An Economic Analysis of Fumigation Alternatives, the Methyl Bromide Ban, and its Implication: Evidence from the Florida Tomato Industry

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Background

Methyl bromide (*bromomethane, CH3Br*), which has been by far the most effective pre-plant fumigant used to control nematodes, soil-borne pests, weeds and plant diseases in agriculture, is being phased out in the U.S. under Montreal Protocol due to its destructive effect on ozone depletion. It is now only permitted under Critical Use Exemptions (CUEs) in a very limited scale under close government scrutiny. Scientific research up to now hasn't found such feasible fumigant alternatives with consistent, high technical effectiveness and low cost as methyl bromide (MBr).

The technological shock, coupled with intense competition from Mexico, a developing country still allowed to use methyl bromide under Montreal Protocol, has caused significant economic damage (increasing production cost and decreasing yield) to the Florida tomato industry, the largest fresh tomato supplier in the nation. Florida fresh tomato production decreased from 45 thousand acres in 2001 to 29 thousand acres in 2012. The farm gate value of the industry slumped from $620 million in 2010 to $270 million in 2012 (NASS/USDA, 2013).

Objectives

- Compare cost-effectiveness of MBr:Pic (67:33) and alternative fumigation strategies;
- Analyze risk efficiency of MBr:Pic (67:33) and alternative fumigation strategies.

Field trials and Data Sources

Yield and input use data were collected from field trials conducted by the University of Florida in Balm, Florida in fall 2013. The treatments applied in the trials were shown as follows:

	Treatment		Rate	(Unit/A)	Applied
1	Non-fumigated		-	-	-
2	MBr:Pic (67:33) *(67% of Methyl bromide and 33% of Chloropicrin)*		350	lb	8" Shank
3	MBr:Pic (50:50) *(50% of Methyl bromide and 50% of Chloropicrin)*		350	lb	8" Shank
4	TE3 *(Telone II, Chloropicrin and DMDS)*		400	lb	8" Shank
5	PicChlor 60 *(1,3-Dichloropropene and Chloropicrin)*		300	lb	8" Shank
6	FL-3 way	*Telone II*	122	lb	6" Yetter
		Chloropicrin	150	lb	8" Shank
		Kpam	60	gal	Drip

There were four fields and each field had four replicate blocks. Each block had three beds, divided into six same plots and each plot was 2.67' wide, 75' long (200 sqft = 0.0046 treated acre). Total treated acreage for each field was 0.1104 acre. Six treatments were applied on the six plots in each block.

All treatments were covered with VIF mulch and applied the same amount of fertilizers, pesticides, fungicides, irrigation during the growing season. Unlike commercial operation, herbicides were not applied in the field trials.

Reference:
1. Hardaker, J.B, Richardson, J.W., Lien G., K. Schumann. "*Stochastic Efficiency Analysis with Risk Aversion Bounds: A Simplified Approach.*" The Australian Journal of Agricultural and Resource Economics, 48:2, pp. 253-270.
2. Sydorovych et al. "*Economic evaluation of methyl bromide alternatives for the production of tomato in North Carolina*." Horttechnology, Oct-Dem 2008 18(4).

Methods

Partial budget analysis is to estimate and analyze the economic effectiveness of MBr:Pic (67:33) and its alternatives. It compares the negative effects of applying a new treatment relative to a base or standard treatment to the positive effects associated with the new treatment relative to the base or standard treatment. In this study, fumigation cost, harvest cost and average yield which change with different treatments were specified. Other costs which were fixed across treatments are excluded of the analysis.

Second-order stochastic dominance (SSD) and **stochastic efficiency with respect to a function (SERF)** is to identify and rank different fumigation strategies in the field trials based on risk efficiency of yield and gross return under given risk aversion. The Constant Relative Risk Aversion (CRRA) utility function is used to calculate the Certainty Equivalent (CE) of the average yields and gross returns of all six treatments under given risk averse coefficient range.

$$U(c) = \begin{cases} \frac{c^{1-r}}{1-r} & if\ r > 0, r \neq 1 \\ Ln(c) & if\ r = 1 \end{cases} \quad \text{and} \quad U(CE) = E(U(c))$$

where r is relative risk averse coefficient (RRAC). In this study, r is assumed from 1 to 4.

Results

Partial budget analysis results:

Table 1: Total negative effects (added costs and reduced returns), total positive effects (reduced costs and added returns), and total effects of the selected alternative soil treatments relative to MBr:Pic (67:33) in the tomato production system.

MBr and selected alternative treatment	Added costs of the alternative treatment ($/acre)	Reduced returns of the alternative treatment ($/acre)	Total negative effects of the alternative treatment ($/acre)	Reduced costs of the alternative treatment ($/acre)	Added returns of the alternative treatment ($/acre)	Total positive effects of the alternative treatment ($/acre)	Total effects of the alternative treatment relative to MBr ($/acre)
Non-fumigated	0	6175.20	6175.20	3545.61	0	3545.61	-2629.59
MBr:Pic (67:33)	0	0.00	0.00	0	0	0	0
MBr:Pic (50:50)	0	856.42	856.42	369.59	0	369.59	-486.83
TE-3	0	1748.42	1748.42	892.59	0	892.59	-855.827
PicChlor 60	0	3568.52	3568.52	1897.8	0	1897.8	-1670.72
FL-3 way	0	4402.54	4402.54	1592.84	0	1592.84	-2809.7

Table 2: Estimated fumigation costs for MBr:Pic (67:33) and selected alternative soil treatments and the fumigation costs of the alternative treatments relative to MBr:Pic (67:33) in tomato production.

MBr and selected alternative treatment	Fumigation labor costs ($/acre)	Fumigation machinery costs ($/acre)	Fumigation material costs ($/acre)	Total fumigation costs ($/acre)	Fumigation costs relative to MBr:Pic (67:33) ($/acre)
Non-fumigated	70.01	43.77	598.00	711.78	-1680.16
MBr:Pic (67:33)	64.79	49.15	2278.00	2391.94	0.00
MBr:Pic (50:50)	69.06	52.39	2159.00	2280.45	-111.49
TE-3	69.77	52.93	1898.00	2020.71	-371.24
PicChlor 60	73.33	55.63	1463.00	1591.97	-799.97
FL-3 way	92.99	106.95	2012.70	2212.64	-179.30

Note: The fumigation machinery costs only included diesel and lubricant costs; depreciation and other non-cash overhead were excluded. The original price of methyl bromide in 1997 before its ban was used instead of current MBr prices after adjusted through Producer Price Index (PPI).

Results cont.

Table 3: Marketable tomato yields, the harvest costs, including labor and materials, gross returns for MBr:Pic (67:33) and selected alternative fumigant treatments, and the difference in the harvest costs and gross returns relative to MBr:Pic (67:33).

MBr and selected alternative treatment	Jumbo and extra large tomato (lbs/Acre)	Large tomato (lbs/Acre)	Medium and small tomato (lbs/Acre)	Total Yield (lbs/Acre)	Gross Revenue ($/acre)	Gross returns relative to MBr:Pic (67:33) ($/acre)	Harvest Cost ($/acre)	Harvest Cost relative to MBr:Pic (67:33) ($/acre)
Non-fumigated	6633.15	4605.98	6875.00	18115.49	8309.20	-6175.20	2543.41	-1865.45
MBr:Pic (67:33)	12759.51	6977.58	11665.08	31402.17	14484.39	0.00	4408.87	0.00
MBr:Pic (50:50)	11872.28	6694.97	10996.60	29563.86	13627.97	-856.42	4150.77	-258.10
TE-3	10855.30	6095.11	10738.45	27688.86	12735.98	-1748.42	3887.52	-521.35
PicChlor 60	9974.86	5395.38	8212.64	23582.88	10915.88	-3568.52	3311.04	-1097.83
FL-3 way	11502.72	4656.25	5175.27	21334.24	10081.85	-4402.54	2995.33	-1413.54

Note: Tomato marketing prices are: $12.65/carton for jumbo and extra-large tomatoes, $11.21/carton for large tomatoes and $10.5/carton for medium and small tomatoes (Each carton contains approximately 25lb tomatoes).

Stochastic efficiency with respect to a function results:

Figure 1 & 2: Comparison of MBr:Pic (67:33) and other treatments' CDF series for adjusted yields and gross returns.

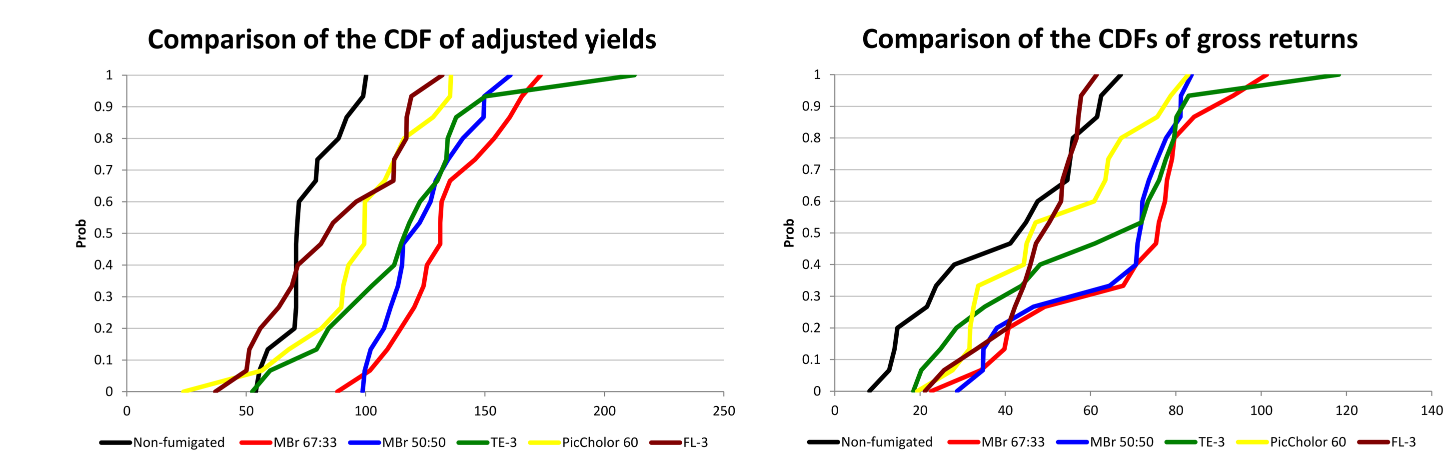
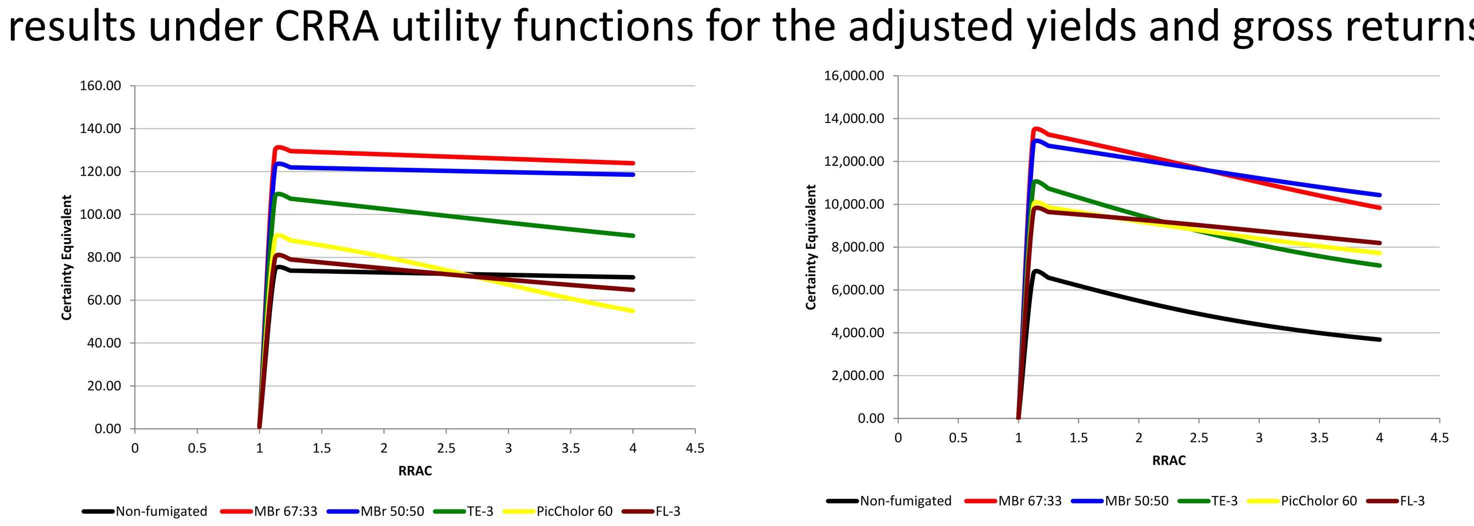


Figure 3 & 4: Comparison of MBr:Pic (67:33) and other treatments' SERF results under CRRA utility functions for the adjusted yields and gross returns.



Conclusions

MBr:Pic (67:33) produces the highest average yield and gross return, followed by followed by MBr:Pic (50:50), TE-3, PicChlor 60, FL-3 way and non-fumigated treatment. Though fumigation costs of MBr:Pic (67:33) treatments are higher than other treatments, its outstanding yield performance still makes it the most cost effective fumigation, producing more positive effects than other treatments.

SERF analysis indicates MBr:Pic (67:33) is the most preferred fumigation under given risk aversion. As for yield performance, SERF shows than MBr:Pic (67:33) is the most risk efficient followed by MBr:Pic (50:50) and TE-3; for gross return, MBr:Pic (67:33) is surpassed by MBr:Pic (50:50) at the breakeven RAC (2.62), but both are more risk efficient than other treatments.

In general, the MBr:Pic (67:33) is the most cost effective and risk efficient of all treatments studied.