Economics of Microbial Inoculants as part of IPM practices in apple production in the U.S.

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INTRODUCTION & BACKGROUND

Disease management in crops worldwide is heavily dependent upon application of synthetic pesticides for pathogen and insect control. However, excess application of pesticides can enhance the development of pest resistance increasing chemical input use requirements. Also, tightening environmental regulations discourage chemical application. Moreover, prices of synthetic pesticides have been increasing. These trends make producers look for alternative risk reducing and yield enhancing technologies.

Biological Control Agents (BCAs) offer an attractive alternative to synthetic pesticides. Microbial Inoculatnts (MI) are BCAs that include virus, bacteria, and fungi.

The use of BCAs is still marginal. However, their usage has been growing at an annual rate of 10% representing 4.25% of total pesticide market in 2010 (Bailey et al., 2010). MI represented 30% of total sales of biocontrol pesticides in 2006,. The total value of sales for MI was valued at $205 millions (Thakore, 2006).

The chosen crop is apples as the technology is already being applied. According to the United States based Environmental Working Group, apples rank as the most contaminated fruit and vegetable produce.

In 2006, the EPA declared that the pesticide azinphos-methyl (AZM) cannot be used in apple production after September 30, 2012. AZM has been the pesticide most used by Washington State apple growers since the late 1960s and, in 2008, 80% of Washington apple growers used AZM primarily to control codling moth (Cassey et al., 2010). In addition, in 2011, the National Organic Standard Board voted to phase out by October 2014 antibiotics streptomycin and oxytetracycline which are the primary tools to prevent fire blight.

OBJECTIVES

First, it is necessary to understand the potential substitution effect that MI may have on chemical pesticides. Second, quantifying overall production impacts of MI and estimating production efficiency for adopters is essential for adjudicating success of the technology.

References:

•Bailey, K. L., S. M. Boyetchko and T. Längle. "Social and economic drivers shaping the future of biological control: A Canadian perspective on the factors affecting the development and use of microbial biopesticides." *Biological Control 52 (2010): 221-229.*

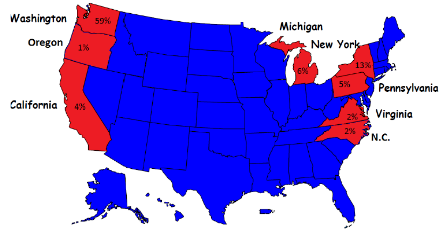
•Cassey, A. J., S. P. Galinato and J. Taylor (2010). Impacts of the Azinphos-methyl Ban in the Apple Industry and Economy of Washington State. WSU Extension bulletins. Washington, WSU.

•Kumbhakar, Subal C., and C. A. Knox Lovell. 2000. *Stochastic frontier analysis*. New York: Cambridge University Press.

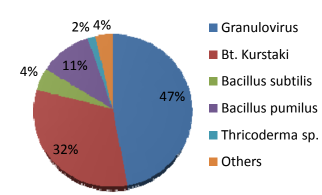
•Thakore, Y. "The biopesticide market for global agricultural use." *Industrial Biotechnology 2* (2006): 194-208.

DATA

2007 USDA's Agricultural Resource Management Survey (ARMS) for apple production.



Only conventional (non-organic) farmers. The use of biological control is defined as a dummy variable. In the sample of 547 conventional farms, 197 farms were using on average 3 biological control products. 96% of the biological control products used fall into the MI definition.



METHODOLOGY

First, a pesticide use function

1. Pesticide = f(price, MI, farm characteristics, pest pressure index, state dummies)

Then a damage control production function

2. Y = f (X) g (Z)

For f(X) we assume Cobb-Douglas functional form, whereas for g(Z) a exponential and logistic forms are used

and a stochastic production frontier to measure technical efficiency

3. $Y_i = f(X_i;\ \beta)\ \exp\{v_i\}\ TE_i$

Pest control inputs tend to be correlated with the error term. In order to correct for possible endogeneity, we use 2SLS with pesticide use as the first stage equation (1) and the production function (2) using fitted pesticide use values as the structural equation.

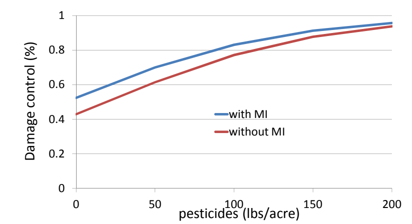
Endogeneity does not bias estimates of technical efficiency with stochastic distance functions (Kumbhakar and Lovell, 2000).

RESULTS

Pesticide usage increases with MI.

MI affects positively the outputs

	Cobb-Douglas basic		With exponential damage		With logistic damage	
	coefficient	t value	coefficient	t value	coefficient	t value
pesticide	0.1255 *	1.77				
experience	-0.0013	-0.56	-0.0003	-0.13	-0.0003	-0.12
trees	-0.0051	-0.88	-0.0116 **	-2.18	-0.0121 **	-2.27
labor	0.0886 ***	4.99	0.0774 ***	6.55	0.0786 ***	6.73
irrigation	-0.0058	-0.96	-0.0096	-1.33	-0.0093	-1.29
fuel	-0.0032	-0.64	-0.0038	-0.70	-0.0039	0.70
bees	0.0066	1.03	-0.0008	-0.13	-0.0009	-0.13
nitrogen	0.0183	0.79	0.0263 *	1.79	0.0265 *	1.80
potash	0.0410 *	1.89	0.0293	1.60	0.0285 *	1.65
phosphate	-0.0741 **	-2.28	-0.0755 **	-2.58	-0.0747 **	-2.55
sulfur	-0.0217	-0.45	-0.0173	-0.30	0.0143	-0.42
MI (dummy)	0.1208 *	1.71				
Acres harvested	0.0762 ***	2.64	0.1626 ***	6.88	0.1649 ***	7.01
Michigan	-0.0077	-0.07	-0.0091	-0.07	0.0111	0.09
Oregon	-0.4016	-1.58	-0.4059 ***	-2.62	-0.4072 ***	-2.63
New York	0.1924	1.61	0.1868	1.43	0.2058	1.58
Pennsylvania	0.3973 ***	3.53	0.3693 ***	2.64	0.3904 ***	2.82
North Carolina	-0.8564 ***	-3.86	-0.8090 ***	-3.10	-0.7913 ***	-3.04
California	-0.1268	-0.47	-0.4398 ***	-3.00	-0.4279 ***	-2.92
constant	10.9300 **	2.39	9.6541 **	2.29	9.6114 **	2.28
damage control						
Constant (, μ)			0.5346 ***	4.02	0.2845 *	1.65
pesticide			0.0108 *	1.91	0.0154 **	2.56
MI (dummy)			0.2106	1.46	0.3787 *	1.93
number of obs.	510		525		525	
R2 adjusted	0.3654		0.3739		0.3751	
population	15497		15953		15953	



	all farms	adopters	non adopters	efficiency gains
all farms	0.6085	0.6254	0.6002	**0.0252**
California	0.6170	0.6616	0.5986	0.0630
Michigan	0.6186	0.6287	0.6140	0.0147
New York	0.5826	0.5725	0.5862	-0.0137
North Carolina	0.5829	0.5018	0.5909	-0.0891
Oregon	0.6104	0.6843	0.5661	0.1182
Pennsylvania	0.6174	0.6204	0.6162	0.0042
Washington	0.6198	0.6236	0.6157	0.0079

CONCLUSIONS

Estimation of a pesticide use function confirms observed paradigms regarding producer attitudes toward production risk and resulting chemical use, i.e., that BCAs are often perceived as "insurance" used more extensively by wealthier farmers.

MI technology significantly increases yields and reduces the marginal productivity of pesticides.

According to this study, MI can complement, rather than substitute, agricultural chemical use easing compliance with regulations and positively impacting yields.