host defense response.[2]

Growing out the Mushrooms

Oyster mushrooms prefer a temperature between 10˚C and 21˚C to produce economically viable mushrooms. The humidity must be kept high during the fruiting phase, between 80 and 90 RHM. Plenty of fresh air must be introduced to expel the carbon dioxide buildup and supply oxygen for mushroom growth. If your room is 10m in length, 5m wide and 3m high, you will have 150m³ of air to replace 4 – 8 times an hour.

Small X cuts, 25mm, are made on the surface of the plastic mushroom grow bag or container to introduce fresh air to the mushroom mycelium as well as a 12 hour light cycle. The combination of lowered temperature, light and fresh air will bump the mycelium into its fruiting stage (pinning initiation). Within 7 days small pins would have formed, these will develop into adult mushrooms within 5 days, depending on the ambient room temperature. Cooler air will produce sturdier, bluer in color mushrooms but will take longer to develop. Higher temperatures may produce adult mushrooms from pins within 3 days. These mushrooms tend to be whiter in color and will lose shelf life as they become more fragile.

Mushrooms are harvested by turning the bouquet of mushrooms to either side while holding at the base of the mushroom stems. After harvest, mushrooms must be kept in the cooling facility at 4˚C until processed.

Growth parameters – Winter Oyster Mushroom: [1]

Spawn Run:

Temperature: 75° F. (24° C.)

Relative Humidity: 85%

Duration: 12-21 days

C02: 5000-20,000 ppm

Fresh Air Exchanges: 1 per hour

Light Requirements: N/A

Primordia Formation:

Temperature: 50-60° F. (10-15.6° C.)

Relative Humidity: 95%

Duration: 3-5 days

C02: < 1000 ppm

Fresh Air Exchanges: 4-8 per hour

Light Requirements: 1000-1500(2000) lux.*

Fruitbody Development:

Incubation Temperature: 60-70° F. (10-21° C.)

Relative Humidity: 85-90%

Duration: 4-7 days

C02: < 1000 ppm

Fresh Air Exchanges: 4-8 per hour.

Light Requirements: 1000-1500 (2000) lux.

Cropping Cycle:

3-4 crops, 7-14 days apart, over 45-55 days.

These growth parameters is referenced in Growing Gourmet and Medicinal Mushrooms – Paul Stamets

References:

[1]Growing Gourmet and Medicinal Mushrooms – Paul Stamets
[2]http://www.biocontrol.entomology.cornell.edu/pathogens/trichoderma.html