REVIEW ARTICLE

PESTICIDES APPLIATIONS AND THEIR PERSISTANCE IN VEGETABLES

Ankush Sheoran* and Rohit Rana

Department of Chemistry, Panjab University, Chandigarh
Email: ankushsheoran16@gmail.com

Received-27.10.2017, Revised-16.11.2017

Abstract: Although pesticide application is an essential component of modern crop production technology, however, in recent years, contamination of food commodities especially the vegetables, with trace amounts of these chemicals has become a growing issue for the general population. Unfortunately the debate has restricted to the quality standards and norms pertaining to drinking water and foods at the point of consumption. But more fundamental source of contamination of natural resources including food products with chemical pesticide residues at the farming level is of serious concern, because of their persistence or presence and often ignored. Without solving this problem at basic level, setting down the quality standards at the consumption level is not going to solve the problem, especially in developing countries like India where enforcement of rules and regulations is very weak or absent. Although some pesticides application have banned but still their residues are being reported in food products and natural resources like soil and water due to its high persistence and low biodegradability. Therefore, it is essential to create awareness amongst consumers and producers about health risks and production practices like non-pesticidal management activities should be encouraged for healthy and safe environment.

Keyword: Pesticides application, Vegetable crops, Drinking water, Health hazards

INTRODUCTION

India has agriculture based economy and most of rural population is involved in agricultural practices. Agriculture in India contributes about 14% to the national GDP, although the contribution of this sector has decreased as compared to previous year which was 30% in 2000. The reason behind this decrement is the growth of other sectors, particularly the service sector (Ministry of Agriculture, 2015). Apart from production of cereals crops, India ranks second in production of vegetable crops throughout the world (APEDA, 2015). Production of various vegetables and horticultural crops throughout the country may be ascribed to the diverse climate that provides the required conditions for the production of variety of fresh fruits and vegetables in different eco-regions. India is reported to be the largest producer of ginger and okra and second largest producer of potato, onion, cauliflower, brinjal and cabbage across the world. Although due to international food diversification, import and export of agricultural products has been increasing qualitatively and quantitatively during recent years, while agriculture is still the main dependent sector for rural self-employed population, whose average farm size continues to decline with population growth and they contribute to approximately 68% of population of the country (Ministry of Agriculture, 2015). The superfluous usage of agrochemicals including pesticides for fulfilling escalating quest for higher profit has resulted in several ecological and environmental consequences as well as unsafe practices in farming sector. Thus, in this era of intensified agricultural technologies, use of pesticides provides uncountable benefits by reducing the insect-pest incidence and increasing the crop productivity. A wide range of pesticides are used for crop protection globally for the cultivation of vegetables due to heavy pest infestation throughout the crop season (Kalara, 2003; Parveen and Masud, 2003). Pesticide refers to any chemical substance used for preventing, attracting, repelling or controlling any pest including unwanted species of plants or animals during production, storage, transport, distribution and processing of food or agricultural commodities. Or in general words, pesticides are the chemicals used for control of pest infestation and diseases of crops. Around 203 pesticides have been registered for use in Indian agriculture for the control of various insects/pests and diseases. These pesticides can be broadly classified into Insecticides (used against insect pests), Herbicides (for killing and controlling weeds), Fungicides (for controlling diseases) and others. On the basis of chemical composition pesticides can be classified into organophosphate compounds, organo-chlorines, synthetic pyrethroids, carbamates, bio-pesticides etc. Pesticide production and use in India showed a different behaviour from global trends. Insecticide use in India is around 75%, compared to 32% in the world. Herbicide use is only 12% in the country while worldwide, consumption of herbicides is 47%. Similarly, while carbamate and synthetic pyrethroid compounds are used the most globally (45% together), in India, organophosphates constitute 50% of the consumption. Bio-pesticides used is only upto 1% of total pesticides consumption in India, while worldwide bio-pesticides contribution is about 12%. As per the classification of World Health Organization, based on their acute toxicity pesticides can be classified into four classes. This classification includes Class Ia – Extremely hazardous, demarcated by red color; Class Ib – Highly Hazardous, symbolized by an yellow colored triangle; Class II – Moderately Hazardous, demarked by a blue triangle;

*Corresponding Author

Class III - Slightly Hazardous while the remaining class is supposed to be "Not likely to be Hazardous". The most important point to note down is that about two-thirds of the pesticides consumed fall under WHO Class I and II.

Apart from reducing the crop loss, the extensive use and low biodegradability of pesticides may result into their accumulation in the food products and causes potential health risks to consumers (Baker *et al.*, 1994; Freemark and Boutin, 1994 and Clark and Ohkawa, 2003). The pesticide residue is defined as substance or mixture of substances in food, feed, soil, water and air originating from the use of pesticides and includes the specified degradation and conversion products, metabolites, reaction products and impurities (Dhaliwal, 2006). As a result of indiscriminate use of pesticides by the unskilled persons, only a small portion of applied pesticides reaches the targeted species; remainder enters in food chain and later on it indirectly passed on to human beings. Amongst food items, fresh fruits are the most vulnerable part of the diet, as they are mostly consumed directly after picking as compared to vegetables and grains that are cooked which in turn reduces and metabolizes the pesticide residues (Newsome *et al.,* 2000). For issues concerning human health, several pesticides were detected to exceed Maximum Residue Level (MRL) in vegetables in recent years. Maximum Residue Limit (MRL) is the maximum concentration of a pesticide residue that is legally permitted or recognized as acceptable in or on a food, agricultural commodity, or animal food. The concentration is expressed in milligrams of pesticide residue per kilogram of the commodity. Under the PFA Act, MRL or Tolerance Limits (TLs) are fixed considering MRLs recommended by Codex or based on supervised trials conducted in India as well as the dietary habits of our population.

Pesticide Residues in Vegetables

In India, 51% of the food commodities have been detected with pesticide residues (Gupta, 2004). Vegetables mostly found to be contaminated were okra, brinjal, lettuce, cucumber and tomato. Pesticides found in most of the vegetable samples in the preliminary observations were Chlorpyrifos, Monocrotophos, Endosulfan, DDT and Lindane *etc*. (Nishant and Upadhyay, 2016). The percentage of pesticide use on vegetable crops of total pesticide use in the country is constantly increasing for the years as it was only 13-14% of the total pesticide use in the 1990s (Sardana, 2001) while the share has increased to 21% in 2010-11(Peshin *et al.,* 2014). Many studies support the presence of pesticide residues in vegetables, on an average, this percentage is 50- 70% in India as mentioned by Karanth, 2002; Charan *et al.*, 2010 and Ranga Rao *et al.*, 2009. A study conducted by Charan *et al.* in 2010, revealed that 35.62% of total contaminated samples exceeded the maximum residue limit (MRL) values recommended by the Food and Agriculture Organization (FAO)/ World Health Organization (WHO). According to a report, over 98% of sprayed insecticides and 95% of herbicides reached non-target destinations such as other species, air, water and soil. It is also reported that pesticide drift occurs when pesticides are delivered from the air as particles are carried by the wind to other areas, potentially spreading the area contaminated. Literature reveals that vegetables contaminated with pesticide residues above their respective maxi-mum residue limit MRL (Bhanti and Taneja, 2005) may pose health hazards to consumers (Mukherjee and Gopal, 2003). Dikshit and Mishra (1985) found that the residues of carbaryl and endosulfan persisted above their tolerance limits of 2.00 and 5.00 ppm, respectively only up to harvest (35 days after spraying) in unprocessed potatoes. In case of endosulfan @ 0.525 kg a.i./ha, the residues persisted to the level of 2.00 ppm at 65 days (30 days storage). Reddy *et al.* (2000) monitored the insecticide residues in market samples of grapes. The residues level of acephate, methamidophos, chlorpyriphos, monocrotophos and quinalphos in var. Thompson seedless were (above MRL), 2.6743, 0.1383, 0.8341, 1.3648 and 0.4132 mg kg^{-1}, respectively. Gajbhiye *et al.* (2000) showed that the residues of imidacloprid in tomato leaves were persisted up to 30 days after the seed treatment @ 10g/kg. While, residues of aforesaid molecule @ 20g/kg seed persisted up to 45 days and at 60 days after transplanting, the seedlings were free from residues. The residues of quinalphos on mango was detected till the last sampling (15 days) in both concentrations of 0.05 and 0.1% by imparting 3.30 and 3.32 days as half life and waiting period of 11.50 and 14.20 days, respectively, as suggested by Vijayalakshami (2002). Arora and Singh (2004) determined the residues of chlorpyriphos and cypermethrin in/on okra and brinjal fruits at harvest in IPM and non-IPM plots. The residues of chlorpyriphos in IPM plots were (0.104 μg g^{-1}) not exceeded the MRL (0.2 μg g^{-1}) and in non-IPM it was found to be exceeded (5.75 μg g^{-1}), while, cypermethrin residues were above MRL in non-IPM plots. Moreover, in brinjal, residues of monocrotophos were crossed the level of MRL in non-IPM plots and BDL in IPM. The waiting period and half life of fenazaquine 10 EC @100g a.i. ha^{-1} in apple fruits were 10.5 and 3.9 days, respectively (1999). Moreover, in 2001, residues of aforesaid treatment were persisted for 25 days and 30 days for fenazaquin @200g a.i. ha^{-1} by showing 13.0 and 4.9 days of waiting period and half life, respectively (Sharma *et al*., 2006). According to Mohapatra *et al.* (2006) residues of lambda-cyhalothrin @ 15g ha^{-1} and 30 g ha^{-1} in /on acid lime were persisted for 20 days by imparting 3.4 and 8.0 days as half life and waiting period, respectively. Moreover, in juice samples maximum residues (0.080 and 0.130 mg/kg) in both treatments were observed on 10th day. Gupta *et al*. (2008) proved that residues of bifenthrin @ 25 and 50g a.i. ha^{-1} in okra fruits persisted up to 7 days and degrade to its half life at 1.32 and 1.58 days, respectively. However, fipronil residues @50 and 100g a.i. ha^{-1} showed 0.65 and 1.12 days as half life and 3 days as waiting period, respectively, furthermore, indoxacarb residues found to be highly degradable molecules by imparting 1 day as waiting period. Dissipation pattern of propineb @ 2.0 kg a.i. ha^{-1} in tomato showed maximum initial deposition, 5.41±0.13 μg g^{-1} and persisted for 15 days (0.05±0.13 μg g^{-1}) with a half life of 2.23 days and 2.02 days as waiting period in season-I (2005-06), moreover, in season-II, the half life and waiting period of same treatment was 2.28 and 2.02 days, respectively, as indicated by Akhtar (2009). Charan *et al*. (2010) screened the farm gate vegetables samples for pesticide residues and stated that 1 samples of okra was contaminated with methyl parathion (0.22 μg g^{-1}) which was exceeded the MRL (0.2 μg g^{-1}) among 25 samples. In case of brinjal, 4, 7 and 2 samples out of 46 were contaminated with monocrotophos, methyl parathion and cypermethrin, respectively. The degradation kinetics of carbendazim @ 0.05 and 0.1 % in mango fruits showed maximum initial deposition of 2.48 and 5.28 mg kg^{-1}, while it was 1.23 and 2.51 mg kg^{-1} in mango pulp, respectively. Moreover, up to 12 days the residues of carbendazim found above MRL in treatment of 0.1% by exhibiting 4.0 days as half life and pre harvest interval of 2.5 and 7.0 days for both doses, as discussed by Bhattacherjee and Panday (2010).

Monitoring of pesticide contamination

Indiscriminate use of pesticides has created a very alarming situation in the country as well as throughout the world, hence, monitoring and assessment of pesticide contamination in farm produces has become a necessity. Residue analysis on one hand provides measures of the nature and level of any chemical contamination within environment and its persistence and simultaneously continue to search for pesticides which are less persistent and less toxic for human beings (Tan and Soo, 2001). Thus, there is need to determine, quantify and confirm pesticide residues particularly in vegetables for both research and regulatory purposes. The pesticides in food commodities are generally analyzed by spectrophotometry (Caldas *et al.,* 2001 and Janghel *et al.,* 2007), thin layer chromatography (TLC) (Rathore and Begum, 1993 and Patil and Shingare, 1994), high performance liquid chromatography (HPLC) and high performance liquid chromatography-mass spectrophotometry (HPLC-MS) (Debayle *et al.,* 2008 and Islam *et al.,* 2009), gas chromatography (GC) (Kumari 2008 , Abhilash *et al.,* 2009) and GC-MS (Thanh *et al.,* 2008). The choice of method depends on the type of substrate and ageing of residues.

Good agricultural practices for management of pesticide residues

Keep an inventory of all chemicals. Store all chemicals in their original containers. Never store herbicides with other pesticides.

Always use only recommended pesticides at the specified doses and frequency and at the right time.

Education and training in the proper use of pesticides. The improper use or misuse through lack of understanding creates residue problems.

Unused pesticide solution and washings generated by cleaning spray pumps contain pesticide residue. Dispose of them properly to avoid pollution.

Avoid indiscriminate use of pesticides

Adopt Integrated Pest Management System

Use of safe pesticides which helps in conserving predators/ parasites

Strictly follow waiting period before harvesting

Maintain healthy soil with compost and mulch so that pest problems are minimal.

Vegetables and fruits should be thoroughly washed with clean water

Reduce spray drift in orchards by using lower pressures, larger nozzles and less volatile pesticides and by spraying when there is little or no wind.

Proper precautions must be taken for the control of house hold insects / stored grain pests.

Use botanicals / microbial insecticides for the control of various crop pests

Purchase pesticides only from authorized dealers

Banned pesticides should not be used for pest control

Get detailed information from the authorized people before mixing of various pesticides.

Always read product labels carefully before applying any pesticide, mix and apply as directed.

CONCLUSION

Although some pesticides are banned, but their persistence in various food commodities still exists. To provide adequate food for growing population, the usage of pesticide is necessary but dissemination of information regarding food safety, pesticide handling and good agricultural practices among farmers is also a dire need. Therefore, the rational recommendation of pesticides requires that it must not only provide an effective control of pests but at the same time their residues on food commodity must also be toxicologically acceptable. Moreover, good agricultural practices and household processes are the important and effective tools in minimizing pesticide residues in food commodities for healthy environment.

REFERENCES

Islam, S., Afrin, N., Hossain, M.S., Nahar, N., Mosihuzzaman, M. and Mamun, M.I.R. (2009). Analysis of some pesticide residues in cauliflower by high performance liquid chromatography. American Journal of Environmental Science 5(3):325-329.

Debayle, D., Dessalces, G., Florence, M. and Loustalot, G. (2008). Multiresidue analysis of traces of pesticides and antibiotics in honey by HPLC-MS-MS, Analytical and bio-analytical chemistry 391(3): 1011- 1020.

Abhilash, P.C., Singh, V. and Singh, N. (2009). Simplified determination of combined residues of lindane and HCH isomers in vegetables , fruits , wheat, pulses and medicinal plants by matrix solid-phase dispersion (MSPD) followed by GC-ECD. *Food Chemistry*. 113(1): 267-271.

Akhtar, S.A. (2009). Dissipation and transloction of propineb in tomato. *Pesticide Research Journal* 22 (2): 145-147.

APEDA (Agricultural and Processed Food Products Export Development Authority) (2015). Fresh Fruits & Vegetables.Agricultural and Processed Food Products Export Development Authority (APEDA), Ministry of Commerce andIndustry, Government of India.
http://www.apeda.gov.in/apedawebsite/six_head_product/FFV.htm.

Arora, S. and Singh, D.K. (2004). Determined of Chlorpyriphos and Cypermethrin residues in/on okra. *Pesticide Research Journal* 16 (2): 68-70.

Baker, J.L. *et al.*, (1994). Aquatic dialogue group: Pesticide risk assessment and mitigation, SETAC Press, Florida, pp. 188.

Bhanti, M. and Taneja, A. (2005). Monitoring of Organochlorine Pesticide Residues in Summer and Winter Vegetables from Agra, India – A case study. *Environmental Monitoring and Assessment*. 110(1-3): 341-346.

Bhattacherjee, A.K. and Pandey, B.K. (2010). Dissipation of carbendazim in mango in pre and post harvest treatments. *Journal of Plant Protection science* 2 (1): 65-70.

Caldas, E.D., Conceiçao, M.H., Miranda, M.C.C., de Souza, L.C.K. and Lima, J.F. (2001). Determination of dithiocarbamate fungicide residue in food by spectrophotometric method using a vertical disulfide reaction system. *Journal of Agricultural and Food Chemistry* 49(10): 4521-4525.

Charan, P.D., Ali, S.F., Yati K. and Sharma, K.C. (2010). Monitoring of pesticide residues in farmgate vegetables of central Aravalli region of Western India. *American-Eurasian Journal of Agricultural & Environmental Sciences* 7(3): 255-258.

Clark, J.M. and H. Ohkawa (eds.). (2003). Environmental fate and safety management of agrochemicals, ACS Symposium Series 899. ACS, Washington D.C., pp. 357.

Dhaliwal, G.S. (2009). An Outline of Entomology, Kalyani Publishers, Ludhiana.

Dikshit, A. K. and Mishra, S. S. (1985). Residues of endosulfan and carbaryl in potato tubers at harvest and after storage. *Indian Journal of Plant Protection* 13: 105-108.

Freemark, K. and Boutin, C. (1994). Non-target plant risk assessment for pesticide registration. *Environmental Management* 18(6): 841-854.

Gajbhiye, V.T., Kumar, R., Gupta, R.K. and Kalpana (2000). Translocation and Persistence of Imidacloprid in Tomato. *Pesticide Research Journal* 12 (1): 127-129.

Gupta, P.K. (2004). Pesticide exposure—Indian scene. *Toxicology* 198: 83–90.

Gupta, S., Sharma, R.K., Gupta, R.K., Sinha, S.R., Singh, R. and Gajbhiye, V.T. (2008). Persistence of new insecticides and their efficacy against insect pests of okra. *Bulletin Environmental Contamination and Toxicology* 8: 1-9.

Janghel, E.K., Rai, J.K., Rai, M.K. and Gupta, V.K. (2007). A new sensitive spectrophotometric determination of cypermethrin insecticide in environmental and biological samples. *Journal of the Brazilian Chemical Society* 18(3): 590-594.

Kalara R.L. (2003). Pesticide residues in vegetable. In Proceedings of symposium on risk assessment of pesticide residues in water and food (pp. A1-9).By ILSI Washington DC, ITRC Lucknow and ICMR, New Delhi, India on October 28-29.

Karanth, N.G.K. (2002). Challenges of limiting pesticide residues in fresh vegetables: the Indian experience. In: Hanak, E.E., P. Boutrif. and M.P. Fabre. (Eds.), Food Safety Management in Developing Countries. CIRAD-FAO, Montpellier, France, pp. 11-13.

Kumari, B. (2008). Effect of household processing on reduction of pesticide residues in vegetables. *ARPN Journal of Agricultural and Biological Science* 3 (4): 46-51.

Ministry of Agriculture. (2015). Agricultural Statistics at a Glance 2014. Ministry of Agriculture, Government of India. Oxford University Press, New Delhi, India

Mohapatra,S., Sharma, D. and Rekha, A. (2006). Residues of Lambda cyhalothrin in/on Acid Lime (*Citrus aurantifolis*). *Pesticide Residue Journal* 18 (1): 74-75.

Mukherjee, I. and Gopal, M. (2003). Pesticide residues in vegetable. In Proceedings of symposium on risk assessment of pesticide residues in water and food (pp. A1-8).By ILSI Washington DC, ITRC Lucknow and ICMR, New Delhi, India on October 28-29.

Newsome, W.H., Doucet, J., Davies, D. and Sun, W.F. (2000). Pesticide residue in the Canadian market basket survey-1992 to 1996. *Food Additives and Contaminants* 17(10): 847-854.

Nishant, N. and Upadhyay, R. (2016). Presence of pesticide residue in vegetable crops: A review. *Agricultural Reviews* 37(3): 2016: 173-185.

Parveen, Z. and Masud, S.Z. (2003). Monitoring of pesticide residue in human milk. *Pakistan Journal of Science and Industrial Research* 46: 43-46.

Patil, V.B. and Shingare, M.S. (1994). Thin-layer chromatographic spray reagent for the screening of biological materials for the presence of carbaryl. *Analyst*, 119(3): 415-416.

Peshin, R., Kranthi, K.R. and Sharma, R. (2014). Pesticide use and experiences with integrated pest management programsand Bt cotton in India. In: Peshin, R., Pimentel, D. (Eds.), Integrated Pest Management Experiences with Implementation: Global Overview, vol. 4. Springer, Dordrecht, The Netherlands, pp. 255-268.

RangaRao, G.V., Sahrawat, K.L., Srinivasa, R.C., Binitha, D., Reddy, K.K. and Bharath, B.S. (2009). Insecticide residues invegetable crops grown in Kothapalli Watershed, Andhra Pradesh, India: A case Study. *Indian Journal of Dryland Agricultural Research & Dev*elopment 24: 21-27.

Rathore, H.S. and Begum, T. (1993). Thin-layer chromatographic behaviour of carbamate pesticides and related compound. *Journal of Chromatography A*, 643(1): 321-329.

Reddy, J.D., Rao, N.B. and Sultan, A.M. (2000). Insecticide Residues in market samples of grape berries. *Pestology* 16 (9):17-22.

Sardana, H.R. (2001). Integrated Pest Management in Vegetables, In: Training Manual on IPM for Zonal Agricultural Research Stations, pp. 105-118.

Sharma, I.D., Dubey, J.K. and Patyal, S.K. (2006). Persistence of Fenazaquin in Apple Fruits and Soil. *Pesticide Research Journal* 18 (1): 79-81.

Tan, G.H. and Soo M. T. (2001). Multiresidue analysis of pesticides in vegetables using liquid chromatography with atmospheric pressure ionization mass spectrometry (LC-API-MS) and a heated nebulizer. *Malaysian J. of Chemistry*. 3(1): 1-12.

Thanh, D.N., Ji, E.Y., Dae, M.L. and Gae, H.L. (2008). A multiresidue method for the determination of 107 pesticides in cabbage and radish using QuEChERS sample preparation method and gas chromatography mass spectrometry. *Food Chemistry*. 110(1): 207-213.

Vijayalakshmi, K. (2002). Dissipation of quinalphos on mango (*Mangifera indica*) fruit. *Tropical Agriculture (Trinidad)* 78 (1): 39-42.