PRODUCING SHIITAKE SPAWN FOR THE INOCULATION OF LOGS by Gary Leatham

Development of a successful large-scale Shiitake industry in the United States will depend on the formation of domestic spawn producers who can supply high quality spawn from tested and proven strains of Shiitake. Growers producing their own spawn are gambling. The relatively small investment for proven inoculum is minor compared to the time and labor lost in a large-scale failure. To produce quality Shiitake spawn in quantity will require knowledge of fungal culture, aseptic transfer techniques and quality control in addition to a basic knowledge of Shiitake cultivation. Knowledge of aseptic transfer techniques is especially important because some mushrooms are poisonous. It is essential that, when attempting to produce Shiitake spawn, other mushrooms are not propagated instead.

The following is a basic method for the production of Shiitake spawn suitable for the inoculation of logs. The fungus is grown on small pieces of wood which are later to be inserted into holes drilled into suitably prepared logs. Provided the correct microbiological procedures are followed, an experienced individual will find the method simple but effective. This method may be modified to suit a particular spawn producer’s requirements, including the intentional production of spawn of other wood-rotting fungi.

(SEE SPAWN, PAGE 2).

SPRING SHIITAKE TRIP TO JAPAN PLANNED

We are organizing a Spring trip to Japan to get some first hand information on the cultivation of Shiitake mushrooms. The Shiitake Trip will be about 10 days long and include visits to: a Shiitake farm inoculating logs; both commercial and small scale Shiitake farms that are fruiting Shiitake naturally and in chambers on logs and cultured substrate; a Japanese Shiitake research center such as the Mori Institute and a Japanese spawn supplier. The Spring Shiitake Trip will be an excellent way to learn Japanese Shiitake cultivation methods and to explore Japan with others of similar interests. The tour is contingent upon reaching a minimum group size. Contact the Forest Resource Center at the above address by mail for more information by February 1st, 1985 to reserve a place on the Shiitake adventure of a life time!

BOB HARRIS’S OBSERVATIONS by Bob himself

At the request of Joe Deden and the SE Minnesota Forest Resource Center I was invited on an inspection tour of many examples of Shiitake log cultivation around Minnesota. Some were research oriented using different wood types, conditions, handling techniques, etc., with varying degrees of success. I would like to share a few observations I made.

The single most important factor in success or failure during the first 6 to 12 months involved the moisture content of the logs. Of course I am assuming that all logs used were properly handled and of good quality (i.e., not dragged in mud on the ground, extensive bark damage, large limb scars, etc.). The central

(SEE OBSERVATIONS, PAGE 3)
containers must also be free of contaminants. Sterile spawn containers are open to the air for inoculation only when in a sterilized chamber. Standard microbiological chambers or laminar sterile airflow hoods are highly recommended, but unfortunately are expensive. A homemade chamber can be constructed from a large corrugated fiberboard box (Fig. 1) lined with aluminum foil or plastic. To reduce the possibility of contaminating the chamber with airborne spores, the chamber should be used in a room with limited air movement. Sterilize immediately before use by spraying or wiping the inside of the chamber with 70 percent ethanol (danger: flammable) or a 0.25 percent solution of household bleach (danger: poisonous liquid and fumes). For more convenient sterilization, commercial germicidal lamps (danger: direct exposure to ultraviolet rays may burn skin and eyes) may instead be mounted in the chamber.

To produce spawn, use hardwood chips or pegs of a convenient size to plug into holes drilled into logs [e.g., 1 to 1.5 cm diameter x 2 cm long (1/4 to 3/8 in. x 3/4 in.)]. An ideal material out of which to make pegs is the 3-foot lengths of doweling material commonly sold at hardware stores. By weight, mix 10 parts of dry wood pegs or chips (that have not been treated with a fungicide) and 1 part of rolled oats or bran of any grain (as a nitrogen supplement). Soak 1/2 to 2 hours in 10 parts of water by weight with occasional mixing. Warm water will hasten the hydration of the wood chips. After the moisture is evenly distributed, fill glass containers, or sterilizable polypropylene plastic bags one-half to two-thirds full of the medium. Plug jars with cotton or loosely tie plastic bags with a rubber band. Do not seal plastic bags or they will explode during sterilization. Steam sterilize in a pressure cooker or autoclave with 13- to 15-pounds-per-square-inch (lb/in.²) pressure (about 121°C or 250°F) for 30 to 40 minutes, or boil for approximately 1 hour. After removal from the sterilizer, the plastic bags should be sealed with the rubber band. Allow the containers to cool. Inside the sterile chamber, carefully introduce a piece of inoculum with sterile forceps into the containers and reseal or replug them. The inoculum may be a piece of spawn or a piece of tissue from a healthy, fresh mushroom that one desires to propagate.

If selecting from a mushroom that one desires to propagate, it would be wise to surface sterilize the mushroom by lightly wiping it with a sponge soaked in 70 percent ethanol (danger: flammable). Immediately afterwards, tear the mushroom in half length wise and take a small piece with sterile forceps from the center of the stem or cap. Forceps may be sterilized with ethanol or a flame. The piece of mushroom should not have been in contact with either an outside surface of the mushroom or the gills. This small piece of mushroom is the fungal strain which produced that particular mushroom. If the above procedure is followed, the spawn should be free of contaminants.

Once inoculated, grow the spawn at 22° to 27°C (70° to 80°F) for 2 to 3 months. To avoid the introduction of "weed fungi," do not open the containers. Discard any container which is contaminated or shows abnormal fungal growth. Common contaminants often are seen as a black, green, or blue coloration inside the spawn container. With age, however, Shiitake spawn may occasionally produce brown colored liquid droplets
This sign indicates that you should use the aged spawn as soon as possible.

For convenience, pure stock cultures may also be maintained in Petri plates or cotton-stoppered test tubes, using Sabouraud-maltose agar or another suitable culture medium and standard microbiological techniques. Once established, stock cultures on agar or on wood chips can be stored in sealed plastic bags at 4° C (40° F) with 1 to 2 years between transfers to new media.

Gary Leatham is a Research Chemist for the Forest Products Laboratory in Madison, Wisconsin.

EDITOR'S NOTES - Joe Deden
The November issue of SHIITAKE NEWS completes our first year of providing you with more information on Shiitake cultivation. By completing the enclosed questionnaire you can help us determine what's working and on what areas we need to concentrate our efforts on in the upcoming issues.

In the March 85 issue, we would like to list who has subscribed to the newsletter so that you can contact others in your area on an individual basis. This might allow the local pooling of knowledge/equipment and might pave the way for cooperative marketing efforts and spawn purchases. Please notify us in writing by February 15th if you wish to have your name remain unlisted.

The September Pot Luck Shiitake Grower's Dinner was a great success. Fifty plus growers from six states spent an all together too short afternoon exchanging ideas and getting to meet new friends. Tentative plans for next year include an overnight stay and informal presentations.

If you have received three copies of this newsletter then it's time to renew your subscription! Subscriptions run for one year from the date that they are received. Please save us some time and hassles and renew your subscription by using the form on page 7.

OBSERVATIONS CONTINUED
principle is that Shiitake grows best when the moisture content is high inside the log and the bark kept much drier. This favors Shiitake while inhibiting competitors. The ideal moisture content will vary according to species used and method of handling. However, before discussing the particular examples, it appears necessary to request a standardization of the terminology concerning moisture and water content.

In my booklet, "Shiitake Gardening and Farming", I describe the formula for moisture content as: % Moisture = Fresh Wgt - Dry Wgt/Fresh Wgt X 100. This is based on simple algebra (Editor's note: Bob's mother was a math teacher!) and the current standard used in both biology and the mushroom industry. The sum total of the solids and water in a log add up to 100% and no more. This is also the same formula indicated by G. Leatham in his Forest Products Journal article when saying the moisture of the logs must be a minimum of 30% dry weight basis. In addition this is the same measurement indicated by the log moisture gauge I sell in my catalogue, according to the manufacturer, Delmhorst Instruments.

The confusion enters from the standards used by the lumber industry, as defined by the industry and publications of the Forest Products Laboratory, Department of Agriculture. In this case moisture content is defined as: % Moisture = Fresh Wgt - Dry Wgt/ Dry Wgt X 100. While this may be useful for measurements in DRY wood, its application to green timber can lead to figures greater than 100%.

I propose the standardization be the former rather than the latter as being more consistent with the standards in the

---

GARDEN PROPERTIES

sterile air flow ducttm unit 1: (photo) hepa filter provides total sterile air field for inoculations. smaller, larger units, much more. catalogue $2, p.d.m. gps, inc., p.o. box 722, bryn mawr, pa 19010
mushroom growing industry and moisture gauges.

Having accepted now that % Moisture = Fresh Wgt - Dry Wgt/Fresh Wgt X 100 as a standard measurement, the ideal moisture content is 35–45% inside the log and less than 15% in the outer bark layer. Under these conditions Shiitake grows very well and very few contaminants will grow on the outside of the log. 15% is the minimum level necessary for most fungal growth. How this is achieved will depend on wood species type and handling procedures.

Aspen and related species will have a higher moisture content than oaks and require a longer curing time to prevent contamination. Because of the thinner bark it is harder to keep the internal moisture high and the bark dry. The logs may be stacked with more air flow or incubated exclusively with the Box Method (see "Shiitake Gardening and Farming"). In addition it is useful to inoculate heavier, using at least 30 plugs in a 40" long 4" diameter Aspen log. If contaminants appear on logs incubated out doors, providing more air circulation will help. Exposing such logs to open air and drier conditions will arrest growth of contaminants. Proper conditions will often control unwanted growth, although an integrated program of fungicide application may aid in this. Benomyl (Benlate) has been used in the Orient and is currently registered for use in the cultivation of mushrooms. The fungicide is a wettable powder, applied in a pump spray at 250–500 ppm at the time of felling, post inoculation, and half way through the incubation period. I am not personally in favor of this, but I cannot raise strong objections to its use since the material has a short term life and deteriorates within a matter of days, i.e., long before harvest. The best solution is still proper control of air flow.

In summation, if logs are properly harvested and handled initially, then control of contaminants is made by regulating moisture inside the log and bark. With oaks having thick good bark, moisture can easily be kept at 35–45% inside and 15% in the outer bark outdoors, or in the Box Method. With Aspens this becomes more difficult, except with the Box Method. Note that if using the Box Method of incubation, the cellulose material must be less than 15% moisture and the internal moisture of the logs at the high end of 35–45 % range.

Bob Harris and Jennifer Snyder own and operate Mushroompeople in Inverness, California.

HELPFUL HINT Green mold contaminants indicate the moisture is too high on the outside bark. If dried out soon enough, it will not interfere with the spawn growth.

When visiting the forest Resource Center why not stay overnight at...

Mrs. B's
Historic Lanesboro Inn
Lanesboro, Minnesota
55949
Telephone
(507) 467-2154

reservations requested
Mushrooms have intrigued people for centuries...and why not! Within a few feet of each other, one may find a prized delicacy and another which is deadly poisonous. In fact, there seems to be an endless variety of them growing in lawns, gardens, and forests. There are reports of mushrooms growing up through asphalt driveways, and from walls and carpets. However, one of the mushroom's most impressive characteristics is the ability to pop up and grow overnight with no prior visual warning. This and other characteristics have led to a general misunderstanding of the mushroom. Fortunately, an explanation of the mushroom's life cycle helps clear away much of the mystery and at the same time describes what a mushroom is and how it is able to grow so quickly.

Many refer to the mushrooms as plants but actually they are only the fruit of the larger fungi. Their purpose is the production and dispersal of tiny spores whose function is somewhat like seed. The mushroom's unique often umbrella like architecture is designed to allow the spores, that are produced on the gill surfaces on the underside of the cap, to be lifted away from the ground, discharged into the wind, and at the same time protected from the rain. Massive numbers of spores are produced by each mushroom to ensure that a few land in a moist, favorable environment for growth.

Mushrooms are only the fruit of a fungus. Our attention will be directed toward the parts of the fungi that produce them. These fungi are biological wonders in their own right. Collectively they have developed the ability to utilize almost any kind of vegetative matter for food. This adaptability has made fungi very important in nature since many are ideally suited to start the breakdown of prairie or forest litter allowing the valuable nutrients to be more expeditiously recycled. If the mushroom is edible, the fungus can therefore be used to turn wood, leaves or other plant residue into food for man.

The life cycle of a mushroom begins when a windblown spore is deposited in a favorable location with adequate food and moisture. Soon it germinates forming a long thread of living cells called a hypha. The hypha grows from its tip allowing it to creep forward. Vegetative matter found in its path is broken down by an arsenal of enzymes released outside the hypha. The liberated nutrients are absorbed and used to support further growth and some are stored for fruiting. When a pocket of suitable food is encountered, the hypha branches and most of the new tips grow into and around the food to allow its rapid consumption. While this is happening, some tips grow out away from the food. In this way, any food encountered is efficiently collected and the colony expanded to locate new food supplies. Repeated branching and growth of the hyphae form the extensive network of cells called the mycelium which is the vegetative part of the fungal organism, the living "body" of the fungus. Such a growth pattern can be seen in the home as the growth on moldy bread or oranges; however, these fungi do not produce mushrooms. Out of doors, mushroom mycelia can often be observed growing under the loose bark on fallen logs or

**ANNOUNCING**
MUSHROOM PRODUCERS INC.

...a cooperative grower organization for the production of shiitake and other specialty mushrooms

...marketing expertise provided by Gourmet House, Inc. marketing arm for the largest producer, processor, supplier and oldest cooperative of wild rice and wild rice relative products world wide

Inviting member and distributor inquiries: Mushroom Producers Inc. c/o Gourmet House, Inc. 402 11th Street SE Grand Rapids, MN 55744 (218) 326-0574

**SHIITAKE INOCULATION SUPPLIES**

**SPAWN** - Pick of the crop, fruits spring and fall, excellent cap formation!

**DRILLS** - Brad point - prevents bark damage, Sizes 5/16 or 3/8.

**STOP COLLARS** - Locks on drill to limit depth of penetration, Sizes 5/16 or 3/8.

**WAX** - Cheese wax - costs no more than paraffin - Does a much better job!

**BURLAP** - 6' X 300' bulk rolls - gets your logs off to a fast start.

**SHADE FABRIC** - Creates a near perfect forest environment. Use same area for laying and raising, near your water source.

SOHN'S OAK FOREST MUSHROOMS
BOX 20, WESTFIELD, WI 53964

Write for a price list.
within piles of leaves or forest litter where it appears as a fuzzy, white growth.

In nature, a mycelium from one spore usually cannot fruit alone; therefore, during its growth it must meet a hypha from another spore of the opposite mating type. When such a pair joins, the hyphae fuse and grow together as one organism. This mated pair forms a colony that can produce mushrooms. Some fungal colonies such as mushroom "Fairy Rings" have been estimated to be hundreds of years old and are still actively growing and producing mushrooms.

How fungi form mushrooms from their extremely thin hyphae seems an amazing feat. This is made possible only because the mycelium has previously extended over a large area and absorbed the massive amount of nutrients necessary. Mushroom formation usually begins in the older hyphae where the conditions for growth are becoming unfavorable due to a scarcity of food. Hyphal tips bend toward each other and fuse; the repeated branching occurs forming a small, dense, ball-like structure called the primordium. A primordium is difficult to locate with the naked eye since it is usually only about 0.5 - 1 millimeter (1/64 - 1/32 in.) in diameter and often buried in the loose fuzzy mycelium. The problem is something like looking for a golf ball in a cotton bin. The mushroom's secret for fast growth is very simple. The primordium usually contains most of the cells required in the final mushroom and the energy source and raw materials needed to expand it have already been stored. So, when the correct environmental conditions prevail, such as adequate rainfall combined with an appropriate temperature, the hyphae collectively pump nutrients and water through themselves into the primordium thus promoting its rapid expansion. This last growth phase often take 12 - 96 hours to complete. Therefore, many mushrooms do indeed pop up overnight.

Gary Leathem is a Research Chemist for the Forest Products Laboratory in Madison, Wisconsin.
These Farmers Hope That Demand Will Mushroom for Fancy Fungus

By Michael Days
Staff Reporter of The Wall Street Journal

Most people will happily pay $2 and up for a pound of little white button mushrooms. But will they pay four times that amount for large, dark brown wide-gilled mushrooms known as Shiitakes?

Faced with cheap imports from Asia, American mushroom farmers have begun to grow Shiitakes, an exotic,fleshy strain of fungi their hoping will become the next gourmet craze.

Shiitakes are a familiar sight in Chinese and Japanese restaurants, but recently they've begun to show up in fashionable American restaurants. In Hollywood, Spago's pizza is topped with them. At Manhattan South, a New York restaurant specializing in fish dishes, customers can have them included in any entree. Barbara Chardon, who owns the restaurant with her husband, says that their smoky taste and meaty texture make them popular. She says people may initially be turned off by the appearance of Shiitake, but "once they bite in, they're sold."

Shiitakes cost so much because they're expensive to grow. Traditionally, Japanese farmers have drilled half-inch holes in oak logs and placed the mushroom spawn in them. Because Shiitakes are wild, and therefore temperamental, they can take two years to produce.

John Sassor, a mushroom farmer in Salem, Ore., uses the Japanese method. He placed the spawn three years ago, and about a year ago he began shipping mushrooms. Now he grows them year-round on oak logs and produces 250 pounds weekly. He plans to increase that yield to 2,000 by 1990. "People are starting to consume more and more," he says.

Meanwhile Gary Schroeder at Phillips Mushroom Farms in Kennett Square, Pa., says he has cut production time to six months by growing his Shiitakes in logs made from sawdust taken from mills in central Pennsylvania. Schroeder said he also adds nutrients to the sawdust; now he produces about 1,500 pounds weekly.

And even Campbell's Soup Co. -- already the country's largest producer of domestic mushrooms -- is experimenting with Shiitakes and other gourmet mushrooms.

The public, however, is cautious. In Boston, the only local store where Shiitakes sell well is in prosperous Beacon Hill. In Chicago, a spokesman for Treasure Island gourmet-food chain says, "It takes a certain kind of person to buy them."

But the farmers are optimistic. "The first time I had them, I turned up my nose at them," says Mr. Schroeder. "But now I always put them in my omelet."

SHIITAKE MUSHROOM RESEARCH PROJECT

The Itasca Development Corporation of Grand Rapids, Minnesota has received a $100,000 grant from the Blandin Foundation to complete the 2nd Phase of a Shiitake mushroom research project over the next three years. The project will evaluate the yields of different strains of Shiitake mushrooms on various test tree species. The technical aspects of outdoor and indoor forced fruiting will be examined and the mushrooms produced will be used to gather related marketing information. The final phase of the project will include the establishment of a for-profit operation in the Grand Rapids area. For more information contact: Richard Korte, Executive Director, One NW Third Street, Grand Rapids, MN 55744 (218) 326-9411.

SUBSCRIPTION FORM

I would like to subscribe to SHIITAKE NEWS and continue to receive this information. $25 annual fee from date of subscription.

NAME ____________________________

ADDRESS ____________________________

CITY ____________________________ ZIP ______________

PHONE (_______)

Send a check with the enclosed form. Make check payable to: Forest Resource Center Call (507) 467-2437 for more information.
WHAT IS THE SOUTHEASTERN MINNESOTA FOREST RESOURCE CENTER

The Southeastern Minnesota Forest Resource Center’s objective is to improve the management of our hardwood resources on private land. The clientele for whom the Forest Resource Center is designed includes landowners, university students, local community education, secondary and elementary education programs, professional foresters and forest scientists. Working in cooperation with Minnesota’s Department of Natural Resources, the Forest Resource Center is utilizing an existing facility that is located in the midst of 900 acres of forest land in the Richard J. Dorer Memorial Hardwood Forest near Lanesboro, Minnesota. Educational programs are being developed in conjunction with the University of Minnesota, College of Forestry, the Agricultural Extension Service and the Minnesota Department of Natural Resources. These accelerated educational/demonstration programs will increase awareness, and the level of knowledge and skills of forest landowners and other participants. Forestry specialists are convinced that demonstration sites, when coupled with personal contact, are the best method to encourage forest owners to implement necessary forest management practices. These forest management skills will help woodland owners move to optimum management on their lands. This will result in improved economic development and quality of life in the region.

Educational classes for adults offered by the Forest Resource Center include programs on black walnut, marketing timber, fuelwood management, timber taxes, woods and wildlife, the cultivation of Shiitake, the Japanese forest mushroom and a comprehensive forestry short course. Ask to be placed on our mailing list if you would like to receive more information about when and where these classes will be held. Programs for elementary and secondary students and other youth groups are also available.

The Forest Resource Center offers many services for people of all ages including quality educational programs, demonstration areas, which depict woodland management techniques and provides a resident forester, who is available 7 days a week when forestry advice is needed.

Private financial support for the educational and other activities of the Forest Resource Center will ensure their continued success. You are invited to become a contributer to this important work by sending your check to the Southeastern Minnesota Forest Resource Center, Rt. 2, Box 158 A, Lanesboro, Minnesota 55949. Donors of $1,000 or more are specially recognized as Patrons of the Forest Resource Center. All gifts to the Forest Resource Center are tax deductible to the full extent of the law and the Forest Resource Center is classified by the IRS as a 501 (C) (3) non-profit organization.

Your financial support will help us continue to reach out and let others learn about southeastern Minnesota’s greatest renewable resource, our beautiful hardwood forest.

SOUTHEASTERN MINNESOTA
Forest Resource Center
Route 2, Box 158A
LANESBORO, MINNESOTA 55949

Calendar

HOW TO GROW AND MARKET SHIITAKE MUSHROOMS to take place on January 28th in Southeastern Iowa. Contact the Geode Wonderland R.C. & D., 50 East Washington, Fairfield, IA 52556 (515) 472-6177

Cross country skiing - whenever snow permits!