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Cost and Benefit Analysis of Tomato Spotted Wilt Virus (TSWV) Management Technology in Georgia.

By

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Abstract

Recent trend depicts that tomatoes and tomatoes products rank 2nd most important vegetable crop in the United States after potatoes and potatoes products contributing 20 percent of total vegetable production. More-so, tomato is equally ranked 2nd in the United States in terms of production value, generating $1.3 billion after head lettuce that contributed $1.4 billion in the same time period. In 2006, 422,000 acres of tomatoes were planted in the United States. Tomato is equally an important economic crop in the state of Georgia. In 2008, it ranked 14th in the Georgia vegetable acreage as 3,985 acres were planted. It also ranked 6th in terms of farm gate value in the same time period generating $51.2 million. Thrips-vectored tomato spotted wilt virus (TSWV) is a serious disease capable of causing damages to the plant, fruits, quality and reducing yields drastically. Managing TSWV can be complex. For instance, metalized UV-mulch may significantly reduce TSWV, but delay tomato maturity, potentially affecting price and market window. Also, resistant tomato lines may eliminate damages due to TSWV, but could have negative horticultural attributes that standard TSWV-susceptible hybrids do not. TSWV can induce irregular ripening in fruit after packing, affecting post harvest costs. This study is aimed at providing the optimal return per unit of enterprise using cost and benefit estimates of the combination of available inputs used in the various management strategies. Thereafter, the result of the differentially developed techniques and risk-rated cost and benefit budgets will be used to determine which of the risk-rated thrips, TSWV and IPM decision criteria would provide superior pareto-optimal economic and financial benefit to tomato growers

Key Words: Tomatoes production, Tomato Spotted Wilt Virus (TSWV), inputs, fixed cost, variable costs, profitability, cost and benefit.

Introduction

Tomato *(Lycopersicon esculentum Mill.)* and products is an important economic crop in the United States vegetable and melon industry. The crop is ranked 2nd after potatoes in the nation in terms total utilization. In 2007 total use was 20 percent, slightly below potatoes that was 28 percent and significantly above lettuce that is ranked 3rd but only captured 8 percent of total use (Kelly and Boyhan, 2006; Fonsah and Hudgins, 2007; Lucier and Dettmann, 2008). Out of the farm value of over $18 billion generated by the United States vegetable industry in 2007 and 2008, almost $11 billion came from the "24 top fresh vegetable and melon crops" due to the increase in price and production respectively. Again, fresh tomato consolidated its 2nd most important vegetable crop status by contributing $1.3 billion of the total, slightly below number 1 ranked head lettuce which contributed $1.4 billion (Lucier and Dettmann). Furthermore, out of the $1.65 billion that was generated by processed vegetables nationally in 2007, tomatoes alone contributed $902 million followed by sweet corn that contributed $237 million in the same time period. On the other hand, canned tomatoes contributed 72 percent of vegetable disappearance in the same time period.

At the state level, fresh tomatoes still play an important roll in the Georgia's economy. Although ranked 14th in acreage out of over 35 plus different vegetables produced in the state, the crop contributed $51.2 million out of $849 million total vegetable farm gate value, thus placing it as the 6th most important commercial vegetable crop in Georgia (Boatright and McKissick, 2008; Fonsah and Hudgins, 2007). Years 2005 and 2006 were even better years with recorded farm gate values of over $74.9 million and $72.6 million respectively (USDA/ERS Quick Stats, 2009; Fonsah and Hudgins, 2007; Boatright and McKissick, 2008).

Harvested acreages, yields, prices and production have all been fluctuating for the past decade. Several factors including natural disasters such hurricane or tropical rains, pests and diseases have been partially blamed. For instance, as high as 6,300 acres and as low as 3,500 acres were harvested in 2005 and 1998, respectively. On the other hand, reported yields have been as high as over 360 cwt in 2001, 2006 and 2007 and as low as 170 cwt in 2004 whereas prices have escalated to $45 per cwt in 2004 and as low as $20 per cwt in 2002 (USDA/ERS Quick Stats, 2009; Fonsah and Hudgins, 2007; Boatright and McKissick, 2008).

Tomato Spotted Wilt Virus (TSWV) is a disease capable of destroying an entire tomato crop if infection begins early in the season. TSWV is a serious disease capable of severely wilting the plant, reducing fruit yield, and ruining fruit quality through scarring and irregular ripening (Riley and Pappu, 2004). Management is complex and can involve various expensive tactics. For instance, reflective metalized (UV-mulch) may significantly reduce TSWV, but delay tomato maturity, thus potentially affecting price and market window. On the other hand, resistant tomato lines may eliminate damages due to TSWV, but could have negative horticultural attributes that standard TSWV-susceptible hybrids do not. Finally, TSWV can induce irregular ripening in fruit after packing, affecting post harvest costs, extrinsic quality and the overall cosmetic appearance (OCA) of the fruit (Fonsah, 2002). Although there are several management options such as reflective metallic mulch and chemicals such as imidacloprid and

Actiguard, studies have shown that a combination of all these management alternatives provides better results (Riley and Pappu, 2000, 2004, Riley, 2008; Kennedy, 2008; Olson, 2008; Riley et al., 2009a; Riley et al., 2009b).

Examples of the impact of this problem can be found in the Crop Loss Reports for Georgia (e.g. for 2003, http://www.ent.uga.edu/pubs/SurveyLoss03.pdf). For instance, this disease caused a loss of $10.3 million to tomatoes and pepper in the state of Georgia in 2003 alone. Cumulatively across vegetables, peanut and tobacco, the disease has caused over $326 million in loss in the last decade to the state. Due to the severity of TSWV, a team of 15 scientists from the University of Georgia (UGA), North Carolina State University (NCSU), Clemson University (Clemson) and University of Florida (UF) were awarded a USDA/CSREES RAMP Grant to investigate and develop a reduced risk system for managing thrips and TSWV in tomato and pepper.

Our study is aimed at providing the optimal return per unit of enterprise using estimates of the combination of available inputs used in the various management strategies. Although several management strategies have been developed, no economic analysis has been carried to determine the financial viability of these different management strategies. Thereafter, the result of the differentially developed techniques and risk-rated budgets will be used to determine which of the risk-rated thrips, TSWV and IPM decision criteria would provide superior pareto-optimal economic and financial benefit to tomato growers. The objective of this study is to develop an economic analysis of managing thrips and tomato spotted wilt virus in tomato in the southeast region of the United States using an enterprise budget (Fonsah et al. 2006; Fonsah and Hudgins, 2007; Byrd et al., 2006; Fonsah et al. 2005; Calkins and DiPietre, 1983) to compare conventional production to a production system enhanced with TSWV management tactics.

Material and Methods

These studies were conducted in 2009 at the Coastal Plain Experiment Station, Tifton, GA to simultaneously evaluate 1) different TSWV-resistant tomato cultivars, 2) reflective plastic mulch and 3) an early season Admire insecticide and Actiguard treatment program. The basic tomato production system used was raised, black plastic covered beds fumigated with methyl bromide (277 kg a.i./ha, Albemarle Corp., Magnolia, AK) with plants staked and tied at 0.6 m spacing in a single row. Fertilizer and other input treatments applied are shown in table 1. Tomatoes for the insecticide, reflective mulch and Actiguard treatments were transplanted on March16 and the cultivar test was transplanted on March 31. 1) A complete block design with four replicates was used for the cultivar test. The cultivars Tycoon (Hazera Seed Company, Coconut Creek FL), Quincy (Seminis, Saint Louis MO), BHN 444, BHN640 (BHN Research Inc, Immokalee FL) and FL47 (Seminis, Saint Louis MO) were included in this evaluation. Cultivar plots were 23 feet in length each. 2) A complete design with four replicates was used for the reflective mulch test using FL47 tomato. Plot lengths were 60 feet length plots by 6 beds with three treatment plots [black plastic (1.25 mil, North American Film, Philadelphia, PA), heat strip mulch (1.25 mil, Sunup Reflective Films/Star Metal Plating, Inc. Escondido, CA)] and solid metalized mulch (Pliant Corporation, Schaumburg, Illinois). Finally, 3) a split plot design with four replicates was used for the imidacloprid-

Actiguard test using 60 feet length plots of FL 47 tomato. The main plots were an untreated black plastic bed and an imidacloprid 10.5 fl oz product/a bed (Admire Pro, Bayer CropScience, Kansas City, KS) treated at transplant. The subplot treatments were Actiguard at transplant then 10, 20 and 30 days and an untreated check. In all of these tests, tomatoes were treated weekly in April and May with preventative fungicide treatments.

Tomatoes from the all trials were systematically harvested from 5-6 plants per plot (converted to an estimated yield per acre) on three consecutive harvests and graded using USDA standards (http://www.ams.usda.gov/standards/tomatfrh.pdf) plus an evaluation of TSWV damage. In the cultivar test, yield from the TSWV-resistant plant lines Tycoon, BHN 444, Quincy, and BHN640 were averaged for budget estimates. Also, a sub-sample of fruit of each grade size of marketable fruit from each plot was gassed with approximately 100 ppm of ethylene for 24 hours and then held for one week to assess the potential for irregular ripening in the marketable fruit. The percentage of TSWV-irregular ripened fruit, completely regularly-ripened fruit, and green to pink ripe fruit were recorded. Fruit from plants with severe TSWV infection and fruit with visible signs of TSWV at harvest were not included in the marketable fruit category. Insect damaged fruit or blossom end rot fruit also were not considered marketable. Crop cost and benefit analysis using enterprise budgets (Fonsah et al. 2006; Fonsah and Hudgins, 2007; Byrd et al., 2006; Fonsah et al. 2005) were generated to compare conventional production to the production system attained with the best TSWV management tactics used from these studies. The price data was obtained from USDA/NASS Georgia Quick Stats, 2009 which was the same source used for the yield and price of the conventional tomato production system in our calculations. We also use 8% interest rate in our variable cost (VC) and fixed cost (FC) calculations respectively.

Assumptions

There are several assumptions in the analysis of these data. First, the conventional management strategy (CMS) that was used to compare to the enhanced TSWV management strategy was developed from historical tomato production figures for the State of Georgia (Fonsah et al. 2006; Fonsah and Hudgins, 2007). The production from the enhanced TSWV management strategy was developed from replicated experimental plot production in 2009 under good growing conditions, but intense TSWV disease pressure. A conventionally treated tomato plot under these conditions (basically our check plots in 2009) performed so poorly as to be not harvestable, i.e., approaching 100% loss. Thus, we assumed that the historical budget provided a fairer comparison to the new enhanced TSWV management system.

Secondly, the yield of the TSWV-resistant plant line used for our calculations was an average of the top four TWV-resistant tomato cultivars currently being used by farmers in the southeast region, i.e., Tycoon, BHN 444, Quincy, and BHN640, only. We assumed that an average production over several of the best cultivars was a realistic, conservative estimate of potential tomato yield. The other tactics, reflective plastic mulch, Admire insecticide and Actiguard treatment program were all evaluated using the conventional-susceptible cultivar for Georgia, FL 47 where they were all shown to provide significant protection from TSWV (Riley, unpublished data). However, with a strongly TSWV-resistant tomato cultivar, the effect of these additional treatments may not be significant. Since these tactics are currently being used commercially, we included these in the budget, but we assumed that these tactics are commercially used more for insurance against damage than actual returned benefit and included the cost here to be conservative. If the commercially available host plant resistance begins to be broken, these tactics will become increasingly more necessary to prevent yield loss.

Results and Discussion

Variable Costs

There were some differences in our variable costs component due to the agricultural practices involved in the management of the Thrips and TSWV compared to the Conventional system. In cases where there was no deviation in the ag-practices, the costs were the same in both systems between the TSWV and Convention system respectively. For instance, our study result depicted that the VC of TSW-resisted line plants were $564 per acre compared to $408 for the Conventional tomato plants (Table 1). The cost of fungicide treatment was higher for TSWV management technique ($265/ac) compared to ($240/ac) for the CMS technique due to the addition of Actiguard compound needed to boost the hormonal system of the TSW-resistant line plants. The result further showed a significant difference in the total variable cost (TVC) of the UV-mulch used and/or recommended for the TSWV technique ($414/ac) as compared to the black plastic mulch used in the CMS technique which only cost $288/ac. Finally, the total pre-VC was $4,314/ac for the CMS technique and $4,663/ac for the TSWV system respectively (Byrd et al, 2007; Fonsah et al, 2006; Fonsah and Hudgins, 2007; Fonsah et al., 2007; Fonsah et al., 2008).

Table 1: Pre-harvest variable cost (PVC)/acre of producing tomatoes using CMS and TSWV Management techniques in the Southeast, USA, 2009.

Variable Cost Inputs Items	Units	Quantity	Price ($)	CMS 1/ ($)	TSWV 2/ ($)
TSW-resist line plants Conventional plants	 Thou	 4.8	117.50 85.00	 408.00	 564.00
Lime & Gypsum	Ton	1.5	108.00	162.00	162.00
Fertilizer granular	Ton	1.0	350.00	350.00	350.00
Fertilizer liquid	Ton	1.0	170.00	170.00	170.00
Metalized mulch Black Plastic Mulch	Roll 4000’	1.8	230 160	 288	414
Fumigation	Acre	200.0	2.85	570	570
Insecticide + TSW mgmt Insecticide	Appl.	21.0	25.8 24.4	 512	542
Fungicide + Actiguard Fungicide	Appl.	4.4	60.2 54.5	 240	265
Herbicide	Acre	1.9	31.34	60	60
Stakes	Thou	4.8	40	192	192
String	Acre	30	1.55	47	47
Labor, machine operation	Hrs.	5.0	7.0	35	35
Labor, production transplant	Hrs.	100.0	5.5	550	550
Crop Insurance	Acre	1.0	140.0	140	140
Consultant	Acre	1.0	70.0	70	70
Cleanup (plastic & stakes)	Acre	1.0	150.0	150	150
Machinery	Acre	1.0	25.7	26	26
Irrigation	Acre	1.0	220.8	221	221
Interest on operation capital	$	4494.3	0.08	156	169
Pre-harvest Variable Costs				4,314	4,663

1/- Conventional management strategy (CMS) variable costs.
2/- Thrips and Tomato Spotted Wilt management (TSWV) variable costs.

Harvesting and Marketing Costs

The harvesting and marketing costs component of the VC covered picking and hauling, grading and packing, container and marketing respectively. The differences in the costs were triggered by the yield since the unit cost for both CMS and TSWV technique were the same. For instance, the cost of picking and hauling was $1,875/ac for the CMS compared to $2,500/ac for the TSWV because of the variability in the quantity of cartons or yield/ac, i.e. 1,500 cartons/ac for CMS compared to 2,000 cartons/ac for TSWV (Table 2). The total harvesting and marketing cost was $5,700 for the CMS technique and $7,600/ac for the TSWV technique. As a result, the total variable cost (TVC) which is the sum of the pre-VC and the harvesting and marketing cost was $10,014/ac for the CMS while the TSWV was $12,263/acre (Table 2).

Table 2: Harvesting and Marketing cost of producing tomatoes using CMS and TSWV Management techniques in the Southeast, USA, 2009.

Variable Cost Inputs Items	Units	Quantity	Price ($)	CMS 1/ ($)	TSWV 2/ ($)
Picking and hauling	Ctn	2000 1500	1.25	1,875	2,500
Grading and packing	Ctn	2000 1500	0.85	1,275	1,700
Container	Ctn	2000 1500	0.85	1,275	1,700
Marketing	Ctn	2000 1500	0.85	1,275	1,700
Total H& M Costs			**3.8**	**5,700**	**7,600**
Total Variable Cost (TVC)				**10,014**	**12,263**

1/- Conventional management strategy (CMS) variable costs.
2/- Thrips and Tomato Spotted Wilt management (TSWV) variable costs.

Fixed Costs

The fixed cost (FC) items for both the CMS and TSWV systems were the same in our study. They included 125 HP tractor that could be used for all the tomato field operations and hauling various equipment such as turning plow, disc harrow, herbicide applicator, bedder, transplanter, cultivator and crop sprayer. In our calculations, we took into considerations the percentage of time the equipment will be utilized in the production of tomato since most famers in the southeast grow multiple crops in rotations. Our result shows that the FC of machine was $285/ac (Table 3).

On the other hand, the FC of irrigation included such items as pipe and fittings, tubing, well (6 – 8 “), pump and motor, filter and auto, storage tank and installation. We also considered cost of the equipment, life-span, depreciation, interest, tax and insurance in our calculations. The FC of irrigation was $67/ac. Due to the variability in the cost of land lease and purchase, we intentionally left if out but recognize that it is a cost whether or not a farmer owns or lease it. Overhead and management cost was 15% of total pre-variable cost which resulted to $647/ac for CMS and $699/ac for the TSWV system. Total fixed cost (TFC)/ acre was $999 for the CMS technique and $1,051 for the TSWV system respectively (Table 3). Total cost of production (TC) which is the sum of total pre-variable cost, total harvesting and marketing cost and total fixed cost was $11,013/ac for the CMS technique and $13,314/ac for the TSWV system (Table 3).

Table 3: Fixed costs per acre of producing tomatoes using CMS and TSWV Management techniques in the Southeast, USA, 2009.

Variable Cost Inputs Items	Units	Quantity	Price ($)	CMS 1/ ($)	TSWV 2/ ($)
Machinery	Acre	1	285.	285	285
Irrigation	Acre	1	67	67	67
Land	Acre	1	0	0	0
Overhead and Management	$	4,663 4,314	0.15	647	699
Total Fixed Cost /Acre (TFC)	**Acre**	**1**		**999**	**1,051**
Total Cost of Production/Acre				**11,013**	**13,314**

1/- Conventional management strategy (CMS) fixed costs.
2/- Thrips and Tomato Spotted Wilt management (TSWV) fixed costs.

Break-Even Analysis (BE)

The Break-even (BE) analysis is an economic and financial indicator that guides the farmer or any business entity on how well they are doing in each step of their standard operation procedures (SOP). Staying above or below the BE point/amount has an impact on profitability. For instance, producing above the BE yield might translate to superior profit margin under ceterus paribus conditions (all things being equal). On the other hand, a break-even variable cost above the calculated variable cost could mean inferior profitability margin, all things being equal (Fonsah, 2007). The results of our study show that the BE VC was $2.88 for CMS and $2.33 for TSWV. On the other hand, the BE yield was 1,366 cartons/ac (25 lbs) for CMS and 1,664 cartons/ac (25 lbs) for TSWV respectively (Table 4).

Table 4: Break-even analysis of producing tomatoes using CMS and TSWV Management techniques in the Southeast, USA, 2009.

Items	CMS 1/ ($)	TSWV 2/ ($)
BE Preharvt Variable Cost (25 lb cartons)	2.88	2.33
BE Harvt & Mktg Cost per 25 lb carton	3.80	3.80
BE Fixed Cost per 25 lb carton	0.61	0.53
BE Total Cost per 25 lb carton	7.29	6.66
BE Yield per Acre (29 lb cartons)	1,366	1,664

1/- Conventional management strategy (CMS) break-even costs.
2/- Thrips and Tomato Spotted Wilt management (TSWV) break-even costs.

Risk-Rated Sensitivity Analysis

The data collected and used for this study showed inconsistencies in yield and prices at different time, season and years. Due to these volatilities, the University of Georgia Agricultural and Applied Economics Department adopted a five-levels risk-rated scenarios in generating an enterprise budget namely, best, optimistic, median, pessimistic and worst case scenarios respectively (Byrd et al., 2006; Byrd et al. 2007; Fonsah, 2007; Fonsah et al., 2006, Fonsah and Hudgins, 2007; Fonsah et al, 2007; Fonsah et al., 2008). This study depicted that the "Median" net return which could be obtained 50% of the time was $2,798/ac for the TSWV system and $1,067/ac for the CMS system. The "Best" net returns of CMS system was $3,645 whereas TSWV was $6,052 almost twice as much (Table 5).

Table 5: Risk-rated sensitivity analysis of producing tomatoes using CMS and TSWV Management techniques in the Southeast, USA, 2009.

	Best	**Optimistic**	**Median**	**Pessimistic**	**Worst**
TSWV Returns 1/ Conv Returns 2/	$6,052 $3,645	$3,882 $1,926	$2,798 $1,067	$1,713 $207	$-456 $-1,512
Risk-rated % Chances	7%	31%	50%	31%	7%
Chances of Profit	TSWV CMS	90% 73%	**Net Revenue**	**TSWV** **CMS**	$2,798 $1,067

1/- Conventional management strategy (CMS) risk-rated sensitivity costs.
2/- Thrips and Tomato Spotted Wilt management (TSWV) risk-rated sensitivity costs.

Conclusion

Tomato production, marketing and trade continue to be a major player in the United States Vegetable and Melon industry and the state of Georgia in particular. Although Thrips and TSWV are major problems to growers in terms of yield, intrinsic and/or extrinsic quality, overall cosmetic appearance and production costs, this article outlined the different management strategies in which growers need to make concise production, marketing, financial and business decisions. The study also demonstrated that despite the increased cost of production associated with managing Thrips and TSWV, the increased yield and the net return are large enough incentive to compensate the tomato growers for the additional cost of production incurred.

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