

warmer than corresponding naturally shaded areas, and must be managed accordingly.

Surrounding Vegetation

Is your woodlot brushy or is the forest floor clean?

Generally speaking, shrubs will provide additional shade and a zone of higher humidity, and are often desirable despite their face-slapping habit. Shrubs will also deflect air flow upward.

If you are growing shiitake on a long term basis, consider landscaping your laying yard. You can plant or transplant young, vigorous trees and shrubs for future laying yards. You can use the different shapes and stature of various plants to create a desired effect.

For example, a specific parcel of our northern dry forest will become a laying yard in several years. We will transplant Spruce on a western slope for wind deflection, and Red Pine and Birch in open areas for shade. While these will not be mature trees by the time we use the area for a laying yard, if we control weeds and fertilize we will effectively decrease evaporative demand and create a diverse woodlot!

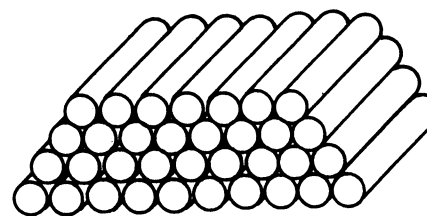
Slope and Slope Aspect

The position on a slope greatly alters microclimate. Hilltops might be too dry and windy, while valley bottoms or depressions might have stagnant air and serve as frost pockets.

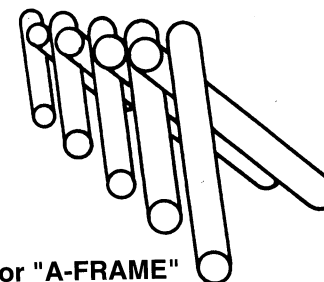
The direction the slope faces also alters microclimate. South and southwest slopes are much warmer than north or east slopes. North slopes will remain cooler much later into the spring than south slopes. Laying yards on slopes must be carefully chosen to maximize the benefits of early spring warming and good air circulation.

Along with finding a home for the logs for the next 6 to 12 months, a stacking configuration must be put to the test.

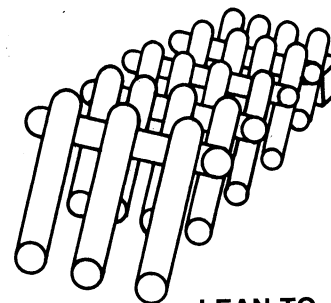
A **stacking configuration** is the way the logs are arranged during spawn run. This configuration can either enhance or detract from the existing beneficial conditions in the laying yard. This is a step most growers have difficulty with because many methods exist and are often mis-used. The four most commonly used stacking configurations and their applications are reviewed below.



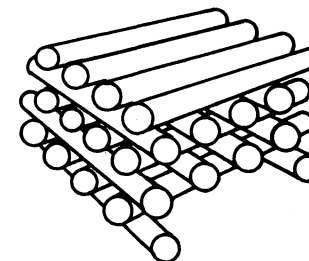
DEAD PILE



"X" or "A-FRAME"



LEAN-TO



CRIB STACK

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Dead Piling

This is a good method for storing logs before inoculation but usually a terrible way to lay them for spawn run. The dead pile typically has poor air circulation, restricts water penetration and allows water to stand on the log surface.

Another phenomenon we have noticed is that as the pile gets higher, people will naturally stack the smaller diameter logs on top. This is an ideal way to dry out those logs.

Dead piles lead to all sorts of problems with contaminants, particularly if your site is moist, humid, and has stagnant air. The only time we learned of a 'success' story using this method was in the arid southwest U.S. Logs were dead piled, covered with a foot of straw, burlapped and irrigated. Apparently this method works in the southwest ... if you have irrigation water.

Avoid this stacking configuration and you will avoid a lot of problems.

"X" or "A-Frame" Stacking

Looks nice in the laying yard! The problems we see with this method are:

- 1) It is an inefficient use of space.
- 2) Growers have the habit of inadvertently increasing the angle of the pile as they stack, which raises logs to an elevation not favorable for spawn run.

If your site is also breezy, this method allows too much air circulation and drying of the logs. Leave this method for fruiting logs (which will facilitate picking) in all but the most humid and rainy areas.

Crib Stacking

This method has been and always will be popular among growers in certain areas of the U.S., and understandably so.

It is an efficient use of space and permits easy mushroom harvesting. This method was widely used in our region at one time, and appeared to work when harvest of just a few mushrooms was all that was expected.

High stacks dry in summer, and don't get covered with insulating snow in winter. (We discovered when the temperature drops to -20 degrees F. and the winds start 'a-blowin,' wood gets freeze-dried. Shiitake may tolerate sub-zero conditions but not exposure to sub-zero wind directly effecting bark surfaces!). It makes good firewood the following season.

Here too, a natural tendency is to place small diameter logs on the top of the pile. The logs on top, regardless of diameter, dry out faster, inhibiting spawn run.

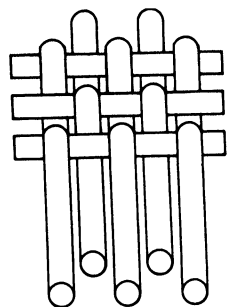
This method is fine if you plan on irrigating intensively, but there are more efficient ways irrigation water can be used. In the north, crib stacks are now left for indoor cultivation where irrigation and humidity are controlled and space is at a premium.

The farther south shiitake is grown, the taller the stacks get. From about Virginia west to Arkansas, very nice spawn run can be found on logs crib-stacked about 4 layers of logs high, though logs in the northern regions of the area benefit from denser canopy cover. Stacks are 4 feet high at the maximum under the densest shade.

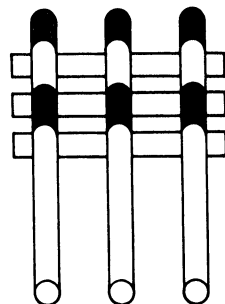
South of that region, cribs usually remain only 4 layers high but the best laying yards are under fairly airy canopies (pine and artificial shade houses) or are A-framed to shed water in the most moist areas.

Crib stacks can be adjusted for airflow readily by increasing or decreasing the number of logs per layer and height. Drier conditions would dictate lower and tighter stacking, which brings about another consideration: "**rain shadows.**"

Tight stacking, while it will decrease airflow and drying rates, will also exaggerate rain shadow effects on lower layers. This results in logs near the bottom of the pile receiving little or no water, creating areas of little or no spawn run. Rain shadows occur in every stacking method and can be located through the use of check logs.



Minimum Rain Shadow



Maximum Rain Shadow

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Lean-To Stacking

In the continental climate we encourage growers to use the **Lean-To** stacking method. Why? This method is easy to manipulate to meet specific conditions of a site.

For instance, in very dry sites, the lean-to is made so logs are barely off the ground - nearly horizontal. In moist areas the stack can be elevated. This method makes efficient use of irrigation water. Because the logs are laid low, snow cover in winter is more likely.

In our own laying yard, the lean-to's are set up so the maximum elevation a log end reaches is 12 inches above ground level, 8 inches being the norm.

We tend to stagger the logs between layers to allow for good water coverage, i.e., we eliminate the rain shadow.

We can stack logs in this fashion for a considerable distance, but we limit the row length to the maximum distance our impact sprinklers will cover. The rows are set up into "blocks" of logs which can be efficiently watered with two sprinklers. The slight

angle of the logs allows water to drain slowly off the log and the low elevation protects them from drying winds. With relative humidity being higher near ground level, our logs are pretty close to being in an ideal situation for rapid spawn run.

If you are not irrigating, don't be shy about laying logs directly on the ground in order to conserve log moisture content, especially during times of drought. Rolling the logs over in mid-season will help redistribute moisture.

The lean-to method is also used for fruiting, discussed later in this book.

Once a laying method is established it should be monitored to see how well it is maintaining log moisture content.

Your conditions are too dry if the spawn is growing in the center of the log (check the ends) and not colonizing the sapwood.

Other signs of dry conditions are "resupinate" (flat, leathery), scaly fungi and bracket fungi - and of course, *Hypoxylon* spp.

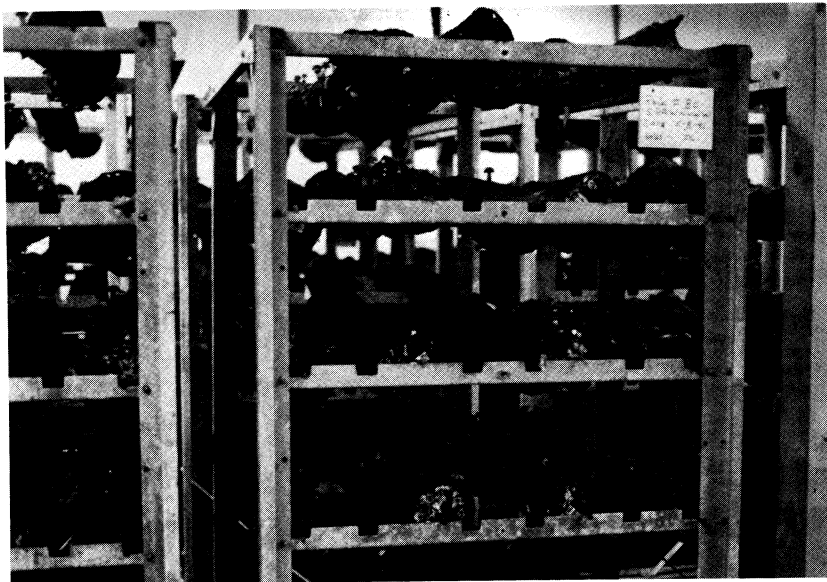
Molds, especially **green molds**, appear in overly moist conditions.

Another problem, and fairly widespread is ***Bulgaria inquinans***, a black jellycup fungi that appears in the summer on first year logs. These look bad but are of no negative consequence.

WE DO NOT RECOMMEND BENLATE DIPS OR SPRAYS. Even low levels can be fungitoxic, not to mention the legal aspects of fungicide use in shiitake cultivation.

If you did your homework during inoculation you should be able to avoid losing bed-logs to contaminants.

Find and determine the current weight of your check logs (marked with paint or flagging tape) that are randomly distributed throughout the laying yard. We take a portable scale out to the logs to do this (easier than bringing logs to the scale!).



Logs are permanently affixed to these fruiting racks and can be wheeled into rain rooms or lowered into soak tanks - then wheeled back to resting areas. The space requirements are substantial.

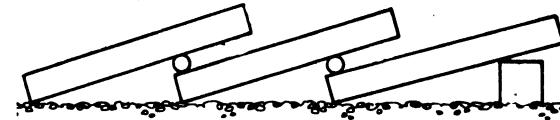
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and rolled into a room where they are 'rained' on for 24 to 48 hours, depending on the age of the log. This is most effective when the water is cold and when water pressure is forceful enough to create a 'driving' rain with large droplets on the logs. The cost of this kind of system, especially if brought indoors, needs close examination because of water and plumbing requirements which can be considerable.

After logs are soaked they are stacked for fruiting, which is usually done in a configuration that will ensure that all sides of each log will be harvestable.

Stacking configurations can vary with location. Outdoors, we use the lean-to method. It is space efficient and allows good access throughout the stack for picking mushrooms.

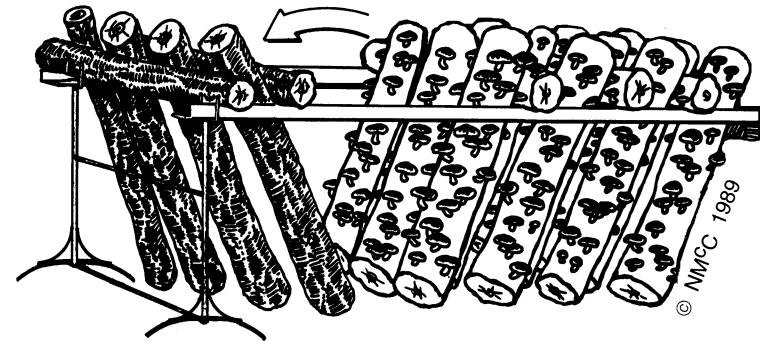
Hints for Building a Lean-To Stack



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- The first layer of logs (usually 3) leans against a board fastened between two trees, or on a large bed-log lying on the ground.
- As "courses" are added, be sure the cross pieces used touch all three logs.
- Irregular bed logs make good cross pieces.
- Use large logs first. As you build, they bear the weight of the stack.

Indoors we use **pick-thru racks**. This is actually the lean-to method contained between two side rails, or two-by-fours, and an end support. It is highly space-efficient.



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After stacking outdoors, the logs are covered with a **protective covering** to minimize wind and rain, stabilize temperatures and localize humidity around the logs. Heat, wind, frost and rain are villains. You can use these protective coverings to great advantage.

Use **burlap** with care, for it absorbs sunlight, raises temperatures, and restricts light, which tends to lighten the color of mushrooms. Burlap is best used as a temporary wind barrier or for frost protection. Its useful life outdoors is about two years.

Plastic can also be used, if it is clear or white. It makes a good supplemental covering during rainy periods, and if used as an outer layer with a burlap or fruiting blanket underneath, plastic provides a good cover during cold or very windy periods.

We avoid using plastic in summer because it causes moisture accumulation on mushroom caps. We will use it in spring while temperatures are still cool - the mushrooms won't "sweat" when contacting it as they tend to in the summer. The useful life of plastic is about 2 to 3 years.

Fruiting blankets are light colored or white synthetic fabric blankets, touted as ideal for maintaining temperature and humidity conducive to primordia formation in the stack.

We like them because they are reflective, have a closer weave than burlap (good wind barriers), and are somewhat water repellent. They moderate temperature around the stacks, effectively eliminating the daytime high and overnight low temperatures. During hot and dry times they can be soaked to raise humidity and cool the stacks.

The ideal fruiting blanket is insulative (at least 1/4 inch nap); water repellent, but capable of absorbing water if you want it to; reflects light; doesn't shed or catch on the logs; and will last forever - until you stop growing mushrooms whence it will dissolve

immediately in the compost pile with fair nutritional value for your tomatoes. Anything that comes close to the first three is great!

After mushrooms are picked, logs are returned to a laying position and **RESTED** for a specified time, typically 8 weeks to 3 months.

(Remember the 'Resting' Rule: "Longer is Better!" If you can stretch it to 12 weeks between fruitings, it is to your advantage. However, most growers find that an 8-week rest is a good compromise).

Although some drying may be desirable in the resting phase, remember that logs need moisture contents over 35% to form primordia. The resting time allows the fungus to replenish itself, after which they can be **forced** for another "**flush**," or crop of mushrooms.

We previously discussed strategies of adapting logs to the laying yard, but what about adapting logs to the adversity of the fruiting environment?

Shiitake cultivation is farming, after all, and there will be environmental obstacles whenever you fruit your logs outdoors. By developing a fruiting strategy you can use the different characteristics of shiitake **strains** to customize your fruiting program.

SELECTING A STRAIN - AND USING IT TO YOUR ADVANTAGE -

Introducing several different spawn strains into your log population gives you the advantage of getting "hands on" familiarity with the diverse aspects of the shiitake fungus.

You can use different strains to extend the growing season outdoors and control quality in specific environmental circumstances. You can use the differing spawn run characteristics of strains to

cold weather strains can be chiseled out of the ice outdoors and fruited by immediately bringing them into a warm environment. While this is enough stimulus to get them to fruit, immersing them in warm water (50 degrees F., or greater) will enhance yields.

This strain category also contains many strains that do not respond to force fruiting but that still can be used by growers to great advantage. Many of the strains in this group fruit only with changes in temperature and rainfall.

Therefore, in the north, they will fruit in early spring outdoors and once again in the fall. They are very effective for extending the growing season, often fruiting just as the snow melts and well after leaf-drop in the autumn.

In the south, these strains will fruit through the winter months outdoors. Logs inoculated with these strains can be brought indoors and fruited effectively by opening the building windows at night and misting the logs to stimulate pin formation. Once mushrooms begin to develop the windows are shut to warm the building and promote rapid mushroom development.

Warm Weather Strains (WW)

Warm weather strains fruit well from late spring into early fall. A great advantage of these strains is their ability to tolerate hotter temperatures while producing relatively thick-capped mushrooms of good quality. Spawn run is faster than cold weather strains but slower than the wide range strains.

These strains, as a whole, respond very well to force fruiting outdoors during the growing season and can also be used for forced fruiting indoors year-round. Like the cold weather strains, they maintain excellent mushroom quality throughout the life of the bed-log.

Wide Range Strains (WR)

Wide range strains fruit well from mid-spring through mid-fall. They are different from the warm weather strains in summertime fruit quality, being generally not as good as warm weather strains in the heat of summer.

However, they degrade wood quickly, recover quickly and respond particularly well to forced fruiting. And they are ideal for indoor or outdoor production.

Wide Range strains need several weeks of warm temperatures to 'acclimate' the shiitake fungus before force-fruiting. This is especially true of logs that have already been fruited several times. Remember this if you bring them indoors to fruit after resting them outdoors during the below-freezing temperatures of winter. This also is why fruiting cannot be rushed until mid-spring in the colder areas of the U.S.

Newly colonized logs can be force-fruited in rapid succession with little or no rest period between soakings for several fruitings, although a long rest period is required after this.

For example, 6 fruitings-per-year logs, fruited 2 times in a month, should be rested for 4 months. Successive fruiting, like this, is especially useful when you need mushrooms in a pinch.

CULTIVATING OUTDOORS - AND EXTENDING THE GROWING SEASON -

There are many benefits to outdoor production.

Generally, all that fresh air and natural sunlight does shiitake good; mushroom quality can be EXCEPTIONAL. Fruiting outdoors is inexpensive and seasonal adversities can be buffered at relatively low cost.

A lot can be accomplished by careful selection of a fruiting space.

You will hear lots of talk about "**fruiting yards**" and "**laying yards**" - fruiting yards being warm and humid; laying yards being well ventilated and protected from extreme temperatures.

Most outdoor yards have microclimates in which you will find each of these areas, therefore rather than distinguish between two physically different locations, we modify the environment around and within the fruiting stack.

Laying yards should be spacious enough to stack logs in a fruiting configuration - ideally, they should be near a cooler or refrigerator to protect the post harvest quality of the mushroom and there should be a place nearby to soak logs.

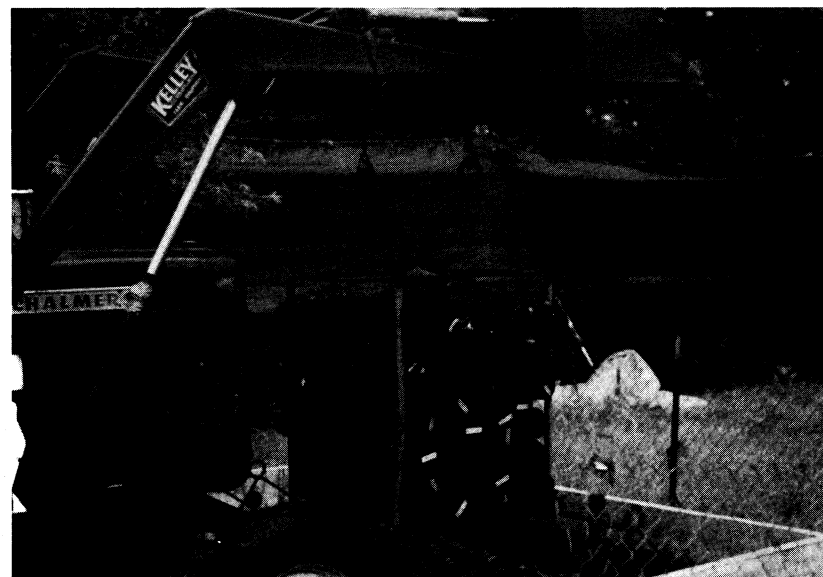
We use large "stock tanks" - they are mobile and we can bring the tank to the logs rather than the labor intensive reverse.

We have seen low profile tanks made with wooden sides, and shallow areas hand dug and lined with plastic tarps. Unused septic tank vaults, old bathtubs, and the deluxe sunken poured cement tank all work well.

You can also use "soaker" hoses placed between or over logs to provide water for fruiting. Having a well in the vicinity is ideal. Well water remains cold which is beneficial for summer fruiting.

Ponds can be used for soaking logs, but you may run into difficulties if:

- 1) The pond water heats up above 68 degrees F. in the summer.
- 2) Herbicides are used for pond weed control.
- 3) Soaked logs sink to the bottom.
- 4) The pond water contains high bacterial and nutrient levels.



Our tractor lifts a rack of logs out of our outdoor soak-tank. This tank was originally supposed to be a septic vault but it was damaged and never used for that purpose. It makes a great soak tank, and with an electric pump, changing the water is a breeze!

A primary disadvantage of growing shiitake outdoors in most climates is you are limited to seasonal harvests which means you'll be limited to marketing to seasonal outlets.

Ideally, you will want to extend the season as long as possible and this can be accomplished through use of protective coverings and strain management.