Profitability Efficiency Analysis of Methyl Bromide Fumigants and Mulch Systems Alternatives for Pepper Production in Georgia.

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Abstract

With the goal of looking for the best fumigant substitute not only effective to production yield but more importantly to profitability and its excellent corresponding mulching option, this study used the complete factorial treatment analysis approach. Seven fumigant options and four mulching alternatives were included in the study and results showed that 1,3-dichloropropene plus chloropicrin and metam sodium (TELPICVAP) and smooth low density black on black polyethylene mulch (METAL) are the most profitable fumigant and mulch option.

Introduction

Fumigation is a method of pest control that completely fills an area with gaseous pesticides known as fumigants to suffocate or poison the pests within. Several chemicals have been used as fumigants but for the last fifty years, Methyl Bromide has been the most extensively used commercial chemical because it is considerably safer and easy to use, cheap and more effective. Because of these qualities, the farmers abandoned practically all other options (McCook, 2006).

Unfortunately, MB was listed as one of the ozone depleting substance by the Montreal Protocol in 1992 and its production should be discontinued by January 1, 1995. More so, an accelerated phase out schedule for MB was recommended during the Ninth Meeting of the Parties in Montreal in 1997. This became a major concern to most U.S. farmers, and in particular to farmers in Georgia where the product is used for the production of it's most economically important vegetable crops such as cucumber, eggplant, green pepper, tomato, squash and zucchini. Other states in the U.S. including Georgia applied for the critical use exemption which is defined as growers not having a readily available replacement, unable to carry out agricultural production without MB and proof of economic hardship caused by the absence of MB (Byrd, Fonsah, Escalante and Wetzstein, 2006). Consequently, finding alternatives to MB use became crucial. This study looks at bell pepper production in particular and intends to suggest the best substitute not only effective to production yield but more importantly to profitability.

The nature of fumigation makes mulching, the process of putting a protective cover over the soil its complementary practice. In essence, this study will not only come up with the best suggested fumigant substitute but also with the superlative corresponding mulching method.

Experiment and Data

Net revenue data from an experiment conducted in 2006 near Tyty, Georgia on Tifton loamy sand will be utilized. Seven fumigant treatments and four mulching methods will be paired factorially with five replications. The fumigant treatments are no

fumigant (NF), methyl iodide plus chloropicrin (MIDAS), methyl bromide plus chloropicrin (MB), 1,3-dichloropropene plus chloropicrin and metam sodium (TELPICVAP), chloropicrin (PIC400), 1,3-dichloropropene plus chloropicrin(TELPIC) and chloropicrin ((PIC250) while the four mulching methods that will be combined with each fumigant treatment are traditional low density black on black polyethylene mulch (LDPE), smooth low density black on black polyethylene mulch (METAL) high barrier black on black Blockade mulch (SMOOTH) and a high barrier silver on black metalized mulch (VIF).

All of the fumigants were applied on February 22 as an in-bed banded treatment. Within five minutes of the fumigant injection, all of the beds were covered with plastic mulch. After 19 days, bell peppers were transplanted to the prepared beds. Peppers plants were spaced 30 cm apart along the row length and 38 cm apart across the bed top and are planted in double rows. Each plot was 10 m in length and bed centers were 182 cm apart. Three weeks after planting, foliar insecticides and fungicide sprays were applied weekly. Fertilizer was applied prior to bed formation. While additional fertilizer was injected through the drip injection. Common pest control and fertilization practices followed the University of Georgia recommendations for commercial pepper production in 2006 (Kelley and Boyhan, 2006).Harvesting is done once a week for five successive weeks starting on May 26.

Throughout the season, visual crop injury estimates were recorded. To monitor the nutsedge emergence, nutsedge plants growing though the polyethylene mulch or through the plant hole were made 3 and 8 week after planting for each entire plot were counted. No other weeds were present in the experimental area.

Analytical Model

Multiple factor analysis, specifically the complete factorial treatment analysis techniques will be implemented to evaluate the relative effects of different fumigant-mulch options on pepper production profitability. This allows more efficient examination that provides information on every factor as well as present relationships between factors. This methodology allows for a better expansion of the scope of inference.

The factorial effects model is given by the following equation:

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \qquad (1)$$

with parameter constraints:

$$\sum_{i=1}^{a} \alpha_i = 0, \qquad \sum_{j=1}^{b} \beta_j = 0, \qquad \sum_{i=1}^{a} (\alpha\beta)_{ij} = \sum_{j=1}^{b} (\alpha\beta)_{ij} = 0$$

where $i = 1,\ldots,a$, the α levels for fumigant

$j = 1,\ldots, b$, the β levels for mulch; and

$k = 1,\ldots, r_{ij}$ the number of replicates at each treatment combination represented by the interactions of the two factors respectively.

The dependent variable in this model, y_{ijk} represents the bell pepper net revenue.

All of the seven fumigation methods were included in the analysis. Each of these fumigation methods is combined with one of four mulching methods giving 28 fumigant-

mulch pairs namely, NF-LDPE, NF-METAL, NF-SMOOTH, NF-VIF, MIDAS-LDPE, MIDAS-METAL, MIDAS-SMOOTH, MIDAS-VIF, MB-LDPE, MB-METAL, MB-SMOOTH, MB-VIF, TELPICVAP-LDPE, TELPICVAP-METAL, TELPICVAP-SMOOTH, TELPICVAP-VIF, PIC400-LDPE, PIC400-METAL, PIC400-SMOOTH, PIC400-VIF, TELPIC-LDPE, TELPIC-METAL, TELPIC-SMOOTH, TELPIC-VIF, PIC250-LDPE, PIC250-METAL, PIC250-SMOOTH, and PIC250-VIF. There are five replications for every fumigant-mulch pair.

Results

In Table 1, separate significance of the two factors, namely fumigant and mulch, in explaining variations in bell pepper net revenue and the interaction of these two factors were presented. The interaction of the fumigant and mulch yielded insignificant results indicating that the effect of fumigation at specific types of mulching options is not important. Specifically, the change in the net revenue in shifting from one fumigant option to another, for instance MB to MIDAS, will be the same for all types of mulching options.

Since the interaction (simple) effect yielded insignificant results, the marginal effects of fumigant and mulch factors were considered individually. Both factors were found to be significant in explaining variations in bell pepper net revenue (Table 1). Table 2 shows the parameter estimates of bell pepper net revenue for each fumigant option. Results suggest that TELPICVAP is the best option for production since it gives the highest net revenue of $3879.90 per acre regardless of the mulching option. Interestingly, the non-

fumigant system gives the second highest net revenue of $ 3773.36 after TELPICVAP indicating that not using any fumigant is more economic efficient than the fumigant choices except for TELPICVAP. The other five fumigant options mean net revenues were all below the control operation even though four of them gave positive net revenues. The net revenue estimate for MIDAS was found to be insignificant. This is reasonable because it is the only fumigant option that gave negative net revenue (- $413.81 per acre). Definitely, this eliminates MIDAS as a good economic efficient fumigant option for bell pepper production.

The result for MB's net revenue being lower than the non-fumigant production is quite surprising since it has been widely used due to its reputation of being cheap and effective. This result, however, might only be true for the certain sample used in this analysis. Also, net revenues are functions of input prices and the development of alternative fumigants available in the market might have some impact on the price of MB making it less competitive thus giving lower net revenues. The results however answer the goal of this paper of finding a good economic alternative for MB that is TELPICVAP.

On the other hand, Table 3 displays the parameter estimates of the bell pepper net revenue for each mulching option. All of the estimates were significant. Comparison of the marginal means recommend that METAL is the best mulching option for production giving the highest net revenue of $3409.06 per acre among the four options independent of the fumigant choice. LDPE gave the second highest net revenue followed by SMOOTH while VIF has the least net revenue among the four.

Ironically, TELPICVAP has the second highest price per pound and total value of fumigant used per acre and still it was the most economic efficient of all the seven fumigant options under study (Table 4). Looking back at the data, it can be observed that TELPICVAP has the highest yield on the average among the other systems hence even though it's the second most expensive among the fumigant options it is yield effective. The net effect of these factors, namely input prices and yield is reflected on the net revenue of production and TELPICVAP's high yield characteristic overcomes its high price making it the most economic efficient option for fumigation.

Lastly, Table 5 shows the mulch prices and the total value of mulch used per acre. Same with the fumigant, the best mulching option is one of the costliest inputs among the four options being compared. METAL and SMOOTH actually have the same price but METAL is more economic efficient since it gives the highest yield among the four mulching options on the average.

Summary and Conclusions

Fumigation and mulching are essential practices in bell pepper production. Methyl bromide has been the most widely used fumigant for the past 50 years however it was listed as one of the ozone depleting substance by the Montreal Protocol in 1992. This occurrence spurred several studies looking for good alternatives to methyl bromide. Past studies look on substitutes effective on yield but only few considered profitability.

This paper particularly searches for the best fumigant substitute not only effective to production yield but more importantly to profitability and its excellent corresponding mulching option. Complete factorial treatment analysis approach was utilized. Fumigant and mulch are the two factors being considered as well as their interaction. The interaction of the two factors appeared to be insignificant. Results showed that 1,3-dichloropropene plus chloropicrin and metam sodium (TELPICVAP) and smooth low density black on black polyethylene mulch (METAL) gave the highest bell pepper net revenue per acre making it the most profitable fumigant and mulch option.

Results of this study agree with the yield efficiency study conducted by Fonsah, Yu, Escalante, Culpepper and Deng which concluded that 1,3-dichloropropene plus chloropicrin and metam sodium (TELPICVAP) is the fumigant option that maximized bell pepper production. TELPICVAP's prices, even though high didn't hamper its economic efficiency.

Similar analysis is suggested to be done on other crops that use methyl bromide extensively. Application on cucumbers, tomatoes, eggplant, squash and zucchini is highly recommended. Further analysis including the fumigant's biological impact is a good extension of this study. Integrating other factors of production, for instance labor, along with the fumigant and mulch alternatives is also another avenue for research.

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Table 1. Decomposition of Factor Effects

Effect	Numerator Degrees of Freedom	Denominator Degrees of Freedom	F value	Pr > F
Fumigant	6	112	23.34*	<.0001
Mulch	3	112	4.34*	0.0062
Fumigant*Mulch	18	112	0.69	0.8154

* Factor effects significant at $\alpha = 0.01$.

Table 2. Parameter Estimates of Bell Pepper Net Revenue for the 7 Fumigant Treatments (N = 140).

Fumigant	Estimate	Degrees of Freedom	t Value	Pr > | t |
NF	3773.36*	112	11.96	<.0001
MB	2398.76*	112	7.61	<.0001
MIDAS	-413.81	112	-1.31	0.1922
PC250	3723.61*	112	11.81	<.0001
PC400	2762.37*	112	8.76	<.0001
TELPIC	3485.67*	112	11.05	<.0001
TELPICVAP	3879.90*	112	12.3	<.0001

* Denotes significance at $\alpha = 0.01$.

Table 3. Parameter Estimates of Bell Pepper Net Revenue for the 4 Mulch Treatments (N = 140).

Mulch	Estimate	Degrees of Freedom	t Value	Pr > | t |
LPDE	2861.49*	112	12	<.0001
METAL	3409.06*	112	14.3	<.0001
SMOOTH	2736.61*	112	11.48	<.0001
VIF	2198.48*	112	9.22	<.0001

* Denotes significance at $\alpha = 0.01$.

Table 4. Fumigant Prices

Fumigant	Price per pound	Quantity Used per acre (in lb)	Total Value of Fumigant used per acre
NF	0	0	0.00
MB	5.45	347	1891.15
MIDAS	11.46	347	3976.62
PC250	2.65	250	662.50
PC400	2.65	400	1060.00
TELPIC	4.77		619.88
Telone	1.92	100.2	192.38
Chloropicrin	2.85	150	427.50
TELPICVAP	9.27		3438.01
Telone	1.92	100.2	192.38
Chloropicrin	2.85	150	427.50
Vapam	4.50	626.25	2818.13

Table 5. Mulch Prices

Mulch	Price per roll	Quantity Used per acre (in rolls)	Total Value of Mulch used per acre
LPDE	151	2.18	329.18
METAL	275	2.18	599.50
SMOOTH	275	2.18	599.50
VIF	240	2.18	523.20