Indian Journal of Agricultural Sciences **82** (12): 1075–8, December 2012

Impact of biopesticide formulation on tomato (*Lycopersicon esculentum*): economics and environmental effects

SUMITRA ARORA[1], ASHOK K KANOJIA[2], ASHOK KUMAR[3], H R SARDANA[4] and SUSHEEL KUMAR SARKAR[5]

National Centre for Integrated Pest Management, LBS Bhawan, Pusa Campus, New Delhi 110 012

Received: 30 January 2012; Revised accepted: 17 August 2012

Key words: Biopesticide formulation, Cow urine-based indigenous knowledge, EIQ, Pest control, Tomato

Tomato (*Lycopersicon esculentum* Mill.) is attacked by number of insect pests and is susceptible to a variety of diseases (Pandey *et al*. 2006; Reddy *et al*. 2007) and it consumes huge amount of pesticides. Large doses of pesticides are applied on tomatoes crop to prevent losses due to insect pests (Yardlm and Edwards 2003), which are harmful to environment besides uneconomical. This paper presents assessment of economics and Environmental Impact Quotient (EIQ) of indigenously prepared Biopesticide formulation (BPF) in comparison with organic, IPM and non-IPM programs of tomato crop.

The BPF utilized was comprising *Phyllanthus emblica* (amla, 4%) fruit, *Curcuma zedooria* (turmeric, 6%), Allum (phitkari, 5%), *Allium cepa* (onion, 3.5%) bulb, *Allium sativum* (garlic, 4%) bulb, *Calotropis procera* (5%). Fresh cow-dung extract (3%), *Lycopersicon esculentum* (Tomato, 6%) leaf extract, *Ferula narthexboiss* (2%), *Azadirachta indica* leaves (5.5%), *Ocimum canum* (tulsi leaves, 4%), cow urine (52%).

The response of tomato crop to different treatments of BPF was observed in field trials at IARI, New Delhi during 2006–07 and 2007–08 (Arora *et al*. 2012). The tomato crop (Pusa Hybrid 2) was raised with six treatments including control each in triplicate. The treatments were BPF @ 5%; BPF @ 5% + Organic; BPF @ 10%; BPF @ 10% + Organic; and Organic. All the five treatments were on residual with zero input and control with no treatment. The plot size was 3 × 3.6 m^2 with row-to-row and plant-to-plant distance as 50 cm. For organic treatment, a uniform application of vermicompost @ 6 tonnes/ha was made in all the plots, ten days prior to transplanting. Two sprays of neem oil @ 3% were applied at flowering and fruiting stage of organic treated plots. The BPF was applied twice @ 3% at nursery stage followed by its four sprays @ 5 and 10%; one each at flowering, fruiting and two in between (at an interval of 20 days) maturing stage (Kanojia *et al*. 2008). The crop was monitored for its pest incidence population by observing fruit damage data before and after every treatment.

For comparative studies, the IPM and non-IPM tomato crop (Sartaj variety) was also raised under same weather conditions with different IPM interventions (Table 1).

The Environmental Impact Quotient (EIQ), which has been used in this study, is an indicator to assess toxicity of individual pesticide active ingredient and combination of pesticides used, developed at Ohio University (Kovach *et al*. 2010). Over 450 pesticides (insecticides, fungicides, herbicide, botanicals and bio-pesticides) are being evaluated and reported for active ingredient toxicity considering various criteria (http://www.nysipm.cornell.edu) under this developed model. The EIQ model is regarded as relatively easy and has been frequently presented in the scientific literature as a useful means to estimate potential environmental hazards associated with agricultural pesticide use (Gallivan *et al*, 2008). Furthermore, the EIQ approach permits the integration of several important environmental and human health impacts into one value that could be reduced through greater use of IPM technologies and practices (Maud *et al*, 2001; Mazlan and Mumford 2005, Badenes-Perez and Shelton 2006, Cross and Edwards-Jones 2006, Morse *et al*. 2006, Greitens and Day 2006, Kleter *et al*. 2007, Stenrod *et al*. 2008, Kovach *et al*. 1992).

To account for different formulations of the same active ingredient and different use patterns, a simple equation called the EIQ Field Use Rating (FUR) was used, where:

FUR= EIQ (Inherent toxicity) of pesticide × % active ingredient in formulation × Rate of application of pesticide × number of application of a pesticide

*Short note

[1]Senior Scientist (e mail sumitraarora@hotmail.com), NCIPM, New Delhi; [2]Scientist (e mail kanojia.ak@mail.com), NCIPM, New Delhi; [3]Principal Scientist (e mail akagronomy@gmail.com), IARI; [4]Principal Scientist (e Mail hrsardana@rediffmail.com), NCIPM, New Delhi; [5]Scientist (e Mail sarkar82@gmail.com), IASRI, New Delhi.

Table 1 Assessment of EIQ Field use ratings based on application of pesticides

Stage of application	Pesticides/ biopesticides/ bioagents applied	Active ingredient in formulation	Rate of application/ha	No. of applications	EIQ total of active ingredient	Field use rating
IPM field data						
Nursery treatment						
soil	*Trichoderma harzianum*				0	0
	Neem cake	0.1	250 kg/ha	1	12.10	302.5
Seed treatment	*T. harzianum*		4 g/ha	1	0	0
	Copper oxychloride	50 WP	1.0 kg/ha	1	NA	
Main field						
Seedling treatment	Imidacloprid	17.8 SL	100 ml/ha	1	36.71	65 343.8
	NSKE	0.1%	5% (5 l/ha)	2	12.10	12.10
	Trichogramma chilonis		1.0 lakh/ha	4	0	0
	HaNPV	1×10^9	250 LE (250 ml/ha)	2	0	0
	Emamectin benzoate	5 WDG	250 g/ha	2	26.28	65 700
	Ridomyl MZ (metalaxyl+ mancozeb=8 + 64% WP)	78 WP	1.0 kg/ha	2	19.07	2 974.92
Total environmental impact						134 333.32
Non-IPM fields						
Nursery treatment						
	captan	50 WP	1 kg/ha	2	15.77	1 577
	Mancozeb	75 WP	1 kg/ha	1	25.72	1 929
Main field/crop						
	Endosulfan	35 EC	2 l/ha	2	38.55	5 397
	Cypermethrin	25 EC	250 ml/ha	2	36.35	454 375
	Profenophos	50 EC	2 l/ha	1	59.53	5 953
	Indoxacarb	14.5 SC	500 ml/ha	2	31.19	452 255
	Quinalphos	25 EC	2 kg/ha	1	42.86	2 143
	Ridomyl	78 WP	1.0 kg/ha	1	19.07	1 487.46
	Dithane M-45	75 WP	1.0 kg/ha	2	25.72	3 858
	Methomyl	40 SP	1.0 kg/ha	1	22.0	880
Total environmental impact					929 854.46	
Organic fields						
	Neem oil	0.25%	0.6 l/ha	2	12.1	3.84
ITK treated BPF					0	0
BPF@ 5%						
Nursery treatment	Neem leaves (Azadirachtin)	0.000275	5 %	2	12.1	0.033275
Main field/Crop	Neem leaves (Azadirachtin)	0.000275	5 %	4	12.1	0.06655
BPF @ 10%						
Nursery treatment	Neem leaves (Azadirachtin)	0.00055	10 %	2	12.1	0.1331
Main field/Crop	Neem leaves (Azadirachtin)	0.00055	10 %	4	12.1	0.2662

For comparing different treatments, EIQ Field Use Ratings and number of applications throughout the season were determined for each pesticide (Table 1).

Benefit/cost (B/C) ratio, was calculated on the basis of cost of cultivation for the crop (Table 2). For BPF and organic treated trials, no input was given to fields, the tomato crop was raised on residuals (residues left from previous crop), while for IPM and non-IPM trials, fertilizers as per recommended dosages, were applied during field preparation stage.

Data analysis for EIQ field use ratings (Table 1) shows that the treatments with BPF and organic inputs have the least values as compared with IPM and non-IPM. Although IPM experiments have high EIQ field use ratings (FUR) but it is far below than values in check/non-IPM field trials. The high FUR (> 130 000) in IPM trials is for the use of single application of imidacloprid and two sprays of emamectin benzoate, active ingredients of which have high toxicity

Table 2 Economic analysis of tomato crop

Treatment	Yield (2006–08)										Average B/C ratio for 2006–08
	2006–07					2007–08					
	Marketable fruits (tones/ha)	Cost of production/ ha (₹)	Returns/ ha (₹)	Income (₹)	B : C ratio	Market-able fruits (tones/ha)	Cost of production/ ha (₹)	Returns/ ha (₹)	Income (₹)	B/C Ratio	
T_1 untreated (control)	15.22	17 600	6 8625	51 025	3.8:1	14.29	17 600	64 305	46 705	3.6:1	4:1
T_2 BPF @ 5%	22.28	21 200	10 0260	79 060	4.7:1	23.73	21 200	1 06 785	85 585	5:1	5:1
T_3 BPF@ 5% + Organic	22.22	31 100	99 990	68 890	3.2:1	23.04	31 100	103 680	72 580	3.3:1	3:1
T_4 BPF @ 10%	36.44	23 600	163 980	140 380	6.9:1	35.17	23 600	158 265	134 665	6.7:1	7:1
T_5 BPF@ 10% + Organic	33.56	33 500	151 020	117 520	4.5:1	31.05	33 500	139 725	106 225	4:1	4:1
T_6 Organic (on residual)	17.51	27 500	78 795	51 295	2.8:1	17.23	27 500	77 535	50 035	2.8:1	3:1
IPM	19.04	44 487.5	85 680	41 192.5	1.9:1	35.13	52 688.7	158 085	105 396.3	3.8:1	
Non-IPM	17.12	46 499.5	77 040	30 540.5	1.6:1	32.04	54 480.6	144 180	89 699	3.5:1	

value. The FUR value for non-IPM trials are observed to be extremely high (> 900 000) for many reasons. It is very interesting to observe that profenophos and quinalphos have highest active ingredient toxicity as per their EIQ values, but their FUR is quite low compared with other molecules. Cypermethrin and indoxacarb insecticides have comparatively low EIQ values but they are leading to very high FUR values due to their % active ingredient and high dosage values with two applications. On comparing different pesticides within an IPM treatment, NSKE is observed to be best followed by ridomyl; while for non-IPM treatment, the safest pesticide is methomyl followed by ridomyl and quinalphos for main crop. For organic and BPF treatments, the FUR values are negligible for not inclusion of any synthetic pesticide application. These two treatments therefore strongly favour safety of environment for tomato crop.

Apart from environmental safety, which remains first priority, the economics part has also to be considered for good crop yield. Although the IPM and non-IPM trials recorded crop yield at par with BPF treatment (@10%) but their cost of production was quite high leading to low B/C ratio (Table 2). The cost of production in case of organic and BPF treatments was significantly lower for both the years because of no application of costly synthetic pesticides. The economic analysis using ANOVA of all treated fields (Table 3) indicates that treatment T_4 (BPF@ 10%) is significantly different from any other treatment and considered as the best treatment with highest yield and B/C ratio. The treatment T_5 (BPF@ 10% + organic) and T_2 (BPF@ 5%) are not significantly different from each other. Similarly T_3 (BPF@ 5% + organic) and T_6 (organic) are not significantly different from each other. T_1 (control, untreated), IPM and non-IPM trials are not significantly different from each other. Out of all treatments T_4 is observed as the best with promising results. The organic plots, although treated with neem and vermicompost did not show any significance but better than control plots and at par with IPM and non-IPM trials. The

Table 3. Statistical economic analysis for field data of tomato crop t Tests (LSD) for profit

Means with the same letter are not significantly different.

t Grouping		Mean	N	trt
	A	134 632	3	t4
	B	106 207	3	t5
	B			
C	B	85 553	3	t2
C				
C	D	72 567	3	t3
	D			
E	D	50 032	3	t6
E				
E		46 692	3	t1
E				
E		45 541	3	ipm
E				
E		33 566	3	nipm

IPM and non-IPM trials are also not found significantly different because of almost same cost of production.

SUMMARY

The indigenously prepared biopesticide formulation (BPF) @ 10% proved to be the best for tomato crop with lowest EIQ-field use ratings resulting in least or negligible impact on environment. The lowest economics involved proves its high social acceptance. Therefore there is a need to opt traditional knowledge as essential and alternate component of pest management, not only for tomato crop, but also to all major crops, to reduce the load and impact of synthetic chemical pesticides for safer environment. If any pesticide schedule or plant protection activity is able to reduce economics involved in the programme along with minimum total EIQ-FUR level, it would definitely add value to the standard of living of farmers by making that technology, socially acceptable.

REFERENCES

Arora, Sumitra, Kanojia, Ashok K, Kumar Ashok, Sahu, Vikrant and Mogha Navin. 2012. Bio-pesticide Formulation to control Tomato lepidopteran pest menace. *Current Science* **102** (7): 1051–7, 10 April 2012.

Badenes-Perez F R and Shelton A M. 2006. Pest management and other agricultural practices among farmers growing cruciferous vegetables in the central and western highlands of Kenya and the western Himalayas of India. *International Journal of Pest Management* **52** (4): 303–15.

Cross P and Edwards-Jones G. 2006. Variation in pesticide hazard from arable crop production in Great Britain from 1992 to 2002: Pesticide risk indices and policy analysis. *Crop Protection* **25**(10): 1101–8.

Gallivan G J, Berges H and McGee B. 2008. Evaluation of the changes in pesticide risk. research project SR9128: Survey of pesticide use and evaluation of the changes in pesticide risk on agricultural crops in Ontario (2005). http://www.agcare.org/File.aspx?id=94b98a8e-8ec1-4314-a906-ca5eca7a435e (accessed 11 June 2008).

Greitens T J and Day E. 2006. An alternative way to evaluate the environmental effects of integrated pest management: pesticide risk indicators. *Renewable Agriculture and Food Systems* **22** (3): 213–22.

Kanojia A K, Arora, Sumitra and Singh, Ranbir. 2008. An indigenous bio-pesticide enhances tomato yield. *ICAR News* **14** (1): 6.

Kleter G A, Bhula R, Bodnaruk K, Carazo E, Felsot A S, Harris C A, Katayama A, Kuiper H A, Racke K D, Rubin B, Shevah Y, Stephenson G R, Tanaka K, Unsworth J, Wauchope R D and Wong S. 2007. Altered pesticide use on transgenic crops and the associated general impact from an environmental perspective. *Pest Management Science* **63**: 1107–15.

Kovach J, Petzoldt C, Degni J and Tette J. 1992. A method to measure the environmental impact of pesticides. *New York's Food and Life Sciences Bulletin* **139**: 1–8.

Kovach J, Petzoldt C, Degni J and Tette J. 2010. *A Method to Measure the Environmental Impact of Pesticides. IPM Program*, Cornell University, New York State Agricultural Experiment Station Geneva, New York. Dept. Entomology, Ohio Agricultural Research and Development Center, Madison Ave., Wooster.

Maud J, Edwards-Jones G and Quin F. 2001. Comparative evaluation of pesticide risk indices for policy development and assessment in the United Kingdom. *Agriculture, Ecosystems and Environment* **86**: 59–73.

Mazlan N and Mumford J. 2005. Insecticide use in cabbage pest management in the Cameron Highlands, Malaysia. *Crop Protection* **24**(1): 31–9.

Morse S, Bennet R and Ismael Y. 2006. Environmental impact of genetically modified cotton in South Africa. *Agriculture, Ecosystems and Environment* **117**: 277–89.

Pandey A Kumar, Namgyal D, Mehdi M, Mir MS, Shikh Bilal Ahmad. 2006. A case study : Major insect pest associated with different vegetable crops in cold arid region Ladakh, of Jammu and Kashmir. *Journal of Entomological Research* **30**: 169–74.

Reddy S G, Swarna, Sharma Debi, Krishna Kumar N K. 2007. Residues of insecticides on sweet pepper and tomat grown under greenhouse and open field cultivation. *Pesticide Research Journal* **19**: 239–43.

Stenrod M, Heggen H E, Bolli R and Eklo O M. 2008. Testing and comparison of three pesticide risk indicator models under Norwegian conditions: A case study in the Skuterud and Heiabekken catchments. *Agriculture, Ecosystems and Environment* **123**: 15–29.

Yardlm E N and Edwards C A. 2003. An economic comparison of pesticide application regimes for processing tomatoes. *Phytoparasitica* **31** (1): 51–60.