After Methyl Bromide: The Economics of Strawberry Production with Alternative Fumigants

by

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Results from a two-year study suggest that drip-applied chloropicrin, and 1,3-D may potentially be economically feasible alternatives to methyl bromide in commercial California strawberry production. Using virtually impermeable film instead of high-density polyethelyne when fumigating may improve economic feasibility, depending on the location and fumigant.

Methyl bromide, combined with chloropicrin, is commonly used as a pre-plant soil fumigant for many crops in California, including strawberries, grapes and almonds. Because methyl bromide is an ozone-depleting compound, the United States and other developed country signatories to the Montreal Protocol banned the use of methyl bromide, beginning in 2005, except for certain "critical uses" that receive annual exemptions to apply a specified amount when no alternative is technically or economically feasible. Commercial strawberry production in California received an exemption for 2005 and for 2006. The application process is underway for 2007.

One of the requirements for obtaining a critical use exemption is that there must be ongoing research efforts to find technically and economically feasible alternatives. In order to be economically feasible, alternatives must be feasible under the pesticide registration and use regulations facing producers. For California strawberry growers, two alternative fumigants that meet regulatory requirements are chloropicrin and 1,3-D (1,3-dichloropropene). While other compounds, most notably iodomethane, also demonstrate technical promise as alternatives, only chloropicrin and 1,3-D are currently registered for use in California. Metam sodium, while registered, is primarily used for weed control, as this product alone is not adequate to suppress pathogens. Therefore, metam sodium is most often used following an application of 1,3-D and/or chloropicrin. While organic strawberry production is growing, organic acreage is only four percent of total acreage: (1,300 of 30,000 acres in 2003). Because of the need for crop rotation in organic production, limited land availability, and high cost of land, it is unlikely that organic acreage will expand significantly as a share of total acreage in the medium term.

Fumigants are volatile organic compounds. Once applied, they volatilize, and enter the air. One way their rate of loss from soil can be reduced is by covering the ground with plastic at the time of application. Reducing the rate of loss keeps the fumigant in the ground longer, which increases, at least potentially, its ability to control pathogens, weeds, and other pests. This physical characteristic suggests that the technical efficacy of alternative fumigants may be improved when less permeable plastic is used, which may alter their economic feasibility. Impermeable films work well to retain fumigants applied through the drip system, which results in improved weed control with chloropicrin and 1,3-D. Due to differences in application techniques, under broadcast fumigation impermeable films do not regain fumigants better than standard films.

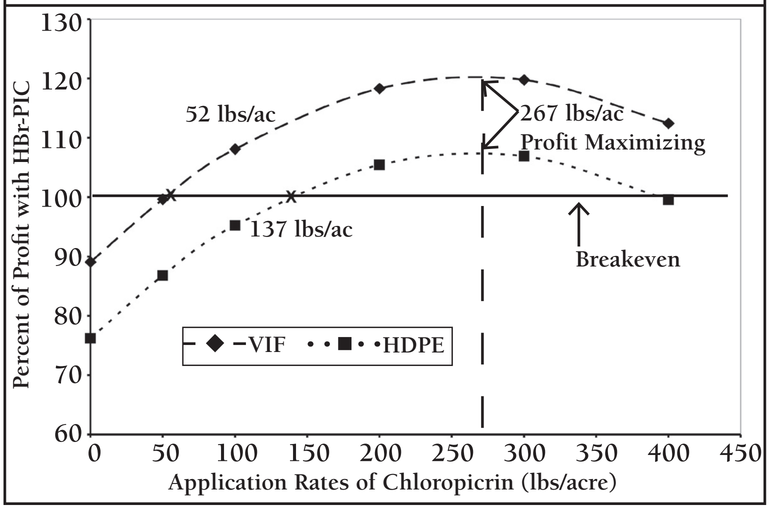
Using data from a USDA-funded project undertaken in cooperation with other UC and USDA researchers, we evaluate the profit-maximizing application rates for chloropicrin and 1,3-D drip-applied to strawberry beds prior to planting. We then compare these profits to profits from methyl bromide-chloropicrin fumigated fields. We also examine how profits are affected by using virtually impermeable film (VIF) to cover the beds, rather than the more permeable high-density polyethylene (HDPE) which is the most commonly used material.

Data and Research Methods

In 2002-03 and 2003-04, field trials were conducted in the Oxnard and Watsonville areas. Each year, in each location, weeding times and yields were measured for twelve treatments under two tarps, VIF and HDPE: The twelve treatments included Chloropicrin EC (PIC) and Inline (1,3-D and chloropicrin), each drip-applied at rates of 50, 100, 200, 300, and 400 lbs/acre; methyl bromide-chloropicrin (MBr-PIC) 67:33 shank-applied at a rate of 350 lbs/acre; and an untreated control. All application rates are reported as pounds per fumigated acre. Only the beds are fumigated, so the application rate per total acre is lower: about 30 percent lower for Watsonville, and about 25 percent lower for Oxnard.

Weeding time and yield information were combined with information regarding weeding costs per hour and other production costs from the UC cost and return

Figure 1. Estimated Profits as Percentage of MBr-PIC Profits: Chloropicrin with HDPE and VIF, Watsonville, 2003-04



studies for strawberries in each region; 2004 cost per pound or gallon information on alternatives collected from suppliers, growers, and other stakeholders; and fresh strawberry price information from the USDA. Profits per acre were calculated for each individual plot, and the resulting values were used to conduct a statistical analysis examining the effects of tarp choice and fumigant application rate on profits.

Estimated Per Acre Profits

Results suggest that at commercially popular application rates of 200–300 pounds per acre, PIC had higher expected profits per acre than methyl bromide in both locations and both years. Results for 1,3-D were not consistent across years and locations. Differences in chemical prices, application costs, yields, and weeding time affect the relative profitability of treatments. Using 2004 prices, MBr-PIC costs 17 percent more per pound than PIC, and 28 percent more per pound than 1,3-D. The cost of a broadcast application of MBr-PIC using HDPE is roughly $200 per acre more than using VIF and drip fumigation, and roughly $400 more per acre than using HDPE and drip fumigation.

Figure 1 illustrates our analysis. It graphs the profits by application rate estimated using the data for PIC in Watsonville in 2003-04. The profits for each application rate of PIC are reported as a percentage of the profits from applying MBr-PIC 67:33 at 350 pounds per acre. The dashed line reports profits when VIF is used. The dotted line reports profits when HDPE is used.

Notice that at each application rate, profits from using VIF are higher than profits from using HDPE. In the results reported here, we estimate a profit difference from using VIF that is required to be constant across application rates. Allowing the application rate to vary does not substantively affect our results in any way. At the profit-maximizing application rate of 267 pounds per acre, PIC is about 20 percent more profitable than MBr-PIC under VIF, and about eight percent more profitable under HDPE. For purposes of comparison, profits for the untreated control plot were 65 percent lower than profits from MBr-PIC.

The "breakeven" rates at which PIC profits equal MBr-PIC profits are marked on the graph. Although these rates are much lower than the profit-maximizing rates, it is important to interpret them with caution. As the application rate increases, the gain from each incremental pound of PIC applied falls, so that the low breakeven rates do not necessarily imply a huge difference in profitability between PIC and MBr-PIC. For example, profits for PIC applied under HDPE equal those for MBr-PIC at an application rate of 137 pounds per acre. Almost doubling the rate to 267 pounds per acre increases profits by eight percent, rather than almost doubling them.

Profit-Maximizing Application Rates

Our statistical approach allows us to estimate the application rate that results in the highest per-acre profit (the profit-maximizing application rate). For Oxnard, the profit-maximizing application rate for PIC is roughly 300 pounds per acre (Table 1). The data are much less informative regarding the profit-maximizing application rate for 1,3-D, and there is much less consistency across datasets. The 2003-04 data generate an estimated profit-maximizing application rate that is larger than the largest experimental rate and is 137 lbs/acre greater than the 2002–03 estimate. For Watsonville, the profit-maximizing application rate for PIC is roughly 260 pounds per acre (Table 2). The profit-maximizing application rate for 1,3-D is approximately 370 pounds.

Effect on Estimated Profit Per Acre of Using VIF

Overall, the results suggest that using VIF increases profits in the Oxnard area (Table 3). Estimates from the 2003-04 dataset have high levels of statistical significance, which means that there is a very low chance that using VIF will not increase profit. The analysis for Watsonville is much less conclusive. The 2002-03 data suggest that using VIF reduces profits, and that this reduction is statistically significant for1,3-D. In contrast, due to differences in yields and weeding times, the 2003-04 data suggest that using VIF increases profits, and that this increase is statistically significant for 1,3-D.

Caveats

Even for questions where our research found a clear answer, it is important to keep in mind that a number of caveats apply to our results. First, we do not consider the cost of purchasing drip irrigation equipment that is robust enough to withstand fumigation, although this may be offset in part by the reduced cost of using a single plastic tarp for fumigation and production, instead of the two plastic tarps used for broadcast fumigation and production. Second, prices and costs change over time. Because we used information from 2004 for the fumigants, changes in relative costs may affect the relative profitability of different treatments. Third, field trial conditions may not fully replicate commercial production conditions, and individual growers' costs may vary from those used here. Fourth, variability in soils and topography may alter the efficacy of the treatments we evaluated, relative to the efficacies demonstrated here. For example, it is much more difficult to achieve uniform drip application of fumigants on hilly fields. Fifth, very little is known about the implications for pathogen control of using alternatives for many years in a row. Sixth, this experiment used clear VIF. Because PIC photodegrades quickly when exposed to sunlight, it may have persisted longer and its performance may have been better, if colored VIF had been used to protect chloropicrin from photodegradation. Finally, another caveat may be the fragile nature of VIF itself. It is a three or five layer material, including one or two impermeable layers. Stretching can break the impermeable layer. Greater care must be used in the installation of VIF which increases labor and machine costs.

Implications and Unanswered Questions

Although subject to a number of significant caveats, our analysis suggests that PIC and 1,3-D are potentially economically viable alternatives to methyl bromide. Two important questions that will affect economic viability, and are as of yet unanswered, regard the effect on the price of strawberries if all growers move to alternatives, and the effect on pathogens of repeatedly using an alternative on the same field. Because yield profiles over time for the alternatives are different than the yield profile for methyl bromide, average prices received by growers may change, which will alter revenues. If alternatives are slightly less effective at controlling a given pathogen, there is the potential for this reduction in efficacy to have larger effects after repeated use.

Table 1. Estimated Profit-Maximizing Application Rates (lbs/acre): Oxnard

	2002-03	2003-04
PIC	276	317
1,3-D	282	419*

** Profit-maximizing point outside of data range*

Table 2. Estimated Profit-Maximizing Application Rates (lbs/acre): Watsonville

	2002-03	2003-04
PIC	259	267
1,3-D	353	381

Table 3. Estimated Gain from Using VIF Instead of HDPE (Dollars per Acre)

Year	2002-03		2003-04	
	Oxnard	Watsonville	Oxnard	Watsonville
PIC	$448	-$260	$1,136*	$1,170
1,3-D	$651	-$1,459**	$1,654**	$1,350**

** Significant at the 10% level ** Significant at the 5% level*

The motivation for research on VIF and other emissions reduction methodologies is to reduce human exposure to fumigants, and improve fumigant performance on soil pests. VIF is just one possible method of accomplishing these goals. Increasing regulatory constraints means that a method to reduce fumigant emission must be found; otherwise, fumigant use will be drastically curtailed. At the same time fumigant emission reduction technology must not be so costly that growers can not afford to use it. California growers have not yet perceived sufficient benefit, either economically or in terms of relaxed fumigant application regulations, to use VIF on a wide scale. The data presented here suggest that there are economic benefits to the use of VIF. However, determination as to whether there are environmental benefits to the use of VIF need to be more thoroughly evaluated.

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