

Shiitake Mushroom Gardening

Introduction

Home production of shiitake (she-TAH-kee) mushrooms can be a rewarding and delectable hobby. These mushrooms can be grown casually or with a concerted effort year-around, indoors, outdoors, on hardwood, or in blocks of sawdust. You will never get mushrooms this fresh from the supermarket.

Shiitake mushrooms are good to eat; an excellent source of protein, trace minerals, B and D vitamins; and low in both fat and calories. Shiitake mushrooms have also been proven to reduce cholesterol.

Shiitake mushrooms do not bruise easily and can be stored for up to a month if harvested at the right time and refrigerated in vegetable or "green" bags. They can also be dried and stored in sealed plastic bags for up to 2 years.

Growing shiitake mushrooms on logs does require patience. You can establish a shiitake garden by purchasing or cutting your own logs in the dormant season and inoculating them yourself. It will take 6 to 12 months for these logs to produce mushrooms. For those with less patience, you can buy sawdust blocks or pre-inoculated logs. You should be able to fruit these right away.

Preparing for Inoculation

What is inoculum or spawn?

Mushrooms grow differently than tomatoes or carrots. They do not have seeds, but they do have spores. However, they are

typically not grown from spores. Most cultivated mushrooms are propagated from mycelium. Mycelium is the vegetative part of the mushroom that consists of a network of fine white filaments or hyphae. The mycelium is what grows in and runs through the log or sawdust. Specially cultivated mycelium is placed in a rich sawdust mixture, and is allowed to run through the sawdust. When it turns white and the sawdust is a solid mass of mycelium, it is then ready for you to use as spawn or inoculum. Shiitake mushrooms have strains where plants have cultivars or varieties. But, like plant varieties or cultivars, mushroom strains are named and have specific characteristics such as the temperature in which they fruit best or the appearance of the cap, the fruiting body or mushroom. Be sure to read the descriptions before making your strain selection.

Picking the right shiitake strain

If you plan to inoculate the logs yourself, order your spawn from a reputable dealer 1 to 2 months before you plan to cut your trees. Spawn producers may not have the most desirable strains available if you wait too late to order. It takes several months to grow spawn from frozen mycelium.

Be sure to read the strain descriptions. The characteristics that are most important are: fruiting temperature requirements, cap appearance, spawn run time (time it takes to fruit), and productivity on logs or in sawdust. It is best to provide the spawn dealer with your desired shipping date so your spawn will be as fresh as possible.

If you are purchasing inoculated sawdust blocks, be sure you choose the most

mature block. When fruiting shiitake mushrooms on blocks, you want the blocks to be brown not white when you remove the bag to fruit them. You can buy the white blocks for less, but you will have to keep them in a warm humid environment for a month or longer before you can fruit them.

Fruiting temperature requirements

There are several shiitake strains available. They are usually categorized by fruiting temperature requirements. Shiitake will generally fruit, forming the edible mushrooms at log temperatures between 41 to 86 degrees F.

- Cool season strains fruit at 41 to 68 degrees F.
- Wide range strains fruit at 50 to 80 degrees F.
- Warm season strains fruit between 50 to 86 degrees F.

It is generally recommended to select several different strains so that you can fruit your logs or blocks at different times of the year. Strains may also vary in productivity, appearance, mushroom size, and the length of time it takes to fruit.

Environment

Select strains that will fruit in the environment where you plan to develop your shiitake garden. Inoculate logs with a warm season strain for summer fruiting if you plan to use the shade of a maple tree.

Also, inoculate logs with a cool season strain if you want to harvest mushrooms in winter. A wide range strain can be used for spring and fall production. Logs grown indoors should be inoculated with a strain that grows at the temperature of the growing room you plan to use.

Condition and appearance of spawn

Most strains can be purchased as sawdust, dowel, or as thimble spawn (see Figure 1). Your spawn should be white and fluffy when you receive it with little or no liquid in the bottom of the bag. If there are green patches such as the weed fungi *Trichoderma* sp., contact the vendor and ask for new spawn.

If the spawn is brown and loose, the mycelium is not well knitted and it was sent to you before it was ready for you to use. You can store unknitted spawn at about 65 to 70 degrees F in a humid environment for a few weeks to see if it will turn white. Or you can return the unknitted spawn, ask for your money back, or replace it with a white bag of spawn. If you receive your spawn more than a few days before you plan to inoculate, you should place it in the refrigerator or a very cool basement. Move spawn to room temperature about 24 hours before you plan to inoculate. When ordering a pre-inoculated log or sawdust block, make sure you tell the supplier the fruiting temperature conditions to get the right inoculated strain.



Figure 1. Shiitake strains can be purchased as thimble (left), dowel (center), or sawdust spawn (right). Photo permission from Field and Forest.

Selecting the best trees

Type

There are several types of trees used for production of shiitake mushrooms. White oaks are the most productive and are bothered the least by invasions of foreign or weed fungi. But, white oaks require the most patience since it usually takes 8 to 12 months from inoculation before the mushrooms first begin to fruit.

Red oak and sweetgum have softer wood and will produce mushrooms in 6 to 8 months. They also require more careful management since they are more susceptible to weed fungi, bark peeling, and rapid water loss.

Shiitake mushrooms also grow on American hophornbeam, northern maple, ironwood, laurel oak, cherry, sassafras, sycamore, tulip poplar, and hickory. How well shiitake mushrooms grow on logs from these trees will depend on how much care you give the logs and how well you control moisture, temperature, and exposure to other fungi. Other types of trees can be used for growing shiitake mushrooms, but even under the best of conditions you will only harvest a few mushrooms per log.

The actual location of the growing tree is also important. The more fertile soils will produce trees with more nutrients and sugars. Trees located on rocky hillsides or under drought conditions will be less nutrient rich.

Sapwood Area

Since shiitake mushrooms feed primarily on sapwood, trees selected for inoculation should have a large sapwood area. You can determine the ratio of sapwood to heartwood by looking at the end of a log after the tree has been cut. Most trees in a particular region will have similar sapwood to heartwood ratios. The lighter or outermost wood is the sapwood and the darker or inner wood is the heartwood (see Figure 2). A small amount of sapwood means the log will probably produce mushrooms for less than 2 years. The cambium area, just under the bark, is

green and probably provides the most nutrients. The bark covering the cambium must remain intact to avoid competing fungi invasion and loss of moisture.

Cutting and buying shiitake logs

Cutting

Logs should be harvested during the dormant season from live, healthy trees. Cutting your own logs is an option only if you have a chain saw and easy access to hardwood trees. Be sure you take a buddy along if you cut your own logs. If you can, cut the tree down 7 days before you plan to inoculate. Logs can then be cut to size and moved to the inoculation site immediately. Another option is to cut the logs and immediately soak them for 3 days and inoculate them within 24 hours of removal from the soak water. This would be the preferred method if conditions have been dry.

If you cannot fell the trees and cut them up in the same day, you can leave the whole trees in the woods uncut and untrimmed for up to 7 to 10 days. Then, cut them to size and inoculate within a few days. You can also

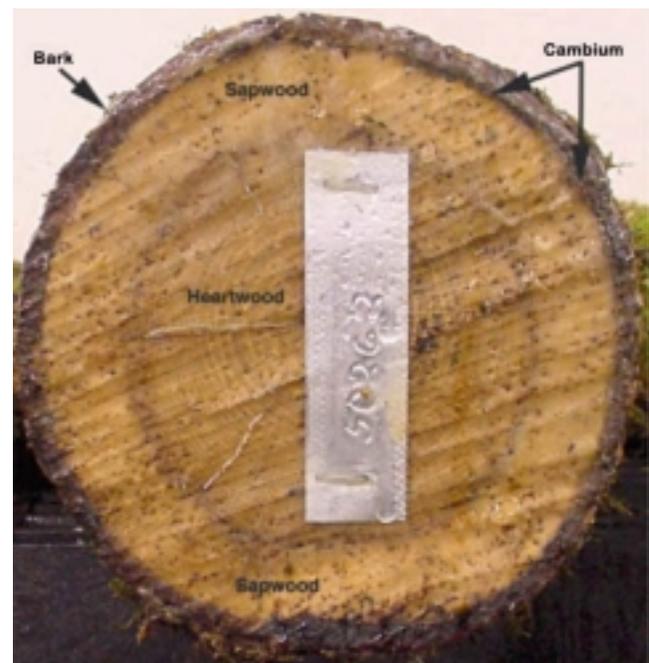


Figure 2. The lighter, outermost wood is the sapwood and the darker, inner wood is the heartwood.

soak these logs prior to inoculation to insure good log moisture. The diameter and length of the log will depend on how heavy you want your logs. A 40-inch log, 8 inches in diameter will weigh about 60 lbs. A 40-inch log, 4 inches in diameter will weigh about 25 lbs. Logs 4-5-inches in diameter produce the most mushrooms. The length of the log is up to you, but should be consistent for easier handling and stacking.

Buying

Buying logs to inoculate can be difficult because the logs must not be split or the bark damaged. They must also be of the type, length, and diameter you specify. Most log cutters will charge from \$0.50 to \$1.00 for a log 40-inches long and 4 to 6 inches in diameter. Agree to accept and pay for only those logs meeting your specifications.

Equipment and supplies

There are several tools necessary for inoculation and there are some that just make inoculation easier. Where possible, several options for equipment or supplies have been given (see Figure 3):

- Use a high-speed drill or angle grinder (not shown) with an adaptor and depth stop; they are faster and more efficient for drilling.
- Use a 5/16-inch bit for dowel spawn or a 7/16-inch bit for sawdust spawn.



Figure 3. Equipment and supplies used for inoculation of logs.

- Use a spawn gun or inoculation tool for sawdust spawn or a hammer for dowel spawn.
- Use cheese, paraffin, bee or candle wax; an option is foam plugs.
- Use a pot or kettle for wax.
- Consider a propane stove or an electric burner if using wax.
- Use a metal turkey baster for wax since a plastic baster will melt. Glass basters are okay, but are easily broken. You can also opt to use a natural fiber brush.
- Use bathroom scales to weigh some of the logs.

Inoculating the Logs

Drill 1-inch deep holes into the log in a diamond pattern: 7/16 inch diameter for sawdust spawn, 5/16 inch for dowel. The first row of holes is drilled down the length of the log; each hole should be 4 to 6 inches apart (see Figure 4). The second row of holes should be staggered two-inches below or above the first row. Continue this pattern around the log (see Figures 4 and 5).



Figure 4. [above] Drill down the length of the log with a 4- to 6- inch spacing, then stagger the next row of holes about 2-inches below or above the first row. Continue around the log.



Figure 5.
Drilling,
inoculation of
log with
inoculation tool
and sawdust
spawn and
waxing with a
baster.

Inoculate the logs immediately after the holes are drilled. The inoculation tool will fill the holes to the bark level with sawdust spawn (see Figure 5). For dowel spawn, use a hammer to securely insert dowels into the drilled holes. Sawdust spawn can be placed in the holes by hand if you do not have an inoculation tool. This method is time consuming and exposes the spawn to more contaminants. Be sure the dowel or sawdust does

not extend above the bark. Once a log has been inoculated, it should fruit for 2 to 3 years. Re-inoculation is not necessary because the mycelium grows throughout the log like roots in soil. The mushroom develops when the mycelium has accumulated sufficient nutrients and the temperature and moisture requirements are met.

Waxing the logs

The inoculation sites and the ends of the logs are generally coated with wax. This reduces moisture loss and keeps the spawn or dowels securely in the hole. Seal sites with wax or place foam plugs in the holes immediately after inoculation.

- Heat wax until it begins to smoke slightly about 260 degrees F.
- Squeeze a light coat of wax using a baster over the inoculation sites to cover the inoculation sites (see Figure 5). You can also use a natural fiber brush to wax the inoculation sites. The wax should sizzle as it hits the log.
- Dip the ends of the logs into the wax or brush with wax to seal them. This will also slow down the invasion of foreign fungi through the ends.

You can also poke foam plugs into the inoculation sites. This usually requires a blunt object, smaller in diameter than the plug, to push it in the top of the hole.

Logs kept in an indoor, humid (90 percent humidity) environment, will not need their ends waxed. If you use foam plugs to secure the spawn or dowels in the holes and do not want to use wax to seal the log ends, keep the logs in a humid environment or mist the logs daily during warm and hot weather. A home or basement, even though they may seem warm, cool or humid do not provide sufficient humidity for logs.

Log Moisture

Monitoring moisture

To determine if your logs are losing too much water, weigh at least one average size log immediately after inoculation:

1. Mark that log with paint or a tag.
2. Weigh the log, then record the weight.

3. Weigh the marked log(s) every few weeks. To determine weight loss, use this formula:

$$\frac{(\text{Original log weight} - \text{Current log weight})}{(\text{Original log weight})} \times 100 = \% \text{ moisture lost}$$

If "% moisture loss" is greater than 10 percent, you will need to mist or water your logs more often. As the mycelium grows and uses up the nutrients, the log will naturally lose weight.

To re-establish a new base weight replace the "original log weight" in the equations with a new weight every 6 months. To obtain a new "original log weight":

1. Soak the log for 48 hours.
2. Remove it from the water and allow it to drain for 24 hours.
3. Weigh the log. This weight will be your new base weight.

Many shiitake gardeners learn to "feel" the moisture in their logs just by picking them up. If they seem light, then they know they have not applied enough water.

Unless you are going to fruit your logs, it is best not to soak the logs to restore moisture. Soaking the logs at the wrong time can cause a break in the mycelium growth cycle and prolong the time from inoculation to fruiting or between fruitings.

Keeping the logs moist

You can use lawn sprinklers, misters, or a greenhouse mist system to keep the logs moist. Logs should be given a fine mist for about 30 minutes in the morning. If you are using a lawn sprinkler, water for about an hour. A good rule of thumb is, if your garden needs water, your logs probably do too. There is no need to water or mist your logs if they are outdoors and it is raining. During spring and fall, when the temperatures are below 80 degrees F, you can water less often. If you plan to fruit logs in the winter, and rainfall is sufficient, you will not need to water.

Mycelia Run

The waiting period

Once a log is inoculated, the root-like structures called mycelia must become organized and grow to take up nutrients and carbohydrates or sugars. Like roots, mycelia need plenty of moisture and a compatible temperature. Logs and mycelium will tolerate cold temperatures and can remain outside in the winter.

Weigh your control log every few weeks. If it loses more than 10 percent of its weight, sprinkle or mist all of the logs for short intervals of 30 to 60 minutes, for several days until the original weight is restored.

Beginning in March, outdoor logs will need to be moved to a shady location and kept moist. Many gardeners cover their logs with burlap, landscape fabric, or some other porous material to keep in the moisture.

Stacking logs

Logs can be stacked several ways during mycelia run. The most important factors are good aeration, moisture, and temperature. If logs are leaned against a tree or "A-frame" stacked, they will tend to lose moisture rapidly (see Figure 6).

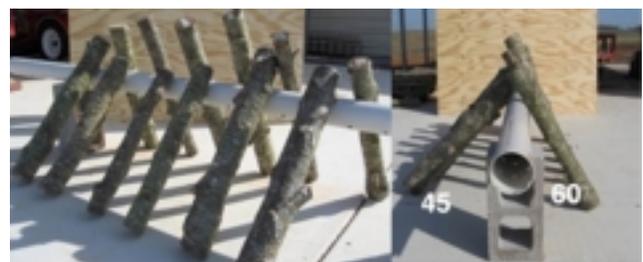


Figure 6. Typical A-frame stack, often used during harvesting.

"Lean-to" and "criss-cross" are the best methods of stacking for mycelium run (see Figures 7 and 8). If logs are stacked like firewood, they receive little aeration and the mycelium in the bark knits the logs together. When you unstack them at a later time, it causes the bark to pull off of the logs. This causes bare spots on the log where moisture



Figure 7. The lean-to stack is one of the best methods of stacking logs during mycelium run.

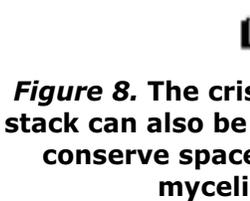


Figure 8. The criss-cross stack can also be used to conserve space during mycelium run.



loss can occur. Weed fungi contamination at these sites is also a problem. One of the worst contaminants is *Trichoderma* sp. In its fruiting stage you will see a green furry patch on the log or sawdust block. *Trichoderma* sp. competes with shiitake for nutrients and reduces productivity.

Logs will begin to show signs of mycelia run or mushroom activity in about 3 months. The inoculation sites will turn whitish first, and then the logs will have white "V- or U-shaped" markings on the ends of the log (see Figure 9). Fruiting will generally not begin for 6 to 9 months after inoculation, depending on the type of wood and the strain of shiitake mushroom you used.



Figure 9. Logs will begin to show signs of mycelia run or mushroom activity in about three months. Notice the white shapes on the end of the log.

Fruiting the Logs

When the mycelium is established in the logs and the temperature and moisture conditions are appropriate, logs will fruit on their own. First, small "pins" or primordia will appear. These will rapidly develop into capped mushrooms.

Wide range strains

If you keep your logs outside, the natural fruiting seasons are spring and fall. When the weather changes during these seasons there is typically plenty of moisture. However, to insure that the log has sufficient moisture to support quality mushroom growth, soak the logs with wide range strains in March and September for 24 to 48 hours. I have used the bathtub, a large trashcan and animal watering tanks for soaking. If the log does not completely fit in the trash can, soak it for 24 hours and then turn it end-for-end and soak another 24 hours. After removing the logs from the soak water you can lean them against a tree or fence in a well-shaded area. You may want to drape clear plastic over the logs to prevent moisture loss, allow light to enter and to keep fruiting mushrooms dry if it rains.

Warm season strains

Outdoor logs inoculated with warm season strains can be fruited in the spring and fall using the aforementioned technique and again in mid-summer by soaking them in very cold water and keeping the log moist or misted until pins appear.

Cool season strains

Logs with cool season strains should be brought indoors during cooler months to a warm location for 1 to 2 weeks and then soaked for 48 hours. After soaking, locate

these logs where air temperatures will remain above 40 degrees F at all times. Fruiting will be slower in winter, but mushroom quality is excellent. These strains will also fruit naturally in early spring and late fall.

Pinning & Fruiting

When the logs begin to fruit, you will first see a small whitish knob emerging from the inoculation sites (see Figure 10). These little knobs or "pins" will develop into mushrooms if the log moisture and air temperature and humidity are right.



Figure 10. Pinning or primordium formation occurs two to four days after soaking. Once pins start to form, logs and pins should be kept dry and temperatures should be at least 60 to 65 degrees F.

Provide heavy shade at this time or newly formed mushrooms will dry out. Do not spray or wet mushrooms while they are developing. This will cause soft mushrooms that will not store well. Dry or eat mushrooms right away if they get wet from rain. If your logs are indoors and you can control the temperature, you will be able to fruit your logs more frequently by soaking them every 10 to 12 weeks.

Pre-inoculated Logs

Pre-inoculated logs are available from some commercial producers and a few mail order companies. Prices range from \$29.00 to \$39.00 for a log 3 to 6 inches in diameter and 13 to 24-inches long. The logs are ready to fruit and even come with directions and a soaking container. You will be able to fruit these logs every 10 to 12 weeks for about 2 to 3 years.

Sawdust Blocks

For the less patient gardener, sawdust block kits cost \$18.00 to \$31.00 each and can be ordered from a shiitake spawn vendor or from numerous online sites. They are made from hardwood sawdust grains and other additives necessary for mycelia growth.

The ingredients are placed in a heat resistant bag and are then autoclaved, which is similar to pressure cooking. After the ingredients cool, shiitake spawn is added to the bag mixture and the bag is sealed. Each bag has a small breathing patch for air exchange. As mycelia grow the sawdust mixture turns white. When the entire mixture is coated white, this is called a "white block." A white block is not ready to fruit.

During the next 2 months, the white block will gradually turn into a "brown block." The brown coating is a hardened shell that helps prevent moisture loss and contamination. When the block is completely brown, you can remove it from the bag and it will usually fruit without soaking. In most cases, you can buy the blocks at either stage. Be sure the brown color is not the sawdust, but rather slick mycelium growth.

After the block is removed from the plastic bag keep it in a humid location where it is exposed to outdoor or fluorescent light. Fruiting should begin within a few days. The block will enter a resting state after all the mushrooms are harvested. Sawdust blocks will need daily misting or a humid environment. You will be able to fruit them again in 3 to 4 weeks by soaking for 12 to 24 hours. You will need a way to hold the blocks under water since they float.

Blocks often become contaminated and can only be fruited a few times. You can harvest up to 1 to 2 pounds of shiitake mushrooms from each block. The first two harvests will produce more mushrooms than later harvests (see Figure 11).



Figure 11. You can harvest several pounds of shiitake mushrooms from a sawdust block.

Harvest

The mushrooms can be harvested at any time by cutting or twisting the stem off the log. Be sure not to leave pieces of the stem sticking out past the bark. Mushrooms are best if harvested shortly after the gills are exposed (see Figure 12).



Figure 12. Shiitake mushrooms store better if harvested shortly after the veil breaks and the gills are exposed. Gills are fully exposed on the left and the veil has not broken on the right.

Storage

If you store your fresh mushrooms in the refrigerator in vegetable bags, they will last up to a month. If you refrigerate them in paper bags they will dry out quickly.

To dry mushrooms using a food dehydrator:

- Cut off the mushroom stems before dehydration.

- Remove dried individual mushrooms as they become just barely flexible, but before they are crisp.
- Store dried mushrooms in a sealed plastic bag.
- Place them in the freezer for 72 hours.
- Keep them frozen or remove them from the freezer and store them in a dry location.

Rehydration

To rehydrate shiitake mushrooms, soak them in water or a seasoned liquid or broth for at least 30 minutes. Shiitake mushrooms absorb flavors of seasonings. They taste best when cooked with onion, leek, or garlic, and are excellent in sauces, stews, or rice, and with steak or eggs.

Supply and Material Sources

Some sources of the supplies and materials mentioned are listed below with the following designations: Sawdust blocks (S); Inoculated logs (L); and Tools and Supplies (T). There are also various Internet sites that list suppliers.

Field and Forest Products (S), (T)

*N3296 Kozuzek Road
Peshtigo, WI 54157
Phone: 715-582-4997
Toll-free: 1-800-792-6220
URL: <http://www.fieldforest.net>
E-mail: info@fieldforest.net*

Fungi Perfecti (S), (T)

*P. O. Box 7634
Olympia, WA 98507
Phone: 360-426-9292
Toll-free: 1-800-780-9126
URL: <http://www.fungi.com/>
E-mail: info@fungi.com*

Lost Creek Mushroom Farm (L)

*P.O. Box 520
9319 South Brush Creek Road
Perkins, OK 74059-0520
Phone: 1-800-792-0053
<http://shiitakemushroomlog.com/>
E-mail: lcmf@provalue.net*

Mushroompeople (T)

*560 Farm Road
P.O. Box 220
Summertown, TN 38483
Phone: 931-964-4400
Toll-free: 1-800-692-6329
<http://www.mushroompeople.com/>*

Glossary

Dormant: Season when hardwood trees lose their leaves. This is generally from mid-October to mid-March.

Inoculation: The introduction of spawn into a medium: logs, sawdust, etc.

Mycelia: The plural of mycelium.

Mycelium: The vegetative part of a fungus made of a mass or network of threadlike tubes.

Spawn: The vegetative growth or pure culture mushroom mycelia on a suitable sterilized substrate such as various agars, grains, or wood chips.

Substrate: The material in which the shiitake mycelia grows. This includes logs, sawdust, grain, etc.

Weed fungi: Fungi other than shiitake that invade a log inoculated with shiitake spawn

Note:

We have made reasonable efforts to assure the accuracy of all information in this publication. However, we are not responsible for links outside of the Alabama Cooperative Extension System domain, their availability or content. Any brand names listed or specific references to vendors are used as examples only. No statement of quality is inferred by their use.

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