THE ECONOMICS OF CURRENT MUSHROOM PEST MANAGEMENT PRACTICES

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ABSTRACT

Survey data from Southeastern Pennsylvania is used to estimate the costs of current mushroom pest management practices. Pest management costs represent a sizeable proportion of the variable costs of producing mushrooms. The practices found are highly variable with costs ranging from $.04 to $.58 per square foot. The frequency of outside applications and steam use before and after the crop are the most significant practices influencing production costs.

INTRODUCTION

One of the many problems facing mushroom growers is the maintenance of pest populations at levels that allow profitable production. The major pests of mushrooms include insects and diseases and both can affect quantity and quality of the produce. Left unchecked, a major pest outbreak can destroy an entire crop.

Mushroom growers currently use a variety of chemical and cultural practices to control pests. The costs for these practices, including steam usage, represent approximately 25 percent of the variable costs of producing mushrooms. The optimal use of these inputs under perfect knowledge occurs when they are used to the point where their marginal costs equal marginal benefits. If the cost and benefit relationships are not known, the farmer will likely use pest management inputs in a suboptimal manner. The inputs can be either over- or underused.

This paper reports results of a study conducted to provide and interpret information on mushroom pest management in an effort to increase the growers' information base. The study focuses on the cost of production aspects of mushroom pest management and it examines ways in which decisionmaking with respect to pest management could be improved. Specifically this study was designed to identify, describe and estimate the costs of current pest management practices and to determine if any of the practices are associated with significant differences in production costs or returns.

CURRENT PEST MANAGEMENT PRACTICES

Mushroom production is unique among crops. There are basically six steps in producing mushrooms. The first two steps involve preparing compost which is the growing medium. The third step is called spawning which is essentially planting the crop. The fourth step, casing, is the addition of 1 to 2 inches of soil or peat moss to the surface of the compost. Pinning or initiating the crop is the fifth step. And, actual production is the sixth step. Mushrooms grow and are harvested in a cyclical fashion with each cycle, called a break or flush, lasting approximately one week. There is a day or two between each flush when no mushrooms are picked. For a complete description of the mushroom production process see Wuest, Duffy and Royse.

In order to determine the current pest management practices, a survey of mushroom producers was conducted during the summer of 1980. Two Southeastern Pennsylvania counties, Chester and Burks, were selected. These two counties produce approximately 40 percent of the entire U.S. production of mushrooms and they have a high concentration of growers. Eighty-nine growers were surveyed and this sample is representative of two-thirds of the the U.S. mushroom producers. The details of this survey are outlined in Duffy.

The study involved only mushrooms produced in above-ground facilities, called houses, or doubles if two houses share a common roof. Mushroom pest management is required both inside and outside the mushroom house. Both chemical and cultural alternatives are available for inside and outside treatments. The following discussion includes only chemical and steam use practices because they are the most prevalent. A complete description of all practices is provided in Duffy.

The growers surveyed produce an average 2.8 pounds of mushrooms per square foot per crop. They operate an average of 10 doubles of 79,386 square feet of growing area. The number of crops per year ranges from one to four with an average of 2.5 (Table 1). The 89 growers reported using 282 different combinations of chemicals and 104 different combinations of equipment.

Outside pest management practices consist of spraying chemicals on the walls of the mushroom house and the grounds surrounding them. Eighty-eight percent of the growers routinely use outside sprays (Table 2). The number of routine outside sprays per crop ranged from one to 252. This illustrates the variation among growers. Some use only one outside spray for the entire crop while others reported as many as three a day everyday.

Inside the houses pest management decisions are made in conjunction with basic production steps. Prior to filling, 33 percent[1] of the growers use a routine chemical program. Between cooldown and spawning 82 percent of the growers use a routine program. And, for spawning, casing, and production, 97, 80 and 61 percent of the growers, respectively, use a routine program (Table 2). There was tremendous variation in application methods used. Equipment use varied from farm to farm. The chemicals used also varied considerably.

Steam usage is the predominant cultural

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[1] A routine chemical treatment is one that is applied on a schedule rather than being applied due to a particular pest problem.

Table 1. General characteristics of growers and their operations, 1980 1/

Item	Average	Range
Yield, pounds per square ft.	2.79	1-5
Number of doubles	10	1.5 - 76
Number of crops per year	2.5	1-4
Number of square feet growing area	79,386	10,000 - 630,000
Years growing mushrooms	19	1-55

1/ Source: Duffy, pp. 34-35.

Table 2. Percentage of growers using routine and emergency treatments 1/

	Routine treatment	Emergency treatment	No treatment
Outside			
Yes	88	37	6
No	12	63	
Prior to filling			
Yes	33	22	51
No	67	78	
Cooldown to spawning			
Yes	82	29	16
No	18	71	
Spawning			
Yes	97	43	1
No	3	57	
Casing			
Yes	80	52	10
No	20	48	
Production			
Yes	61	67	7
No	29	33	

1/ Source: Duffy.

practice. Steam is used at three points in the production process: before compost is put in the house; to complete the composting process; and after the crop. Steam also can be used to pasteurize the casing material. Before and after the crop, steam use is designed to remove insects and disease organisms that may be present from a previous crop or have developed in the current crop. The frequency of steam use and average hours of steam use per time are presented in Table 3.

COSTS FOR CURRENT PEST MANAGEMENT PRACTICES

The production of mushrooms involves many individual decisions by the grower. Differences in house construction, ventilation system, type of compost, etc., all cause minor modifications in production process. These modifications occur between farms, among different houses on the same farm and from crop to crop in the same house. To account for these differences a few basic technical production assumptions concerning the length of time for various production steps were made and are outlined in Duffy.

In addition to the basic biological assumptions, the following economic assumptions were used to estimate mushroom pest management costs:

1) The price charged for chemicals was the average from suppliers during the first two weeks of September, 1980;
2) The equipment charge equals the average price of equipment divided by the average life expectancy with this result divided by the number of crops per year to give the average charge per fill;
3) The assumed wage rate was $6.00 per hour if the owner applied the pesticides. Employee wage rates were recorded in the survey; if both the owner and employees applied the pesticides it was assumed one-half the applications were made by the owners; and
4) The price of steam equals a $31 per hour charge to growers who owned boilers. This was the average of reported rental rates during the survey period.

The estimated costs reported here are for the production system utilizing routine outside chemical applications and assuming steam applications are made on both routine and emergency

Table 3. Steam use in mushroom production, 1980 1/

Item	Number of growers	Percent of growers
Prior to filling:		
Yes	25	28
No	25	28
Occasionally	39	44
Hours of steam use*		
1-5	10	11
6	11	12
7	11	12
8	12	13
9 or more	19	21
Phase II		
Yes	69	78
No	14	16
Occasionally	6	7
Post crop		
Yes	56	63
No	12	14
Occasionally	12	14
Hours of steam use*		
1-6	13	15
7	17	19
8	17	19
9 or more	17	19
11 or more	13	15

* Includes both regular and occasional users.

1/ Source: Duffy, p. 76.

bases. Average costs for emergency chemical treatments and other cultural practices were not estimated due to observed wide variation.

The average estimated cost of pest management inputs to mushroom prouuction is 15 cents per square foot per fill. The observations ranged from 4 to 58 cents with a standard deviation of 8 cents. As reported in a recent USDA study, total variable costs of mushroom production average 57 cents per square foot. Therefore, on the average, pest management inputs, including steam use, represent approximately 25 percent of the total variable cost of production.

On average, 44 percent of pest management costs are for steam, 36 percent for chemicals, 11 percent for labor and 9 percent for equipment. Table 4 provides a complete breakdown of all cost information.

ANALYSIS OF PEST MANAGEMENT COSTS AND PRODUCTIVITY

Chi square tests for association, and multiple regression were the statistical techniques used to determine whether or not and to what extent pest management practices significantly influence mushroom costs of production and yields. The chi square tests were used as an initial sorting technique to determine which practices may be associated with costs and yields. These initial tests for grouping variables were necessary because of the wide variation in mushroom pest management practices. Multiple regression was then used to estimate whether or not the variable groups selected significantly influence costs, and to what degree they affect total production costs.

Eight groups of variables were determined to influence costs significantly. These variable groups are: outside equipment used; the number of outside applications; hours of steam use, both before and after the crop; whether or not a routine treatment was used at cooldown; whether or not a chemical drench at spawning was used; whether or not emergency treatments at spawning were used, and how the casing material was pasteurized.

Several different models were run using these variables or different combinations of them. Problems with multicollinearity were encountered so a range of alternative variable specifications and interaction terms was considered.

The final cost model estimated is presented in equation 1.

Table 4. General cost information for mushroom pest management, 1980 1/

Item	Average	Range	Standard Deviation
Overall average cost per square foot	$.15	$.04-$.58	.079
Average cost outside/square foot	.029	0- .127	.028
Average cost prior to filling/square foot	.016	0- .085	.018
Average cost phase II/square foot	.022	0- .291	.032
Average cost cooldown to spawning/square foot	.005	0- .032	.006
Average cost spawning/square foot	.020	0- .076	.014
Average cost casing/square foot	.015	0- .072	.013
Average cost production/square foot	.006	0- .044	.008
Average cost post crop/square foot	.025	0- .099	.019
Total cost for steam (44 percent)	542	0- 3100	429
Total cost for chemicals (36 percent)	431	24- 1301	261
Total cost for labor (11 percent)	125	0- 548	105
Total cost for equipment (9 percent)	98	0- 369	88

1/ Source: Duffy.

(1) Cost of pest control, per square foot =

$$.065 + .058X_1 + .099X_2 + .006X_3$$
$$(9.67)\quad(4.38)\quad(5.10)\quad(4.23)$$

where

X_1 = 1 if outside applications were twice a week or more, 0 elsewhere

X_2 = 1 if expected hours of steam prior to filling was greater than or equal to 9, 0 elsewhere

and,

X_3 = expected hours of steam post crop

R^2 = .54 and t statistics are in the parentheses

Expected hours of steam use is determined by multiplying the percent of the crops where steam is used by the hours of steam usage. For example, eight hours of steam use 25 percent of the time would be two hours of expected steam use. Prior to filling, the expected hours of steam use is divided into two groups; less than nine hours and nine or more hours. This grouping was chosen after examining the contingency tables. There was a clear division with the majority of growers using less than nine hours of steam and another group of growers, 21 percent, using nine or more hours. Such a clear division did not exist with post crop steam use.

In examining the productivity of pest management inputs several regression models were tested. The results of a simple regression using yield as the dependent variable and cost as the independent variable are present in equation 2.

(2) Pounds of mushrooms per square foot =

2.37 + .002 pest management cost per square foot

where R^2 = .06 and the t statistics for the cost is 2.38.

The other yield regression model presented here uses the same independent variables as the final cost model. These results are:

(3) Pounds of mushrooms per square foot =

$$2.25 + .044X_1 + .427X_2 + .065X_3$$
$$(12.45)\quad(.24)\quad(1.57)\quad(3.30)$$

where: X_1, X_2, and X_3 are defined as before; R^2 = .17 and the t statistics are in parentheses.

Variables X_1 and X_2 are dummy variables. Therefore, care must be used when interpreting the results presented in equations 1 and 3. For example, if a grower used outside sprays twice a week or more and less than nine hours of prior steam the estimated costs without post crop steam use would be \$.123 (\$.065 + \$.058). Or, if the grower used nine or more hours of prior steam the estimated costs without post crop steam use would be \$.222 (\$.065 + .058 + .099). The result for post crop steam use shows us that a one hour increase in the expected value increases costs an estimated \$.006 per square foot.

DISCUSSION OF THE RESULTS

The statistical procedures employed produced stronger results for the cost analysis than for the yields analysis. There are several reasons for this but the most important is that pest management practices are only one of the many factors that influence yield. This would explain the low R^2 and why more variables were not significant in equation 3.

Post crop steam use was the most significant pest management practice in terms of predicting yields. There are at least two possible reasons for this. One is that the post crop steam use prevents pests from remaining in the house to reinfest the next crop. The second reason is that the steam prevents the pests from spreading when the house is emptied.

Post crop steam use is also significant in terms of predicting pest management costs. Steam costs on the average are a sizeable proportion of the pest management costs and post steam use was a major share of the total steam costs.

Having post crop steam use significant for both costs and yields demonstrates one of the fundamental rules for an integrated pest management program, i.e., recognizing the tradeoff between costs and yields associated with different practices. This study demonstrates that increased steam use after the crop will increase costs and yields. Post crop steaming is profitable over a certain range of steam hours, and more research is needed to determine this range, especially when pest populations are considered. It is ironic that post crop steam use is a practice frequently cited by growers as an area to eliminate to cut back costs. It would reduce costs but it may reduce yield more than enough to offset the savings.

Another area where costs savings appear feasible is in the number of outside applications. As noted, this is extremely variable, ranging from 0 to 252 per crop. The best way to capture the influence of the outside application is to use a dummy variable for once a week or less and twice a week or more treatments. Using outside sprays more than twice a week has a significant positive impact on costs. The number of outside sprays, however, did not significantly influence yields. Use of outside sprays throughout the entire crop appears to be excessive. There may be additional benefits to other mushroom houses in the area but this did not show up in this study in terms of increased yields.

Findings also indicate that most growers rely on a routine chemical program. Routine treatment can lead to application of excessive amounts of chemicals, and may not only increase the cost of pest management for the individual grower, but also can increase the speed with which resistance to the chemicals develops.

SUMMARY

There is tremendous variation in mushroom pest management, and its associated production costs and benefits. Mushroom growers surveyed used a wide variety of chemicals, application techniques and number of applications. This wide variation was reflected in the cost per square foot which ranged from \$.04 to \$.58.

Pest management costs, which include all steam used, are a significant proportion of total variable costs. With the existing variation, some growers are able to produce mushrooms more cheaply than others. Any savings in pest management can mean a decrease in the cost of production for some growers.

This study reveals several possible cost saving areas:

1) Outside, many growers use sprays too frequently. If the benefits and costs are compared, a more careful timing of these applications and reviewing the necessity of them would produce considerable savings.

2) Steam use before and after the crop is another area to examine because even though the average cost per square foot was higher for steamers, their average yield was also significantly higher.

3) Many growers must become more aware of their pest management alternatives and use chemicals as needed and not strictly on a routine basis.

Mushroom pest management is extremely complex. However, as more is learned about the dynamics of the pest-crop complex there should be a trend away from routine treatments toward use of chemicals only when needed. Pest management is a sizeable proportion of variable costs of production. As such, any savings in this area can produce substantial savings for the grower. Saving costs in these times can mean the difference between survival and bankruptcy for many growers. Growers must become more conscious of their pest management practices. One of the major goals for most IPM programs is to make growers aware of what they are doing. Everyone has to work together for successful pest management and it is hoped these joint efforts can produce good quality mushrooms at a lower price.

REFERENCES

Duffy, Michael. "Mushroom Integrated Pest Management and the Cost of Current Management Techniques." Unpublished Ph.D. dissertation, Pennsylvania State University, Department of Agricultural Economics, 1981.

Owens, T. Richard, W. R. Garland, K. Kesecker and J. L. Runyan. "The U.S. Mushroom Industry: The Import Challenge." USDA, AMS, ACS, Marketing Research Report Number 1131, July 1982.

Wuest, P. J., M. D. Duffy and D. J. Royse. "Six Steps to Mushroom Farming." Pennsylvania State University, Extension Service, Special Circular 268, 1981.