

MUSHROOM CULTIVATION AND MARKETING

HORTICULTURE PRODUCTION GUIDE

Abstract: The market for mushrooms continues to grow due to interest in their culinary, nutritional, and health benefits. They also show potential for use in waste management. However, as fungi, mushrooms have life cycles very different from those of green plants. The choice of species to raise depends both on the growth media available and on market considerations. Oyster mushrooms, which grow on many substrates, are easiest for a beginner. Shiitake mushrooms already have earned considerable consumer demand. Only two mycorrhizal mushrooms, morels and truffles, have been commercially cultivated. Mushroom cultivation offers benefits to market gardens when it is integrated into the existing production system. A careful analysis of potential markets must be the first step in deciding whether to raise mushrooms to sell. Many information resources are available for further research.

By **Alice Beetz** and **Michael Kustudia**
NCAT Program Specialists
July 2004
© NCAT 2004

Introduction

Small-scale mushroom production represents an opportunity for farmers interested in an additional enterprise and is a specialty option for farmers without much land. This publication is designed for market gardeners who want to incorporate mushrooms into their systems and for those farmers who want to use mushroom cultivation as a way to extract value from woodlot thinnings and other “waste” materials. Mushroom production can play an important role in managing farm organic wastes when agricultural and food processing by-products



Gray Oyster Mushrooms • Glen Babcock – Garden City Fungi

Contents

Introduction	1	Further Resources	15
Growing Mushrooms	2	Conclusion	15
Choosing a Mushroom Species	5	References	16
Species for Beginners	6	Appendix.....	17
Pest Management.....	11	Resources.....	18
Marketing Mushrooms.....	11	Spawn and	
Financial Analysis.....	14	Equipment Suppliers	21

ATTRA is the national sustainable agriculture information service operated by the National Center for Appropriate Technology, through a grant from the Rural Business-Cooperative Service, U.S. Department of Agriculture. These organizations do not recommend or endorse products, companies, or individuals. NCAT has offices in Fayetteville, Arkansas (P.O. Box 3657, Fayetteville, AR 72702), Butte, Montana, and Davis, California.



are used as growing media for edible fungi. The spent substrate can then be composted and applied directly back to the soil. This publication includes resources for entrepreneurs who wish to do further research.

Many people are intrigued by mushrooms' nutritional and medicinal properties, in addition to their culinary appeal. Mushrooms contain many essential amino acids; white button mushrooms, for example, contain more protein than kidney beans. Shiitake mushrooms are less nutritious, but are still a good source of protein. (Royse and Schisler, 1980) As a group, mushrooms also contain some unsaturated fatty acids, provide several of the B vitamins, and vitamin D. Some even contain significant vitamin C, as well as the minerals potassium, phosphorus, calcium, and magnesium. (Park, 2001)

Asian traditions maintain that some specialty mushrooms provide health benefits. Chinese doctors use at least 50 species. Two recent books, *Medicinal Mushrooms: An Exploration of Tradition, Healing and Culture* and *Medicinal Mushrooms You Can Grow*, detail existing research on the health benefits of mushrooms. See the **Resources** section at the end of this guide for specifics on these books and other sources of information.

Mushroom production is labor- and management-intensive. Specialty mushrooms are not a "get rich quick" enterprise. On the contrary, it takes a considerable amount of knowledge, research, planning, and capital investment to set up a production system. You must also be

Producing nutritious food at a profit, while using materials that would otherwise be considered "waste," constitutes a valuable service in the self-sustaining community we might envision for the future.



prepared to face sporadic fruiting, invasions of "weed" fungi, insect pests, and unreliable market prices.

Growing Mushrooms

Mushroom production is completely different from growing green plants. Mushrooms do not contain chlorophyll and therefore depend on other plant material (the "substrate") for their food. The part of the organism that we see and call a mushroom is really just the fruiting body. Unseen is the mycelium – tiny threads that grow throughout the substrate and collect nutrients by breaking down the organic material. This is the main body of the mushroom. Generally, each mushroom species prefers a particular growing medium, although some species can grow on a wide range of materials.

If you are considering mushroom production, become thoroughly familiar with the life cycles of fungi. A very general description is included below. A plant pathology textbook is a good resource for learning more about these complex life cycles.

Once you are familiar with the various fungi life cycles, learn the growth requirements of each of the species you are considering. Two basic references are *The Mushroom Cultivator*, by Stamets and Chilton, and the aforementioned *Growing Gourmet and Medicinal Mushrooms*, by Stamets (see **Resources**).

Growing mushrooms outdoors as a part of a market garden involves little effort after you have inoculated the logs or other substrate with the mushroom spawn. Your duties are mainly to maintain humidity and monitor for fruiting. When mushrooms appear, you add them to your other garden products and sell them. (See *Mushrooms on the Farm and in the Garden*, below.)

Most available markets, however, require more mushrooms than occasional fruiting provides. Indoor production can fill the gaps when outside fruiting lags. The entire operation can also be conducted inside. However, indoor mushroom production demands a much higher level of knowledge, continuous monitoring, and timely manipulation of environmental conditions.

These are the steps in mushroom production— a cycle that takes about 15 weeks (time varies by species) from start to finish.

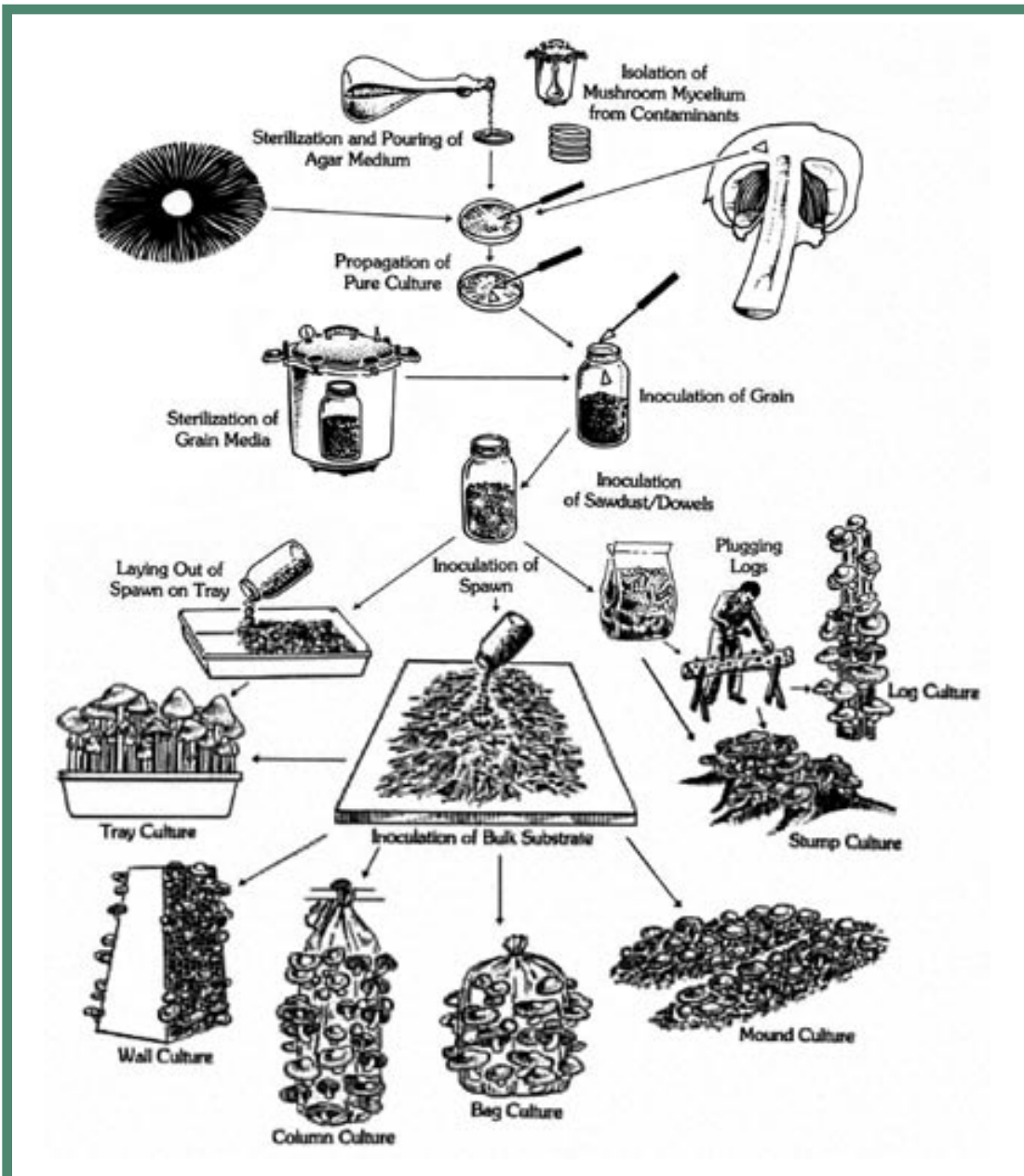
- Choosing a growing medium
- Pasteurizing or sterilizing the medium
- Seeding the beds with spawn (material from mature mushrooms grown on sterile media)
- Maintaining optimal temperature, moisture, and other conditions for mycelium growth and the conditions that favor fruiting (This is the most challenging step.)
- Harvesting, packaging, and selling the mushrooms

- Cleaning the facility and beginning again (Cooner, 2001)

The substrate on which the mushrooms will fruit must be sterilized or pasteurized in order to destroy any fungal and/or bacterial competitors. Low-tech substrate preparation methods are described in the books by Paul Stamets and by Peter Oei (see **Resources**).

To produce spawn, you inoculate a pasteurized medium, usually grain, with the sterile culture of a particular mushroom species. After the culture has grown throughout the medium, it is called spawn. Producing spawn requires exacting laboratory procedures. Terri Marie Beauséjour,

Figure 1



Copyright 1995 by Paul Stamets, <www.fungi.com>. Reprinted with permission.

cultivation chair for the Mycological Society of San Francisco, has written an excellent article that can help the beginner who is put off by the technical aspects of mushroom cultivation. Titled "Getting Started with Mushroom Cultivation: The Wisdom of Simplicity," it is available on the Web at <www.mykoweb.com/articles/cultivation.html>.

Many mushroom suppliers sell several kinds of spawn, and the beginning mushroom farmer should take advantage of this selection in early trials to determine which species grow best on available materials. Eventually, learning to produce spawn might reduce your cost of produc-

tion. Evaluate this possibility only after you have mastered the later stages of cultivation.

While the mycelium is growing—and until it fully occupies the substrate—the mushroom farmer typically manipulates the growing environment to favor mycelial growth. The atmospheric conditions are then changed to initiate "pinheads," and then to complete fruiting. For example, in oyster mushroom production under closely controlled conditions, the grower lowers the temperature and the CO₂ in the grow room to initiate fruiting. Each species has specific requirements for its stages of development. *The Mushroom Cultivator* provides detailed

Mushrooms in Permaculture* Design

**Permaculture is a system of combining perennials, trees, shrubs, and vines to create a "permanent agriculture." Using an intensive design process, the natural elements of an ecosystem are replaced by food-producing relatives, creating an edible landscape.*

Paul Stamets was an early advocate of integrating a variety of mushrooms into a permaculture system. (Stamets, 1994) In his design, agricultural wastes like cornstalks, wheat straw, or rice straw can be used as growing media for oyster mushrooms. After harvest, the spent substrate can be recycled as fodder or mulch for garden soils.

Shaggy manes (*Coprinus comatus*), Stamets notes, do well on manured soils and near compost piles. The King stropharia or wine cap mushroom (*Stropharia rugoso-annulata*) grows best outdoors and plays a key role as a recycler of woody debris. Bees, attracted to the sweet mycelium, help pollinate the green garden plants. The mushrooms are good to eat when small. Large, mature mushrooms attract fly larvae that make excellent fish or poultry food. These can supplement feed for other on-farm enterprises or be sold to pet stores.

Stamets also uses King stropharia mushrooms for their ecological benefits. He found that, when established along

waterways, they acted as microfilters of fecal coliform bacteria generated by his small herd of cattle. He also planted them along greywater runoff areas. Stamets believes mushrooms can play a large role in mycofiltration. (Stamets, 2000-2001)

Stamets grows shiitakes, namekos (*Pholiota nameko*), and Lion's mane (*Hericium erinaceus*) mushrooms on inoculated logs set in a fence row, while other species like maitake (*Grifola frondosa*), reishi (*Ganoderma lucidum*), and clustered wood-lovers are cultivated on stumps as part of a hardwood forest management system. He introduces mycorrhizal species such as chanterelles, King boletes, and others to new areas by "satellite planting," in which seedlings are planted near trees that have a desired mushroom species growing around them. After several years, the seedlings and their mycorrhizal associates are transplanted, creating new patches of mushrooms. Morels are more difficult to propagate, but some types can be encouraged through the use of small burns.

information on the requirements for 16 species. (Stamets & Chilton, 1983)

When you can cut the time between harvests, annual production increases. Short cycles are what large-scale commercial producers aim for, constantly looking for ways to increase efficiency. This is the competition you face if you plan to sell your product on the wholesale market.

Paul Stamets of Fungi Perfecti, an educational and mushroom supply company (See **Resources**), has spent most of his life studying the growth and cultivation of fungi. His book *Growing Gourmet & Medicinal Mushrooms* (see **Resources**) is an invaluable resource for anyone considering the cultivation of any mushroom species. He describes several alternative methods of producing mushrooms, including growing them outdoors on logs, on stumps, and in the garden, as well as indoors in bags or on columns.

Peter Oei, in his *Manual on Mushroom Cultivation* (see **Resources**), describes in some detail how alternative mushroom production systems have been used successfully in developing countries. Many ideas for low-input systems are included. In practice, it is unlikely that the beginner can successfully compete in the wholesale market against highly capitalized and efficient mushroom companies. A better choice for the beginner is to develop a niche market for high-quality fresh mushrooms, then sell them at retail, or to produce a value-added mushroom product, such as a soup mix or sauce.

Mushrooms on the Farm and in the Garden

Fungi cycle nutrients that nourish new life in the soil. Recognizing this essential function, inventive gardeners integrate mushrooms into farm, garden, and permaculture systems. Mushrooms can also be grown in lawns, polytunnels, vegetable gardens, and woodlands. (Edwards, 2000)

Terri Marie Beauséjour, a writer for *Mushroom the Journal*, encourages creativity and imagination when planting mushrooms in a garden. Look at the “fungamentals,” she writes, the necessities such as available substrates, microhabitats, sun,

shade, wind, and humidity conditions. Gardens offer ample substrates—organic waste materials—while plants provide shade and humidity. Plug-inoculated blocks buried among plantings work well for oyster and *Stropharia rugoso-anulata* mushrooms. Beauséjour suggests using a misting sprinkler for mushrooms in gardens. (Beauséjour, 1999)

Grower and author Ken Litchfield notes that mulching, a standard gardening practice, not only regulates soil temperature and humidity but also nourishes fungi. He also suggests surrounding raised beds with partially buried logs to create mushroom habitats. Inside the beds, vegetables, flowers, and shrubs offer the requisite shade and humidity for mushroom cultivation. In weedy areas, Litchfield suggests putting down organic material and covering it with wet cardboard and wood chips, an ideal substrate for fungi. (Litchfield, 2002)

These methods of production are not likely to yield huge numbers of mushrooms. However, they can provide an attractive addition to directly marketed produce.

Choosing a Mushroom Species

A mushroom cultivation kit (check with suppliers listed below) is a handy way to begin to understand the fungal life cycle. Once you successfully use the kit, you can begin to learn the steps that precede that final fruiting stage of the mushroom life cycle. Purchase spawn that will grow on materials you have available. Then design and test a system that duplicates the conditions favorable to all stages of growth. You can use this experience to learn how to create sterile cultures and spawn for the species you are growing.

Choose the species to grow by thinking about:

- What waste materials are readily available to use as a growth medium?
- What kind of facility or environment is available?

- How much will the necessary equipment cost?
- What level of skill is required to manage the life cycle of the fungus?
- What is market demand for this species?

According to these criteria, oyster (*Pleurotus species*) and shiitake (*Lentinus edodes*) mushrooms are probably best for most novices, although the maitake (*Grifola frondosa*) is also a possibility. The former two are relatively easy to grow, and there is already a market for them, largely because commercial producers of white button (*Agaricus bisporus*) mushrooms have been diversifying into specialty mushrooms. If you intend to grow mushrooms commercially, shiitake or oyster mushrooms are your best choices. These two species are more thoroughly covered in the following sections.

A chart in the **Appendix** lists other common species and the materials on which they can be cultivated. Test each species you are considering against each of the questions listed above.

Species for Beginners

Oyster mushrooms

Oyster mushrooms (*Pleurotus species*) are a good choice for beginning mushroom cultivators because they are easier to grow than many of the other species, and they can be grown on a small scale with a moderate initial investment. Although commonly grown on sterile straw from wheat or rice, they will also grow on a wide variety of high-cellulose waste materials. Some of these materials do not require sterilization, only pasteurization, which is less expensive. Another advantage of growing oyster mushrooms is that a high percentage of the substrate converts to fruiting bodies, increasing the potential profitability.



Flamingo Oyster Mushrooms • Glen Babcock – Garden City Fungi

Oyster mushrooms can become an integral part of a sustainable agriculture system. Many types of organic wastes from crop production or the food processing industry can be used to support oyster mushroom production.

Although there are no books devoted entirely to oyster mushroom production, Stamets' books provide basic information. Research on using various agricultural and forest wastes as substrates is reported in the recently published *Mushroom Biology and Mushroom Products*, edited by D.J. Royse. (Royse, 1996) Peter Oei (Oei, 1991) documents a number of commercial production systems for some strains grown in developing countries.

There is an increasing number of Web sites devoted to oyster mushroom production. Lawrence Weingarten describes his production process on his Web site, complete with photos at <www.mycowest.org/cult/i-grow/i-grow-1.htm>.

Two Canadian Web sites also offer additional advice:

- Oyster Mushroom Cultivation
www.gov.ns.ca/nsaf/elibrary/archive/hort/vegetables/pihve94-03.htm



Golden Oyster Mushrooms • Glen Babcock – Garden City Fungi

- Growing Shiitake & Oyster Mushrooms on Hardwood Logs
www.fallsbrookcentre.ca/webmain/programs/Forest/Pamphlet.htm

The MushWorld Web site, <www.mushworld.com/home>, contains excellent technical information about growing oyster mushrooms. The site requires registration, but it is free.

Oyster mushroom cultivation has one significant drawback: some people are allergic to the spores. In these cases, air-cleaning equipment or respirators are necessary in order to safely work in the production facility.

The consumer market for oyster mushrooms is being developed by the larger mushroom companies as they diversify their operations. However, because of the short shelf life of many oyster mushroom varieties, this species may offer a special advantage to the local grower who markets directly and can consistently deliver a fresh, high-quality product.

Shiitake mushrooms

Shiitakes (*Lentinus edodes*) are well suited as a low-input alternative enterprise because they, like oyster mushrooms, can be grown on a small scale with a moderate initial investment. Shiitake cultivation has been thoroughly investigated, and a commercial market already exists in most areas of the United States. Shiitake mushrooms are

grown on logs, either inside or outside. Inside, they can also be grown on compressed sawdust logs or in bottles or bags. See the brief description of these production systems below. Several excellent books and Web sites are also listed below in **Resources (shiitake)**.

Log Production

Hardwood logs approximately 4" to 6" in diameter and of an easily handled length (commonly four feet) are cut during a tree's dormant season. Oaks, sweetgum, cottonwood, beech, birch, willow, and other non-aromatic hardwoods are appropriate species. The denser woods produce for up to twice as long as the softer ones. Smaller diameter logs produce more quickly than larger ones, but for a shorter time.

Handle the logs carefully to avoid soil contact and damage to the bark. This will help prevent contamination by competing fungi. Inoculate the logs with spawn from a strain suitable to your production system. There is a wide variety of spawn from which to choose and several inoculation methods.

After inoculation, the spawn develops a thread-like network – the mycelium – growing throughout the log. During this time, you must protect the logs from dehydration by the sun and wind. Spray or mist the logs to maintain the humidity necessary to keep the mycelium alive and growing. When the mycelium has fully occupied the logs and the temperature and humidity are right for fruiting, the mycelium will initiate tiny "pinheads" at the surface of the log. The pinheads grow into mushrooms in the next couple of days.

To stimulate fruiting, some growers soak the logs in water tanks and/or "shock" them by physical impact or chilling. Others leave the logs in the growing environment and harvest when they naturally fruit.

Be alert for signs that fruiting is beginning. The best grades of shiitakes have caps that still have a slight curl at the edge. Harvest often if you want to earn the best price for your mushrooms. In addition, if you want to deliver a premium product, you must pay attention to post-harvest storage, packaging, and shipping.

Many shiitakes are raised organically. Although it is easier to produce shiitakes organically than some of the other mushrooms, “weed” fungi, as well as pests such as slugs and flies, can reduce fruiting and quality. The producer must monitor, quickly identify, and control these pests or lose some of the crop.

Federal law now controls the use of the word “organic” in marketing. In order to label a product organic, producers must be certified by an accredited third party and document their production and handling practices. For further information, call and request the ATTRA publication *Organic Farm Certification & the National Organic Program*, or see it at our Web site, <www.attra.ncat.org>.

Growing Shiitakes on Sawdust

Today, most shiitakes and many other mushroom species are raised on a sterilized sawdust substrate. Although this method allows a much faster fruiting cycle and a high level of return (110% or more of initial dry weight), it also demands a greater capital investment and more skillful management than log production. In order to achieve fruiting as quickly as possible, you need a building in which you can control the temperature and moisture. The building must be easy to keep clean, and sanitary procedures must be strictly followed to avoid contamination.

The chamber and the steam processor to pasteurize or sterilize the sawdust can represent a significant initial investment. For example, Crop King sells a small mushroom production system, including an inoculation table and bagging station, for about \$5,000. The company’s complete growing system—including equipment, structural components, and technical support—can come to more than \$41,000. Recovering these costs is a challenge for a beginner—especially at current mushroom prices.



Shiitake mushrooms fruiting on sawdust • Glen Babcock - Garden City Fungi

However, innovative producers have used concrete mixers to blend supplemental ingredients and made pasteurized substrate in barrels. Fungi Perfecti sells pressure sterilizers for \$200 to \$1,000, but warns that they are not designed for commercial production.

Using hydrogen peroxide instead of conventional pasteurization is a relatively recent innovation. A manual on this method and more information is available at <www.mycomasters.com/>.

Growing mushrooms on sawdust requires attention to detail—especially careful monitoring and timely processing of the blocks, bottles, or bags. Several of the books listed below, including Stamets (1993) and Przybylowicz and Donoghue (1990), offer more details about this production method.

Shiitake Prices

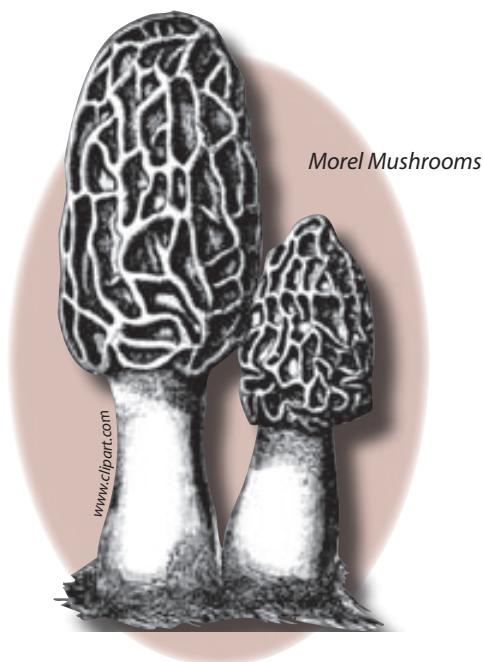
The price for shiitake mushrooms fluctuates throughout the season. Prices are highest in the winter when supply is low, and lowest in summer when production peaks. Except in very mild climates, the only logs that fruit in winter are those maintained indoors. Using strains selected to fruit at cooler temperatures can lengthen the

harvest season and allow producers to capture the higher prices. See the marketing section below for ways to counteract the natural price cycle.

Sources of Further Information on Shiitakes

Several states, including Pennsylvania, California, and Oregon, support university research on shiitakes and may have Extension specialists who can provide information to growers in their states. Others have Extension publications with information specific to their areas. Some of these resources are available on-line at Web sites listed in the **Resources** section. An excellent example is the site maintained by the Ohio State University.

In states without this Extension support, one of the best ways to learn about production is to share information with other growers. There are several local grower organizations, many of which publish newsletters. Ask your state Extension horticultural specialist about local organizations, or you can contact the North American Mycological Association or the American Mushroom Institute (see **Resources**). There are also several books specifically about shiitake production. See **Resources (shiitake)** for more information.



Other Mushroom Species

Mushroom Species with Limited Commercial Production

Some species of mushrooms are not yet commercially cultivated. Many of these are mycorrhizal types; that is, they grow only in conjunction with the roots of a higher plant. Matsutakes and chanterelles are typical examples of such mushrooms.

Mycorrhizal mushrooms are the hardest to grow commercially, because the needs of both the fungus and the host plant must be met in order to produce a commercial crop. Also, the host plant typically must reach a certain physiological maturity before the fungus will fruit. When the host is a tree, this maturation may be measured in decades. Nevertheless, highly prized morels and truffles are mycorrhizal, and they are both now being grown commercially in the United States.

Morels

Commercial production of morels on anything but a small-scale, seasonal basis is currently not a practical option. Morels are being grown year-round, using a patented process, at only one production facility in North America (in Alabama). The patent and facility are owned by Terry Farms and represent the only successful commercial process for fruiting these highly valued mushrooms out of season.

It is, however, possible to establish a morel patch by using a morel starter kit. If you are successful, these mushrooms will fruit in the spring at the same time as wild morels. Morel prices are, understandably, at their lowest during this natural fruiting season. Adding them to a farmers' market stand would certainly attract more-loving customers. You can also dry the product for year-round sales if you can grow commercial quantities in your patch.

Tom Volk's Web site, <http://botit.botany.wisc.edu/toms_fungi/morel.html>, has particularly good information about morel mushroom production.

Truffles

Growers generally begin truffle production by

dipping tree seedlings in a mycorrhizal slurry before planting. After several years, under favorable growing conditions for both the tree and the fungus, truffles form underground fruiting bodies that roughly resemble potatoes. These range from the size of a pea to that of a fist and give off a distinctive odor. Since these “mushrooms” don’t completely emerge from the ground, they have traditionally been sniffed out by pigs or trained dogs.

The requirements for growing the black Perigord truffle, *Tuber melanosporum* Vitt., include choosing an appropriate host plant (usually oak or hazelnut), inoculating its roots with the spawn, and planting it. Frank Garland planted his first inoculated trees in 1980 and harvested the first black truffles grown in the U.S. on October 23, 1993. He has written a production guide based on his experience. (Garland, 1996) Garland also has a consulting business and sells inoculated trees.

One Oregon tree farmer in prime white truffle country found a low-fuss method of cultivation. The white truffle, *Tuber gibbosum*, is a mycorrhizal species associated with Douglas fir and other conifers. This farmer uses a backpack sprayer to apply a slurry made of truffles and spores at the roots of conifers. The inoculated areas have produced between 300 to 1000 pounds per acre per year, significantly more than the unsprayed areas. (Arnold, 1996)

The truffle industry has developed rapidly in Australia and New Zealand. New Zealand’s efforts, as reported by Dr. Ian Hall, were begun in 1987, with harvest recorded on June 29, 1993, just months before Garland found his first truffles in North Carolina. (See <www.fungifest.com/article1021.html>.) Australian researchers also report success in their cultivation efforts, summarized in several articles available on the Web. The articles are found by searching the following main pages for “truffle” or “*Tuber melanosporum*”:

- www.crop.cri.nz
- www.rirdc.gov.au/reports

The Black Truffle (Hall et al., 1994) is out of print, but it was converted to CD ROM format in 2001 and is available for NZ\$49.95 through the Internet at <www.crop.cri.nz/psp/products/truffle.htm>. Chapters cover the symbiotic partnership between truffles and their host plants, his-

tory and folklore, cooking and recipes, how to establish and manage a plantation, climatic and soil requirements, and cultivation and harvesting.

Studies have revealed a lot about the conditions necessary to bring truffles to early fruiting and then to significant production levels. However, because of the crop’s extremely high value and because each success has required an investment of considerable time, it is understandable that some of this information is considered proprietary. Even when fruiting begins, growers themselves may not be able to accurately identify what contributed most to the truffles’ growth.

Each new truffle enterprise is an experiment based on what has already been reported. Check this Web site maintained by a group of scientists investigating truffle cultivation: <www.truffle.org/tuber_directory/>.

Consider combining the production of truffles with the sale of nuts from the host trees, growing annual or perennial crops between the trees, or grazing ruminants among them—sheep have been credited with increasing the French wild-harvested crop yield. (Ludmer-Gliebe, 1997) These or other agroforestry options could provide additional sources of income during early, non-fruiting years and in the seasons when truffles do not produce.

Other Mycorrhizal Species

Mushroom researchers continue to investigate the cultivation of other species for the



commercial market. A loosely organized group of international scientists meets intermittently to share their research. The Web site maintained for this scientific endeavor is <www.mykopat.slu.se/mycorrhiza/edible/home.phtml>.

Until commercial production systems are developed, mushrooms such as chanterelles and matsutake (pine) mushrooms will continue to be collected from the wild for sale to the specialty mushroom market. The harvest of wild mushrooms is strictly regulated in some states. Check with your state department of agriculture regarding laws that apply. You would be wise to carry liability insurance and to be absolutely certain of the identity of mushrooms you sell. Mistakes can be fatal to the consumer. Finally, the forest environment that supports the growth of wild mushrooms is a fragile one. Learn how to conduct your foraging business in a way that protects future harvests.

Mushroom the Journal (see **Resources**) provides excellent information on wild mushrooms. There are also many local mycological societies that schedule “forays” – trips to known mushroom habitats – where the inexperienced forager can learn about various species and how to identify them.

Pest Management

Integrated pest management (IPM) is a least-toxic approach for managing any pest. IPM views pests as a natural part of the farm environment. The integrated management of a pest is accomplished by altering the environment to the disadvantage of that pest. In order to accomplish this, you have to be able to identify what pests are active, how many there are, and how many it takes to hurt your profits. If you know the life cycle of each problem organism, you can take measures to make it hard or impossible for it to complete its life cycle. You may be able to encourage natural enemies that will keep the population below the economically damaging threshold.

Here are some examples of non-chemical methods used to control typical pests in the production of white button mushrooms. Mushroom flies, a common pest among many cultivated mushrooms, are attracted to the smell of decaying vegetation such as mushroom substrates. Screen-

ing the mushroom house ventilation system will keep adult flies out. Double doors and positive atmospheric pressure within the structure also prevent flies from entering. Since adult fungus flies are drawn to standing pools of water on benches, walks, or floors, places where water can collect should be eliminated. Biocontrol is another option for several mushroom pests, the sciarid fly among them. A predatory nematode attacks this fly in its larval form. Therefore, this nematode can be added to the composting substrate to prevent infestation.

For a better understanding of IPM, see the ATTRA publication *Biointensive Integrated Pest Management*. It describes IPM methodology and provides extensive resources for further research.

Each mushroom species in a specific environment has a different pest complex. Because specialty mushroom production in this country is still very new, many pests have not received research attention. Most pests you are likely to encounter, however, have probably already been studied. In any case, you will probably have to design your own pest management system. Stay alert for any evidence of damage to the fruiting mushrooms and act quickly to identify its cause. Use whatever information you can find, along with your own creativity, to devise ways to protect your crop.

Use all the resources you can find – in libraries, at bookstores, or on the Web. Local Extension agents or state Extension specialists can help identify pests and, possibly, determine economic thresholds. They can also help you find biological controls, if cultural and mechanical methods fail.

Marketing Mushrooms

Marketing is the most important consideration of all. If you can't sell your mushrooms at a price that ensures a reasonable profit margin, you don't want to invest in this enterprise. Spend some time – and even some money – educating yourself about marketing your potential product.

This section provides a broad overview of market trends, some ideas about how to research potential markets, references to useful resources,

suggestions about marketing channels, and advice on financial analysis.

Market research and evaluation is perhaps the most challenging part of developing a new enterprise. Luckily, there are many helpful sources. A good place to start is ATTRA's Marketing and Business series, particularly *Direct Marketing* and *Evaluating a Rural Enterprise*. These publications detail the market evaluation process and include extensive resource lists. Other relevant ATTRA publications cover market gardening, value-added products, and agri-tourism. You can find the marketing publications on the ATTRA Web site at <<http://attra.ncat.org/marketing.html>>, or call 800-346-9140 to have them sent to you.

The many Web sites listed in **Resources** (below) will help you find information to further your market research. Another resource, as you analyze the potential for a mushroom business, is your local Small Business Administration office. Not only do they have helpful publications, they also provide some one-on-one assistance.

Market Demand

Some 260 U.S. growers produced more than 844 million pounds of mushrooms in 2002-03, with a farm gate value of \$889 million. (Certified organic mushrooms accounted for only 1 percent of all sales, although 12 percent of growers were certified organic.) The vast bulk of sales were of the *Agaricus* species, which includes white button mushrooms, portobellas, and criminis. The latter two are a brown strain of *Agaricus bisporus*, whose cultivation is managed for extra large (portobella) and very small (crimini) fruiting bodies. (Current statistics are found at <<http://usda.mannlib.cornell.edu/reports/nassr/other/zmu-bb/>>.)

Large, well-established companies produce virtually all *Agaricus* mushrooms; most are located in Pennsylvania and California. Their production houses are full of mushrooms in every stage of development. Mushrooms raised in these systems can be sold profitably on the wholesale market. It is very difficult for a beginning grower to compete with these companies at wholesale prices.

The Mushroom Business

Stella K. Naegely writes in the *American Vegetable Grower* that the key to the mushroom business is to have established buyers and be capable of consistent production. New growers might encounter an uphill educational experience for two or three years. Launching a commercial mushroom operation can cost between \$50,000 and \$250,000, depending on whether a grower starts with an appropriate building. For that reason, it is prudent to start small. Naegely offered the following business tips for people contemplating commercial production. (Naegely, 2000)

- Make the market drive your production. Talk to potential buyers about volume and prices.
- Explore various marketing options: brokers, distributors, farmers' markets, restaurants, grocery stores, food service operations, and co-ops.
- Consider reselling other growers' mushrooms to offer more variety and larger volume.
- Talk to other producers and perhaps a consultant about production systems.
- Consider buying used equipment to reduce initial capital investment.
- Strike a balance between undercapitalizing and a heavy debt load.

Market Research

The goals of market assessment are to project the sales volume and gross income of a new enterprise, to analyze its potential profitability and cash flow, and to gather information about potential buyers and competitors (to help develop a market strategy).

Many specialty mushrooms can be cultivated, but the market, though growing, is still limited. If you are thinking about starting a commercial mushroom enterprise, begin at the end: to whom will you sell them? You cannot make money in any business if you don't have buyers for your product. Learn who buys mushrooms, what

kinds they want, and where they shop. You must thoroughly investigate the demand for each mushroom species or product— as well as the available marketing outlets— before committing large amounts of capital to the enterprise.

Check the local situation on your own. Some common methods for conducting initial research include observation of buyers, surveys of stores, personal interviews with growers, and test marketing (once you have an experimental product). Another function of market research is to evaluate the competition. This will help you determine what market already exists and identify any niches you could fill. To find out more about your competitors, use their products. Talk to them. You may be surprised how much information they will share.

Market Channels

Explore as many marketing strategies as appeal to you. Below are some possibilities.

- Market the fresh or dried product directly to your customers (at farmers' markets, to gourmet chefs, over the Internet, through mail-order offerings)
- Add value to the mushroom by creating processed products (mushroom sauces, dried entrée mixes, teas, extracts)

Shiitake mushrooms harvested from sawdust
Glen Babcock – Garden City Fungi



- Wholesale as fresh produce (on contract or by the batch)

Direct marketing

If you can sell your mushrooms or mushroom products directly to an end user, you will naturally receive a better price than if you sell to a wholesaler. Direct marketing of mushrooms at local farmers' markets, to restaurants, or in supermarkets is possible in many locations. When competing in local markets, excellent service, top quality, and consistent supply, rather than the lowest price, might win the sale, particularly with gourmet chefs. Some chefs specialize in locally grown foods and may be interested for that reason. Others are willing to pay for fresh, premium produce. In any case, establishing a relationship with the buyer and reliably delivering a quality product are essential for this type of marketing.

Local grocery stores are another potential buyer of fresh mushrooms. However, an Arkansas grower found that local grocery chains were interested in her shiitake mushrooms only if she could assure them of a year-round supply. She decided that she had to add indoor production in order to meet this requirement. Natural foods stores are a market that may be more tolerant of seasonal supply. Any chef or grocer will require assurances of both quality and regular supply before switching from established wholesale sources.

Although the wholesaler with an established account creates stiff competition, the small, efficient producer might still have an advantage in some niche markets. For instance, shiitakes grown on logs are generally of higher quality and have a longer shelf life than shiitakes grown on sawdust substrates (the most common mass-production method). Log-grown shiitakes earn prices from three to eight times higher than those grown on sawdust substrates. (Anon., 2003) Find the buyer to whom

quality matters, and you will have found a market for your product.

Locally-grown oyster mushrooms have an advantage because oysters have a very limited shelf life and are too fragile to ship easily. The grower with direct, local sales can supply a fresher product that arrives in better condition.

Wholesale markets

Selling fresh mushrooms to a wholesaler will mean a lower price than if you market directly. However, for growers who choose not to involve themselves in direct sales, there are established wholesale markets for mushrooms. Wholesalers advertise in produce industry periodicals like *The Packer*. Your local librarian or an Internet search can help you locate other such magazines.

Mr. Paul Goland of Hardscrabble Enterprises maintains that there is a steady and growing market for quality dried shiitakes, even though the wholesale market has been depressed by Chinese imports. His buyers—natural foods stores and co-ops—do not buy the Chinese products. He buys several grades of dried shiitakes from growers who ship directly to West Virginia. Contact Paul Goland (see **References**) to learn whether he has a current demand for your product.

Small-scale commercial production of white button mushrooms and other *Agaricus* varieties such as portobellas and criminis is not recommended for the beginner, except on a small scale for direct marketing. A significant capital outlay and a high level of management skills are required to begin production, and at current prices, recovery of the initial investment might not be possible. The market is extremely competitive. More information about the button mushroom business is available from The American Mushroom Institute (see **Resources**).

Adding Value to Fresh Mushrooms

Adding value to fresh mushrooms usually means either developing a processed product, such as a sauce, or drying surplus mushrooms for sale in the off-season, when prices are higher. A value-added product can be sold either directly to the consumer or to wholesalers.

The Persimmon Hill Berry Farm in Missouri (see **References**) offers an example of how a small entrepreneur can create and market a value-added mushroom product. Persimmon Hill developed a recipe for a shiitake mushroom sauce and invested in a commercial kitchen to produce it. The farm buys from local growers who, since the mushrooms are not for the fresh market, can freeze them until they have enough to make a delivery to the processing kitchen worthwhile. During warm weather, when production peaks, they can likewise freeze the shiitakes until Persimmon Hill needs them. These growers receive a better price than they would if they were selling at the lower, peak-season prices, and Persimmon Hill is ensured a steady supply for its sauce. Persimmon Hill sells its products on the Internet and through direct sales on the farm. (See www.branston.com/persimmonhill/.)

Drying shiitakes and other mushrooms is another way to add value and avoid the low prices of the peak season. For more on drying technologies, see the ATTRA publication *Options for Food Dehydration*. (After drying, mushrooms should be held at 0° F. for four days to kill any surviving pest eggs.)

Financial Analysis

As a part of your market research, you need to do a financial analysis of the potential enterprise. Develop an enterprise budget with as much detail as you can provide. As with many farm enterprises, mushroom production is often only marginally profitable when labor and management costs are taken into consideration. An example of an enterprise budget for shiitake

Only by developing a market niche for a high-quality fresh product or by producing a mushroom-based food item can a small-scale beginner hope to compete.

Case Study: Marketing Key for Small-Scale Growers

In the Ozarks of Missouri, Nicola MacPherson and her husband, Daniel Hellmuth, have grown shiitakes on three acres for nine years. The couple grow them the traditional way on oak logs, and they market them under the label Ozark Forest Mushrooms, which carries a USDA organic seal. To sell their mushrooms, however, they've relied on a variety of nontraditional marketing approaches. "To promote sales, you must be prepared to promote your product tirelessly," MacPherson says. Their principal markets are up-scale restaurants, catering companies, and gift catalogs. Customers who demand organic produce, such as CSA (Community Supported Agriculture) subscribers, also provide a reliable market.

MacPherson urges beginners to start modestly, learn the process thoroughly, and develop a small, reliable customer base—say, a half-dozen regular customers—as a foundation. (She offered free samples to help establish a local market.) She cautions new growers not to create a market demand that they cannot meet. Selling to supermarkets, for instance, can be fraught with problems, including the challenge of ensuring product freshness and the recurring need for educating new produce department employees. (Anon., 1998)

log production is available at <www.ext.vt.edu/pubs/vegetables/438-898/shiitakemushrooms.pdf>.

Using this format or a generic enterprise budget from Extension offices or off the Internet, fill it in with as many actual calculations and estimates of costs as you can. If you are considering several mushroom species, do a financial analysis of each one separately. Try to anticipate every cost so that you can construct an accurate financial picture. Include an educational and/or marketing component in your budget, allowing for free samples or flyers with information and recipes, especially if you are developing a new product or will be doing direct marketing.

If you are adding mushroom production to an integrated farming system, financial analysis is more difficult. Making a clear profit might not be as important as making use of off-season labor or the small logs from woodlot thinning to create a saleable product from what otherwise would have been waste.

Further Resources

Two periodicals that include mushroom cultivation information are *The Mushroom Growers' Newsletter* and, to a lesser degree, *Mushroom the Journal*. Subscription information is included, along with citations for several key books, in the Resources section below. Web sites devoted to mushrooms and their cultivation are increasing every year. A selected list of mushroom Web sites is included below.

Some state or local mycological societies have groups interested in mushroom cultivation. To locate chapters in your area, contact the North American Mycological Association (see Resources).

Conclusion

Commercial cultivation of mushrooms is not for everyone. It requires someone who is familiar with fungi life cycles and willing to commit time and money to research, designing a system, and developing a business. The mushroom cultivator must be able to carry out operations on time, be attentive to details, and be vigilant about pest invasions. In most cases, marketing requires excellent public relations skills.

Nevertheless, there is potential for an innovator who can use an existing facility, obtain a low-cost substrate, and produce a reliable supply of a high quality product. As part of a whole-farm system, mushrooms can augment productivity at any scale. Producing a nutritious food at a profit, while using materials that would otherwise be considered "waste," constitutes a valuable service in the self-sustaining community we might envision for the future. It is a challenge some will find worth taking.

References

- Anon. 1998. Grower's business is 'mushrooming.' *Small Farm Digest*. Winter. p. 3.
- Anon. 2003. *Small Farms Research News*. Spring. p. 3.
- Arnold, Ralph. 1996. Grow fungi without the sterile trappings? *Mushroom the Journal*. Summer. p. 35.
- Beauséjour, Terri Marie. 1999. Mushrooms in the garden. *Mushroom the Journal*. Fall. p. 17-19.
- Cooner, Deanna. 2001. Mushroom farming. *AgVentures*. June-July p. 14-15.
- Edwards, Richard. 2000. The missing link? Mushrooms in permaculture. *Permaculture Magazine*. No. 25. p. 37-39.
- Garland, Franklin. 1996. *Truffle Cultivation in North America*. Garland Gourmet Mushrooms and Truffles, Inc., Hillsborough, NC. 41 p.
Available for \$15 from:
Garland Gourmet Mushrooms and Truffles, Inc.
3020 Ode Turner Rd.
Hillsborough, NC 27278
919-732-3041
919-732-6037 FAX
truffleman@mindspring.com
- Green, Judy. 1988. Doing your own market research. *Farming Alternatives*. Cornell University Resource Sheet #6. November. 6 p.
- Hall, Ian R., G. Brown, and J. Byars. 1994. *The Black Truffle*. Rural Industries Research and Development Corporation. New Zealand. 107 p.
- Hardscrabble Enterprises, Inc.
P.O. Box 1124 (or 617 N. Main St.)
Franklin, WV 26807
304-358-2921
hardscrabble@mountain.net
Contact: Paul Goland
- Park, Kwnag-ho. 2001. Nutritional Value of a Variety of Mushrooms. <www.MushWorld.com/sub_en.html>. January. 5 p.
- Litchfield, Ken. 2002. In your yard: More than grass, shrubs and trees. *Mushroom the Journal*. Summer. p. 20-23.
- Ludmer-Gliebe, Susan. 1997. Sheep are essential to French truffle production. November. p. 4-5.
- Naegely, Stella K. 2000. Is there money in mushrooms? *American Vegetable Grower*. February. p. 40-43.
- Oei, Peter. 1991. *Manual on Mushroom Cultivation*. TOOL Foundation, Amsterdam. p. 49-50. (A new edition of this book is now available; see **Resources**.)
- Persimmon Hill Berry Farm
RR 1, Box 220
Lampe, MO 65681
417-779-5443
- Royse, D.J. (ed.). 1996. *Mushroom Biology and Mushroom Products: Proceedings of the Second International Conference*, University Park, PA, June 9-12, 1996. Penn State, State Park, PA. 581 p.
- Royse, Daniel J., and Lee C. Schisler. 1980. *Interdisciplinary Science Reviews*. Vol. 5, No. 4. p. 324-331.
- Stamets, Paul. 2000-2001. A novel approach to farm waste management. *Mushroom the Journal*. Winter. p. 22. Or see at <<http://www.fungi.com/mycotech/farmwaste.html>>.
- Stamets, Paul. 1994. Permaculture with a mycological twist. *The Permaculture Activist*. May. p. 8-10.
- Stamets, Paul, and Jeff Chilton. 1983. *The Mushroom Cultivator*. Agarikon Press, Olympia, WA. 415 p.

Appendix

Mushroom Cultivation Media

Growing Medium	Mushroom Species	
Rice Straw	Straw (<i>Volvariella</i>) Common (<i>Agaricus</i>)	Oyster (<i>Pleurotus</i>)
Wheat straw	Oyster (<i>Pleurotus</i>) Stropharia	Common (<i>Agaricus</i>) Straw (<i>Volvariella</i>)
Coffee pulp	Oyster (<i>Pleurotus</i>)	Shiitake (<i>Lentinus</i>)
Sawdust	Shiitake (<i>Lentinus</i>) Ear (<i>Auricularis</i>) Maitake (<i>Grifola frondosa</i>) Lion's Head or Pom Pom (<i>Hericium</i>)	Oyster (<i>Pleurotus</i>) Ganoderma (<i>Reishi</i>) Winter (<i>Flammulina</i>)
Sawdust-straw	Oyster (<i>Pleurotus</i>)	Stropharia
Cotton waste from textile industry	Oyster (<i>Pleurotus</i>)	Straw (<i>Volvariella</i>)
Cotton seed hulls	Oyster (<i>Pleurotus</i>)	Shiitake (<i>Lentinus</i>)
Logs	Nameko (<i>Pholiota</i>) White jelly (<i>Tremella</i>)	Shiitake (<i>Lentinus</i>)
Sawdust-rice bran	Nameko (<i>Pholiota</i>) Shaggy Mane (<i>Coprinus</i>) Shiitake (<i>Lentinus</i>)	Ear (<i>Auricularis</i>) Winter (<i>Flammulina</i>)
Corncoobs	Oyster (<i>Pleurotus</i>)	Shiitake (<i>Lentinus</i>)
Paper	Oyster (<i>Pleurotus</i>)	Stropharia
Horse manure (fresh or composted)	Common (<i>Agaricus</i>)	
Crushed bagasse and molasses wastes from sugar industry	Oyster (<i>Pleurotus</i>)	
Water hyacinth/Water lily	Oyster (<i>Pleurotus</i>)	Straw (<i>Volvariella</i>)
Oil palm pericarp waste	Straw (<i>Volvariella</i>)	
Bean straw	Oyster (<i>Pleurotus</i>)	
Cotton straw	Oyster (<i>Pleurotus</i>)	
Cocoa shell waste	Oyster (<i>Pleurotus</i>)	
Coir	Oyster (<i>Pleurotus</i>)	
Banana leaves	Straw (<i>Volvariella</i>)	
Distillers grain waste	Lion's Head or Pom Pom (<i>Hericium</i>)	

RESOURCES

Periodicals

The Mushroom Growers' Newsletter is a monthly newsletter that contains cultivation information and current prices of mushrooms at San Francisco and New York markets.

Available for \$35/year from:
The Mushroom Growers' Newsletter
P.O. Box 5065
Klamath Falls, OR 97601
www.mushroomcompany.com/

Mushroom the Journal is a quarterly publication that primarily contains information on foraging, with limited information on cultivation.

Available for \$19/year from:
Leon Shernoff
1511 E. 54th St.
Chicago, IL 60615
www.mushroomthejournal.com/index.html

Bibliography

The National Agricultural Library (NAL) has published several Quick Bibliographies (QBs), results of database searches on a given topic. QBs have been published for both shiitake and oyster mushrooms. They can be downloaded from the NAL Web site.

www.nal.usda.gov/afsic/afspub.htm

Books

Stamets, Paul, and J.S. Chilton. 1983. *The Mushroom Cultivator*. Agarikon Press, Olympia, WA. 415 p.

Includes growing parameters for 16 species and covers every aspect of mushroom cultivation.

Available for \$29.95 from:
Fungi Perfecti
P.O. Box 7634
Olympia, WA 98507
800-780-9126 (toll-free) or 260-426-9292

Stamets, Paul. 1993. *Growing Gourmet and Medicinal Mushrooms*. Ten Speed Press. Berkeley, CA. 592 p.

Companion volume to The Mushroom Cultivator. This third edition updates cultural and growing techniques, adds growing information on new varieties, and discusses strain selection for cultivation.

Available for \$44.95 from Fungi Perfecti (See address above.)

Oei, Peter. 2003. *Manual on Mushroom Cultivation: Techniques, Species and Opportunities for Commercial Application in Developing Countries*. TOOL Publications, Amsterdam, The Netherlands. 274 p.

First published in 1991, and now completely updated, this guide offers information on growing 12 species of mushrooms, with a particular emphasis on growing in developing countries. The manual includes 71 drawings, 93 photo illustrations.

Available for \$53.50 plus \$8 for shipping from:

Western Biologicals, Ltd.
P.O. Box 283
Aldergrove, BC V4W2T8
Canada
604-856-3339 (telephone or FAX)
western@iprism.com or westernb@shaw.ca

Also available to developing countries from C-Point Publishers in the Netherlands. For ordering information, contact Ine Klerkx, <ine.klerkx@cpoint.nl>.

Hadeler, Hajo. 1995. *Medicinal Mushrooms You Can Grow*. The Cariaga Publishing House. 196 p.

Excellent guide to wood-loving mushroom cultivation, from plugging old stumps to enriched sawdust culture in sterile bags. Covers medicinal species well. Well written and illustrated; index.

Out of print, but some are still available from amazon.com

Hobbs, Christopher, and Michael Miovic (ed.). 1995. *Medicinal Mushrooms: An Exploration of Tradition, Healing and Culture*. Third

Edition. Botanical Press, Santa Cruz, CA.
252 p.

Mushroom toxicity, use in traditional medicine and in the human diet are supported by clinical studies and explorations of cultural influences in this technical coverage. More than 100 species of edible fungi are documented.

Widely available for \$18.95.

Associations

The North American Mycological Association (NAMA) publishes a bi-monthly newsletter, *The Mycophile*, and publishes an annual directory that provides names and addresses of all NAMA members and every mycology association in North America. NAMA focuses more on finding and identifying wild mushrooms than commercial cultivation.

Annual membership is \$35. Contact:
NAMA
336 Lenox Ave.
Oakland, CA 94610-4675
www.namyco.org/

The American Mushroom Institute is a source of information on the mushroom industry. It serves mainly large, highly capitalized commercial producers.

AMI Washington DC Office
One Massachusetts Avenue, N.W.
Suite 800
Washington, D.C. 20001
202-842-4344
ami@mwmlaw.com
www.americanmushroom.org

AMI Avondale Office
1284 Gap Newport Pike
Suite 2
Avondale, PA 19311
610-268-7483
MushroomNews@kennett.net

Web sites

[Note that addresses may change. A search of the Web should provide current locations.]

How to Grow Mushrooms

www.gov.ns.ca/nsaf/elibrary/archive/hort/organic/990015.htm

From the Nova Scotia Department of Agriculture and Fisheries, this Web page offers a good overview of growing mushrooms in compost.

The Mushroom Council: Six Steps to Mushroom Farming

www.mushroomcouncil.org/production/six-steps.htm

From the Pennsylvania State University Agriculture Extension Service, this page describes step by step phase I composting, phase II composting, spawning, casing, pinning, and cropping.

Permaculture with a Mycological Twist: The Stametsian Model for a Synergistic Mycosphere

www.fungi.com/mycotech/permaculture.html

This article carried on the Fungi Perfecti Web site describes permaculture applications for mushrooms. (See the sidebar.)

Mush-World

www.mushworld.com/home/

"Total mushroom information" is the banner claim here. This excellent resource features sections on cultivation, pests and disease, and medicinal mushrooms, as well as the monthly webzine Mushworld. Requires free registration for access. Highly recommended.

Penn State Mushroom Spawn Laboratory

MushroomSpawn.cas.psu.edu/

A comprehensive Web site with resources on mushroom science and cultivation.

Gourmet Mushrooms

www.arrowweb.com/MUSHROOM/

Source of mushroom kits and mushroom nutraceuticals; extensive bibliography on the medicinal value of mushrooms (<www.gmushrooms.com/Healthref.html>).

Fungal Jungal: Western Montana Mycological Society

www.fungaljungal.org

A good example of a regional mycological society Web site filled with diverse resources, including information on morels, fire ecology, a western mushroom photo guide, and recipe lists.

The Mushroom Council
www.mushroomcouncil.org/

*Home of the mushroom industry's marketing council, this site contains useful information about consumer buying trends and providing for food service needs, as well as nutritional and production information; focuses mainly on *Agaricus* spp. with no specialty mushroom differentiation.*

Resources (shiitake)

Bibliography: shiitake

Rafats, Jerry. 1996. Shiitake: Cultivated Mushroom. Quick Bibliography Series B:90-4. National Agricultural Library, Beltsville, MD.

A bibliography of articles on shiitake mushrooms. Though somewhat dated (published in 1996), this collection still contains valuable information for shiitake producers. It's available on-line at <www.nal.usda.gov/afsic/AF-SIC_pubs/qb9613.htm>.

Books: shiitake

Harris, Bob. 1994. Growing Shiitake Commercially. 2nd Ed. Science Tech Publishers, Madison, WI. 72 p.

Large-scale cultivation of shiitake mushrooms using traditional oak logs. Based on many years' work, including material from recent visits to Japan. Some of the most modern and cost-effective methods are presented with photographs and drawings.

Available from Mushroompeople (See **Suppliers**).

Kozak, M.E., and J. Krawczyk. 1993. Growing Shiitake Mushrooms in a Continental Climate. 2nd Ed. Field & Forest Products, Peshtigo, WI. 114 p.

Describes step-by-step year-round shiitake cultivation, from log inoculation to fruiting.

Excellent reference for inland producers

Available for \$17.50 postage paid from Field & Forest Products, Inc.
(See Suppliers.)

Przybylowicz, Paul, and John Donoghue. 1990. Shiitake Growers Handbook. Kendall/Hunt Publishing Co., Dubuque, IA. 217 p.

Book covers a wide range of topics, from log cultivation to sawdust cultivation. Information includes both scientific material and practical advice. Emphasis is on presenting as much information as possible rather than selectively choosing the best or most advanced methods.

Widely available for \$25.

Jones, Kenneth. 1995. Shiitake: The Healing Mushroom. Healing Arts Press, Rochester, VT. 128 p.

www.parkstpress.com/titles/shiita.htm

This book describes the nutritional benefits and traditional uses in Chinese medicine for shiitake mushrooms. Chapters cover shiitakes used in folk medicine for controlling cholesterol, cancer prevention, treating viruses and chronic fatigue syndrome.

Widely available for \$9.95.

Web sites: shiitake

The Ohio State University Extension Office features a series of on-line fact sheets that detail shiitake cultivation.

- Shiitake Mushroom Production: Introduction and Sources of Information and Supplies
<http://ohioline.osu.edu/for-fact/0039.html>
- Shiitake Mushroom Production: Obtaining Spawn, Obtaining and Preparing Logs, and Inoculation
<http://ohioline.osu.edu/for-fact/0040.html>
- Shiitake Mushroom Production: Logs and Laying Yards
<http://ohioline.osu.edu/for-fact/0041.html>
- Shiitake Mushroom Production: Fruiting, Harvesting and Crop Storage
<http://ohioline.osu.edu/for-fact/0042.html>

- Shiitake Mushroom Production: Economic Considerations
<http://ohioline.osu.edu/for-fact/0043.html>

Growing Shiitake Mushrooms

<http://osueextra.com/pdfs/F-5029web.pdf>

From the Oklahoma Cooperative Extension Service, this factsheet offers an overview of shiitake cultivation suitable to hardwood forests of east and central Oklahoma.

Spawn and Equipment Suppliers

[This list is not comprehensive and does not imply endorsement of these companies.]

Amycel Spawn
P.O. Box 560
Avondale, PA 19311
800-795-1657 or 800-995-4269 (toll-free)
www.amycel.com

Choice Edibles
584 Riverside Park Road
Carlotta, CA 95528
707-768-3135
www.choiceedibles.com

CropKing
5050 Greenwich Road
Seville, OH 44273-9413
330-769-2002
330-769-2616 FAX
www.cropking.com/mushroom.shtml

Field & Forest Products
N3296 Kozuzek Rd.
Peshtigo, WI 54157
800-792-6220 (toll-free)
www.fieldforest.net

Fungi Perfecti
P.O. Box 7634
Olympia, WA 98507
260-426-9292
www.fungi.com

Garden City Fungi
P.O. Box 1591
Missoula, MT 59806
406-626-5757
www.gardencityfungi.com

Gourmet Mushroom Products
P. O. Box 515 IP
Graton, CA 95444
707-829-7301
707-823-9091 FAX
www.gmushrooms.com/pots/

Hardscrabble Enterprises, Inc.
P.O. Box 1124 (or 617 N. Main St.)
Franklin, WV 26807
304-358-2921
hardscrabble@mountain.net
Contact: Paul Goland

L.F. Lambert Spawn Co.
1507 Valley Rd.
Coatesville, PA 19320
610-384-5031

Long Ridge Farms
406 Tom Cook Rd.
Sugar Grove, NC 28679
828-297-4373

Mushroompeople
P.O. Box 220
560 Farm Rd.
Summertown, TN 38483
931-964-2200
www.thefarm.org/mushroom/mpframe.html

Myco Supply
P.O. Box 16194
Pittsburgh, PA 16237
800-888 0811 (toll-free)
www.MycoSupply.com/

Northwest Mycological Consultants
702 NW 4th St.
Corvallis, OR 97330
541-753-8198
NMC@nwmycol.com

Sylvan Spawn Laboratory
West Hills Industrial Park

Kittanning, PA 16201
800-323-4857 (toll-free) or 724-543-2242

J.B. Swayne Spawn Co.
P.O. Box 618
Kennett Square, PA 19348
610-444-0888

UNICORN Imp. & Mfg. Corp.
113 Highway 24
Commerce, Texas 75429 USA
800-888-0811 (toll-free)
UNICORNbag@aol.com
www.unicornbags.com

Western Biologicals, LTD.
P.O. Box 283
Aldergrove, BC VOX 1A0
CANADA
604-856-3339
western@prismnet.bc.ca

By Alice Beetz and Michael Kustudia
NCAT Agriculture Specialists
July 2004
© NCAT 2004
IP 087
Slot 75
Version 042705

The electronic versions of **Mushroom Cultivation and Marketing** are located at:

HTML

<http://www.attra.org/attra-pub/mushroom.html>

PDF

<http://www.attra.org/attra-pub/PDF/mushroom.pdf>

IP 087

Slot 75

Version 042905