

Principal Investigator

Jill Jacoby
3971 Rehbein Rd.
Duluth, MN 55803
218-724-9786
pumilios@aol.com
St. Louis County

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Award Amount

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Staff Contact

Wayne Monsen
651-201-6260

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Organic Mushroom Cultivation and Marketing in a Northern Climate

Project Summary

This project was designed to address several questions and goals. The first was to attempt to grow shiitake mushrooms on a variety of hardwood trees. Shiitake mushrooms are known to grow best on oak species, however in northern Minnesota oak trees are not abundant. Is the lack of oak trees a deterrent to shiitake production, or could another hardwood species such as maple provide an adequate substrate for shiitake cultivation?

Also of interest was how well shiitake mushrooms would grow in a northern climate and what strains of spawn would perform the best in a cold climate.

The third goal was to develop a market in the Duluth, MN area for organically/locally grown mushrooms (farmers' markets, restaurants and/or grocery stores). Oyster mushrooms were grown on straw and on locally available tree species and marketed along with shiitake mushrooms.

The outcomes for both cultivation and marketing showed some surprising results.

Project Description

The site of this project was in rural Duluth where I grow a variety of organic vegetables

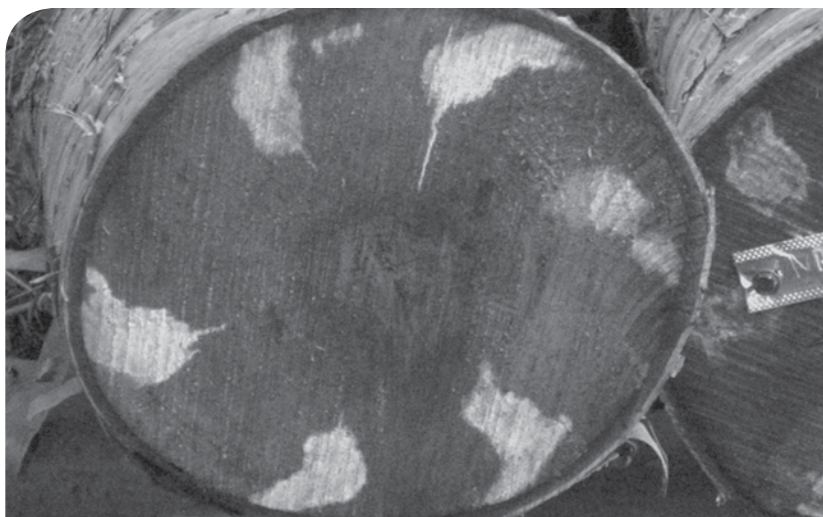
and fruits, primarily for my own consumption. It was in the late 1990s when my friend and mentor, Rob Aptaker, introduced me to the idea of growing shiitake mushrooms on oak logs. Rob grows shiitake mushrooms in an urban setting in Allentown, PA and taught me how to inoculate logs. I inoculated a few of my own logs and found that I enjoyed growing mushrooms. Rob Aptaker has been a cooperator on this project.

This project is important because the answers gleaned from it will assist others in determining if shiitake cultivation is a viable specialty crop from a socio-economic and consumer acceptance standpoint, as well as climate and tree species relevant to cultivation.

The project began in 2009, and it is important to note that both shiitake and oyster mushrooms take at least 12 months from inoculation to fruiting, which puts data collection about one year behind the project start date. In other words, logs that were inoculated in the spring of 2011 will not appear in this final report. This is unfortunate, because my personal learning curve as well as the quality of logs retrieved for this project both improved over time.

Data collected and displayed in the results section of this report were measured in grams.

Birch log showing mycelium growth of shiitake mushrooms.



Grams were used as a unit of measurement because grocery store containers of mushrooms are available in 100 gram (3.5 oz) units. One container of shiitake mushrooms from a grocery store (not organically grown) costs about \$4.30 in Duluth, MN. By displaying results in grams, it is easy to determine the net value of the product.

For shiitake mushrooms, the results compare grams of mushrooms harvested from different tree species and from different spawn strains. Oyster mushroom data compares spawn strains only, as results presented are for mushrooms grown on aspen logs (the preferred wood species for oyster mushrooms).

Obtaining Logs

Each new season begins with obtaining winter cut logs for both shiitake and oyster mushroom inoculation. Trees that are cut in winter have more nutrients and sugars in the wood than trees cut in the growing season, and that is beneficial to the mushrooms. Trees cut after sap begins to rise may easily loosen bark and mushroom yield may be lower. This season I obtained 100 oak logs from a logger located in Brule in northwestern Wisconsin and 100 maple logs from a second logger north of Two Harbors in northeastern Minnesota. I also obtained two large aspen trees with diameters of 12 – 15", which were used for oyster mushrooms. In 2010, I used 61 oak, 39 maple, 18 aspen and 17 birch trees for shiitake cultivation. In 2009, I utilized 25 oak, 13 maple, 32 aspen and 15 birch trees for shiitake cultivation. The logs used for shiitake were in the range of 4 - 7" in diameter.

Inoculating Shiitake Logs

The shiitake logs were inoculated between April 21 and May 7, 2011. Two volunteers from the University of Minnesota Duluth's Sustainable Agriculture Club assisted with inoculations on April 21. Holes were drilled into the logs using a modified angle grinder (which has more power than a drill) and a 7/16" drill bit with a stop that makes a precise hole to a 1" depth. A palm inoculator was used to deliver the spawn into the hole, which was then sealed with melted cheese wax. Logs were then set out under large spruce trees.

Shiitake Spawn

A variety of spawn strains were purchased from Field and Forest Products, Inc. located in Peshigo, WI. This company offers a wide range strain that fruits between 55 - 75°F; a cold weather strain that fruits between 45 - 70°F; and a warm weather strain that fruits between 50 - 85°F. Each year of this project I have used different strains from these three different temperature ranges to determine what works best for a cold climate. For 2011 inoculations I used:



Rob Aptaker inoculating logs with shiitake mushroom spawn.

Miss Happiness - cold range – 39 oaks and 6 maples
 Snowcap – cold range – 34 oaks
 Native Harvest – wide range – 40 maples (suggested for use with maple logs)
 New Moon – warm range – 46 maples (suggested for use with maple logs)
 West Wind – wide range – 21 oaks and 5 maples

In previous years, I split the spawn between the various tree species, but for 2011 I wanted to go for maximum harvest potential which is why I used only maples for the two spawn strains that were suggested for maple logs (New Moon and Native Harvest). All logs were labeled with the spawn name and date of inoculation.

Oyster Mushroom Inoculation

I used the two common methods of growing oyster mushrooms: the "totem" method, which is used with large diameter (12 – 15") aspen trees, and the "straw in cardboard box" method. As the totem name implies, this inoculation technique places log sections one-on-top of another. I started with a large black plastic trash bag. I placed two big handfuls of spawn in the bottom of the bag, and then a log section about 2' tall is placed on top of the spawn. Next I added another handful of spawn and another log, which is then topped with another handful of spawn. Totem sections were labeled with the spawn name and date of inoculation. The plastic bag is then tied closed and left to sit in a shady spot. Totems were inoculated on May 7 and the bags were

open on August 17, 2011. A total of 13 totem sections were inoculated and all showed mycelium growth upon opening the bags. Generally, these totems will produce mushrooms the following year, although as the results show, I did get some oyster mushrooms in the fall.

Additionally, I inoculated straw in cardboard boxes on May 12 and 16 (opened on June 24) and on June 5 (boxes opened on July 9). The use of straw for inoculation is good for summer flushes of oyster mushrooms (whereas totems generally produce in the fall). Straw provides a quick method for growing oyster mushrooms, but the tradeoff is that you get fewer mushrooms than from the totem method. The method for inoculating straw is much like making lasagna. First the bale of straw is soaked in water (I use a large stock tank) for 3 days to kill any competing spores and weed seeds. Spawn and straw are layered until the straw fills the box. Boxes were labeled with the spawn name and date. I placed a clear plastic sheet on top of the straw and then put the entire box in a black plastic trash bag. The boxes were placed in shady areas. This year I used three strains of spawn; PoHu in three boxes, Italian in five boxes, and Blue Dolphin in one box.

2009 Results

In April 2009, I ordered the equipment and mushroom spawn required to inoculate logs. For this first year I purchased nearly all of my logs from local loggers. My need for logs coincided with a severe ice storm in the Silver Bay area and the aspen, birch, and maple logs I used were salvaged from this ice storm. The oak logs were cut in Wisconsin and purchased through a local logger. I requested winter cut oak logs that were from 4 - 6" in diameter and 30 - 36" in length. Contrary to popular belief, mushroom cultivation must be done on live, healthy logs and the logs should be cut in the winter before the tree uses energy for leaf production.

Shiitake Mushrooms

The logs were inoculated for shiitake mushrooms between April 17 and April 21. Inoculation of shiitake logs consists of drilling 7/16" diameter holes into the logs 1" deep and spaced at 6" intervals along the length of the log and in rows about 1½" apart to create a diamond pattern. The holes are then filled with spawn, which is a mixture of sawdust and mushroom mycelium (purchased commercially). The holes are covered with melted food-grade wax to reduce moisture loss. I inoculated 25 oak, 13 maples, 32 aspen, and 15 birch logs with three different strains of shiitake spawn. The three strains I used fruit under a variety of temperature ranges chosen for a northern climate. Each log was labeled with the type of spawn used and the date of inoculation and then was laid out in a lean-to stacking configuration under

the shade of large spruce trees to allow the mycelium to run throughout the logs.

I noticed that either woodpeckers or chipmunks removed some of the wax covering the inoculation holes on the shiitake logs. I plan to use a thicker coating of wax on the holes to prevent this from reoccurring next year.

Shiitake logs generally take 6 months to a year before they are ready to fruit so I will not have results until next year. Next year I will try forcing fruiting to have mushrooms ready for a specific event such as a Saturday farmers' market. I plan to use a stock tank to soak the shiitake logs for 24 to 48 hours (depending on air temperature) and then place the logs in a vertical position for fruiting and picking. I expect it to take about 2 weeks to have mushrooms available for the farmers' market.

Oyster Mushrooms

I used two different growing methods for the oyster mushrooms: the totem method, which is used with large diameter soft hardwood tree species, and the "straw in cardboard boxes" method. The power company was clearing trees from a nearby right of way and I was fortunate to obtain winter cut, large diameter (8 - 10") aspen logs cut in about 2' lengths. These logs were inoculated between April 20 and April 24 with the totem method. This involves placing a handful of spawn in the bottom of a large plastic bag, then placing the largest diameter log upright on top of the pile of spawn, then another handful of spawn on top of that log, then the next largest diameter log on top of that one, capped with more spawn. The idea is to create a totem pole of logs, using the largest diameter first for stability and then alternating logs and spawn, using two lengths of logs. Then the black plastic garbage bag is drawn up and over the entire structure and closed loosely at the top.

The logs need to incubate in temperatures of 60 - 80°F for at least 4 months and up to 1 year. I uncovered the logs on September 13 and found that they were covered with white fuzz which indicates mycelium growth. Because I used large diameter logs, I suspect it will be at least 1 year before the logs fruit. Similar to the shiitake mushrooms, I used several strains of oyster spawn to cover a wide range of temperatures and inoculated 30 logs with oyster mushroom spawn. I will have data on mushroom yield next year.

I also wanted to try inoculating straw to have mushrooms in the current season. Straw is a quick way to grow oyster mushrooms with a faster spawn run, but you sacrifice quantity for speed. I purchased one oat straw bale (oat straw is recommended) and set up two cardboard boxes and one wood cold frame growing chamber. Before the straw could be used, it was soaked in a stock tank of water for 3



Totem method of inoculating aspen logs with oyster mushroom spawn.

days to kill other fungi and bacteria. Inoculating straw is like making lasagna, alternating layers of spawn and straw until the box is full. I placed two big handfuls of spawn on the bottom of the box, then straw, then more spawn, until I reached the top of the box. Then I used a clear, heavy plastic over the top, folded the box tops back into place, and placed a black plastic bag over the entire box to prevent any seeds in the straw from sprouting. The boxes are set in a shady location to rest for 1 month. After a month, I took off the black plastic, puffed the clear plastic up to make a little tent and every other day I misted the top of the straw with water. The three boxes were all started on May 10 and fruiting began on June 23 in the cold frame and July 8 and 10 in the cardboard boxes, and continued through September (Table 1).

Table 1. 2009 Oyster Strains and Straw Production

Oyster Strain	Total Grams Produced
Grey Dove (cold frame)	1,951.8
Grey Dove (cardboard box)	1,352.2
Italian (cardboard box)	1,320.9

As a point of reference, a container of oyster mushrooms purchased in a grocery store in Duluth weighed 100 grams (3.5 oz) and cost \$3.49. The expense for this method of growing included the straw (\$6.00), the spawn (\$46.00), and a stock tank (\$150.00) for soaking the straw in water. So, theoretically, if I sold all the oyster mushrooms that I grew from these three boxes of straw my income would have been \$161.40 and my expenses would have been \$202.00. Next year's expenses will only be for straw and spawn. The stock tank will be used for many years.

It was interesting to note that the cold frame produced more mushrooms than the two cardboard boxes. The cold frame was placed in a different location from the two cardboard boxes, but was still under a big tree for shade and received the same amount of misting as the cardboard boxes. I believe the humidity was better regulated in the cold frame because there was more space between the straw and the plastic top. There were more spotted beetles in the cardboard boxes than in the cold frame. This leaves me to consider building more cold frames for next season as well as trying floating row covers on the cardboard boxes.

2010 Results

There were many different results to report for 2010. Activities ranged from obtaining and inoculating logs with both oyster and shiitake spawn, as well as harvesting and selling mushrooms.

Obtaining Logs

Obtaining logs is labor intensive and is the aspect of this project that requires the most thought on my part. Purchasing logs from local loggers creates an expense and requires me to travel in order to pick up the logs and bring them to my inoculation site. The spring of 2010, as in 2009, provided an opportunity to obtain some free logs. Just about 6 miles from my home there was a large parcel of land being cleared primarily of aspen, with some birch as well, for future development. I introduced myself to the loggers and told them of my mushroom growing project, and came away with enough aspen for growing this year's oyster mushrooms, and some birch which I used with shiitake spawn. Additionally, I purchased maple, birch, and smaller diameter aspen from a logger in northern Minnesota, and oak from a logger in northwestern Wisconsin. These logs were used for shiitake production.

I am learning the importance of building relationships with loggers and explaining what is required for mushroom logs. The oaks that I had purchased in 2009 were cut, limbed, and



Oyster mushrooms growing in straw in a cardboard box.

Table 2. Oyster Mushrooms on Straw – 2010 Inoculation

Oyster Strain	Date Inoculated	Total Grams Produced
Italian 1	4/26/10	953.9
Italian cold frame	4/26/10	1,291.0
Italian 2	7/3/10	112.5
Italian 3	7/3/10	509.2
Italian 4	7/3/10	66.0
Grey Dove 1	4/26/10	156.6
Grey Dove 2	4/26/10	82.8
Grey Dove 3	4/26/10	0
PoHu 1	6/4/10	1,727.2
PoHu 2	6/4/10	1,520.4
PoHu 3	6/4/10	1,033.3

moved mechanically – all of which injured the bark of those trees. A wound to the bark causes moisture loss, which can be detrimental to the mushroom growing process. Therefore, I had several conversations with my oak supplier to see how I could obtain logs that were cut by hand and treated gently! The log supply I received in 2010 was smaller in diameter and better treated, but they were still not the ideal logs in size and condition. My hope for 2011 is to be able to cut my own oak trees, or at least be present to supervise the cutting. The maple, birch, and aspen logs purchased in northern Minnesota were treated very well and I have had no problems with bark damage.

Inoculating Shiitake Logs

Inoculation for shiitake mushrooms occurred from April 15 to 18. An important difference between this year and last was the use of a drill bit with a stop on it, which allowed for drilling a hole to the exact 1" depth needed for use with the inoculation tool. Inoculating at this depth will help prevent chipmunks from getting at the spawn.

This year I used four strains of shiitake spawn that provides for a range of fruiting temperatures. I used a warm weather strain that was developed specifically for use with softer woods on some of the maples, birch, and aspen. All totaled I inoculated 61 oak, 39 maple, 18 aspen, and 17 birch logs.

Table 3. Oyster Mushrooms Grown on Totem Logs – 2009 Inoculation

Oyster Strain	Date Inoculated	Grams Produced in 2010
PoHu 1 – Aspen	4/23/09	510
PoHu 2 – Aspen	4/23/09	74.5
PoHu 3 – Aspen	4/23/09	869.9
Summer Blue 1 – Birch	4/23/09	24.8
Summer Blue 2 – Birch	4/23/09	208.3
Summer Blue 1 – Aspen	4/23/09	572.9
Summer Blue 2 – Aspen	4/23/09	289.3
Summer Blue 3 – Aspen	4/23/09	372.9
Summer Blue 4 – Aspen	4/23/09	741.7
Summer Blue 5 – Aspen	4/23/09	50
Blue Dolphin 1 – Aspen	4/20/09	309.1
Blue Dolphin 2 – Aspen	4/20/09	327.7
Blue Dolphin 3 – Aspen	4/20/09	534
Blue Dolphin 4 – Aspen	4/20/09	436.7
Blue Dolphin 5 – Aspen	4/20/09	473.5

On 12 of the largest diameter birch, I experimented with a “kerf” type of inoculation. Kerf inoculations are made by cutting across the log with a chainsaw to a depth of about 1”, and then packing the cut with spawn and covering with melted cheese wax. I chose to do this because there were a few cuts in the bark of the larger birch logs. All other logs were inoculated with a palm inoculator and sawdust spawn and the holes were covered with melted cheese wax.

Inoculating Oyster Mushrooms

Once again I used the two common methods of growing oyster mushrooms: the totem method, which is used with large diameter aspen, and the “straw in cardboard box”



Soaking shiitake inoculated logs to stimulate fruiting.

method. I used large diameter (6 - 8") aspen trees, which were logged before the buds began to swell from an area that was being cleared for development. I set up 11 totem configurations (spawn, log, spawn, log, and spawn, all in a large plastic trash bag) on April 24. The totems stayed covered in the plastic bag (which maintains both moisture and warmth) until August 19 when they were uncovered. All of the totems had white mycelium growth. The totems were labeled with the name of the spawn used and the date. The totems should produce mushrooms in 2011.

Additionally, I inoculated a total of 11 cardboard boxes and one cedar cold frame by alternating layers of spawn and straw. The bales of straw must first be soaked in water for 3 days as a way to sterilize and pasteurize it. After layering spawn and straw, I placed clear plastic over the top of the box and placed the entire box in a large black plastic trash bag to retain moisture and temperature. These bags were opened 1 month later and the clear plastic was puffed up to create a little tent to retain humidity. I used three different strains of oyster mushrooms (Italian, PoHu, and Grey Dove) that fruit over different temperatures. I inoculated the straw at various times throughout the spring and summer to match the preferred temperature ranges. These strains were chosen because of good production in 2009 for Italian and Grey Dove and because PoHu is a strain designed especially for use with straw.

Fruiting Results - Straw

The results are given in grams to provide a reference point for market (Table 2). A container of oyster mushrooms purchased in a Duluth grocery store weighs 100 grams (3.5 ounces) and costs \$3.49. The Italian strain planted in the spring produced more volume of mushrooms than in the summer. For a second year, the cold frame

produced a higher volume than most of the cardboard boxes. Grey Dove did not perform as well in 2010 as in 2009 and this could have been a result of temperatures or moisture (locations were identical for both years). The super performer of 2010 was the PoHu strain, which was specifically developed for use on straw. It is interesting to note that when box #1 was opened on July 4, mushrooms were found growing all over the box and in one picking produced 1,221.7 grams or 2.69 pounds of mushrooms!

Fruiting Results – Oyster Totem Logs Inoculated in 2009

The fall of 2010 was fairly wet and this was very beneficial to the totem logs inoculated in 2009. Fruiting of the totem logs began on October 2 and continued on some logs until November 11 (Table 3). Most of the logs were large diameter (7 - 10") aspens that were winter cut and inoculated between April 20 & 23, 2009. I also inoculated a few birch logs to see if they worked.

Not all logs inoculated in 2009 bore fruit in the fall of 2010 (none of the Italian inoculated logs fruited) and those that did produce fruit provided a relatively small amount for totem log cultivation. This leads me to believe that the logs that did produce fruit will fruit again in 2011 and those that did not fruit at all very likely will this upcoming year.

The largest profusion of mushrooms was found closest to the ground around the base of the logs and in the leaf litter. Fewer mushrooms were produced on top of the log or in between the two logs. The mushrooms produced from the totem logs seemed to dry up faster than those produced in boxes (with plastic over the top) and this provided a smaller window for picking. It wasn't uncommon for me to note a small mushroom one day and find that it had dried up by the next day. Therefore, I picked these mushrooms at a smaller size than I did the mushrooms grown on straw.

Fruiting Results – Shiitake Logs Inoculated in 2009

Oak, aspen, maple and birch logs were inoculated in 2009 with three strains of spawn to cover a range of temperatures. The log diameters were about 5 - 6" which were on the large end of what is typically used for shiitake cultivation and I anticipated that mycelium runs would take longer, hence a delay of at least 1 year for mushroom production.

On April 19, I noticed shiitake mushrooms starting to develop on 1 oak log, 2 maple logs, and 1 birch log. I placed these logs upright against a large spruce tree and watched daily for additional growth. I was able to pick just a few mushrooms from each log and when no more mushrooms came, I decided to soak those logs in a tank of water to attempt to stimulate more fruiting. The logs were soaked in a stock tank for 24 hours and then reset upright against a large spruce tree. The oak log and two birch logs responded to the soaking, but again only with a

few mushrooms. I will watch these 2009 inoculated logs closely for signs of fruiting in 2011 and will attempt to stimulate fruiting by soaking the logs in a stock tank.

Marketing Mushrooms

I had enough oyster mushrooms at the right time to attend three farmers' market days. I attended the market held on Wednesdays at the University of Minnesota, Duluth twice and attended the Brimson Farmers' Market once on a Saturday. Although I made very little money from my mushrooms, I learned some valuable information that will help me at future farmers' markets.

The first thing I learned is that oyster mushrooms do not have a long shelf life. I can hold them in my refrigerator for two days if they are picked just before their prime. This becomes a difficulty if market day is held once a week. Attending various markets on different days will help with this problem. Additionally, mushrooms do not like sun, requiring an umbrella or tent-like structure to shade them during market.

I spoke with some blueberry marketers at a market and they shared with me that they take orders in advance and when the berries are ready they call their customers. I thought this would be useful for my marketing and would help eliminate the short shelf life dilemma. I plan to try this next year.

Another problem I ran into was the flush of mushrooms produced from the totem logs in late fall. All of the markets were closed for the season and I had several pounds of mushrooms. I called a restaurant that uses local and organically produced foods and told her about my mushrooms and I asked for \$30.00 for the 2 pounds that I had. She told me that her supplier in Minneapolis



Shiitake mushrooms on oak logs.

sells them to her for \$21.00 for 5 pounds. An industrial mushroom grower undercut my prices! I ended up drying the mushrooms in a food dehydrator, and realized this will provide a good way to save mushrooms I can't sell immediately.

2011 Results

Keeping in mind that logs inoculated in 2011, the third year of this project, will not fruit until 2012. The following results for shiitake and oyster mushrooms include those logs that were inoculated in years 1 and 2, in 2009 and 2010 respectively. Both shiitake and oyster mushroom logs will produce for several consecutive years.

Mushrooms were picked daily when present, allowing for each mushroom to reach a maximum size. Each producing log was numbered and labels provided the spawn type and date of inoculation. In this manner, I was able to keep records of each log's productivity. Weight measurements were made using an Acculab Vicon scale.

Shiitake Mushrooms Production

In 2011, I collected shiitake mushrooms from logs inoculated in 2009 and 2010. Oak, maple, birch and aspen logs were inoculated with a variety of shiitake mushroom strains in 2009 and 2010. Unfortunately, there were no shiitake mushrooms produced on aspen logs. These logs are too soft of a wood and dried out quickly, never giving the mycelium the opportunity to run.

The oak logs that were obtained in 2009 were not appropriate for mushroom production and this had impacted the data and results for year

Table 4. Shiitake Mushroom Production in 2011 from Logs Inoculated in 2009

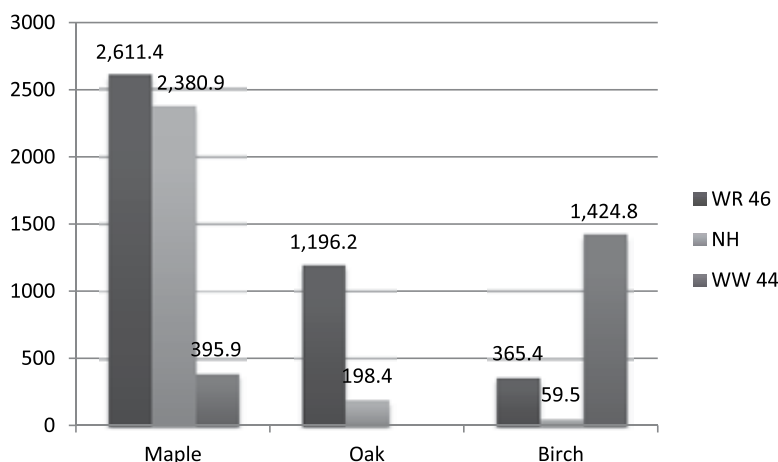
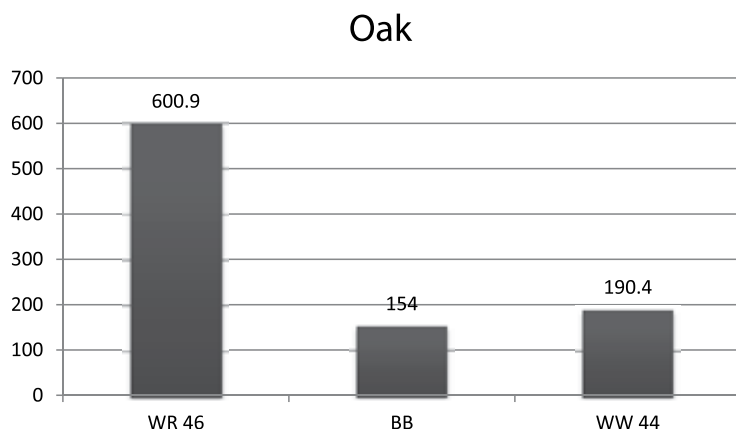


Table 5. Shiitake Mushroom Production in 2011 from Logs Inoculated in 2010

one. It is important for interested mushroom growers to learn from my mistake. Many loggers use heavy equipment to drag logs from the forest and then place the logs in a mechanical de-limber that damages the bark. Bark that is split or has holes in it will dry out and not provide a good host environment for the mycelium. Despite the damage to my logs in year one, I went ahead with inoculation in the spirit of experimentation. However, a true comparison of spawn types and tree species is hard to obtain for 2009 logs because of the condition of these logs. Table 4 shows the various types of spawn strains and tree species used in 2009.

The spawn strain WR 46 was superior to other spawn for oak and maple species. This is a wide range spawn that produces mushrooms in the 55 - 75°F temperature range. The fact that shiitake production in maple was higher than in oak was most likely a result of the poor condition of the oak logs. However, the fact that WR 46 did well in maple is encouraging for mushroom production in areas without oak trees.

Also of interest is that WW 44, a warm weather strain, grew mushrooms in birch, a tree species not used for shiitake production. It may be possible to add birch as a mushroom producing log; this is encouraging as birch is readily available in northern regions.

Despite soaking logs from all tree species (soaking stimulates mushrooms to fruit) from the 2010 inoculation, only oak logs produced mushrooms this year (Table 5). These oak

logs were in good condition and had not been mechanically manipulated like those from 2009. I anticipate that additional maple, oak, and birch logs will fruit in 2012 as the spawn continues to run throughout the logs. It is not unusual for logs to require more than 12 months before they fruit. As with the 2009 logs, WR 46 was again the most productive strain of spawn. Spawn strains used in 2010 included: WW 44 - a warm weather strain that fruits between 50 and 85°F, New Moon (NM) - also a warm weather strain, Bolshoi Breeze (BB) - a cold weather strain that fruits between 45 and 70°F, and WR 46 - a wide range strain that fruits between 55 and 75°F.

Unfortunately, I must conclude that due to the time required for logs to go from inoculation to production, this data really is incomplete at this time. The condition of the 2009 oak logs do not allow for a conclusive assessment of spawn in oak logs. Year 2 logs, which were inoculated in 2010, will likely produce vigorously in 2012. Year three logs were inoculated in 2011 and no data is available.

Total shiitake mushroom production in 2011 came to 10,036.2 grams or 100 boxes weighing 100 grams. At the prevailing market price of \$4.30 per box, that would have a net market value of \$430.

Oyster Mushrooms Grown in Straw

Similar to the shiitake mushrooms, the year 2011 produced mushrooms from logs inoculated in 2009 and 2010. A few mushrooms were obtained from the PoHu and Blue Dolphin strains of spawn, but not enough to market. The spring weather was cold and rainy which caused all but two boxes to become moldy.

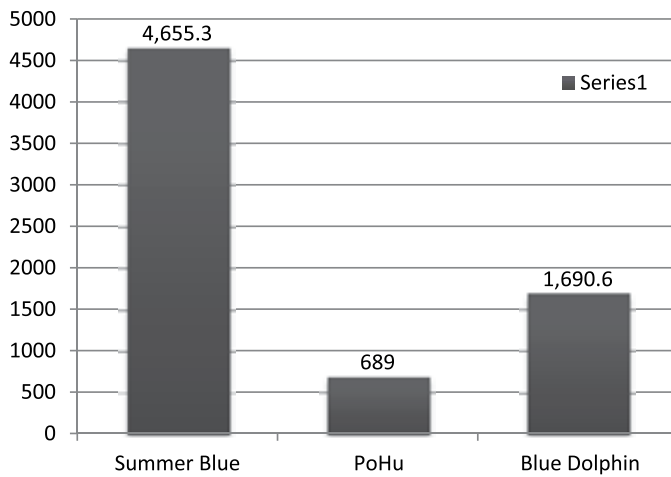
Oyster Mushrooms Grown on Aspen logs – Totem Method

This year's production occurred from aspen logs inoculated in 2009, 2010, and 2011. The total weight in grams for the 2011 production of the 2009 inoculated logs was 1,527.8

Table 6. Comparison of Oyster Mushroom Production in 2011 from Logs Inoculated in 2009 and 2010 - Totem Method

Summer Blue (grams)		PoHu (grams)		Blue Dolphin (grams)	
2009	2010	2009	2010	2009	2010
1,527.8	862.2	2,233.5	1,454.4	3,051.7	1,607.5

Table 7. Oyster Mushroom Production in 2011 from Logs Inoculated in 2010 – Totem Method



grams from Summer Blue, 2,233.5 grams from PoHu, and 3,051.7 grams from Blue Dolphin.

For comparison, these same logs produced mushrooms in 2010, but in smaller amounts. Summer Blue produced 862.2 grams, PoHu 1,454.4 grams, and Blue Dolphin produced 1,697.5 grams (Table 6).

Mushrooms are sensitive to a variety of factors including temperature, humidity, and amount of rainfall. Any one of these factors could have resulted in the fruiting differences.

Logs that were inoculated in 2010 also fruited in 2011 (Table 7). The strain Summer Blue was a proven winner producing 4,655.3 grams, vastly outperforming PoHu and Blue Dolphin. In addition to being productive, these mushrooms are a beautiful shade of blue turning to blue-grey as they mature.

A few logs that were inoculated with the strain Grey Dove in the spring of 2011 produced a flush of mushrooms of 641.1 grams in the fall of 2011.

The oyster mushroom strains Summer Blue and Blue Dolphin were the most productive compared to all strains that produced in 2010 and 2011. Mushrooms produced were big, firm, beautiful, plentiful, and tasty!

The downside of the totem method for Oyster mushrooms is that this method produces fall mushrooms. All of the 2011 mushrooms came in October, well after the local farmers' markets closed for the season.

Oyster mushroom production in 2011 came to 14,489 grams. Theoretically, in terms of marketing, this amounts to 144 boxes at 100 grams each, with a value of \$3.50

each (the going grocery store rate), or a total net value of \$504. Realistically however, mushroom fruiting occurs at the will of the mycelium; sometimes a few mushrooms at a time, other times the day after market, or in the fall after markets close. I provide more information on this in the marketing section.

Marketing Mushrooms

As I alluded to earlier, small-scale mushroom production created some difficulties with marketing. Growing oyster mushrooms on straw helped to provide summer flushes, which could be taken to market. To be more financially viable, many more boxes of straw would need to be inoculated. The main problem I contended with in growing oyster mushrooms in straw was not having enough mushrooms that were ready for market day.

The shelf life of oyster mushrooms is about 5 days in the refrigerator. If a farmers' market occurs once a week, these mushrooms would not be fresh. Having more boxes and spacing out the timing of inoculation may assist with this problem.

Oyster mushrooms grown on aspen logs tend to fruit in the fall (October and November in my case) and this is well after farmers' markets have closed for the season. Both years forced me to use a food dehydrator to dry the oyster mushrooms. It could be possible to develop a market for dried mushrooms in the future.

I ran into similar volume and market day readiness issues with the shiitake mushrooms. However, when all 3 years of my logs are producing, I will have more volume and this should eliminate not having enough mushrooms ready for a market day.

The total volume of oyster and shiitake mushrooms produced in 2011 would have amounted to a market value of about \$900. In reality though, I only had enough volume to make marketing worthwhile on three occasions. My income for 2011 was about \$105 dollars. I have been developing an email list that will allow me to send out alerts when I have mushrooms and this will facilitate selling small quantities.

While attending farmers' markets I found that many people were not familiar with oyster or shiitake mushrooms. I spent a fair amount of time educating potential consumers about how I grow mushrooms (people thought they were wild mushrooms) and how to cook them. For 2011, I created two "science fair" type of display boards showing the various procedures in growing shiitake and oyster mushrooms. I used these displays at my field day held in

July and found that it provided a backdrop for teaching about mushroom cultivation. I now take these displays with me to farmers' markets and find that it creates a bridge to dialogue with potential customers.

Management Tips

1. Use a thick coating of wax to cover the inoculation holes to prevent damage from woodpeckers or chipmunks.
2. Use floating row covers on oyster mushroom boxes. These will protect the mushrooms from damage from spotted beetles.
3. The logs are hard to identify as they age. To keep track of the logs, write the tree species, strain of mushroom, and date on the log with a permanent marker. Metal labels decompose, fall off, and bend and therefore are not reliable.
4. Use a drill bit with a stop on it to make the correct size hole in the logs.
5. Pay attention to oyster mushrooms fruiting on totem logs so that they don't dry up.
6. Build relationships with loggers so that they understand what is needed for mushroom logs.
7. If you cannot sell all of the mushrooms you can dehydrate them in a food dehydrator to use or sell later.
8. Store mushrooms in a plastic container rather than a plastic bag. This will help them keep longer.
9. Mushrooms do not like sun and heat. Bring a shade structure, a cooler and ice packs to help keep mushrooms cool.

Cooperators

*Rob Aptaker, Mushroom Grower and Consultant,
Allentown, PA*

David Abazs, Round River Farm, Finland, MN

Project Location

This project is located on the edge of Duluth and Rice Lake Township. Take I-35 north to the 21st Ave. E. exit. Take 21st Ave. E. to Woodland Ave. and bear right (north). Take Woodland Ave. to the three way stop sign at Calvary St. and turn left. The next street you come to is Arnold, turn right. Take Arnold to Rehbein and turn left.

Other Resources

Field and Forest Products, Inc. Mushroom spawn, instructions, and growing supplies. Peshtigo, WI. 800-792-6220. Website: www.fieldforest.net

Fungi Perfecti. Mushroom spawn and growing supplies. Olympia, WA. 800-780-9126. Website: www.fungi.com

Kozak, M.E.; Krawczyk, J. (1993). Growing shiitake mushrooms in a continental climate. Peshtigo: Field & Forest Products, Inc.
