Agricultural Economics Research Review
Vol. 19 July-December 2006 pp 269-280

Integrated Pest and Disease Management in Tomato : An Economic Analysis

T.M. Gajanana, P.N. Krishna Moorthy, H.L. Anupama, R. Raghunatha and G.T. Prasanna Kumar [1]

Abstract

The adoption of IPM technology in tomato using African marigold as a trap crop, root dipping of seedlings in Imidacloprid, soil application of neem/pongamia cake, spraying of botanicals like pongamia soap and bio-pesticide like *Ha NPV* has been found effective in both insect as well as disease management. The IPM technology has been found economically viable as the yield on IPM farms has been found higher by about 46 per cent, cost of cultivation has been less by about 21 per cent and the net returns have been higher by 119 per cent. The technology can be considered environment-friendly as it uses more of eco-friendly inputs and less of chemicals. The constraints like non-availability of botanicals and bio-pesticides should be addressed on priority basis to make the technology sustainable and more popular.

Introduction

Tomato (*Lycopersicon esculentum*), an important vegetable crop in India, is grown on an area of 4.58 million hectares with a production of 74.62 million tonnes. Karnataka is a major tomato-growing state with an area of 40,235 hectares and production of 11,43,425 tonnes. The most important insect pest of tomato is fruit borer, *Helicoverpa armigera* (L).

[1] Indian Institute of Horticultural Research, Bangalore-560 089, Karnataka
E-mail: gajanana@iihr.ernet.in

The financial support to the impact analysis research under the NATP (PME Cell, MM Project on 'Validation and Promotion of IPM in Vegetables') is gratefully acknowledged. The authors thank Dr S. D. Shikhamany, Director, IIHR, Bangalore, for providing the facilities to carry out the work. The support extended by Dr Lalitha Anand, Coordinator, NATP-PME Cell, IIHR, Bangalore, Dr Mruthyunjaya (PI, NATP, PME Cell), Dr Amerika Singh (PI) and Dr T. P. Trivedi (CCPI) of the Lead Centre, NCIPM, New Delhi of the MM Project, is gratefully acknowledged. The useful comments of the anonymous referee are also gratefully acknowledged.

In spite of regular spraying of insecticides, its incidence in farmers' field varies from 10 to 20 per cent and at times, this pest causes yield loss up to 40 per cent (Tiwari and Krishna Moorthy, 1984). In the absence of an effective alternative method, the farmers are over-dependant on chemicals for the management of this pest. Reduction in the efficacy of a variety of insecticides, including synthetic pyrethroids, for the management of this pest has also been reported (Srinivasan and Krishna Moorthy, 1992). An Integrated Pest Management (IPM) technology using the African marigold as a trap crop was developed at the Indian Institute of Horticultural Research, Bangalore (Srinivasan *et al*., 1993; 1994). In this technology, one row of marigold is followed by 14-16 rows of tomato and two sprays of endosulfan (0.07 %) are made. Khan *et al.* (1996) had reported that using of the African marigold as trap crop for the control of borer could give additional returns of Rs 12,809/ha over the farmers' practice. Later studies at IIHR, Bangalore, revealed that 4-6 sprays of *Helicoverpa armigera* nuclear polyhedrosis virus (*Ha NPV*) at an interval of 4-6 days, starting from the flowering stage were successful in controlling the fruit borer in tomato (Krishna Moorthy *et al.,* 1993; Mohan *et al*., 1996).

In addition to the fruit borer, leaf miner, *Liriomyza trifolii* (Burgess) and red spider mite, *Tetranychus urticae* (Koch) are the other important pests of tomato. Soil application of neem cake at 20 days after planting (DAP), sprays of neem seed powder (NSP) extract or neem soap or pongamia soap are recommended for the management of these pests (Krishna Moorthy *et al.*, 2003a). Early blight (*Alternaria solani*), late blight (*Phytropthora parasistica*) and powdery mildew (*Leveillula taurica*) are the major fungal diseases of tomato. Leaf curl, a insect vector (white fly, *Bemisia tabaci*) transmitted virus disease, is another major problem in tomato cultivation. Following of the recommended spacing (90 cm × 60 cm for hybrids), staking, removal of all the leaves up to 25 cm from the plant base and all severely-diseased leaves are important cultural practices recommended for disease management in tomato. In addition, sprays of need-based fungicides are required for managing these fungal diseases. Using tolerant hybrids/varieties, root dipping in Imidacloprid just before transplanting and spraying it at 15 days after planting (DAP), and uprooting the plants showing leaf curl disease are the management strategies for tomato leaf curl virus disease (TLCV).

The IPM technology as described above was demonstrated in farmers' fields in the Kesthur village complex under the National Agriculture Technology Project (NATP), "Validation and Promotion of IPM Technology" in the Doddaballapur taluk of Bangalore district during the year 2000-01. This IPM was highly successful in reducing the number of synthetic pesticide applications and increasing the yield and returns to the farmers. Therefore, during the year 2003, it was extended to the Chikkaballapura taluk of Kolar district in Karnataka. The impact of the IPM was evaluated by NATP "Prioritization, Monitoring and Evaluation (PME) Cell" of IIHR, Bangalore. The acceptance, adoptability and sustainability of this IPM were also enumerated during this impact assessment. The results of this study are reported in this paper.

Database and Methodology

Study Area, Sampling and Data Collection

Since the IPM technology had been demonstrated in the Doddaballapur taluk in Bangalore Rural district and the Chikballapur taluk in Kolar district, these taluks were selected as the study area. The Kesthur village complex consisting of 8 villages in the Doddaballapur taluk and 6 villages in the Chikkaballapur taluk were selected for collection of data. In these villages, tomato is commercially cultivated and the farmers generally cultivate leaf curl tolerant F1 hybrids and plants are invariably staked. Data were collected from 3-4 farmers in each selected village of the study area. Finally, data were collected from 46 randomly selected sample farmers on input-use pattern, costs and returns by the survey method using a specially designed schedule. Information on the adoption of the components of IPM was also collected. The farmers were post-stratified as IPM and non-IPM farmers, depending upon whether they followed the IPM practices or not. Information about the adoption of IPM and the constraints in its adoption was also elicited from the sample farmers. The components of IPM technology in tomato were:

(a) Dipping of roots of the seedlings in Imidacloprid, spraying of Imidacloprid 15 DAP and physical removal of TLCV-affected plants

(b) Wider spacing of 90 cm × 60 cm

(c) Use of the African marigold as trap crop in the ratio of 1:16 plants

(d) Soil application of neem cake after 20 DAP @ 250 kg/ha

(e) Use of botanicals like Pongamia soap and neem-seed powder (NSP), and

(f) Use of biopesticide *Ha NPV* @ 250 LE/ha three times, at 28,35 and 42 DAP.

Adoption of IPM Technology

An index was developed to assess the adoption of IPM technology by the farmers, considering its 6 components[2]. Scores were given to each component according to the extent of its use. Based on the following practice completely, partially, or not at all, the scores of two, one and zero were given, respectively for each component. Thus, a farmer, who had followed all the six components completely, had a score of 12 and the one who had not followed any of these components, had a score of zero. The score 6 was fixed to demarcate the farmers as IPM adopters or non-adopters[3].

Assessment of Economic Impact

The partial budgeting technique was used to assess the economic impact of adoption of IPM technology (Birthal, 2003). The important impact indicators used were yield, cost of cultivation, cost of production and net returns and benefit-cost ratio (BCR). The significance of difference in the indicators between IPM and non-IPM adopters was studied using the t-test. The IPM technology was considered superior if the profits were higher compared to those in farmers' practice. This could be written symbolically as:

$\Pi (T) > \Pi (F)$

i.e. $TR (T) - TC (T) > TR (F) - TC (F)$

or

$TR (T) - TR (F) > TC (T) - TC (F)$

$\Delta R (T) > \Delta C (T)$

where,

TR (T) = Total returns from IPM technology

TR (F) = Total returns from farmers' practice

TC (T) = Total cost incurred by IPM farmers

TC (F) = Total cost incurred by non-IPM farmers

ΔR (T) = Change in the revenue due to adoption of IPM

ΔC (T) = Change in the cost due to adoption of IPM

---

2 Discussion with the scientists in the Divisions of Entomology and Pathology of IIHR, Bangalore, indicated that all the components were equally important in controlling the pests and diseases.

3 Tamizheniyan *et al*. (2003) used the index for studying the adoption of IPM in paddy.

Further,

$TR = \Sigma Pi.Yi$

$TC = \Sigma Pj.Xj + a$

where

Pi = Price of the ith output (i = 1,…,n)

Yi = Quantity of the ith output (i =1,…..,n)

Pj = Price of the jth input (j =1….,m)

Xj = Quantity of the jth input (j =1…..,m)

a = Fixed costs like rental value of land, depreciation, etc.

Impact on Health

To understand the beneficial effects of IPM on health, information was collected about the type of health hazards faced by the farmers during and after the spraying of chemicals.

Constraints

The main constraints faced by the farmers in the adoption and spread of IPM (as opined by farmers) were also elicited from the sample farmers.

Results and Discussion

Adoption of IPM

Based on the adoption index, 29 farmers were categorized as IPM adopters and 17 as non-adopters. The extent of adoption was also assessed in terms of different components of technology and is reported in Table 1. It may be seen from Table 1 that the overall adoption of IPM was 75 per cent. It may also be observed from the table that wider spacing (94%) and neem cake application (65%) components of IPM technology were followed by some of the non-IPM adopters also, which indicates the scope for the spread of the technology. The component-wise adoption of IPM is discussed below.

Root dipping of tomato seedlings in Imidacloprid: This is an essential component of IPM and it ensures control of vector-transmitted TLCV. It was adopted by about 55 per cent of the IPM farmers. The adoption rate was slightly lower of this component than other IPM components. In fact, many of the farmers had stopped raising their own seedlings and were purchasing the seedlings raised in the nursery (There are more than 200 nurseries in and around Bangalore). The roots of the seedlings were in coco

Table 1. Extent of adoption of IPM components

(in per cent)

Sl No.	Components	IPM adopters	Non-adopters
1	Root dipping of seedlings in Imidacloprid	55.17	-
2	Trap crop usage	68.96	17.65
3	Wider spacing (90 cm × 60 cm)	68.96	94.11
4	Soil application of neem cake	86.20	64.70
5	Ha NPV application	93.10	-
6	Pongamia soap/NSP application	79.30	17.65
	Adoption index	74.66 (8.96)*	30.42 (3.65)*

*Figures within the parentheses indicate the adoption scores

pith and were in the form of a ball which helped the development of roots. This ball was a part of the seedlings and had to be planted intact. This helped in a better establishment of seedlings. If the root dipping in Imidacloprid was followed, the ball got disturbed and establishment became difficult. Some farmers had not followed the root dip and hence the rate of adoption was less of this than other components.

Wider spacing: Wider spacing of 90 cm × 60 cm was recommended for the management of TLCV and fungal diseases. It was interesting to note that the non-IPM adopters also followed this component, which indicated the awareness of farmers about this disease management component.

Trap crop usage: The African marigold was used as a trap crop for controlling the activities of fruit borer. This component though was used by about 69 per cent IPM adopters, only 31 per cent of them followed the recommended rows. The others used it as a border crop. It was noted that about 18 per cent of the non-IPM adopters also used marigold as the border crop. Traditionally, the farmers have been using this with the belief that marigold flowers attract insects from the tomato crop and save the main crop.

Use of botanicals: Botanicals like pongamia/neem soap have been advocated to control the pests of tomato. About 79 per cent of the IPM adopters used this component. It was interesting to note that about 18 per cent of the non-IPM adopters also used pongamia soap which was indicative of the demonstration effect on them. However, neem soap was not available to them through any agency other than IIHR, Bangalore.

Soil application of neem/pongamia cake has been traditionally followed by the farmers with the belief that it controls the soil-borne pathogens as well as red ants. It was found that even 65 per cent of the non-IPM adopters used this component which augurs well for the spread of IPM.

Use of bio-pesticide (*Ha NPV*): About 93 per cent of the IPM farmers followed this component of IPM and were happy with the results, as it could control the fruit borer in some cases even without the trap crop. However, the *Ha NPV* is not readily available except through only 3 pesticide shops in the Bangalore and Kolar districts. Quality of *Ha NPV* is very crucial for the effective control of pests.

Economic Impact of Adoption of IPM Technology

The adoption of IPM assessed in terms of yield, returns and cost, revealed a definite positive economic impact of adoption of IPM technology on tomato farms. The yield was higher on IPM (65.35 t/ha) than non-IPM (44.72 t/ha) farms. The cost of cultivation was lower on IPM (Rs 86641/ha) than non-IPM (Rs 1,10,008/ha) farms. Consequently, the cost of production was lower on IPM (Rs 1.32/kg) than non-IPM (2.46/kg) farms. The net returns were higher by Rs1,25,476/ha, indicating an increase of 119 per cent due to adoption of IPM. The BCR was higher at 3.66 for IPM than non-IPM farmers at 1.95.

Impact of Adoption of IPM on Pesticide-use

The impact of adoption of IPM in tomato was assessed in terms of reduction in number and quantity of chemical sprays on the tomato crop.

Table 2. Indicators of impact of adoption of IPM technology in tomato

Sl. No.	Indicators	Adopters	Non-adopters	Difference, %
Economic analysis				
	No. of sample farmers (No.)	29	17	-
	Yield (kg/ha)	65,349	44,715	46.15*
	Total returns (Rs/ha)	3,17,375	2,15,266	47.43
	Cost of cultivation (Rs/ha)	86,641	1,10,008	-21.24*
	Net returns (Rs/ha)	2,30,734	1,05,258	119.21*
	Cost of production (Rs/kg)	1.32	2.46	
Partial budget analysis				
	Added returns (Rs/ha)	1,02,109	-	
	Change in cost (Rs/ha)	-23,367	-	
	Added net returns (Rs/ha)	1,25,476	-	
	BCR	3.66	1.95	

* Significant at 5% level

Table 3. Impact of IPM on pesticide-use

Sl No.	Plant protection indicators	Adopters		Non-adopters		Difference, %	
		Avg. No./ farm	Qty/ ha	Avg. No./ farm	Qty/ ha	No.	Qty
A. Sprays							
1	Insecticides (litre)	1.69	1.35 (0.43)	7.70	9.51 (3.09)	-78.05*	-85.80*
2	Fungicides (kg)	0.89	1.39 (0.79)	6.70	11.24 (6.86)	-86.72*	-87.63*
3	Botanicals (kg)	1.00	3.96	-	-	-	-
4	Bio-pesticide, *Ha NPV* (litre)	2.13	0.47	-	-	-	-
	Total	5.71	-	14.40	-	-60.35	-
B. Cost of plant protection (Rs/ha)		4,165		16,288		-74.43*	

* Significant at 5% level
Note : Figures within the parentheses are a.i. of pesticides used

The total number of sprays was reduced from 14.40 to 7.01, including the application of botanicals and biopesticides (Table 3). The number of chemical sprays was as low as 3 on IPM farms, indicating the beneficial effects of the IPM technology. The impact of adoption of IPM was more pronounced in terms of reduction in quantity of chemical pesticides. The insecticide used was as high as 9.51 litres/ha on non-IPM farms as compared to only 1.35 litres/ha on IPM farms. In the case of fungicide, it was 11.24 kg/ha on non-IPM farms and only 1.39 kg/ha on IPM farms. The technical grade equivalents (active ingredient) of the chemical pesticides used was much less on IPM farms (0.43 litre of insecticides and 0.79 kg of fungicides as against 3.09 litre and 6.86 kg, respectively) than non-IPM farms. The reduction in the quantity of chemical-use brought down the cost of plant protection by about Rs12,1223/ha. The difference in the cost of insecticides and fungicides between IPM and non-IPM farms was found to be statistically significant at 5 per cent level of probability.

Impact of IPM on Labour-use

The labour used on IPM farms was less than that on non-IPM farms (Table 4). A significant reduction in labour-use was in plant protection operation and it was mainly due to less number of sprays, from 14 to 5 sprays. The man-days for harvesting were higher on IPM farms, and this could be attributed to the higher yields obtained by them. However, the

Table 4. Labour-use on IPM and non-IPM farms in the cultivation of tomato

(man-days)

Operations	IPM	Non-IPM
Nursery	2.61	3.33
Manure	12.64	10.40
Fertilizer	10.66	6.57
Transplanting	11.98	9.80
Earthing up	16.28	17.56
Staking	90.07	109.22
Plant protection	61.97*	122.47
Weeding	40.88	58.17
Harvesting	202.34	133.58
Total	449.43	471.10

* Significant at 5% level

difference was not statistically significant. Thus, it cannot be inferred conclusively that IPM was labour-saving technology, except in the plant protection operation.

Impact of IPM on Reduction of Health Hazard and Contribution to Environment

The adoption of IPM technology ensured the use of less chemicals and more eco-friendly inputs like botanicals and bio-pesticides. The farmers felt that the use of eco-friendly inputs had brought down the incidence of health hazards associated with the spraying of chemicals. In fact, about 53 per cent of the non-IPM adopters reported health hazards like headache, eye irritation, stomach upsets, etc. in the labourers due to spraying of chemical pesticides. None of the IPM adopters expressed the incidence of such health hazards. The share of eco-friendly inputs (farmyard manure, soil application of neem cake and pongamia cake) and spraying of bio-pesticides like pongamia soap and *Ha NPV* was more on IPM (6.21%) than non-IPM (4.5%) farms. This indicates that IPM can also contribute to the reduction of environmental pollution. The farmers also revealed that spraying of pongamia soap had improved the appearance of the produce as it imparted a luster to it.

Constraints

Though IPM technology was found useful in enhancing the yield, reducing the cost and increasing the returns, certain constraints were also

Table 5. Share of eco-friendly inputs on IPM and non-IPM farms

(Rs/ha)

Sl No.	Particulars	Adopters	Non-adopters
1	Cost of eco-friendly inputs *	5,527	5,347**
2	Total cost of cultivation	86,642	1,10,009
3	Share of eco-friendly inputs (%)	5.58	4.66

* Eco-friendly inputs include FYM, neem and pongamia cake and botanicals like neem/pongamia soap and bio-pesticide like *Ha NPV.*

**Non-adopters had not used botanicals and bio-pesticides, but had used eco-friendly inputs like neem and pongamia cakes.

reported by the farmers in the adoption and spread of this technology. It was observed that about 69 per cent of the farmers grew the trap crop but only 31 per cent of them followed the recommended rows of trap crop and tomato. The major constraints in adoption of the trap crop were the lack of planning in preparing marigold nursery before sowing of the main crop and fear of losing the yield due to reduction in the number of rows of main crop. The non-availability of botanicals like pongamia soap, NSP and *Ha NPV* at local pesticide shops was another constraint. The quality of botanicals and bio-pesticides being important for the success of IPM, their non-availability in desired purity also acts as a constraint in the adoption and spread of IPM.

It was observed that though many bio-pesticide firms were manufacturing *Ha NPV*, it was not readily available to the farmers. Only three pesticide shops in the Bangalore and Kolar districts sell this product and only one firm sells pulverized neem-seed powder. The neem soap and pongamia soap were available only through IIHR, Bangalore. The support by the state agriculture and horticulture departments in promoting the IPM is lacking at farmers level. The IPM can only be promoted by providing incentives to the IPM farmers and making inputs readily available through cooperative societies.

Conclusions

The IPM technology with African marigold as a trap crop and sprays of *Ha NPV,* neem soap, pongamia soap and NSP and soil application of neem cake for the management of the major insect pests, fruit borer and leaf miner, in tomato and root dipping of tomato seedlings in Imidacloprid, wider spacing and physical removal of TLCV-affected plants has been found effective. The technology is economically viable as the cost of cultivation is less and the returns are higher on IPM than non-IPM farms. The health hazards associated with the indiscriminate spraying of chemicals have been found absent on IPM farms and the IPM technology could be termed as environment-friendly. The technology needs to be popularized and made sustainable by addressing the constraints of availability of botanicals and bio-pesticides and the trap crop seeds at the time of sowing of the main crop. Since management of fruit borer has been possible with *Ha NPV* sprays, trap crop may be an option for the farmers.

References

Birthal, P.S., (2003) Economic potential of biological substitutes for agrochemicals, *Policy Paper No. 18,* New Delhi: National Centre for Agricultural Economics and Policy Research.

Khan, H.K., K.N. Chandre Gowda and G.N. Nagaraja, (1996) Economic analysis of IPM practices in hybrid tomato, *Agricultural Banker*, **20**(1): 38-41.

Krishna Moorthy, P.N., K. Srinivasan, K.S. Mohan, M. Mani and C. Gopalakrishnan, (1993) Integrated management of *Helicoverpa armigera* on tomato, *Abstract of Proceedings of Golden Jubilee Symposium on Horticultural Research: Changing Scenario,* Horticultural Society of India, New Delhi, pp 258.

Krishna Moorthy, P.N., N.K. Krishna Kumar, Girija Ganeshan, A.T. Sadashiva and S.S. Hebbar, (2003a) Integrated pest management in tomato cultivation*, IIHR Extension Bulletin (NATP) – 02,* IIHR, Bangalore

Krishna Moorthy. P.N., N.K. Krishna Kumar, S. Prabhu Kumar, R. Raghunatha and G.T. Prasanna Kumar, (2003b) Validation of IPM of tomato fruit borer using NPV sprays and marigold as trap crop. In: *Proceedings of the Symposium on Biological Control of Lepidopteran Pests*, Eds: P.L. Tandon, C.R. Ballal, S.K. Jalali and R.J. Rabindra, Bangalore, pp. 261-265.

Mohan, K.S., R. Asokan and C. Gopala Krishnan, (1996) Isolation and field application of a nuclear polyhedrosis virus for the control of fruit borer *Helicoverpa armigera* (Hubner) on tomato. *Pest Management in Horticultural Ecosystems*, **2**(1): 1-8.

Srinivasan, K. and P.N. Krishna Moorthy, (1992) Changing scenario of pest problems in solanaceous and leguminous vegetables and their management, In: *Proceedings of the National Seminar on Changing Scenario in Pests and Pest Management in India*, Eds: H.C. Sharma and M. Veerabhadra Rao, Central Plantation Crops Research Institute, pp.103-115.

Srinivasan, K., P.N. Krishna Moorthy and T.N. Raviprasad, (1993) Evaluation of different trap crops for the management of fruit borer, *Helicoverpa armigera* (Hubner) on tomato, *Abstract of Proceedings of Golden Jubilee Symposium on Horticultural Research: Changing Scenario*, Horticultural Society of India, New Delhi, pp. 259.

Srinivasan, K., P.N. Krishna Moorthy and T.N. Raviprasad, (1994) African marigold as a trap crop for the management of the fruit borer *Helicoverpa armigera* on tomato. *International Journal of Pest Management*, **40**(1): 56-63.

Tamizheniyan, S., K.B. Umesh and Vijesh V. Krishna, (2003) Integrated pest management in rice production in Tamil Nadu: A resource economic analysis, *Agricultural Economics Research Review*, **16**(1): 1-10.

Tiwari, G.C. and P.N. Krishna Moorthy, (1984) Yield loss in tomato caused by fruit borer, *Indian Journal of Agricultural Sciences*, **54** : 341-343.