Economic analysis of new post-harvest IPM technologies

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Abstract

A spreadsheet model was developed to evaluate the economic costs of new post-harvest IPM-based pest control technologies, such as grain chilling, against traditional methods, such as phosphine fumigation. The model considers 34 different factors. When applied to the storage of popcorn, a high value specialty crop, and wheat, the operating costs of chilled aeration compared to phosphine fumigation with ambient aeration were 22% and 56% lower for Midwestern U. S. conditions. The effect of high capital investment with low variable costs, as with chilled aeration, was compared to low capital investment and high variable costs of phosphine fumigation using multi-year Net Present Cost (NPC) analysis. For the case studies evaluated, chiller unit prices around $ 90,000 were found to be a reasonable capital expenditure for this new IPM-based pest control technology.

Introduction

The most important part of any financial analysis is the gathering of the appropriate financial data. Without good data upon which to base evaluations, the results can be misleading and possibly disastrous (Winicur, 1987). For this project, an economic model was created for a Midwestern popcorn facility using a combination of information from field tests, input from the processor, and historic economic data

The analysis developed in this project is based on a variation of the net present value called net present cost (NPC). Because grain conditioning and integrated pest management (IPM) during storage is a single step in a long processing chain it is difficult to associate income flows directly with changes in storage practices. The NPC method allows for evaluation of expense flows associated with storage only. By isolating the expenses associated with the summer storage process from all other events before and after this time frame, it is possible to look much more precisely at the alternatives proposed. Of course, since this method looks only at expenses, the results must be evaluated on the basis of a minimum discounted expense rather than the maximum discounted income. Therefore, when looking at the results of the model, the lower the NPC the better.

Amortization is used to annualize the total NPC, which makes it easier to understand and to compare one project or alternative to another. The amortized NPC can be equated to ten equal annual payments which, given the time value of money, are equivalent to the total NPC.

Literature review

Very little research has been done on the economics of grain storage and conditioning. Most of the literature available on this topic involves marketing considerations and the calculation of the carrying cost. An example of this is Anderson (1988) who references the opportunity cost of grain storage as the grain price multiplied by the interest rate and the storage time Anderson et al. (1995) notes that the one primary reason for storing grain is to increase net return. Unless the market produces a high enough price to cover storage costs, even the best management will result in a net loss. According to Uhrig (NCR 217) storage costs can be broken down into fixed ownership costs which include: depreciation, taxes, insurance, and interest, and variable costs associated with storage which include: conditioning, sampling, shrink, insurance, repairs, and marketing. An overview of the actual dollar values associated with both fixed and variable costs can be found in Anderson et al. (1995) and Uhrig (NCR 217) and were used in combination with field test data as a basis for values in the economic model developed. While all of these articles do a good job of analyzing annual costs, no articles were found that evaluated a given system over a number of years. The only economic analysis found involving chilled aeration was Maier et al (1989). That analysis was based on the use of chilled aeration to store high-moisture corn. While life cycle costing was used, the situation modeled did not involve integrated pest management or conditioning, and thus has minimal bearing on this project.

A primary objective of this research was to apply a multi-year economic model to field test data collected in 1994 at a commercial Midwestern popcorn facility in order to identify potential economic benefits for chilled aeration, and to

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determine the necessary conditions to make chilled aeration feasible. Because no information could be found that modeled the use of grain chilling compared to fumigation and ambient air conditioning, it was necessary to develop a new model in order to achieve the objective of this research. This post-harvest IPM economic model was developed with the purpose of being sufficiently flexible to allow for the economic comparison of traditional pest control methods to any new IPM-based pest control technology.

Methods

Development of the economic model was based primarily on data and information gathered during the 1994 field tests (Maier et. al., 1997; Mason et. al., 1997). From this information, parameters associated with the integrated pest management during summer storage of popcorn were determined and a model structure was developed to accommodate the necessary factors (Rulon, 1996). Table 1 summarizes the individual spreadsheet model sheet titles and their associated letters to help clarify the model structure.

Table 1. Economic model sheet titles.

Sheet Letter	Sheet Title
A	Facility Description
B	Ambient Conditioning And Aeration Worksheet
C	In-House Fumigation Worksheet
D	Contract Fumigation Worksheet
E	Chilled Aeration Worksheet
F	Annual Operating Cost Analysis Summary
G	Net Present Cost – In-House Fumigation
H	Net Present Cost – Contract Fumigation
I	Net Present Cost – Chilled Aeration
J	Net Present Cost – Chilled Aeration Lease Option
K	Net Present Cost Summary

The first part of the model, Sheet A, is a general facility description that allows the user to briefly describe the facility to be modeled. These parameters include such items as: grain type, bin size, fan horsepower, labor costs, and electrical cost.

Sheet B accounts for parameters associated with aeration and conditioning of the stored product. This includes the number of samples taken during the summer storage season to monitor quality, the labor required to collect and analyze the samples, and conditioning labor associated with monitoring grain quality (including IPM practices such as pitfall and pheromone trapping) and ambient conditions in order to operate fans at the proper time.

The In-House Fumigation Worksheet, Sheet C, represents the costs associated with fumigation by the processor using their own labor and equipment. Inputs for this sheet consist of both standard inputs, such as chemical cost and labor requirements, and management practices, such as the number of fumigation, aeration time following each fumigation, and training costs. Sheet C also allows for the use of a grain protectant to help prevent infestations.

Contract fumigation, Sheet D, was not used at the facility where the 1994 field tests were conducted. However, it was identified as an important option to include in this model. A large number of commercial facilities are currently using contract fumigators to help shield themselves from liability and regulatory concerns. As regulations continue to increase, it is expected that the number of contract fumigation will continue to grow. This is a fairly simple alternative to model because it consists of only the number of fumigation, aeration time per fumigation, charges for both the chemical and its application, and the optional grain protectant charge Another benefit of having this alternative in the model is that it will allow processors to evaluate their in-house fumigation methods in comparison to contract charges in order to determine whether they should continue to expose themselves to the risk of conducting fumigation themselves.

The Chilled Aeration Worksheet, Sheet E, is the most complex of all of the input sheets because it accounts for both conditioning and pest control accomplished through chilled aeration. Based on the 1994 trials, it was determined that the small prototype chilling unit could handle approximately 8 bins. The field test data suggested that two chilling cycles approximately six weeks apart are required to maintain grain temperatures below the desired 15C threshold at this Midwestern facility. This is based on 4,500 bushel bins, which required an average chilling cycle time of 117 hours. The initial investment price of $ 50,000 was based on the production costs of the Purdue prototype grain chiller from AAG Manufacturing, Brookfield, WI (Maier and Rulon, 1996). This value is high because of the prototype nature of this unit, and is expected to be much lower once commercial production begins. An option for an annual lease payment is also included on this sheet to help evaluate alternative ways to finance the large capital investment associated with a chilling unit.

Results and discussion

The base model represents the most accurate model of the 1994 field test data possible and is used for two reasons. First, the use of the base parameters verifies the proper operation of the model for a known facility. Secondly, the

results produced are used as a starting point for case studies to be modeled. They will identify the conditions necessary to make chilling and other current and future IPM-based technologies competitive with traditional conditioning and stored-product pest management practices.

Annual operating cost analysis

Based on the information provided on Sheets A through E it is now possible to evaluate the four treatments in terms of annual operating costs Although this does not provide any information about the capital expenditures required for each alternative or give weight to the time value of money, it provides a useful comparison. At first glance, the data in Table 2 appears to indicate that chilled aeration is significantly more expensive than either of the fumigation treatments with costs of $0.176 per unit compared to $0.061 per unit for in-house fumigation and $0.065 per unit for contract fumigation. This would be true if chilled aeration were used solely as a replacement for fumigation and not for aeration and conditioning. However, the combination of aeration for conditioning and fumigation for pest control, which is the current practice on popcorn, is 14.8% higher per unit than chilled aeration. The actual differences are − $0.026 per unit for in-house fumigation with aeration and − $0.030 per unit for contract fumigation with aeration.

The fact that chilled aeration shows lower operating costs than either of the fumigation plus aeration alternatives is significant for the analysis of the net present cost figures This indicates that if chilling were not competitive with the other treatments based on amortized NPC, it would most likely be due to non-operating cost factors, such as the initial cost of the chilling unit.

Table 2. Annual operating cost analysis summary.

Ambient Aeration and Conditioning	0.141 $/unit
In-House Fumigation	0.061 $/unit
Contract Fumigation	0.065 $/unit
Chilled Aeration	0.176 $/unit

Net present cost analysis

The next step in the analysis was to undertake a true comparison of the four alternative treatment practices using the net present cost analysis format. The four alternatives modeled are:

1. Combination of Ambient Aeration and Conditioning with In-House Fumigation
2. Combination of Ambient Aeration and Conditioning with Contract Fumigation
3. Chilled Aeration
4. Chilled Aeration with Lease Option

The net present cost analysis is the true measure of an investments' value over time. As opposed to the annual operating cost, the NPC takes into account the initial capital investment, the cost of ownership, and the potential tax benefits of owning capital equipment. All of these factors are measured over a ten year period and costs associated with events further out in time are discounted back to their value in today's dollars. The amortized NPC value given with each NPC table represents the annualized cost of each alternative. In each year the expenses were calculated and inflated according to the pre-defined inflation factors. An after-tax expense was then calculated based on the premise that all expenses would offset a portion of income and thus reduce the firms taxable earnings. For in-house fumigation and chilled aeration there is also a tax shield effect generated by the depreciation of the capital investment, which must be given credit. The discount factor for the given year was applied to the net expenses in order to arrive at a net present cost value for each year. The NPC values for all years were then summed into a total NPC. Finally, the total NPC was amortized to generate an amortized NPC value, which could easily be compared between alternatives.

The amortized NPC for chilled aeration using the small prototype unit is 197% higher than that of either in-house fumigation with aeration or contract fumigation with aeration. In fact, the amortized NPC value for chilled aeration of $0.345 per unit is nearly twice that of the amortized NPC for in-house fumigation of $0.175 per unit (Figure 1). In comparing the two, the NPC values for chilled aeration are actually 66% to 71% lower than the values for in-house fumigation in every year except Year 0 when the initial investment in equipment occurs. This reflects the lower annual operating cost of chilled aeration as noted in the annual operating cost analysis. As was expected, the initial investment of $50,000 for purchasing the chilling unit would be too high. However, this should not be considered surprising because the cost of the prototype chilling unit is significantly higher than the cost of a production unit. As part of the case studies the necessary price/capacity relationship required for production chilling units will be determined. Results from that analysis will give the chiller equipment cost needed to make chilling competitive with traditional ambient aeration and fumigation treatments, which was presented by Rulon et. al (1997). Rulon et. al (1998) found for several case studies evaluated, that chiller unit prices around $90,000 were a reasonable capital expenditure. The same analysis procedure can be employed for comparing any other alternative pest control technology to traditional methods

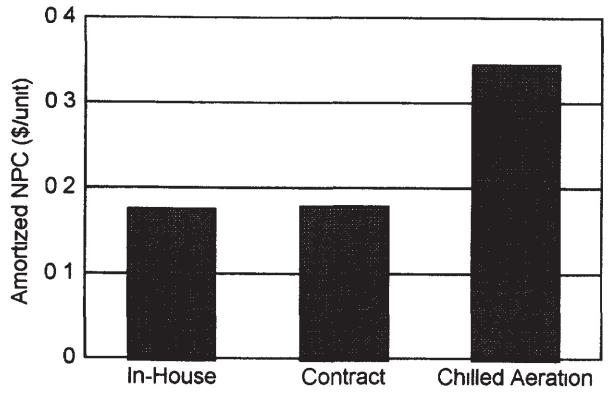

Fig. 1. Amortized NPC values for each treatment modeled

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