Crop Profile for Mushrooms in Pennsylvania

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General Production Information

THE PENNSYLVANIA MUSHROOM INDUSTRY

Agriculture is Pennsylvania's leading industry with mushrooms it's largest cash crop. In the 1996 crop year, mushrooms had a farm gate value of $272 million. Mushroom production has continued to increase at 7% a year since 1970, even though the number of mushroom farmers has decreased from 537 in 1970 to 126 in 1996. Sixty percent of the crop is marketed as fresh mushrooms, with the crop grown and harvested 12 months of the year. Mushroom substrate makers (composters) use large amounts of low value farm products including: straw, hay, corn cobs, poultry litter, wheat straw bedded horse manure. Mushroom farmers not only produce a valuable crop, they also purchase and recycle large quantities of other farm grown materials. Pennsylvania leads the nation in mushroom production supplying 45% of the nation's total, with California second at 18% of the nation's total production of 778 million lbs. Farms that produce Pennsylvania's 350 million mushrooms per year are concentrated in the southeastern portion of the state. It is estimated that Chester Co. produces about 240 million lbs per year. Berks Co. may account for 90 million lbs per year. The remainder of the Pennsylvania production comes for Armstrong County, in the western part of the state. That county produces about 20 million lbs per year.

THE CROP CYCLE

Substrate preparation, mushroom composting, is a process of recycling organic matter to create a physical and biological medium optimized for mushroom production that requires 4 to 6 weeks. The process normally involves a 2 wk to 3 wk preconditioning period, a 2 to 3 wk windrow period with periodic turnings, filling into beds or trays, and the last phase of composting that is a closely managed process which includes steam pasteurization at 140°F for 4-6 hr. The substrate is spawned (seeded) and the spawn is allowed to grow through the compost for 2 wks. Spawn is a sterilized cereal grain, rye, millet, wheat, etc, that is thoroughly grown through with mushroom mycelium. Spawn is produced in an aseptic building by about a dozen highly specialized companies who sell their products to mushroom farmers. When the substrate is colonized by the spawn, a top dressing, a casing that is made from sphagnum peat moss (or similar material) and agricultural limestone, is applied to the surface of the substrate. The casing is irrigated periodically and both temperature and carbon dioxide levels are managed during the 4-10 day period required for the spawn to reach the surface of the casing and form into small primordia of mushrooms called pins and buttons. Mushrooms grow rhythmically, being ready for harvested every 5 to 7 days. Each wave of mushrooms is called a break or flush with farms keeping the crop for 3 breaks. Harvesting is currently done by hand. After 3 breaks have been harvested, the production room is steam pasteurized, cleaned out and prepared for another filling. Each production room is occupied by a crop for 10 to 12 weeks which means 4-5 crops can be grown in a room each year. The standard production room contains 8000 ft^2 of producing surface and it is called a 'double'; average production is 5.8 lbs ft^2 (fresh weight) per crop cycle.

Insect Pests

Mushroom farming is an intensely managed form of food production. The substrate used for mushroom growing, mushroom compost, is prepared by carefully formulating the substrate ingredients and subjecting them to a closely managed aeration and watering regime that results in a selective substrate for the commercial mushroom *(Agaricus bisporus)*. The organic matter on the composting wharf has the potential for supporting very large populations of house flies (*Musca domestica*) and stable flies (*Stomxys calcitrans*). Together, growers call these nuisance flies. Nuisance flies around composting areas are mostly managed with cultural controls to make the habitat unsuitable for breeding, such as eliminating sites with standing water, and by releasing Pteromalid parasitoids against the pupal stage of nuisance flies, or by encouraging barn swallows to roost close to the composting site since barn swallows feed on nuisance flies.

One component of composting is steam pasteurization that eliminates most insects and nematodes from the substrate. Steam pasteurization takes place in a room where the substrate is layed out in beds or trays at a depth of 10 to 18 inches. Pasteurization requires 2 to 4 hr when the compost and air temperature is held to at least 140°F. The substrate containers are also steam pasteurized during this process. Outside air used to manage the compost temperatures is filtered to minimize ingress by adult flying insects and fungal spores. Fine screens over openings, caulked cracks in walls and ceilings and air filters reduce the insect threat.

However, two flies (a Sciarid, Lycoriella mali, and a Phorid, Megaselia halterata) that are potential crop threats are attracted by the odor of the substrate. This attraction to substrate odor is very strong. This threat is managed by minimizing breeding and roosting sites of the flies by mowing the grass, eliminating still water, periodic Baygon or Diazinon applications to the grass surrounding a mushroom farm and the outside walls of the mushroom house. For adult flies that survive these practices and invade the substrate, insect growth regulators (methoprene, cyromazine and diflubenzuron or Dimlin) are effective for the Sciarid fly. The growth regulators are incorporated into the compost or watered into the casing. The Phorid fly is best managed with the mentioned organophospates except that only Diazinon is labeled for crop use. Extracts from the neem tree (azadirachitin) bacterial metabolites (*Bacillus thuringiensis* var *israeliensis*), and entomophagous nematodes (*Steinernema* spp.) are biological insecticides that are currently being adopted by a few growers. Recent formulations of azadirachitin are showing good efficacy and adoption. The Bt and nematodes can require additional management and cost compared to the IGRs, and have not yet provided their dependability. Resistance has become a serious problem, with Sciarids showing significant resistance to pyrethroids and insect growth regulators within the last five years, and insecticide use patterns have changed due to resistance. Mushroom farmers have used Integrated Pest Management practices since 1980. Blacklights with adjacent sticky panels are used for monitoring. Insect pest management is best achieved by eliminating breeding and roosting sites, protecting the substrate with screens and air filters and, when needed as determined with fly monitors, insecticides are used.

POTENTIAL FOR CROP LOSS FROM INSECTS

The Sciarid fly (larvae) has caused major and minor crop losses intermittently at most mushroom farms. Exclusion of Sciarid adults from mushroom growing rooms and incorporation of an insect growth regulator into the mushroom substrate have been major factors in lowering crop losses caused by the Sciarid fly. Application of IGRs are restricted to crops with large fly populations determined by insect monitors. Left unchecked, the Sciarid fly will damage a mushroom crop by limiting the yield of mushrooms by as much as 70%. They can bore into the stem, leaving black tunnels that seriously reduce crop quality. In addition, Sciarid flies serve as vectors for disease causing organisms, which reduce the yield further and also reduce the quality of harvested mushrooms, and create a significant nuisance to the pickers.

Phorid flies pose a threat to crop yields and crop quality mostly as vectors of mushroom pathogens, both fungi and bacteria. Large populations or phorid flies inevitably mean crop losses due to a number of different diseases. Without efficient management of fly populations, both sciarid and phorid flies, there is little likelihood of disease free mushroom crops. On their own, phorid flies cause ‘fly speck’ on mushroom caps which reduces the quality of mushrooms to a cull grade. Only organophosphates and pyrmethrin are effective for managing phorid fly populations.

Diseases

Mushrooms are afflicted by fungal, bacterial and viral pathogens that can cause diseases resulting in significant crop losses. The etiology of the virus pathogen is such that by indexing master spawn cultures, farmers do not purchase infected spawn. This combined with sound sanitation and hygiene have significantly reduced crop losses because of virus infection. Crop losses related to virus epidemics can range from 10% to 100%. There are two major bacterial pathogens of mushrooms, both members of the genus *Pseudomonas* which are ubiquitous in nature. The one bacterium causes bacterial blotch, a discoloration of the mushroom crop. Integrating irrigation and dew point temperature management lessens the risk of bacterial blotch by inducing the surface of mushrooms to dry quickly after an irrigation. However, there are occasions when water chlorinated to 150 ppm chlorine is used to reduce population levels of the bacterium on the mushroom cap. This treatment must be coupled with some cap drying for maximum effectiveness. Bacterial blotch reduces mushroom crop value by 30% to 80%.

A few fungi are serious threats to the mushroom crop. Most recently, a Trichoderma green mold epidemic swept through mushroom crops for 3 years causing major losses measured in the $100 to $200 million. Improved sanitation, hygiene, fly control and the application of benomyl to mushroom spawn before the spawn is mixed with the substrate have reduced the continuing threat to 5% to 10% crop loss. When Trichloderma green mold was at its worst, crop yields were reduced an average of 35%, with a range of 20% to 80%. The other benzimidazole with a mushroom label, thiabendazole, is a much less effective spawn treatment. Another persistent disease is caused by a species of the genus *Verticillium*. This disease, known as Verticillium spot and dry bubble, routinely causes crop losses between 15% and 60%, and at times 100%. Sanitation and farm hygiene are important management strategies for this disease, as is an effective insect management program. Fungicides registered for use on this disease include: chlorothalonil, benomyl and thiabendazole. These fungicides can reduce disease incidence between 25 and 55%, but this level of disease control is difficult to see in a crop. The most widely used fungicide used for control of Verticillium is chlorothalonil. Casing surface weed molds are mostly cosmetic, although their occurrence can be impeded by the use of any of the three labeled fungicides.

THE ROLE OF NON-PESTICIDAL ACTIVITIES IN DISEASE MANAGEMENT

Mushroom substrate is a selective medium for the growth of mushroom spawn. When the bulk ingredients are muddy, too broken down, not broken down enough, too wet, improperly processed, incorrectly formulated or incorrectly supplemented, other organisms grow in mushroom substrate and most are known as weed molds. The factors mentioned can compromise the selectivity of mushroom substrate and the resultant molds are managed by modifying the practices and procedures used to prepare the selective substrate for mushroom spawn.

Steam pasteurization of growing rooms for 12 to 24 hr at 150-160°F at the end of each crop lowers the population of propagules from disease-causing organisms and flies. This practice is the backbone of a sound sanitation program at mushroom farms. Routing washing of tools and equipment that come into contact with compost or the crop with sanitation chemicals is another practice that lowers the threat of crop contamination by unwanted insects and pathogens. Regularly washing plastic picking baskets with water before they are used is another way the introduction of contaminants is avoided. Clean work clothes for mushroom farm employees minimizes the risk of carrying yesterdays' contaminants into this day's work area. Washing and squeegying floors in production rooms after each pick reduces the likelihood of employee's shoes serving as carriers of contaminants.

Paving or oiling farm roads reduces the dust load at mushroom farms, and road (field) dust is a primary source of a few mushroom pathogens. Concrete on the area where mushroom substrate is piled before it is filled into trays or beds, as well as appropriate drainage to assure muddy water does not cross the area, eliminates two major compost-borne, heat resistant fungal pathogens. Monitoring baled peat moss, used as mushroom casing, for free-living nematodes allows peat moss to be steam pasteurized only when nematode numbers are too high.

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