Mushrooms: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance

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Executive Summary

The white button mushroom (*agaricus bisporus*) accounts for 99 percent of all the mushrooms grown in the U.S. Specialty varieties, such as the shiitake and the oyster mushroom, make up the remainder. Production of specialty mushrooms, however, has been increasing. Their sales almost doubled between 1991/92 and 1993/94.

Pennsylvania and California dominate U.S. mushroom production. Pennsylvania's production accounted for 47 percent of U.S. output in 1993/94, and California accounted for 17 percent. Mushrooms are produced indoors on stationary beds and in portable trays. With the tray system, mushrooms are moved from room to room with each succeeding stage of production.

There were 355 mushroom growers in the United States in 1993/94, down from 468 in 1986/87. The decline in the number of growers is largely attributable to farm consolidation during the late 1980's. During this time, a number of farms expanded to gain greater production efficiency, while some operations, particularly the smaller ones, quit producing mushrooms.

The majority of mushroom farms are family operations. Many of Pennsylvania's farms have been in business three to four generations, with second-generation farms considered new operations.

Mushroom production, however, is dominated by several large firms, including Campbell's Soup Company, which owns eight mushroom farms throughout the U.S., and Monterey Farms, which owns five farms in California, Texas, and Tennessee. There are 5 or 6 mid-sized farms producing 5 million to 20 million pounds annually, and about 100 farms each producing 1 million to 5 million pounds annually. U.S. specialty mushroom production is dominated by six farms.

Mushroom production involves an integrated series of operations, and is dependent on controlled environments. The unsuccessful completion of any one phase can lead to yield losses or crop failure. Traditionally, mushrooms were grown on beds in mushroom houses. The houses are called "doubles" because they were built in pairs under one roof. Newer methods involve mushroom production in trays that can be moved from room to room for different phases of the production cycle.

Mushroom houses are well-insulated, vapor-proof buildings with temperature, humidity, and air exchange controls. Houses for *agaricus* mushrooms use minimal light, since this variety does not need light to fruit. Shiitake and oyster mushrooms, however, are grown in lighted houses, since light is necessary for their production. Mushroom production is nearly independent of outside weather, since modern houses and equipment provide favorable conditions for all phases of the growing cycle.

Mushroom production consists of six principal steps: composting--Phase I, and composting--Phase II, spawning, casing, pinning, and cropping. Although shiitake and oyster mushrooms follow a similar production cycle to the button variety, shiitakes and oysters require different growing mediums (substrates),

are irrigated differently, have different production cycle lengths, and different numbers of croppings (harvestings).

About 30 percent of the U.S. mushroom sales volume is sold for processing. Most processed mushrooms are canned in tins or glass jars. There are about a dozen processing plants that can mushrooms. Usually, these processors also can other vegetables as well. Very little mushroom drying is done in the United States. Specialty mushrooms are sold only to the fresh market.

Natural perils that can affect mushroom yields are excessive rain, excessive heat and humidity, excessive cold, high winds, and other seasonal factors. Mushroom production occurs indoors and is largely insulated from outside weather conditions. On occasion, however, outside weather makes controlling the inside climate difficult.

Autumn is an especially difficult season for mushroom growers. Because the weather is more predictable during the winter and summer, it is easier for growers to control heating, cooling, and moisture levels than during autumn. In autumn, sudden temperature changes increase the difficulty of controlling conditions inside the mushroom house. Inaccurate temperature and humidity controls can cause discolored or blotched mushrooms, which would be unmarketable in the fresh market.

Weather conditions can also interfere with compost production, particularly phase 1 composting, delaying the processing or resulting in inferior compost. Brown outs, total power outages, or equipment breakage can interfere with controlling the mushroom house climate.

Even though natural perils may cause losses, it is questionable, for several reasons, whether or not mushroom growers would participate in a multi-peril crop insurance policy. First, growers tend to be wary of Government programs because many believe they are already regulated too much. Second, growers currently can obtain insurance against fires or other disasters, such as equipment failure. Third, virtually all commercial mushroom production occurs indoors, where it is largely isolated from naturally-occurring perils, such as unseasonable cold, moisture extremes, wind storms, and hail, which cause most yield losses among outdoor crops.

Finally, few producers participated in ad hoc disaster assistance. Disaster payments to mushroom growers totalled only $3,397 since 1988. Most of this money went to shiitake producers with outdoor operations. Shiitake growers account for only a small fraction of the mushroom industry.

Despite these factors, some growers may participate in crop insurance. Participation, however, may be limited to the minimum catastrophic level of coverage.

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Mushrooms: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance

Introduction

Pennsylvania and California dominate U.S. mushroom production. Pennsylvania's production accounted for 47 percent of U.S. output in 1993/94, and California accounted for 17 percent. Mushrooms are produced indoors on stationary beds and in portable trays. With the tray system, mushrooms are moved from room to room with each succeeding stage of production. Mushroom production is heavily dependent on controlled environments.

The white button mushroom (*agaricus bisporus*) accounts for 99 percent of all the mushrooms grown in the U.S. Specialty varieties, such as the shiitake and the oyster mushroom, make up the remainder. Production of specialty mushrooms, however, has been increasing. Their sales almost doubled between 1991/92 and 1993/94.

Button mushrooms are sold either for fresh use or for processing. Fresh sales account for about 65-70 percent of the total volume. Pennsylvania is the largest producer of mushrooms for processing, but also grows mushrooms for fresh use. California grows mostly for the fresh market. Specialty mushrooms are sold only for fresh use.

This report examines those aspects of the U.S. mushroom industry that relate to the demand for crop insurance and the feasibility of developing a mushroom crop insurance policy.

The Mushroom Market

Supply

Production of the button mushroom has increased from 58.3 million pounds for the fresh market and 148.5 million pounds destined for processing in 1970/71, to 522.4 million pounds of fresh-market output and 254 million pounds for processing in 1992/93 (Tables 1 and 2). The use of higher spawn rates, increased picking frequency, and a shortening of the production cycle have contributed to increased production efficiency.

Processing was the principal use for domestic mushroom output prior to the mid-1980's. Production for processing, however, declined continuously throughout the 1980's and by 1987, fresh market use had overtaken the processing use (Tables 1 and 2). Imports account for only a small fraction of the fresh market supplies.

The decline in processing use was due to greater demand for mushrooms for the fresh market, as well as competition from imports, mostly from China and Taiwan. Imports from China were banned in 1989, however, due to the discovery of canned mushrooms contaminated with *staphylococcal enterotoxin* bacteria.

Table 1 --U.S. fresh mushrooms: Supply, utilization, and price, farm weight, 1970-95

Crop year 1/	Supply: Production 2/	Supply: Imports 3/	Supply: Total	Utilization: Exports 3/	Utilization: Total	Utilization: Per capita use 4/	Season-average price 5/: Current dollars	Season-average price 5/: Constant 1987 dollars 2/
	Million pounds					Pounds	Cents/pound	
1970	58.3	0.3	58.6	0.0	58.6	0.3	54.4	155.0
1971	66.3	0.4	66.7	0.0	66.7	0.3	57.9	156.5
1972	76.7	0.1	76.8	0.0	76.8	0.4	55.5	142.7
1973	102.3	0.2	102.5	0.0	102.5	0.5	57.1	138.3
1974	126.1	0.0	126.1	0.0	126.1	0.6	60.7	135.2
1975	142.1	0.3	142.4	0.0	142.4	0.7	71.9	146.1
1976	151.2	0.0	151.2	0.0	151.2	0.7	82.4	157.6
1977	191.1	0.0	191.1	0.0	191.1	0.9	90.1	161.2
1978	229.5	0.4	230.0	0.6	229.3	1.0	94.9	157.4
1979	255.8	0.5	256.3	0.7	255.6	1.1	95.8	146.0
1980	275.1	0.7	275.7	0.6	275.2	1.2	94.7	132.1
1981	319.1	0.8	319.9	1.8	318.1	1.4	96.8	122.7
1982	337.2	1.1	338.3	1.6	336.7	1.4	100.0	119.3
1983	388.1	0.8	388.9	1.6	387.4	1.6	96.5	110.7
1984	419.9	1.0	420.9	1.4	419.5	1.8	93.5	102.7
1985	427.2	1.0	428.2	1.9	426.3	1.8	94.8	100.4
1986	454.8	1.4	456.2	2.9	453.3	1.9	96.9	100.0
1987	468.9	1.2	470.1	2.9	467.3	1.9	94.9	94.9

1988	484.7	1.9	486.6	3.2	483.4	2.0	97.9	94.2
1989	511.9	2.1	514.0	9.9	504.1	2.0	100.0	92.2
1990	511.9	3.5	515.4	17.7	497.7	2.0	98.1	86.6
1991	497.0	4.6	501.5	14.5	487.0	1.9	99.5	84.6
1992	522.4	3.8	526.2	17.4	508.8	2.0	99.8	82.5
1993	520.6	3.3	523.9	11.6	512.2	2.0	103.0	83.4

1/ Crop year begins July 1 of the year listed and ends on June 30 of the following year.
2/ Source: National Agricultural Statistics Service, USDA.
3/ Source: Bureau of the Census, U.S. Department of Commerce and Statistics Canada.
4/ Total disappearance divided by total U.S. population on January 1.
5/ Deflated using the GDP implicit price deflator, 1987=100.

Table 2--U.S. mushrooms for processing: Supply, utilization, and price, farm weight, 1970-95

Crop year 1/	Supply: Production 2/	Supply: Imports 3/	Supply: Beginning stocks	Supply: Total	Utilization: Exports 4/	Utilization: Ending stocks	Utilization: Total	Utilization: Per capita use 5/	Season-average price 6/: Current dollar	Season-average price 6/: Constant 1987
	Million pounds							Pounds	Cents/pound	
1970	148.5	53.6	--	202.2	0.0	--	202.2	1.0	39.0	111.1
1971	165.1	71.4	--	236.5	0.0	--	236.5	1.1	41.5	112.2
1972	177.3	85.7	--	262.9	0.0	--	262.9	1.2	38.0	97.7
1973	177.2	81.8	--	259.0	0.0	--	259.0	1.2	36.7	88.9
1974	173.0	88.6	--	261.5	0.0	--	261.5	1.2	40.9	91.1
1975	167.7	99.8	--	267.5	0.0	--	267.5	1.2	53.0	107.7
1976	195.9	121.0	--	316.9	0.0	--	316.9	1.4	66.9	127.9
1977	207.6	150.8	--	358.4	0.0	--	358.4	1.6	65.2	116.6
1978	224.5	148.3	--	372.7	0.9	--	371.9	1.7	64.2	106.5
1979	214.2	179.3	--	393.5	1.0	--	392.5	1.7	57.6	87.8
1980	194.5	155.7	--	350.3	0.5	--	349.7	1.5	58.6	81.7
1981	198.0	157.2	--	355.2	0.7	--	354.5	1.5	55.5	70.3

1982	153.6	199.5	--	353.1	0.4	--	352.7	1.5	60.8	72.6
1983	173.5	252.2	--	425.7	0.7	--	425.0	1.8	64.6	74.1
1984	175.8	243.3	--	419.1	1.0	--	418.1	1.8	57.4	63.1
1985	160.8	273.9	--	434.6	1.0	--	433.6	1.8	54.9	58.2
1986	157.1	297.9	--	455.0	0.4	--	454.6	1.9	56.4	58.2
1987	162.9	239.0	--	401.9	1.1	--	400.9	1.6	61.0	61.0
1988	183.1	198.7	--	381.8	1.7	--	380.1	1.5	66.5	64.0
1989	203.1	190.0	--	393.0	12.6	--	380.4	1.5	65.3	60.2
1990	237.2	205.2	--	442.4	14.6	--	427.9	1.7	61.5	54.3
1991	249.9	213.8	--	463.7	18.4	--	445.3	1.8	63.8	54.3
1992	254.0	203.5	--	457.4	22.2	--	435.2	1.7	58.2	48.1
1993	234.2	233.8	--	468.0	23.7	--	444.3	1.7	66.2	53.6

1/ Marketing year begins July 1 and ends June 30. 2/ Source: National Agricultural Statistics Service, USDA. 3/ Source: Bureau of the Census, U.S. Dept. of Commerce. Includes canned, frozen, and dried mushrooms. Canned converted to fresh-weight basis using a factor of 1.538, frozen factor was 1.5, dried factor was 10.0. 4/ Source: Bureau of the Census, U.S. Dept. of Commerce. Includes dried/dehydrated mushrooms. Canadian dried mushroom imports are added to exports from 1979-88. 5/ Total disappearance divided by total U.S. population on January 1. 6/ Deflated using the GDP implicit price deflator, 1987=100.

Subsequently, imports from Indonesia, Hong Kong, Taiwan, and other countries increased to replace some of the decline in Chinese imports. Imports, however, have not reach the same levels as before the ban.

Domestic production for processing increased following the ban on Chinese mushrooms, and has risen to record levels since 1991. China has since improved its mushroom processing industry and is allowed to export to the U.S., but only on a lot-by-lot basis.

Production of specialty mushrooms has been increasing rapidly due to their rising popularity among consumers. The shiitake mushroom is the most popular specialty variety, accounting for about two-thirds of specialty production in 1993/94. Oyster mushrooms account for about one-quarter of the specialty output. Production of shiitake and oyster mushrooms nearly doubled between 1992/93 and 1993/94 (Table 3).

Since mushrooms are grown in an artificially-controlled atmosphere, their harvest season is not dependent on the exterior climate. Produce merchandisers, institutional and restaurant users, and consumers can depend on adequate supplies being available at the time they want them.

Demand

Fresh market use has lead the way in increased mushroom consumption. Consumption of fresh mushrooms increased from 0.5 pounds per person per year during the 1970's to 1.9 pounds during 1985-90. Consumption has remained at about 2 pounds per person annually during the 1990's.

The use of processed mushrooms also grew during the past three decades, but at a slower rate than for fresh market use. Processed mushroom use increased from just over 1 pound per person per year during 1970-75 to a peak of 1.9 pounds in 1986, and has since stayed steady at about 1.7 pounds per year.

To increase demand for mushrooms, the Mushroom Council was authorized by Mushroom Promotion, Research, and Consumer Act provisions of the 1990 Farm Act. The Council, funded by growers, works to promote mushroom sales and increase consumer awareness about mushrooms and mushroom uses. It compiles recipes that use mushrooms, conducts promotional activities, and promotes more convenient packaging. The Council also funds production research.

Prices

Mushrooms are highly perishable, and growers confront daily market prices that are highly variable. Generally, fresh market prices are significantly higher than processing prices.

While the season average prices that producers receive for their mushrooms has fluctuated from year to year, the annual average growth rate has increased less than three percent since 1970 for both fresh and processing uses (Tables 1 and 2).

Table 3--Specialty mushrooms: Production and sales

Year/variety	Total Production	Volume of sales	Value of sales
	--1,000 pounds--	--1,000 pounds--	--$1,000--
1993/94 total:	8,807	8,404	28,671
Shiitake	5,732	5,559	20,569
Oyster	2,082	1,939	4,839
Other	993	906	3,263
1992/93 total:	5,005	4,569	16,356
Shiitake	2,955	2,752	10,677
Oyster	1,089	1,000	2,579
Other	961	817	3,100
1991/92 total:	4,679	4,267	16,053
Shiitake	2,802	2,537	10,183
Oyster	1,098	1,046	3,287
Other	776	684	2,583

Source: USDA, National Agricultural Statistics Service. *Mushrooms*, Vg 2-1-2 (8-94).

Prices for specialty mushrooms were very volatile about twelve years ago, when the industry was in its infancy. Today, as the specialty industry is becoming more mature, prices are more stable (Wuest).

The Mushroom Industry

Pennsylvania is the number-one producer of mushrooms, accounting for 47 percent of domestic output in 1993/94 (Table 4). California ranks second with 17 percent, and Florida ranks third with 5 percent.

There were 355 mushroom growers in the United States in 1993/94, down from 468 in 1986/87 (USDA, NASS). The decline in the number of growers is largely attributable to farm consolidation during the late 1980's. During this time, a number of farms expanded to gain greater production efficiency, while some operations, particularly the smaller ones, quit producing mushrooms (Wuest).

Industry Structure

The majority of mushroom farms are family operations. Many of Pennsylvania's farms have been in business three to four generations. Second-generation farms are considered new operations (Wuest).

Mushroom production, however, is dominated by several large firms. The largest includes Campbell's Soup Company, which owns eight mushroom farms throughout the U.S., and Monterey Farms, which owns five farms in California, Texas, and Tennessee. There are 5 or 6 mid-sized farms producing 5 million to 20 million pounds annually, and about 100 farms each producing 1 million to 5 million pounds annually (Phelps).

U.S. specialty mushroom production is dominated by six farms, and Pennsylvania is the major producing state (Phelps). Phillips Farms, in Pennsylvania, is reportedly the largest U.S. producer. Major commercially-grown specialty mushrooms include the crimini, portabella, shiitake, and oyster varieties. The enoki variety of specialty mushroom is mostly grown in California.

Specialty mushroom producers generally grow only specialty varieties (Phelps). The few growers who produce both specialty and button mushrooms use separate buildings for the specialty varieties since specialties require different growing conditions (Royse).

The American Mushroom Institute (AMI), a national voluntary trade association, represents the mushroom industry in policy issues and sponsors production research. The AMI publishes a monthly periodical, *Mushroom News*, that provides production, marketing, and labor relations information. AMI is funded by growers fees. An estimated 85-90 percent of the growers belong to the AMI.

Table 4--*Agaricus* mushroom production and sales by state

Year/State	Area of Production: Growing Area	Area of Production: Total Filling	Volume of Sales	Value of Sales
	1,000 Square feet		1,000 lbs.	$1,000
1993/94:				
California	3,593	22,598	128,003	135,203
Florida	1,554	6,736	37,886	41,005
Pennsylvania	17,131	62,081	354,793	271,262
U.S. total	31,102	136,479	754,783	691,965
1992/93				
California	3,937	22,998	128,545	129,866
Florida	1,554	6,751	39,563	40,416
Pennsylvania	16,246	66,746	370,113	261,729
U.S. total	30,635	141,909	776,357	669,398
1991/92				
California	--	21,246	121,934	121,208
Florida	--	6,143	34,427	38,693
Pennsylvania	--	64,321	358,270	261,420
U.S. total	--	138,148	746,832	653,841

-- = Not available.

Source: National Agricultural Statistics Service. *Mushrooms*. Vg 2-1-2 (8-94).

Varieties

Four varieties of the *agaricus* mushroom are produced in the U.S.: 1) the smooth white has a smooth cap and a white cap and stalk; 2) the off-white has a scaly cap and a white stalk and cap; 3) the cream has a smooth to scaly cap, a white stalk, and a cap that is white to cream; and 4) the brown has a smooth, chocolate brown cap and a white stalk. Within each variety, there are various "isolates" which vary in flavor, texture, and cultural requirements. Generally, the white and off-white cultivars are grown for the fresh market, while the cream and brown cultivars are used for processing.

The brown *agaricus* mushroom has grown in popularity since the late 1980's, and is marketed as a fresh, specialty mushroom. When it is sold with the cap closed, it is a "crimini" mushroom. When it is sold with the cap open, it is called "portabella."

The shiitake mushroom (*Lentinus edodes*) originated in Japan, and is the most popular mushroom variety in that country. Shiitakes were not grown in the United States prior to 1970 because importation of its spawn was not permitted. Shiitakes are now the second most popular variety in the U.S. Most shiitakes are sold to wholesalers catering to the restaurant trade (Molin). The oyster mushroom (*Pleurotus spp.*) has been grown commercially in the United States only since the late 1970's (Molin).

Some of the less common specialty mushrooms include the enoki (*Flammulina velutipes*), maitake (*Grifola frondosa*), nameko (*Pholiota nameko*), and pompom (*Hericium erinaceus*). These varieties account for about 10 percent of total specialty mushroom sales (Molin). Most other edible varieties are collected from the wild (Phelps).

Cultivation and Management Practices

Mushroom production involves an integrated series of operations. The unsuccessful completion of any one phase can lead to yield losses or crop failure. Traditionally, mushrooms were grown on beds in mushroom houses. The houses are called "doubles" because they were built in pairs under one roof. Newer methods involve mushroom production in trays that can be moved from room to room for different phases of the production cycle (Trigiano).

Mushroom houses are well-insulated, vapor-proof buildings with temperature, humidity, and air exchange controls. Houses for *agaricus* mushrooms use minimal light, since this variety does not need light to fruit. Shiitake and oyster mushrooms, however, are grown in lighted houses, since light is necessary for their production. Mushroom production is nearly independent of outside weather, since modern houses and equipment provide favorable conditions for all phases of the growing cycle (Royse and Schisler).

Mushroom production consists of six principal steps: composting--Phase I, and composting--Phase II, spawning, casing, pinning, and cropping (Wuest, Duffy, and Royse). Although shiitake and oyster mushrooms follow a similar production cycle to the button variety, shiitakes and oysters require different growing mediums (substrates), are irrigated differently, have different production cycle lengths, and different numbers of croppings (harvestings). The production cycle for a button mushroom, from spawn (planting) to fruit, is 6 weeks. For shiitake mushrooms, the process takes 3 months, and for oyster mushrooms, it takes 3 weeks. Most growers begin a new production process every week, enabling them to harvest continuously.

The traditional production system is called the single-zone, or bed, system. With the single-zone system, button mushrooms are grown on fixed beds built in tiers with alleys between the beds. All production phases, beginning with Phase II composting, take place in the same bed. In the tray (or multi-zone) system, the trays are moved by fork lift from room to room, with a different room used for each production phase (Hordness).

Mushrooms consist of the cap and the stem. As a mushroom matures, the cap opens and the gills are exposed. Mushroom spores, equivalent to seeds in higher order plants, are produced in the gills. The spores are microscopic in size, and are produced in large numbers. They germinate into mycelium, which is buried in the substratum (compost) and sends up fruiting bodies (mushrooms) when the proper environmental conditions occur.

Germination of the spores, however, is unpredictable. As a result, growers do not 'seed' compost with spores. Instead, spawn companies grow the mycelium in a laboratory setting. The mycelium is placed onto steam-sterilized grain, and will, in time, grow through the grain. The mixture of grain and mycelium is called "spawn." Growers purchase spawn and use it to seed compost (Royse and Schisler).

Nearly all commercially-grown mushrooms are produced using compost.[1] The raw materials used to make the compost may vary by mushroom variety. The compost should be a medium in which other fungi do not grow or grow at a much slower rate than the mushrooms. The objective of composting is to create a substrate which has sufficient nutrients to produce a good crop of mushrooms, but that provides little or no nutrition for other fungi and competitor organisms (Royse and Schisler).

Climate

Most mushrooms are produced indoors in a highly-controlled atmosphere. Temperature requirements are different at each phase, and are described below, as each phase is explained. Although most shiitakes are grown in houses, some are grown outdoors. In 1993/94, an estimated nine percent of shiitake mushrooms were produced outdoors on natural wood logs (USDA, NASS).

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[1] As an exception, small quantities of shiitakes are grown on natural logs.

Compost Requirements

Two types of compost are used in button mushroom production. The most common, natural compost, is the least expensive. It is made from horse manure with a wheat straw base. The second is synthetic compost, which is usually made from hay and crushed corn cobs. Both types of compost require the addition of nitrogen supplements and gypsum. Compost must go through two preparation phases before it can be used for mushroom production.

Six Steps in Button Mushroom Production

<u>Phase I Composting</u>

Phase I compost production usually occurs outdoors on a concrete slab called a wharf. Some composting is done in enclosed buildings, or a structure with a roof may be used.

Phase I composting is initiated by mixing and wetting the ingredients as they are combined in the compost pile. As the straw or hay softens, the materials become less rigid and more easily compacted. Gypsum, water, and nitrogen are added as the compost is turned, usually by a large compost turner. Once the compost is wetted, aerobic fermentation begins as microorganisms grow and reproduce. The compost develops as the raw ingredients are decomposed by the activity of microorganisms and heat, yielding a food source suited for mushroom production, but not conducive to the growth of other fungi and bacteria. Heat, ammonia, and carbon dioxide are by-products of phase I composting.

Composting requires adequate moisture, oxygen, nitrogen, and carbohydrates for continued bacterial growth. When one of these items is depleted, the composting activity stops. Nitrogen, which may be in the form of brewer's grain, soybean, cottonseed, or peanut seed meals, or chicken manure increases the bacterial activity. Synthetic compost requires ammonium nitrate or urea at the outset to provide the compost microflora with a readily available form of nitrogen for growth and reproduction. Gypsum is added to the mixture to allow air permeation.

The compost pile is turned every two days, and must be kept at a temperature of 145^{o} F to 170^{o} F. Phase I lasts 7 to 14 days, depending on the nature of the material at the start of the process and its characteristics at each turn. At the end of Phase I, the compost should have a chocolate brown color, be soft and pliable, have a moisture content of 68 to 74 percent, and emit a strong ammonia smell.

In the past few years, on-farm composting in Pennsylvania has become less common. About a half-dozen composting wharfs in Pennsylvania make and sell compost to mushroom growers. Three-to-four dozen Pennsylvania farmers, however, still make their own compost (Wuest), as do growers in California.

Phase II Composting

Phase II composting pasteurizes the compost to kill insects, nematodes, and pest fungi. It also removes the ammonia which forms during Phase I. Phase II takes place indoors, either in the trays or beds in which the mushrooms will eventually be grown or in a cement-block bin designed for this procedure. The compost is placed at a uniform depth and density. This allows the gas exchange needed for the ammonia and carbon dioxide to be replaced by fresh air.

Phase II is a controlled, temperature-dependent process using air to maintain the compost in a temperature range best suited for de-ammonifying organisms to grow and reproduce. Phase II can be done under either a high-temperature or low-temperature system.

The high-temperature system involves an initial pasteurization period during which the compost temperature is raised to at least 145° F for 6 hours. This temperature can be reached by use of natural heat generated during micro-organism growth, or by injecting steam into the room. After pasteurization, the compost is reconditioned by flushing the room with fresh air to quickly lower the temperature to 140° F. The compost is then allowed to gradually cool further until the ammonia is dissipated. The use of a high-temperature Phase II system takes 10 to 14 days to complete.

The low-temperature system involves initially increasing the compost temperature to about 140° F, either with steam or heat generated by micro-organisms. After reaching this level, the compost temperature is lowered to 125° F to 130° F. Pasteurization occurs 24-48 hours later when steam is injected into the room, raising the air and compost temperatures to 140° F for 2 to 4 hours. After pasteurization, the air temperature is lowered again, forcing the temperature of the compost down to the 125° F to 130° F range. The temperature is further lowered over the next 4-5 days until the ammonia dissipates.

The ammonia level concentration at the end of Phase II must be less than 0.07 percent, or it will be lethal to the mushroom spawn (see below). Temperatures must be lowered to about 75° F to 80° F before spawning (planting) can begin.

Spawning

"Spawning" refers to the planting operation ("spawn" is used to describe the planting material). Companies making spawn start by sterilizing a mixture of rye grain, water, and chalk. Wheat, millet, and other small grains can also be used. Mycelium is then added to the sterilized grain, after which it is bottled and incubated at 74° F. The bottles are shaken 3 times at 4-day intervals over a 14-day period of active mycelial growth. Once the grain is colonized by the mycelium, the product is called spawn.

The spawn is thoroughly mixed into the compost. When a bed system is used, spawn is mixed with a special spawning machine. With the tray or batch system, spawn is mixed into the compost as it moves along a conveyor belt or while falling from a conveyor into a tray. Once the spawn is mixed in, the compost temperature is maintained at 75º F and the relative humidity is kept high to minimize drying.

Under these conditions the spawn will grow, producing a thread-like network of mycelium throughout the compost. Eventually, the mycelia fuse together, and the spawn appears as a white to blue-white mass through the compost. As the spawn grows, it generates heat. If the heat exceeds 80º F to 85º F, depending on the cultivar, it may kill or damage the mycelium and reduce the crop's productivity and quality.

In the spawning stage of button mushroom production, high humidity is necessary to prevent the compost from over-heating and killing the spawn. High relative humidity is maintained either by equipment (in newer houses), or by watering the walls and floor (in older houses).

The time needed for spawn to colonize the compost depends on the spawning rate and how well it is mixed in the compost, the moisture content and temperature of the compost, and the composition and quality of the compost. Typically 14 to 21 days are required for the spawn to completely colonize the compost. At this point, the casing (or top dressing) is applied.

Casing

A casing (or top dressing) is applied to the compost when the spawn growth has completely colonized the compost and begins to cover the bed. Casing can be made of clay-loam field soil, a mixture of peat moss with ground limestone, or reclaimed weathered, spent compost. Casing does not need nutrients since its purpose is to act as a water reservoir and a place where rhizomorphs (very fine fusion of mycelium) form. Casing material needs to be able to hold moisture, which is essential to the development of a firm mushroom.

The casing must be pasteurized to eliminate any insects and pathogens. It must also be distributed uniformly over the surface of the compost to allow the spawn to develop evenly, permitting the mushrooms to develop at a uniform pace.

After the casing is applied, compost temperatures must be kept at about 75º F for up to 5 days, with high relative humidity. After the 5 days, the compost temperature should be lowered by about 2º F each day until small mushrooms (initials or pins) have formed. The casing must remain moist throughout this period.

During the casing stage, the casing is sprinkled intermittently to raise the moisture to the proper level before pins form. Watering at this stage is often learned only by experience.

Pinning

The development of the mushroom fruit is called an "initial." Initials form as an outgrowth on rhizomorphs. Once initials form, watering is stopped. Too much moisture can cause mushrooms to form below the surface of the casing.

Once the initial quadruples in size, it becomes a "pin." Pins continue to expand and grow larger through the button stage, and ultimately a button enlarges to a mushroom. Harvestable button mushrooms appear 18 to 21 days after the casing is applied. The pinning stage affects the potential yield and crop quality.

Pins develop when the air's carbon dioxide content is 0.08 percent or lower, depending on the cultivar. The carbon dioxide level is lowered by allowing fresh air into the growing room. (Outdoor air has a carbon dioxide level of about 0.04 percent). The timing of fresh air introduction is very important, and is only learned through experience.

Generally, it is best to ventilate as little as possible until the mycelium has begun to show at the surface of the casing, and to stop watering at the time when initials are forming. If the carbon dioxide level is lowered too soon, the mycelium stops growing through the casing and mushroom initials form below the casing surface. Such mushrooms will be dirty at harvest time.

Cropping

Cropping refers to the harvesting of mushrooms. Mature button mushrooms are ready for harvest about three weeks after the casing is applied. Mushrooms are harvested by hand. The base of the mushroom is trimmed, and the clean mushroom is placed in a basket.

The development of a large number of harvestable mushrooms at one time is called a flush, break, or bloom. The harvest period for a given flush lasts from 3 to 5 days. The flush period is followed by a few days when no mushrooms are available for harvest and a new crop of harvestable buttons is developing. The cycle repeats itself in a rhythmic fashion, and harvesting can go on as long as mushrooms continue to mature. Usually a single spawning produces harvestable mushrooms for 35 to 42 days, although sometimes they can be harvest for up to 60 days.

Most of the crop is harvested from the first two flushes, with output from subsequent breaks declining considerably. Growers generally harvest button mushrooms from a given spawning for four to six weeks (about three breaks). Relatively few mushrooms are produced after three croppings and harvesting can be unprofitable. Also, the incidence of pests and diseases increases with each cycle.

The air temperature during cropping should be at 57° F to 62° F. This range favors mushroom growth and minimizes disease and insect outbreaks. The relative humidity in the growing room must be high enough to minimize drying of the casing, but not so high that the cap surfaces become clammy or sticky.

Outside air is needed to control both air and compost temperatures during the harvest period. Outside air also displaces carbon dioxide given off by the growing mycelium. The more mycelial growth there is, the more carbon dioxide that is produced. Since more growth occurs early in the crop, more fresh air is needed during the first two breaks than during later ones.

The presence of mature mushrooms on the bed inhibits the development of new pins. When mature mushrooms are picked, this inhibitor is removed and the next flush moves towards maturity. The time between pickings is 7 to 10 days.

Button mushrooms are normally picked before the vail (cap) is fully extended. The exception is with portabella mushrooms, which are harvested after the cap has opened. Maturity is assessed by how far the veil is stretched, not by the size of the mushroom. Therefore, mature mushrooms may be either large or small. Farmers and consumers, however, prefer medium-to-large mushrooms.

After the last flush of mushrooms has been picked, the growing room is closed off and the room pasteurized with steam. This final pasteurization is designed to destroy any pests which may be present, minimizing the likelihood that the next crop will be adversely affected. After the house is steamed, the spent compost is removed to prevent contamination by any surviving pests or fungi. The trays, bed boards, and posts are cleaned, and the interior of the house is steamed again. The trays or beds are then ready for refilling for the next crop (Trigiano).

Specialty Mushroom Production

Shiitake and oyster mushroom production follows similar steps to those used in button production. One difference, however, is in the type of substrate used. Shiitake mushrooms are grown on sterilized sawdust. Shiitake spawn are mixed into the sawdust and placed in plastic bags, usually the size of a loaf of bread. The spawn hold the sawdust so tightly that it will form into the shape of the bag, most commonly a log. The logs are placed indoors on shelves of metal netting. Mushrooms form on all surfaces of the log.

Oyster mushrooms are grown on sterilized straw, corn cobs, coffee pulp, waste paper, pulpmill sludge, cotton bolls, cotton waste, or cotton seed hulls. They can be grown in polyethylene bags, trays, beds, pressed blocks, vertical structures, or baskets (Ellor). The most common practice involves the use of straw in 5-foot-long bags that have holes on all sides. The bags are filled with straw that is pre-inoculated with spawn. The bags are then hung from hooks in the mushroom house. Mushrooms form on all surfaces of the bag.

Shiitake and oyster mushrooms are irrigated differently than the button variety. Shiitake logs are immersed in water every 10 days. Oyster mushrooms are grown in high humidity, much like a dense fog (Wuest).

The cropping cycles also differ. Shiitake mushroom logs can be harvested at 6 month cycles. Oyster mushroom bags are harvested for 3 weeks.

Packing and Shipping Fresh Mushrooms

Once harvested, the button mushroom has a shelf life of about 7 days under optimum conditions. The shelf life for shiitake mushrooms is 3 weeks, and for oyster mushrooms, about 3 days (Wuest). Freshly-harvested mushrooms must be kept refrigerated at 35° F to 45° F. To prolong shelf life, it is important that mushrooms "breathe" after harvest, so storage in a non-waxed paper bag is preferred to a plastic bag.

Quality deterioration is slowed by removing heat from harvested mushrooms, and by assuring that a proper storage temperature is maintained (Wuest). The harvested mushrooms are placed in a vacuum cooler or an ice-bank cooler to quickly remove internal heat, after which they are transported in refrigerated trucks to maintain a low temperature.

Because of their short shelf life, mushrooms are sold immediately after harvest. Growers deliver mushrooms 2 to 3 times a day to processors, wholesalers, or brokers to prevent quality deterioration.

Mushroom operations usually package their own mushrooms. The mushrooms are packaged and placed into four-, eight-, or twelve-ounce tills (boxes). Runners then take the full till to a packaging station in the house. There, the till is weighed (mushrooms lose weight through water loss by the time they get to their final destination), and then it is wrapped and labelled.

Growers who package their mushrooms in tills receive premium prices for their product. Some growers still ship their mushrooms in bulk to wholesalers, who inspect, weigh, pack, slice, and over-wrap. Mushrooms sold to the restaurant industry are often blanched and then packed in liquid, increasing their shelf life to 4 to 5 weeks. Mushrooms for processing are shipped in 20-pound lugs.

Marketing

About 30 percent of the U.S. sales volume is sold for processing; 40 percent of Pennsylvania's output is processed. Most processed mushrooms are canned in tins or glass jars. Very little mushroom drying is done in the United States. Specialty mushrooms are sold only to the fresh market (Wuest).

There are about a dozen processing plants that can mushrooms. Usually, these processors also can other vegetables as well.

The largest mushroom processor is Giorgio Foods in Temple, Pennsylvania (Berks County). There is one canner of mushrooms in Michigan, one in Ohio, and several in Pennsylvania and New Jersey (Phelps).

Giorgio Foods obtains its mushrooms from its own farms and through contracts with farms in Berks County. These farms contract their total mushroom crop at a fixed price set by the processor. Giorgio can change the price even after the contract is set, depending on supply and demand conditions. The independent farms that contract with Giorgio Foods have a long, established tradition of marketing their mushrooms in this fashion and continue the tradition even though the fresh market may bring a higher price.

Other Pennsylvania growers, particularly in Chester County, and other growers in Berks County, sell mainly to the fresh market. Almost all of California's mushrooms are sold to the fresh market. Growers use several methods to sell to the fresh market (Wuest, Phelps):

- They may sell to wholesalers who establish a price, which changes daily;
- They may own an interest in a wholesale operation and sell to the fresh market or to processors as a residual market (the most popular method in Pennsylvania);
- They may sell to commission agents, and obtain the market price less a commission;
- They may selling to food-service buyers who sell to restaurants and specialty shops; or
- They may sell directly to large retail grocery chains and terminal markets (the most popular method in California).

Mushrooms are shipped by refrigerated truck or by air. Use of air transport, such as Federal Express, is more common for specialty mushrooms than the button variety. While mushrooms are marketed regionally, it is not uncommon for mushrooms to be shipped all over the country.

Specialty mushrooms growers who produce on a seasonal basis sell their mushrooms to different markets then those who grow year round. Seasonal growers sell to farmers' markets and other seasonal markets. Year round specialty mushroom growers market their mushrooms similarly to the *agaricus* growers.

Costs of Production

For many fresh-market vegetables, harvesting and marketing expenses may account for 50 percent or more of total production costs. Producers of such crops sometimes face market prices that may be less than the variable harvesting and marketing costs at harvest-time. In such situations, the producer may incur a smaller loss by abandoning the crop than by harvesting and selling.

The cost of harvesting mushrooms is estimated at about 20 to 25 percent of total production costs (Wuest, Hordness). This proportion is low relative to many other agricultural crops.

Mushroom growers usually harvest their crop regardless of the market price. Growers do not abandon their mushrooms and let them decay because this would increase the chances of disease spreading throughout the farm. Also, many growers establish new crops every week and need the rooms for the next crop.

Mushroom prices fluctuate from day to day and many growers are philosophical about prices. *Agaricus* growers also have the option of selling to the processing market if the fresh market is saturated. Growers also may sell to established customers at low prices to maintain a good business relationship.

Specialty mushroom growers face a slightly different marketing situation than button growers. While specialty mushroom prices are less variable than when the industry was very young, they are still not as stable as the *agaricus* market. Market gluts do occur. Whereas the processing price tends to set a lower limit on the returns that growers receive for fresh-market button mushrooms, there is no such residual market and, therefore, no price floor, for fresh-market specialty mushrooms.

If growers believe prices may get too low, they may discard their excess production to maintain prices. As with button mushrooms, specialty mushroom growers harvest the crop despite oversupply, to reduce the threat of diseases.

Production Perils

Natural perils that can affect mushroom yields are excessive rain, excessive heat and humidity, excessive cold, high winds, and other seasonal factors. Mushroom production occurs indoors and is largely insulated from outside weather conditions. On occasion, however, outside weather makes controlling the inside climate difficult.

Autumn is an especially difficult season for mushroom growers. Because the weather is more predictable during the winter and summer, it is easier for growers to control heating, cooling, and moisture levels than during autumn. In autumn, sudden temperature changes increase the difficulty of controlling conditions inside the mushroom house. Inaccurate temperature and humidity controls can cause discolored or blotched mushrooms, which would be unmarketable in the fresh market (Samp).

Weather conditions can also interfere with compost production, particularly phase 1 composting, delaying the processing or resulting in inferior compost. Brown outs, total power outages, or equipment breakage can interfere with controlling the mushroom house climate.

Excessive Rain

Excessive rain can be a particular problem during Phase I composting because this activity is done out of doors. Too much rain during composting can cause the compost to be improperly cured. Yields from a crop of mushrooms produced in poorly-cured compost could be reduced by 30 to 40 percent from normal levels (Wuest).

Excessive Heat and Humidity

Periods of excessive heat make it difficult to maintain temperatures inside the house at the levels necessary to produce a good yield. Also, during prolonged periods of high temperatures, electric utilities may reduce the amount of electricity available, causing growers to lose the use of their air conditioners. Since the spawn are very sensitive to heat, high temperatures in the mushroom house during the growing phase can cause the spawn to become infertile and result in crop loss. Long periods of time without air conditioning, and high heat levels, increase the risk and the magnitude of crop losses. Some growers have generators and backup systems to assure climate control in cases of equipment failure or power outages.

Excessive Cold

As with excessive heat, excessive cold can also cause lowered yields if the in-house temperatures fall outside the optimum ranges. Problems due to excessive cold are very rare, occurring perhaps once every 10 to 20 years (Royse). Excessive cold could be more of a problem for smaller growers who do not have state-of-the-art facilities.

Shiitake growers, who grow their mushrooms outdoors on natural logs, are more susceptible to yield losses from excessive cold and frost than growers with indoors operations. Outdoor growers, however, make up a small part of total production.

Wind Storms and Heavy Snow

Wind storms and heavy snows can cause yield losses by damaging the mushroom house. Wind storms occasionally blow the roof off a mushroom house exposing the beds to the uncontrolled outside weather. Further, heavy snow storms have collapsed mushroom house roofs. Yield losses from the destruction caused by these storms generally range from 20 to 80 percent, depending on how quickly a crew can harvest the remaining mushrooms (Wuest).

Insects

Insects are less of a problem now that growers monitor and use insecticides to control populations in the house. They also use preventative and exclusionary methods to keep insects from entering the house. However, insects can still present problems. Sciarid flies and phorid flies are the major insect pests of mushrooms.

The timing of an insect's presence is critical. For example, a fly entering a room at spawning time has a much greater potential to cause damage than one entering after casing. It has more time to increase its population and to cause greater crop loss. Therefore, fewer flies can be tolerated early in the crop cycle than later (Coles).

Adult sciarid flies are attracted to the aroma of phase II compost that has yet to be colonized by spawn. Females ready to lay their eggs most often try to enter mushroom houses just prior to and after spawning. Although the adult sciarid is not detrimental to mushroom production, the larvae get into the stem of the mushroom and make them unsalable for either fresh or processing use. The sciarid fly can be controlled and managed by using insect growth regulators and fly monitors (Coles).

Phorid flies are attracted to actively-growing mycelium. They will most often be detected in the mid-spawn run, or when the spawn is actively colonizing, but not prior to spawning. The phorid fly does not feed on or damage the crop directly, but carries the verticillium virus, which can cause yield losses (Coles).

Diseases

Diseases are controlled by careful composting and exactly regulating the climate in the mushroom house. If detected early in the infection, some bacterial and fungal diseases can by controlled with management practices.

Mushroom diseases can be easily carried from house to house, and from crop to crop, so recommended sanitation practices must be meticulously followed. The greatest losses occur when an infection develops in a newly-started crop.

Bacterial Diseases

The major bacterial diseases affecting mushrooms are bacterial blotch and mummy disease. Both can be controlled through adjustment to the climate of the mushroom house and proper sanitation and hygiene procedures.

Bacterial Blotch

Bacterial blotch (*Pseudomonas tolaasii*) causes brown or golden-brown blotches or lesions to form on the mushrooms. It can occur at any time of the year. The bacteria can be controlled with proper ventilation and by raising the temperature in the house to dry the mushrooms after irrigation.

Symptoms of the blotch can appear after the mushrooms have been harvested. Mushrooms with bacterial blotch lose value on the fresh market, but can be sold for processing at a reduced price (Wuest).

Mummy Disease

Mummy disease (*Pseudomonas* var.) can begin developing two to three weeks before harvest. The disease causes mushrooms to die and dry up, or mummify. Affected mushrooms are not saleable. Mummy disease is mainly a problem for spring and summer crops. The disease is most common in bed houses with single-zone systems. Multi-zone, or tray, systems rarely have problems with mummy disease (Wuest).

Viruses

Viruses are less of a problem for mushroom growers than for other vegetable producers. LaFrance disease is the main viral infection affecting mushrooms, and its presence has diminished in recent decades.

LaFrance Disease

LaFrance disease was a major problem for mushroom growers during the 1960's, causing crop losses of 80 to 100 percent in affected houses. Today, the disease is rare, showing up in two or three crops a year (out of 52) on a given farm. Symptoms of the virus include curved mushroom stems, prematurely opening caps, and pins that do not develop. Meticulous sanitation controls the virus. Spawn companies check cultures for viral infections. Once infected, yield losses due to LaFrance disease usually run about 20 percent (Wuest).

Fungal Diseases

Many of the fungi that affect mushroom production are soil-borne. They are spread through dust, insects, equipment, and on pickers' clothing. Fungicides are available for most fungal diseases. The two most widely used fungicides, Vorlex and Bravo, are not registered for use in every state. Neither chemical completely eradicates fungal diseases, but rather decrease the incidence of disease, by a maximum of 30 percent (Wuest).

Verticillium

Verticillium fungicola causes brown spots on mushrooms, downgrading their quality and value. It can also prevent pins from developing, reducing yields. The disease is found on several varieties of mushrooms, including the common *agaricus*, the oyster, and some varieties of wild mushrooms. Verticillium spores are sticky, and are disseminated by wind, free-moving water, flies, clothing, and equipment. Once an infection occurs, verticillium usually cause yield losses of 5 to 10 percent. If the infection is very severe, verticillium can destroy up to 60 percent of a crop.

Occurrences of verticillium in Pennsylvania are greatest from March through December. In January and February, it is less of a problem. Lower fly populations and snow in January and February minimize the incidence of pathogens and help prevent the disease from spreading easily (Wuest).

Green Mold

Green mold (*Trichoderma harzianum*) is new to the U.S. mushroom industry, and the cause of the fungus is unknown. It has caused losses of about 30 percent in crops in Pennsylvania. Green mold was a particular problem in 1993.

Production has rebounded as growers have taken precautions to control the disease. At the end of a crop, the room is sterilized with steam, and sanitizing chemicals are used on all surfaces. Worker movement between rooms and houses is also restricted to control the disease. These precautions have lowered the spread of the disease. There is, however, no known cure for green mold.

Mildew

Dactylium mildew occurs under conditions of high humidity in mushroom houses when outside conditions are humid and temperatures are mild. Mildew can run through a house in three to four days. Salt and Benlate both kill the fungus. Lowering humidity inside the house can also kill the mildew. Occurrences of mildew are rare.

Lipstick

Lipstick is a red fungus that contaminates compost and can sometimes remain active even after pasteurization. If the lipstick fungus grows, it causes mushrooms to open early. Yield losses can be up to 40 percent of a crop. Occurrences of lipstick are rare (Wuest).

State Analyses

California

California is the second-largest producer of mushrooms in the United States. There are approximately 12 farms located along the coast, with the heaviest concentration in the San Jose area. The largest producer in California is Monterey Mushrooms, which has three farms. Campbell Soups owns one farm in California. One owner believes that new mushroom farms are unlikely to emerge in California because of the state's tight environmental restrictions (Hordness). Farms in California tend to be among the largest in the industry. Most of the workers are unionized (Phelps).

California growers mostly produce their mushrooms using the tray system. Only two big bed systems exist in the state (Hordness). All the growers do their own composting. While the industry is young relative to the Pennsylvania industry, no new houses have been built in California since the mid-1970's (Hordness).

The *agaricus* mushroom is the most common variety grown in California. There are very few specialty growers in the state, although it is the major producer of the enoki variety.

<u>Marketing</u>

California's mushrooms are sold mainly for fresh use. Excess supplies are sold to canners or to the artichoke industry, which marinates and bottles them. Growers sell directly to brokers at terminal markets in Los Angeles and San Francisco, to chain stores, and to restaurant supply wholesalers. Growers do their own packing, most commonly in 10-pound boxes. Only about 20- to 25-

percent of the mushrooms are packed into tills (small boxes for consumer sale). Growers secure their own trucking, mostly through commercial carriers.

Production Perils

Excessive rain, power outages, and the availability of raw materials for composting are the most important production perils in California. Insects, diseases, and other weather-related problems do not significantly affect mushroom production in the state.

Excessive rain can make composting difficult. During periods of continuously rainy weather, it is difficult to make good, nutritious compost, potentially reducing yields.

Power outages can be a problem because air conditioning is a critical resource in mushroom houses in California. Without air conditioning, the spawn may overheat and become infertile.

Availability of raw material for composting is also a potential problem. Many growers contract with wheat growers to ensure an adequate supply of wheat straw. However, bad weather in wheat-growing areas can cause a shortage of supplies and result in high costs. This year, heavy rains in northern California resulted in flooding in wheat fields and is expected to boost costs.

Availability of horse manure is also an issue. Many growers depend on horse manure as their major component in composting. Most of the manure comes from race tracks, and if racing is curtailed the supply diminishes. While other materials for compost are available, it is difficult to switch from one method of composting to another, and yields may ultimately be affected.

Demand for Crop Insurance

Many California growers currently have insurance to protect against equipment failures and fire. California growers tend to be wary of government programs, and feel there is already too much interference, both at the state and Federal levels. They also do not generally suffer significant crop losses due to diseases, insects, or weather factors. Growers may, however, be interested in crop insurance, particularly at the catastrophic loss level.

Pennsylvania

Pennsylvania is the major U.S. mushroom state, with production concentrated in Chester and Berks counties. In 1992, Chester County accounted for 70 percent of the state's farms and 52 percent of its sales (Table 5). Output is concentrated around the Kennett Square area of the county. Chester County mushrooms are mostly sold to the fresh market, with the processing market used for residual sales.

Berks County accounted for 22 percent of Pennsylvania's farms and 29 percent of its sales in 1992. Of the 34 farms in Berks County, 23 grow mushrooms

Table 5--Pennsylvania mushroom production, area and sales by county, 1992 and 1987

Counties	1992			1987		
	Number of farms	Production area	Sales	Number of farms	Production area	Sales
		Sq. ft.	$1,000		Sq. ft.	$1,000
Berks	34	5,747,311	91,119	58	7,862,043	53,113
Chester	109	14,761,861	164,960	133	14,965,246	125,901
Lancaster	6	138,876	--	5	159,380	--
Westmoreland	3	168,804	--	5	214,160	--
All others	3	10,070,000	54,522	--	--	--
Total	155	30,886,852	314,713	204	33,029,829	225,291

Source: 1992 U.S. Census of Agriculture.

under contract with Giorgio Foods, the major processor in the area. The remaining farms in the county sell mostly to the fresh market.

Pennsylvania grows mainly white *agaricus* mushrooms. While specialty mushrooms are still only a small part of the mushroom industry, Pennsylvania produces the greatest quantity of most specialty varieties.

Pennsylvania's mushroom industry is the oldest in the nation. Many farms have been in the same families for several generations. While there are some younger farms, many went out of business in the 1980's.

The majority of Pennsylvania's mushroom farms use the older, bed system where the entire production process takes place in the same room. At one time growers did their own composting, but most currently purchase compost from composting wharves. There are about six to eight composting wharves in the state that provide the bulk of the compost. Three to four dozen farmers continue to make their own compost (Wuest).

Marketing

Larger growers, who produce for the fresh market, often have on-sight packing facilities and pack their own mushrooms. Packers sell to wholesalers at a central warehouse for shipment to retail stores. Packers also ship mushrooms to terminal markets throughout the country. Smaller growers transport their mushrooms to farms with packing facilities. About 30 to 40 percent of the state's fresh mushrooms are prepackaged for delivery to major supermarket chains.

Production Perils

Pennsylvania mushroom producers have more insect, disease, and weather-related problems than do California growers. Greater weather fluctuations make Pennsylvania growers more susceptible to excess rain, wind, snowstorms, and humidity problems than growers in California. During humid weather, it is difficult to maintain the proper climate inside the mushroom house. Storms and high winds have been know to blow off or knock down mushroom house roofs, destroying the crop. Other perils include diseases, such as bacterial blotch, mummy disease, LaFrance disease, verticillium, green mold, mildew, and lipstick.

Growers are susceptible to brown-outs during the hot summer. If power utilities reduce voltage during periods of heavy electricity use, mushroom growers lose the use or effectiveness of air conditioners. Some growers, especially the larger ones, have backup generators for such situations. General equipment failure, such as the break down of an air conditioning system, creates a similar potential loss situation to that caused by a power failure.

Most of Pennsylvania's mushroom farms employ non-union workers. Many of the farms provide housing for their workers, who often are from Latin American and Puerto Rico. The industry claims to have good employer-worker relations.

There has been an incident, however, where a farm closing was attributed to problems due to the inability of the owner and unionized workers to come to an agreement in re-negotiating workers' contracts (Phelps).

Demand for Crop Insurance

Pennsylvania mushroom growers are similar to California growers in their distrust of government programs, both state and Federal. Also, because many of Pennsylvania's growers have been in the business for a long time, they know the art of growing mushrooms (Wuest). Growers already have access to commercial insurance for fire and equipment break downs which may also cover crop loss.

Some growers may participate in the CAT portion of the Federal crop insurance program, if a policy were offered, because of the low cost of participation. Pennsylvania growers may face more perils than do those in California, providing an added incentive for the purchase of mushroom insurance.

Mushroom Insurance Implementation Issues

Implementing a crop insurance policy for mushrooms would involve some of the same issues encountered in offering insurance for containerized nursery plants. Both crops involve multiple crops planted and harvested throughout the year, and both crops are produced using several different production systems. The production perils for a given crop are different for the different production systems.

Another common problem is that, despite being grown under controlled-climate conditions, both crops can be damaged by weather extremes. Extreme cold can overwhelm protection systems in place for containerized plants, and extreme heat can overwhelm the cooling systems needed for mushrooms.

As with containerized nursery crops, non-traditional yield measures would be needed to measure production history and yield losses.

Adverse Selection

Adverse selection would not likely be a major issue in offering a mushroom policy. Almost all commercial mushrooms are produced indoors, which reduces climate and location as crop loss factors. Since mushrooms are grown indoors, insect and disease controls are easier to implement than for other agricultural commodities.

Setting Reference Prices

An annual average price would probably be a quite adequate guide for setting reference prices. Prices for button mushrooms are relatively stable within the year, and from year to year, and an annual average of monthly prices closely reflects current prices throughout the year.

USDA reports average grower prices for fresh market and processing mushrooms that could serve as a starting point for estimating a reference price (USDA, NASS). The fresh market price, however, is an average of prices received by producers for mushrooms as sold at the first point of sale, and includes an unspecified amount of return for marketing services. If, in a given state, part of the fresh market mushrooms are sold f.o.b. packed by growers, part are sold bulk to brokers or re-packers, and some are sold retail at roadside stands, the average price as sold is a weighted average of the average price for each method of sale.

Each method of sale contains returns for different amounts of marketing services and it can not be determined how much of the reported price represents returns for marketing services and how much represents a farm-gate return to the grower for mushrooms. Some adjustment would need to be made to the reported return to arrive at a farm-gate equivalent price.

The price for processing mushrooms represents average grower returns for mushrooms delivered to the processing plant, and includes returns for growing, harvesting, and delivering to the processor. Average grower prices may need to be adjusted downward by the amount of harvesting and marketing expenses to arrive at a reference price reflecting the in-the-bed value of mushrooms.

Market Prices and APH Distortions

Most mushroom growers are philosophical about low prices. They have been in the industry for a long time, and do not make drastic changes in production when price fluctuate (Wuest). If growers feel prices are too low, they may decide to wait a week or two before starting a new crop.

Variations in market prices are unlikely to cause any distortion in mushroom yields because growers can usually sell surplus production for processing during periods of fresh market gluts and they are reluctant to let mushrooms go unharvested. Unharvested mushrooms increase the risk of diseases and pest infestations, which can spread throughout a farm.

Estimating "Appraised Production"

Appraised production can be based on the production history of the farm, or on an estimate of the average amount of mushrooms normally produced on a certain size bed, tray, or log. Such estimates may need to take into account seasonal variations in expected production, especially for those specialty mushrooms grown out-of-doors.

Moral Hazard

There are quite a few opportunities for moral hazard in mushroom production, because many minor variations in the environment can affect yield. It would be easy for a grower to cause (and relatively difficult to document) a crop failure or yield reduction by failing to maintain the proper production environment in the mushroom house at all times. Disease and pest problems could also be left uncontrolled.

Moral hazard appears unlikely to be a problem, however, if crop insurance were to be offered for mushrooms. The consequences of neglecting one crop may extend to future crops, as pests and diseases could spread from room to room. In addition, growers usually establish themselves with wholesalers and in some cases retailers, and they try to fulfill their supply obligation to these buyers. If a grower developed a reputation as an unreliable supplier, buyers are likely to go elsewhere for their mushrooms.

Availability of Individual Yield Data

There does not appear to be a source for individual yield data other than the growers themselves.

Demand for Insurance

It is questionable, for several reasons, whether or not mushroom growers would participate in a multi-peril crop insurance policy. First, growers tend to be wary of Government programs because many believe they are already regulated too much. Second, growers currently can obtain insurance against fires or other disasters, such as equipment failure. Third, virtually all commercial mushroom production occurs indoors, where it is largely isolated from naturally-occurring perils, such as unseasonable cold, moisture extremes, wind storms, and hail, which cause most yield losses among outdoor crops.

Finally, few producers participated in ad hoc disaster assistance. Disaster payments to mushroom growers totalled only $3,397 since 1988. Most of this money went to shiitake producers with outdoor operations. Shiitake growers account for only a small fraction of the mushroom industry.

Despite these factors, some growers may participate in crop insurance. Participation, however, may be limited to the minimum catastrophic level of coverage.

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