J. Hortl. Sci.
Vol. 4 (2): 191-194, 2009

Short communication

Comparative study of pesticide residue pattern in vegetables grown using IPM and non-IPM practices

Debi Sharma, P.N. Krishna Moorthy[1] and A. Krishnamoorthy[1]
Division of Soil Science & Agricultural Chemistry
Indian Institute of Horticultural Research, Hessaraghatta Lake P.O.
Bangalore -560089, India.
E-mail: dsharma@iihr.ernet.in

ABSTRACT

Pesticide residue persistence pattern in three vegetable crops, viz., tomato, cabbage and cauliflower, cultivated following previously developed pesticide residue-free IPM packages, was compared with a crop cultivated under conventional or non - IPM conditions. It was observed that vegetables grown as per IPM practices were safer to consume at harvest compared to those grown as per conventional cultivation practices, with chemical control as the sole means of plant protection. Pesticide residues, if present, were mostly in trace amounts (< 0.01 ppm) in vegetables grown as per IPM practices, except the residues of methomyl and monocrotophos in cabbage, where slightly higher levels of pesticides were observed.

Key words : Cabbage, cauliflower, IPM, pesticide residues, tomato, vegetables

Indiscriminate spraying of pesticides not only results in excessive toxic residues on vegetable crops, but also leads to resurgence of non-target pests and adverse effects on natural enemies. Integrated pest management (IPM) technologies, either with no residues of pesticides or residues below permissible levels, have been developed for cabbage, cauliflower and tomato crops at the Indian Institute of Horticultural Research (IIHR), Bangalore (Krishnamoorthy, 2004). These IPMs have also been demonstrated in farmers' fields and found to be economically feasible albeit, with some constraints (Gajanana *et al*, 2004; 2006). Large scale validation and promotion of IPM in these crops was taken up at IIHR, Bangalore, in the year 2004-05 under the Mission-mode NATP sub-project – "Validation and promotion of IPM in vegetables" with National Centre for Integrated Pest Management, New Delhi, as the lead centre. Apart from recording pesticide spray pattern in IPM and non-IPM (which follow a different schedule of plant protection treatments, mostly with insecticides) of these crops in farmers' fields situated around Bangalore, pesticide residues in these crops too were analyzed and compared. This was done to assess whether excess pesticide residues remained on vegetable crops grown under non-IPM conditions compared to those grown under IPM conditions.

IPM practices were carried out in tomato (varieties: Mruthyunjaya-2, Arjun, Abhinav, US-816) in farmers' fields located at several villages lying between latitudes 12^0 58' N and 13^0 14' N and longitudes 77^0 23' E and 77^0 38' E, viz., Thammarasanahalli, Agrahar, Kandavara, Thirhalli, Thorenagasandra, Thirumalapura, Patrenahalli, Vaderahalli, Agalgurki, Augatta and Kodi Ramasandra. Cabbage IPM was demonstrated in 92 farms in 40.77 ha area, cauliflower IPM was demonstrated in 25 farms covering 10.5 ha area and tomato IPM was demonstrated in 168 farms in 79.22 ha area. Area cultivated in each case varied from 0.1 ha to 2.0 ha, but most of the fields were less than 1 ha in size. Tomato samples, at harvest, were collected from 22 fields with a sample size of 2 kg in each case. Tomato fruit samples were also collected from 6 farmers' fields where non-IPM practices were followed. Tomato varieties grown in these fields were the same as mentioned above and the fields were located at Kodi Ramasandra, Devashettahalli, Patrenahalli, Thirnahalli and Kuppali villages. While collecting the samples, information regarding name of farmer, village, variety, area of cultivation, date of planting, pesticides used, number and stage of spray, etc. were collected.

In a similar manner, heads of cabbage (cv. Hare Krishna, Unnathi) were collected from six farmers' fields where cabbage IPM was demonstrated (villages:

[1]Division of Entomology and Nematology, IIHR, Bangalore-89

Kalenahalli, Thammarasanahalli, Adde, Thirnahalli) and from four farmers' fields where non-IPM was followed (village: Meda Agrahara). Cauliflower (cvs. Basanth, NH-6) were also collected from six farmers' fields where IPM practices were demonstrated (villages: Siddenayakanahalli, Haralur, Thammarasanahalli) and from four farmers' fields where no IPM practices were followed (villages: Patrenahalli, Thammarasanahalli, Agrahara).

Samples thus collected in each case were subjected to multiclass, multipesticide residue analysis (MRM) procedures (Handa *et al*, 1999). Samples (cut, mixed and quartered) were extracted with acetonitrile using Waring blender. The extract was filtered using Buchner funnel and the filtrate partitioned with 3 x 50 ml chloroform after adding 50 ml of saturated sodium chloride solution. Chloroform layers were collected, combined, dried and concentrated before cleaning-up using adsorption column chromatography. The final determination of organophosphate and carbamate residues was carried out using GLC with thermionic sensitive detector (TSD). In another step, the same sample was extracted with acetonitrile, filtered through Buchner funnel and partitioned against 3 x 50 ml hexane. The hexane layer was dried, concentrated and cleaned-up through adsorption column chromatography using Florisil as an adsorbent. The cleaned up extract was eluted and determined by GLC with electron capture detector (ECD) for analyzing organochlorine and synthetic pyrethroid pesticide residues. Some important pesticides which could not be analyzed by the above MRM were analyzed individually by methods given in Table 1. Results obtained from the above analyses were compared to those obtained for 45 pesticide standards available in our laboratory and residues of pesticides determined.

Tomato

Although the number of pesticides showing detectable residues was higher in tomatoes grown under IPM practices when compared to tomatoes grown under non-IPM practices, residues in former were found at very low levels and well within permissible limits (Table 2). Twenty three per cent of the IPM tomato did not contain detectable pesticide residues. Most of the pesticides detected in tomato were present only in one sample. Carbendazim and Triazophos residues, however, were detected in 5 and 4 samples, respectively. Of the six tomato samples drawn from fields where no IPM practices were followed, one sample contained no detectable pesticide residues. Three samples, however, contained residues of either Triazophos or Lambda cyhalothrin above the permissible levels at harvest (Table 2).

Table 1. Summary of pesticide residue protocols used

Pesticide	Method of estimation	Reference
Mancozeb	Spectro-photometry	BIS, 1993
ETU (toxic metabolite of Mancozeb)	HPLC	Ahmad *et al*, 1995
Carbendazim	HPLC	Sharma & Awasthi, 1999
Imidacloprid	HPLC	Ishii *et al*, 1994
Indoxacarb	HPLC	Anonymous, 2000
All other pesticides	GLC	Handa *et al*, 1999

Cabbage

In cabbage too, none of the pesticide residues was found to be present above permissible levels in samples drawn from farmers' fields where the crop was grown as per IPM schedule (Table 3). However, residues of Acephate, Methomyl and Monocrotophos were high (upto 1.6 ppm, 4.2 ppm and 1.9 ppm, respectively). In cabbage grown under

Table 2. Status of pesticide residues in tomato samples from IPM and non-IPM plots

Name of pesticide	Residues in IPM samples (ppm)	Residues in non-IPM samples(ppm)	MRL (ppm)
No residues detected	(6)	(0)	-
Acephate	-	0.003 (1)	2.0
Carbendazim	0.01-0.112 (5)	0.014 (1)	0.5
Chloropyrifos	0.003, 0.01 (2)	0.003, 0.02 (2)	0.5
Chlorothalonil	0.001 (1)	-	2.0
Cypermethrin	0.038, 0.001 (2)	-	0.5
Deltamethrin	0.001, 0.002 (2)	0.001 (1)	0.2
Dicofol	0.01 (1)	-	1.0
Dimethoate	0.001 (1)	-	1.0
Endosulphan	0.002, 0.087 (2)	0.019 (1)	3.0
Ethion	0.08 (1)	0.05 (1)	0.5
Fenamiphos	-	0.01 (1)	0.2
Fenvalerate	0.003 (1)	-	1.0
Fluvalinate	0.35 (1)	-	0.5
Imidacloprid	0.01 (1)	0.04, 0.05 (2)	0.1
Lambda cyhalothrin	0.01 (1)	0.70 (1)	0.1
Lindane	0.01 (1)	0.011 (1)	1.0
Malathion	0.01 (1)	-	3.0
Methyl parathion	0.002 (1)	-	0.01
Monocrotophos	0.08 (1)	-	1.0
Profenofos	0.003 (1)	-	2.0
Triazophos	0.35 (4)	0.01-0.04 (4)	0.1

*Figures in parenthese show number of samples with residues of a particular pesticide

**No. of samples: Total = 31, IPM = 26 (none above MRL), non-IPM = 6 (3 above MRL)

Table 3. Status of pesticide residues in cabbage samples from IPM and non-IPM plots

Name of pesticide	Residues in IPM samples (ppm)	Residues in non-IPM samples (ppm)	MRL (ppm)
No residues detected	-	(0)	-
Acephate	0.03 – 1.67 (4)	-	2.0
Chlorothalonil	0.001, 0.01 (2)	0.001 (2)	5.0
Chlorpyrifos	-	0.8, 1.55 (2)	1.0
Dicofol	-	0.01(1)	1.0
Dichlorovos	0.067 (1)	-	0.5
Dimethoate	0.015, 0.031 (2)	0.08 (1)	2.0
Indoxacarb	-	0.21 (1)	5.0
Lindane	0.22 (1)	-	3.0
Fenamiphos	0.01 (1)	-	0.2
Fenitrothion	-	3.02 (1)	0.5
Methomyl	4.0, 4.2 (2)	1.42, 5.50 (2)	5.0
Monocrotophos	0.13 (1)	-	0.2

*Figures in parenthesis show number of samples with residues of a particular pesticides

**No. of samples: Total = 10, IPM = 6 (none above MRL), non-IPM = 4 (3 above MRL)

Table 4. Status of pesticide residues in cauliflower samples from IPM and non-IPM plots

Name of pesticide	Residues in IPM samples (ppm)	Residues in non-IPM samples (ppm)	MRL (ppm)
No residues detected	(2)	(0)	-
Acephate	0.18 (1)	3.2 (1)	2.0
Cypermethrin	-	0.06, 0.10 (2)	0.5
Dimethoate	0.01 (1)	-	5.0
Fenvalerate	-	0.11 (1)	3.0
Indoxacarb	0.21 (1)	0.010, 0.205 (2)	1.0
Lambda cyhalothrin	-	0.05 (1)	0.4
lindane	0.01 (1)	0.001 (1)	1.0
Methomyl	-	5.9 (1)	5.0
Monocrotophos	-	0.01 – 0.05 (3)	0.2

*Figures in parenthesis show the number of samples with residues of a particular pesticide

**No. of samples: Total = 10, IPM = 5 (none above MRL), non-IPM = 5 (3 above MRL)

non-IPM practices, of the four samples collected, three contained residues of at least one pesticide above permissible level (Table 3). Methomyl is used for controlling the pest *Spodoptera litura* in cabbage and cauliflower. Although it is recommended to be used only as a bait by mixing with jaggery, it is often sprayed directly on the crop resulting in persistence of its residues. Monocrotophos, although banned for use in vegetables, is extensively in use by farmers against biting, chewing and sucking insects. Triazophos used against leaf miner in tomato has a low MRL and is, therefore, toxic even at very low levels.

Cauliflower

In the case of cauliflower, all five samples collected from farmers' fields where IPM practices were demonstrated and followed, were safe with respect to levels of pesticide residues (Table 4) of which 2 samples did not have detectable levels of any pesticide. All cauliflower samples grown under conventional non-IPM practices contained detectable levels of pesticide residues. Residues of acephate, methomyl and monocrotophos were detected above permissible levels in some of the samples.

All three vegetables grown by IPM practices did not contain pesticide residues above permissible levels at harvest. Residues of several pesticides could be detected in these, albeit at low levels. The residues were mostly present as traces (<0.01 ppm) in these samples, but, in some cases, e.g. cabbage (IPM), methomyl (4.0 – 4.2 ppm) and monocrotophos (0.13 ppm), residues were present only slightly below permissible levels (5 ppm and 0.2 ppm, respectively). Monocrotophos is not recommended for use in IPM of cabbage while methomyl is recommended to be used only as indirect bait. This shows that either these farmers had not followed the IPM schedule strictly, or, there was spray-drift from nearby fields. Pesticide residue levels were generally higher in vegetables grown without following IPM recommendations, with some of the pesticides having residues above safe or permissible levels (Tables 2, 3 and 4). In addition, 18.6% of the total samples grown under IPM did not contain any detectable residues of pesticides. However, only 4.5% of the total samples grown under non-IPM practices did not contain any detectable pesticide residues. It was noted that, in general, residues of traditional pesticides such as cypermethrin, monocrotophos, triazophos, acephate, etc. were found above detectable levels in non – IPM vegetables.

Therefore, 50–75% of vegetable samples grown under non-IPM conditions contained residues above permissible levels at harvest. However, since the sample size of non-IPM vegetable samples was small (4-6), per cent contamination data cannot be extrapolated to all three vegetables at harvest. Instead, in this study, the figures were used merely for comparison, and it was seen that tomato, cabbage and cauliflower grown as per IPM practices were safer to consume at harvest compared to those grown as per conventional cultivation practices (non-IPM), with chemical control as the sole means of plant protection. The study, therefore, brought out the fact that pesticide residues were found in lower quantities in IPM – vegetables and were within permissible levels. It also brought out the need for further field demonstrations and strict compliance of IPM in these vegetables.

ACKNOWLEDGEMENT

The authors gratefully acknowledge financial assistance received from National Agricultural Technology Project (NATP) under ICAR for carrying out the above study.

REFERENCES

Ahmad, N., Guo, L., Mandarakas, P. and Appleby, S. 1995. Determination of dithiocarbamate and its breakdown product ethylene thiourea in fruits and vegetables. *J. AOAC Int'l.*, **78**:1238 -1243

Anonymous. 2000. Residue analysis of indoxacarb. Protocol of Dupont Chemical Co. USA, DUP/MP/065/008

Krishnamoorthy, A. 2004. Final Report, 2000 – 2003, Development of pesticide residue free IPM package for vegetables. PSR 41, IIHR, Bangalore. 213 pp.

BIS. 1993. Draft Indian standard for analysis of mancozeb residues in food. Bureau of Indian Standards, New Delhi, India

Gajanana, T.M., Krishna Moorthy, P.N., Anupama, H.L., Prasanna Kumar, G.T. and Ranganath, R. 2004. Economic analysis of integrated pest management in cabbage. *Pest Mgt. Hortl. Ecosys*., **10**:55-59

Gajanana., T.M., Krishna Moorthy, P.N., Anupama, H.L., Ranganath, R. and Prasanna Kumar, G.T. 2006. Integrated pest and disease management in tomato: an economic analysis. *Agril. Econ. Res. Rev*. **19**:269-280

Handa, S.K., Agnihotri, N.P. and Kulshreshtha, G. 1999. Multiresidue methods for estimation of pesticide residues In "Pesticide Residues : Significance, Management and Analysis" Research Periodicals and Book Publishing House, India, pp. 136-145

Ishii, Y., Kobori, I., Araki, Y., Kurogochi, S., Iwaya, K and Kagabu S. 1994. HPLC determination of the new insecticide imidacloprid and its behaviour in rice and cucumber. *J Agril. Fd. Chem*., **42**:2917-2921

Sharma, D and Awasthi, M.D. 1999. High performance liquid chromatographic method for analysis of carbendazim in fruits and vegetables. *Pest. Res. J*., **11**:23-126

(MS Received 16 January 2009, Revised 6 July 2009)