**Sustainable Production Practices in Mushroom Farming**

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U.S. mushroom farmers produce more than 861 million pounds of mushrooms annually, contributing $1 billion towards the nation's economy (USDA National Agricultural Statistics Service 2010-2011 Mushroom Crop Report). Mushroom farms operate year round to provide a safe, abundant and nutritious food product for consumers throughout the United States. In addition, mushroom farms serve as environmental stewards, recycling agricultural byproducts, using environmentally friendly best management practices and engaging technology to find new efficiencies across the mushroom production spectrum.

This document provides an overview of the efforts of the mushroom farm community to produce this popular food product in an environmentally sustainable manner. To ensure all aspects of mushroom production are covered, the document addresses the following areas:

- Raw Materials/Inputs
- Growing Facilities
- Mushroom Production
- Environmental Management Plans
- Energy Usage
- Post-Production

Mushrooms are produced in 33 states. The tri-state area of southeastern Pennsylvania, Maryland and Delaware produces more than 65 percent of the nation's mushrooms. Every mushroom farm in the United States is family-owned, with some being led by the fourth generation.

This strong sense of connection to the farms and the land is at the core of many of the environmental management strategies being used to protect not only natural resources, but also employees, neighbors and consumers.

**Raw Materials/Inputs**

Mushrooms are grown on nutrient-rich material called substrate. In creating substrate for mushroom houses, those in the mushroom farm community are also providing a valuable service by recycling byproducts from other agricultural sectors.

One of the main components of mushroom substrate is straw-based horse stable bedding. For the mushroom farms in southeastern Pennsylvania, Maryland and Delaware, the majority of the bedding materials are transported from within a 100 mile radius of mushroom farms. This is due, in large part, to the robust equine industry in the tri-state area, including horse racetracks, breeding farms and boarding stables. Grass hay, a renewable resource, is also a common bulk ingredient. Mushroom growers can use hay that is not suitable or has been rejected as feed hay. Grass hay can be grown on land and soils not suitable for other crops.

In central and western states, local wheat straw is the main component of mushroom substrate. The use of wheat straw provides a market for this by-product and a secondary source of income for wheat farmers.

In addition to the recycling of stable bedding, mushroom substrate may include crushed corncobs, cottonseed hulls, soybean hulls, peanut hulls and cocoa shells, providing a useful solution for byproducts that previously posed waste management challenges for other agricultural operations. Farms are often strategically located near local sources of these inputs.

In the composting process of making substrate, other products such as brewers grain, seed meals and poultry litter are introduced as nitrogen-producing materials. Once again, the mushroom farm community is extending the value of byproducts and decreasing the direct application of items such as poultry litter on the land, as well as the need to handle or store these items. This is especially important to the Chesapeake Bay Watershed and other sensitive watersheds throughout the United States.

With the many diverse inputs required to form the growing matter for mushrooms, managing the composting process that produces substrate is extremely important – both from environmental and economic standpoints.

Substrate is the final product of a composting process that requires weeks of intense management. Composting is done on a wharf with an impervious surface and a leachate collection system. In recent years, composting wharves have benefitted from design efficiencies such as new pad layouts and compost coverings. Some composters are also now moving stages of the composting process indoors, where they can better control water, odor and raw materials management.

Compost ricks are monitored for moisture content to gauge the appropriate need for added water. A standard protocol for composting operations is to use leachate from the wharves and growing rooms to add moisture to mushroom substrate as it is being formed. This ensures no nutrients are lost from the facility and decreases the potential for runoff. Wastewater lagoons are lined and aerated to reduce odors.

In addition, management efficiencies on the composting wharves have the added benefit of controlling inputs, including water and other resources used when creating substrate. This, in turn, means less risk to the environment from raw materials at the wharf.

**Growing Facilities**

Mushrooms are grown indoors on stacked aluminum or wooden trays in production rooms inside larger buildings called mushroom houses. By growing mushrooms indoors, producers are better able to control environmental factors and related energy needs.

In recent years, technological advances have made production more efficient and environmentally friendly. Modified or new buildings use modern construction techniques, including environmental best management practices, as well as infrastructure

materials that are more durable and longer lasting. The switch to these new materials decreases the need to replace growing beds, and also improve the process by which the growing rooms are cleaned and sanitized, decreasing the amount of cleaning products that must be used.

Just as updated facilities allow producers to be more efficient in terms of resource utilization, advances in heating, ventilation and cooling equipment have changed the way mushroom houses are heated and cooled. Managing temperature and humidity in the growing houses is critical to the production of an abundant, top quality mushroom crop. Today, farmers are better able to program HVAC systems to use minimal inputs and energy to grow mushrooms. These changes combine to allow for enhanced production efficiencies while minimizing the impact on the environment.

Modernization of the growing process and enhancements to infrastructure also enable producers to place stronger controls on the resources used in the production of mushrooms. Growers can reduce raw materials, control energy requirements and recycle or reuse more of the resources used during the crop cycle.

**Mushroom Production**

During the various stages of mushroom production, environmental best management practices are used to ensure inputs and natural resources are used in an appropriate, efficient manner.

To begin the process of growing mushrooms, beds must be filled with the aforementioned substrate. During a process known as "spawning," natural materials such as rye grain, wheat, millet or other small grains are used as the host for mycelium to be introduced into the substrate-filled beds. Using these grains provides an ecologically sound, all-natural solution to introducing mushroom spawn to the substrate-filled growing beds.

Once the mushroom beds are filled with substrate and inoculated with spawn, a top-dressing called "casing" is applied. Researchers continue to investigate ways to re-use spent mushroom substrate (SMS) (material that has been removed from beds after the completion of the mushroom growing and harvest cycle) and the casing material as ingredients in substrate preparation, as well as other uses that are described in the Post-Production section.

As in the production of any agricultural commodity, controlling pests and diseases is a constant challenge faced by all producers. Given the unique qualities of mushroom production, a commodity-specific Integrated Pest Management (IPM) Handbook was developed by The Pennsylvania State University, The American Mushroom Institute and the Pennsylvania Department of Agriculture. The Handbook examines the pest organisms that pose the greatest threat to mushroom yield and quality and serves as a reference manual and an educational tool for mushroom growers and researchers. It is published in English and Spanish.

From localized use of natural products to control molds to the introduction of bio-friendly nematodes to control pests, a strong IPM program supports a farm's bottom-line as well as the environment. The mushroom farm community continues to work closely with researchers and educational institutions such as Penn State University to enhance and expand the IPM practices that are used by producers.

Water management plays a significant role in the growing process. As existing farms are retrofitted and new mushroom farms built, it is not unusual to see environmentally-friendly enhancements such as grey water storage/recycling systems that supplement existing grey water management systems that include lined ponds, biofiltration swales and land application of wash water. In some instances, grey water can be used for heating and cooling of growing rooms, finding optimal value in a farm's water resources.

**Environmental Management Plans**
Since 1997, the Best Practices for Environmental Protection for the Mushroom Farm Community, published by the PA Department of Environmental Protection, has shaped environmental plans on farms across the country. Currently, members of the mushroom farm community are working closely with conservation and environmental protection agencies to update and enhance this document. Best management practices that focus on water and land management, water usage and air quality.

Each farm has its own unique Environmental Management Plan, detailing conservation and management protocols for the operation. This plan is an important document for guiding farm-based environmental management efforts. By proactively working with regulatory and conservation partners, the mushroom farm community is able to be both good stewards of land and water resources, as well as good neighbors.

**Energy Usage**
As mentioned in the Growing Facilities section, mushroom houses are benefitting from advances related to heating and cooling equipment. By using technology as a production tool, growers are able to streamline energy use and control costs.

In addition to HVAC system advances, mushroom growers are also working with their energy providers to time more effectively their energy use. By managing the growing process to avoid the use of energy during peak load times, farmers lessen the stress on local energy grids and ensure resources are not overused during key periods.

During various phases of production when temperature control is critical, mushroom growing houses are "sealed" to maintain constant temperatures and reduce energy needs. This also fits in with farms' integrated pest management plans which focus on pest exclusion from the growing rooms.

**Post-Production**
Looking broadly at the sustainability efforts of the mushroom farm community, practices beyond the growing and harvesting stages must also be addressed.

On the farm, once the final crop of mushrooms has been harvested, the spent substrate (SMS) is removed from the mushroom growing rooms. Research demonstrates that this material retains nutrients and fungal suppression qualities that make it an ideal crop production and landscaping component. Marketed as "Mushroom Compost" after the last harvest of mushrooms, this compost rich in organic matter, has high value for conifer production, turf grass managers and landscape contractors. Mushroom Compost has been used successfully for runoff mediation and riparian buffer projects, green roofs, artillery fungus suppression, evergreen farms, athletic fields, landfill caps for establishing vegetation, restoration of degraded coal mine lands for wildlife vegetation, myco-remediation and neutralizing acid mine drainage.

Many agricultural producers who deliver mushroom substrate ingredients, as described in the Raw Material/Inputs section, backhaul Mushroom Compost to their farms. The Mushroom Compost is used on crop fields as an organic fertilizer reducing the need for inorganic fertilizers and lime.

At the farm-level, mushroom stem stumps and unmarketable mushrooms are added to the composting pile, reducing the stress on local landfills and introducing additional organic material to Mushroom Compost.

Across the mushroom farm community, all growers, packers and processors use non-disposable harvesting bins to store and transport mushrooms. This again reduces the impact mushroom production has on the environment and gives farmers, packers and processors durable bins that can be easily cleaned and sanitized.

**Summary**

The mushroom farm community is proud of its long-standing record as one of the valuable stewards of the earth's resources, turning the waste products of other agricultural commodities into a delicious, nutritious food. Mushroom growers continue to find ways to reduce its impact on the environment and become even better stewards of the land and conservation practitioners. From the recycling of agricultural byproducts to reducing inputs on the farm and at the packaging and processing facilities, the U.S. mushroom farm community is embracing environmental management and creating a stronger, more sustainable future for its farms and neighbors.