



Growing and Selling Shiitake Mushrooms

Practical Farmers of Iowa 2020 Growing and Selling Shiitake Mushrooms

- **Instructor:**
- **Mike Levine, Co-Owner, Nature and Nurture, LLC**
www.natureandnurtureseeds.com
- With over 20 years of experience in shiitake mushroom production, Mike Levine has experimented with different outdoor production systems and species of edible mushrooms. During this session, learn some of Mike's preferred cultivation techniques, and his methods for packaging, storing and selling mushrooms.

History of Growing Mushrooms on Logs

- People have been cultivating Shiitake (*Lentinula edodes*) mushrooms on logs for over 800 years. Some say it's been over 3000 years. There are written records of them being consumed as early as 199 AD and records of cultivation during the Sung dynasty in China (960-1127 AD).
- Pure spawn cultures of shiitake were first developed in the 1920s.
- Traditionally, suitable trees located in forests where Shiitake grew were sliced open to expose the underlying wood to airborne Shiitake spores. When Shiitake spores landed on the wood they would germinate, and the culture would grow throughout the log.

History and the Present

- An improvement on this method used wooden wedges and later, wafers to inoculate logs more effectively. Now we use wooden dowel plugs for best results.
- It is believed that Shiitake were the first mushrooms ever purposely cultivated by people
- Shiitake is currently the 2nd most cultivated species of mushroom in modern times.



Shiitakes on logs in the 21st century

- The introduction of the Shiitake culture to our logs via wooden dowels (plug spawn) or using sawdust (sawdust spawn), has greatly increased the efficiency of cultivating mushrooms on logs while greatly decreasing the rate of contamination.
- Further, increased water management (i.e. artificial watering/soaking of the logs) has not only led to better management of the mushroom life cycle but has dramatically increased yields.
- Consequently, gourmet mushroom cultivation on logs has become a fun-filled hobby for many—and a lucrative business for some—with some very delicious (and sometimes profitable) results!
- However, growing mushrooms on logs can be slightly labor intensive, depending on the number and size of the logs being handled. Most agree, though, that a good harvest is well worth the effort put forth—9 to 12 warm months after preparing your logs you should begin harvesting your first crop of delicious, mouthwatering mushrooms.

Urban Mushroom Farming

- Urban farmers use their land to produce wholesome and nutritious foods. Contrary to traditional farmland, however, the urban landscape harbors trees, buildings and other obstacles that block the sun, resulting in areas of dappled light and shade. While these areas may not provide enough sunlight to grow traditional food crops, they can be extremely well-suited for growing mushrooms.
- Accordingly, cultivating mushrooms allows an urban farmer to devote a greater portion of his or her property to food production. It also allows the opportunity to realize a greater and more diversified nutritional profile, as mushrooms are not only wholesome and delicious but they offer an excellent nutritional complement to vegetable crops;

Dietary Benefits

- They are high in dietary fiber, rich in protein and polysaccharides, low in fat and simple carbohydrates, and are a good source of many B vitamins and minerals.
- Notably, they are also one of the only produce items to contain vitamin D.
- Some varieties of mushrooms also have proven, medicinal health benefits, including the ability to lower serum cholesterol and inhibit malignant tumors.
- In Asian countries, Shiitake, Reishi, Turkey Tail and Maitake are used to treat cancer, leukemia, hypertension, immunodeficiency diseases and a host of other maladies.

Basic Considerations for Mushroom Cultivation

- Start with an understanding of the ecology of the mushroom you are growing. Saprotrophic fungi are best suited for home cultivation.
- Always use high quality spawn from a reputable spawn provider, such as **easygrowmushrooms.com**. Mushroom cultivation requires an investment of time and labor. The only way to achieve maximum yields for your efforts is by employing high quality spawn.
- Keep your hands and equipment clean during the inoculation process.

Basic Considerations

- Always use freshly-cut logs, from disease-free trees. There are a plethora of fresh logs available in the urban environment but many are from trees that have been removed because they were dead or diseased. Explain to your log provider, be it the local utility company, tree company, etc., what you are using the logs for and what type of wood you prefer. Logs from diseased trees or from those that have been lying around exposed to the environment will most likely have other fungi already growing within them and, therefore, are unsuitable for mushroom production. Non-diseased logs will display nice, clean rings at their ends—logs that are infected will display a mottling of their rings.
- Monitor and maintain the moisture content of your substrate. Mushrooms are up to 90 percent water by weight. They require moist conditions for maximum yields. Your log should be at an optimal >35% during spawn run and >50% during fruiting.
- Know your mushrooms! Make sure to carefully identify each and every mushroom you grow before they are eaten or distributed. Shiitake, for example, have a brown cap with a white spore print—make sure to completely identify them before you eat them!

Getting Started— Variety Selection

There are three basic varieties of Shiitake Mushroom Spawn:

- **Wide Range Varieties:** These are rapidly-colonizing varieties (incubation periods as low as 6 months) that fruit over a broad range of temperatures (50° to 80° F). Wide range varieties are very responsive to force-fruiting (i.e. soaking the logs for 36-48 hours to stimulate a flush of mushrooms) and are the most reliable for beginners.
- **Warm Weather Varieties:** These are moderately-rapidly colonizing varieties (incubation periods as low as 6 to 8 months) that fruit best during warm weather (highs from 60 to 88 F). Warm weather varieties produce the nicest-looking mushrooms during the heat of summer and are responsive to force-fruiting.
- **Cold Weather Varieties:** These are slower-colonizing varieties (9 to 12 months) that fruit in the early spring and late fall (43° to 73° F). Cold weather varieties produce the overall nicest looking mushrooms of all the varieties and are used as season extenders as they will fruit earlier in the spring and later in the fall than wide range or warm weather varieties. They will not, however, produce mushrooms in the heat of the summer. Cold weather strains are the least responsive to force-fruiting.

Getting Started—Log Species

- The preferred species of wood to use for Shiitake cultivation are white and red oak. Most species of oak (*Quercus* species) can be used. The exceptions are the evergreen oaks such as “live oak” (*Quercus turbinella*).
- Other types of hardwoods that can be used include hard maple, sweetgum, locust, hickory, chestnut, alder, hornbeam and ironwood. Very soft wood substrates such as aspen, cottonwood, and poplar, will fruit for a couple years, but the quantity and quality are significantly less than using hardwoods.
- As a general rule the harder the hardwood the better suited the logs will be for Shiitake cultivation. Avoid conifers and fruit trees.

Shiitake Cultivation on Logs

3 phases

- **Inoculation:** You will only need to inoculate your mushroom log once. Even after you pick the mushrooms, the Shiitake culture is still living in your log.
- **Incubation:** After inoculation, the log will then go through the alternating processes of incubating and fruiting.
- **Fruiting:** After your initial incubation period your mushroom log may keep producing mushrooms for up to 6 or more years. Expect to be able to fruit your log 3 times a year (spring, mid-summer and fall).



BUY SPAWN FROM A
REPUTABLE SPAWN COMPANY

- Easygrow Mushrooms and Composting LLC
- Field and Forest Products
- Fungi Perfecti LLC
- Northwest Mycological Consultants
- Mushroompeople

Log Harvesting

- Cut logs from live, healthy trees that are 3"-8" in diameter (some recommend 4"-10")
- 2-4' long
- while trees are dormant (from leaf fall until just before the bark slips due to the spring sap run).
- When cutting the logs, make sure that you can easily lift them for future forcing.

Yield

- Natural fruiting – flushes/yr
- Force fruiting – 3-5 flushes/yr
 - You may see reduced yields per flush with 5 flushes/yr
- Yields are generally highest in years 2 and 3 with 75% of total yield during these 2 years
- BE or biological efficiency is the ratio of the fresh weight of the mushrooms to the initial dry weight of the substrate. Maximum biological efficiency of shiitake production on logs is 33% of the dry weight of a log. So a 60 lb log with a 50% initial moisture content has a dry weight of 30 lbs and can produce a maximum of 10 lbs over the lifespan of the log. Actual yields will most likely be lower.

Measure moisture content of logs

- Make a slice 4" to 6" from end of log.
 - Slice 1" round from end.
 - Weigh slice and place in 175° F oven overnight.
 - Reweigh slice and calculate moisture content.
-
- Logs should be at least 35% moisture content for spawn run.
 - Below 25% your shiitake culture will expire.
 - Optimal moisture content for fruiting is 50% to 60%.

Moisture Content Details

- **Moisture Content = $(WW - DW) / WW \times 100 = \%LMC$**
- **Log dry weight = $\%LMC \times \log \text{fresh weight} / 100$**
- Once you have the value for your log dry weight you can determine the current moisture content of your log any time simply by weighing your log and plugging the value into the log moisture content formula.
- **Log Moisture Content = $\text{Current weight} - LDW / \text{Current weight} \times 100$**
- WW = Wet Weight
- DW = Dry Weight
- LMC = Log Moisture Content
- LDW = Log Dry Weight

Inoculation

- The Shiitake culture is introduced to your log by drilling 5/16" holes 1" deep along the periphery of the log
- Space the holes 4" to 6" apart in rows running along the length of the log. Alternate the rows so that the inoculation holes are staggered, forming the diamond pattern shown in the above diagram. Space your rows 2" apart in between each row. The Shiitake culture will run much faster along the grain of the wood than it will against the grain.
- The dowels are inserted with the whack of a hammer or rubber mallet (preferred). Make sure to get a dowel in every hole—uninoculated holes allow moisture to escape and contaminating fungi to enter.
- Once the dowels are in place, cover each hole with a dab of melted cheese wax. Then tag each log with an aluminum tag indicating the strain and date of inoculation. The logs are now ready to incubate.



Inoculation Details

- Practical – high speed angle grinder at about 10,000 rpm.
- Cordless drill doesn't work in oak very well. Bit will often get stuck and it's hard to get it out.
- Fast production – there are automatic and semiautomatic inoculators, but they use Styrofoam capped plugs. Not sure if that's organic and I don't like using Styrofoam
- Preferences for plug/sawdust – I prefer plugs because you only need a hammer to inoculate.
- Palm and thumb inoculators work for sawdust, but I've experienced repetitive strain and bruising from using them for larger projects. Plugs cost more than sawdust, but are much easier to use.

Inoculation Details

- Inoculation – it generally takes 3 people 2 hours to inoculate 1000 plugs.
- 1 lb of wax for 1000 plugs.
- It seems to work out to being able to drill, plug, wax, and stack about 6-7 logs/hour. Let us know if you can do it faster or if you can't figure out why it's going so slow.
- 8.5 mm bits work for 5/16 plugs
- Don't use multiple strains in 1 logs or they will compete and you will get less yield
- Field and forest sells the [Okuda "Pegasus" Semi-Automatic Log Inoculation Tool - 12.5mm](#) If you are inoculating 1,000's of logs each season – fills and seals 60-70 holes per minute – needs 2 hp air compressor

Alternate Inoculation Kerf Cut



Alternative Inoculation Mushroom Raft



Label Each Log

- 1) Date of inoculation
- 2) Name of strain used in log



The Incubation Process

- Incubate your logs in a warm area that is protected from both sun and wind.
- Not in direct contact with the soil as contaminating organisms from soil can ruin your Shiitake log.
- Incubating the log on a couple of garden or cinder blocks, covered with some burlap, 80% shade cloth or other such material is best.



The Incubation Process

- You can either incubate in an outbuilding or garage or choose a location where the natural vegetation of your property provides the necessary environment.
- The initial incubation period for your log will be approximately six months (or up to 18 months for cold-weather varieties). At the end of that period your log will show signs of colonization by the presence of the white Shiitake culture covering the end of the log.
- Note the whitish culture covering the end of the lower log. This log is ready to fruit!



The Fruiting Process

- Fruiting your Shiitake log (i.e. producing Shiitake mushrooms) can be done passively or pro-actively.
- Generally you get what you put into it. Although you may see a few mushrooms if you simply let Mother Nature water your log.
- You will see a dramatic increase in productivity if you make the effort to “force” or soak them to initiate fruiting.





The Laying Yard



Forcing Logs

- Forcing logs stimulates them to fruit by simulating a naturally occurring disturbance.
- This can be done mechanically, electrically, or most commonly by soaking.
- While soaking is the most practical and effective way to inducing fruiting, these methods could be used in combination to further increase yields.







Soak Forcing

- Start by soaking your log in a CLEAN plastic garbage can, a clean, food-safe 55-gallon drum, a clean stockade tank or, as pictured here, a bathtub.
- Make sure your logs are warmer than your soaking water. Soak your log for at least 24 hours in cold water and then check the moisture content.
- If it is not yet at least 45%, soak it for another 24 hours. 45% is the lowest minimum moisture content for a reasonably decent yield, although 50% to 60% is optimal. Again, you get what you put into it. The closer you soak up to 60% moisture content, the better the yields you will achieve. You will, however, realize diminishing returns after soaking your logs for 48 hours.

Soak Forcing

- Do not soak the logs for over 72 hours as they will go anaerobic and die. Do not soak older logs if their bark is loose because it may just fall all the way off, effectively ending the life of that log.
- Next, stand your log upright, again trying to avoid setting the log directly in contact with the soil.
- Protecting your log against wind and sun is extremely critical at this phase, so pick your spot well. Loosely covering your log with a tarp or thick row cover fabric helps build up humidity.
- Normally, within 10-14 days your shiitake will emerge from your log. In cold weather this process can take 3-4 weeks. Many times, the initial flush of mushrooms emerge from the inoculate holes, but later they will build up pressure in other places and “pop” through the bark.



Mechanical Forcing

- Roughly knock over the logs, drop them, or strike them with a mallet. This simulates a tree or branch falling to the ground and can stimulate a log to fruit if it has enough moisture and weather conditions are right.

Electrical Forcing

- Shock the log with a pulsed power generator. This simulates a lightning strike to a tree and can stimulate fruiting and increase yields by up to 2x in Shiitake.

Harvesting Shiitake

- Pick your mushrooms by slicing them at the bark with a sharp knife or gently twisting off. Do not leave “stumps” on the log, as these become target sites for contamination.









Pests and Disease

- Slugs – these are our worst pest
- Thrips (hang out in gills, but don't do much damage) – set the mushrooms on a screen table for a few minutes after harvest and most will fall out of the gills – in larger numbers they can turn the gills brown prematurely, but they haven't been much of a problem unless we are late to harvest the mushrooms
- Fungal disease and contamination – we have never had a significant problem because we have good airflow and we don't overwater our logs, but Trichoderma is said to be a big problem.



Vitamin D

- Shiitake has produces Vitamin D2 converts to D3 when exposed to UVB radiation
- 110 IU/100 g when grown and dried indoors
- 10,900 IU/100 g when grown indoors and dried outdoors with gills facing down for 2 days in the sun (6 hours/day)
- 46,000 IU/100g when grown indoors and dried outdoors with gills facing up for 2 days in the sun (6 hours/day)
- This will also work very well with previously dried shiitakes and even better with ground dried shiitake.
- Outdoor grown Shiitake contains 5-7 times more vitamin D than the indoor-grown variety and shiitakes grown in latitudes closer to the equator naturally have more vitamin D than those grown in northern regions.
- Be careful not to consume too much Vitamin D from mushrooms!

Storage

- Cool mushrooms quickly after harvest
- Store at close to 32 degrees
- for each hour out of fridge after harvest you lose ~1 day of storage.
- Shiitake can remain edible for about 3 weeks when stored properly, but I don't like to sell them after about 7-10 days. In fact I prefer to sell them the same day they are picked or within 3 days.

ORGANIC PRODUCTION

Same rules apply as in any other organic production

It's fairly simple to do log grown culture organically.

Always ask your certifier about the inputs and methods you are using. Ask your certifier!

- 1. Logs must be from organically-maintained land.**
- 2. Spawn must be certified organic.**
- 3. Wax must be organic (non-synthetic).**
- 4. No synthetic pesticides.**

Logs “must be harvested from a designated area that has had no prohibited substance, as set forth in § 205.105, applied to it for a period of 3 years immediately preceding harvest of the logs”.

**§ 205.204 Seeds and planting stock
practice standard.**

**(a)The producer must use organically
grown seeds, annual seedlings, and
planting stock: Except, That,**

**(1) Non-organically produced, untreated
seeds and planting stock may be used to
produce an organic crop when an
equivalent organically produced variety
is not commercially available.**

Production Quantity

- Grow for hobby? 50-100 logs for a family of 4
 - Homesteading? 100-500 logs
 - Small part-time business? 1000-2000 logs for supplemental income
 - Small full-time business 10,000 logs – may be difficult to market them all or get the price you want
-
- Who wants to be the next shiitake kingpin in Michigan?
-
- Prices – we sell ours for \$16.50/lb to restaurants or up to \$25/lb retail

Marketing and Sales

- Marketing – this is a difficult one that I don't have all the answers to. Production is often inconsistent so it's hard to promise production numbers, even with forcing.
- Best is to have relationships with chefs who value the product and will take them when you have them.
- It's much more difficult to sell to stores because you will be competing with sawdust grown shiitakes that sell for \$3-\$7/lb.
- The dried market for shiitake is not good because you are competing with dried shiitake from China which is incredibly cheap. If you were to sell them dried here you'd definitely want to have certified organic product, but you'd need to dry them in a proper facility.
- It's possible you could sell them to a local store more good \$ if marketed as local. Your mileage may vary.

Grading Shiitake

- **USA**
- #1 Premium Grade with in-rolled margin and are caps are medium size (1-3")
- #2 Caps are fully expanded, size of mushrooms is small or large
- Opportunity to create specialty markets for large caps (for stuffing) or small caps for garnishes or other creative ideas.

Grading Shiitake

- **Japan and China**
- Dried Shiitake Grades
- Donko quality dried mushrooms – cracked caps that occur when wet mushrooms are growing quickly, but then humidity drops. Can be simulated with controlled conditions, but often happens naturally in the spring. In Japan, these dried donko quality shiitakes can sell for 3x the price. At Nature and Nurture, we don't charge more for donko quality mushrooms, we just charge the same high price all year-round for our certified organic outdoor log grown shiitakes. It takes a lot of time, patience, and hard work to produce high quality log grown shiitakes so don't sell yourself short!
- Koshin – fully expanded cap, thin flesh, and longer stems
- Koko – intermediate quality with thick flesh, but no cracking and in-rolled margins – this represents most of what is on the market

Donko Quality



Koshin
Quality



Koko Quality



Mushroom Sensitivity/Allergy

- Mike is sensitive to chicken-of-the-woods, honey mushrooms (including *Entoloma abortivum*), giant puffballs, and huitlacoche
- Oyster mushroom farmers often develop a sensitivity to the spores and can develop lung problems from them – this could happen with other species too so pay attention to your body and be careful
- You will need to educate your customers a few things about mushrooms and this is one of the very important ones

Specialty Mushroom Instructions

- You can grow other mushrooms on logs, similar to shiitake cultivation. Although the initial inoculation and incubation procedure is exactly the same as that of shiitake, there are different strategies for fruiting some of these mushrooms.

Oyster (White, Lavender and Phoenix), Dryads Saddle, Lobster-Flavored, Lion's Mane, Pink Crab and Turkey Tail Mushrooms

- Use softer hardwoods such as aspen, cottonwood and poplar for these varieties. After the initial incubation period (6-12 months) soak the logs for 24 hours to initiate fruiting. Fruit these specialty mushrooms just as you would shiitake. Pick the Dryads Saddle when young (older specimens are tough--but still make a good soup base, according to Chris). Trametes (Turkey Tail) make medicinal tea while the others are delicious when sautéed or integrated into other recipes.



Chicken-of-the-Woods and Hen-of-the-Woods (Maitake)

- After the initial incubation period (18 months), plant your logs (in a shady location) vertically into the ground 1½ feet deep (two feet of log above the ground). Water every two weeks during dry spells. The Chicken-of-the-Woods will appear in mid to late summer, the Hen-of-the-Woods will emerge in the fall. Oak logs are best for Hen-of-the-Woods while Chicken-of-the-Woods will grow on a variety of hardwoods.



Nameko

Cherry logs can be used to grow
nameko mushrooms



Reishi

- After the initial incubation period (12 months), plant your logs, in a shady location, horizontally into either soil or sawdust (a mixture of soil and sawdust works well). You may bury them completely or allow the top 1/3 of the log to peek through the ground. Reishi will grow all summer and fall and are used to make a delicious and invigorating medicinal tea.

Continued Care

- After fruiting, continue to store your log(s) in an area that is protected from both sun and wind.
- Soak your log for 24 hours approximately once every two months between the months of April and October. Use common sense—soak less during rainy times and more during dry spells.
- Logs will continue to produce until their bark falls off (so be gentle with the logs!). Check the moisture content of you log as often and reasonable as possible (after a season or so you'll get an idea of how fast your log may dry). Cover your log(s) with 80% shade cloth, burlap or a tarp to overwinter.



Steps to Making a Spore Print

- Before you eat *any* mushroom other than those you buy at a grocery store, it is essential that they be indisputably identified as the mushroom you want to eat. Shiitake can be identified by the following characteristics. First, the cap will have a stalk coming from the middle of the cap. The gills of Shiitake will look a bit ragged and will produce *white* spores. You should make a spore print of your first Shiitake before you eat it. If it is anything but white, do not consume the mushroom, as it will not be Shiitake. While it is extremely unlikely to produce anything but Shiitake, like Mom said it's better to be safe than sorry! To make a spore print, perform the following steps:
 - Remove the stem from the cap.
 - Place the cap gills down on a black piece of paper.
 - Place a glass or bowl over the mushroom cap.
 - Wait 4 hours and remove the bowl and cap.
 - You should see a white deposition of spores on the black paper. When you do, you will know that they are safe to enjoy!!

Review of Ten Basic Steps

1. Strain selection.
2. Select and cut suitable trees.
3. Inoculate logs with dowels or sawdust spawn.
4. Measure moisture content of logs.
5. Label logs.

Review of Ten Basic Steps

6. Lay for incubation.

a. Shade/canopy cover—Deciduous forests have too much light for good mushroom production in early spring but are somewhat cooler in summer compared to coniferous forests. Conifers offer shading in spring before deciduous trees leaf out, but overall are generally brighter and warmer during summer. Use shade cloth to supplement natural tree cover or build a shade house.

b. Protection from wind.

c. Incubate 6 to 18 months, depending on strain and season of inoculation.

d. Check log moisture content periodically.

7. Fruiting the logs.

a. Stacking for fruiting—optimize surface area for harvest, balance with humidity. Lean-to stacking.

c. Harvesting—twice a day during peak production.

8. Return logs to laying yard.

9. Monitor for moisture content and contamination.

10. Soak as needed to maintain proper moisture content



Nature and Nurture Seeds

- Shameless Self-Promotion
- Next year we may start selling smaller quantities of shiitake plug spawn on our seed website. In the meantime, if you want larger quantities you can order them online from Chris Wright at EasyGrow Mushrooms and Composting, LLC
www.easygrowmushrooms.com
- **If you have any questions, please don't hesitate to contact the friendly and reliable staff of Easygrow Mushrooms and Composting LLC at info@easygrowmushrooms.com!**
- If you are interested in our Midwest adapted heirloom organic vegetable seeds you can order them from our seed company, Nature and Nurture Seeds
www.natureandnurtureseeds.com
- **Thank you and happy harvesting.**