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Survey on Pests and Pesticides Usage Pattern and Studies on Flubendiamide Residues in Market Samples of Exotic Vegetables

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An extensive survey on pests and pesticides usage pattern on exotic vegetables was conducted among the farmers in Kotagiri block, Nilgiris district of Tamil Nadu during 2017. A list of pests on exotic vegetables were reported, of which tobacco caterpillar (*Spodoptera litura* Fab.), cutworm (*Spodoptera exigua Hubner*), aphids (*Myzus persicae* Sulzer) and leaf miner (*Liriomyza trifoli* Burgess) were major pests in lettuce, where as diamondback moth (*Plutella xylostella* L.) was a major pest in broccoli and red cabbage. Insecticides like flubendiamide (39.35% SC), spinosad (2.5% SC), chlorantraniliprole (18.5% SC), imidacloprid (70% WG) and acephate (75% SP) were widely used for management of pests of exotic vegetables. Pest management information was obtained from private company as farmers were involved in contract farming. The level of knowledge among the farmers on pesticide residues and practice of measuring, handling pesticides, disposal of pesticide containers and usage of biopesticides and traps was also assessed. The survey led to inference a strict vigil on pesticide usage pattern against crop pests and is highly essential to ensure food safety and safeguard human and environmental health. Study on residue status of flubendiamide in exotic vegetable samples collected from the market and farmgate revealed residues below detectable limit.

Key words: Exotic vegetables, Pests, Pesticides usage pattern, Knowledge and Practice

Growing of the exotic vegetables such as lettuce, broccoli, parsley and red cabbage has a great scope in India. Market potential is escalating for such exotic vegetables at the rate of 15 to 20 per cent per annum. The consumption is increasing day by day as India imports more than 85 per cent exotic vegetables. This scope has created interest among Indian farmers to cultivate exotic vegetables. In certain regions of India, exotic vegetables and fruits cultivation has become a profitable venture than growing traditional vegetables (Rao *et al.,* 2015). Like indigenous vegetables, these exotic vegetables are also ravaged by insect pests and diseases. The pests like tobacco caterpillar (*Spodoptera litura* Fab.), cutworm (*Spodoptera exigua Hubner*), aphids (*Myzus persicae* Sulzer), diamondback moth (*Plutella xylostella* L.), cabbage looper (*Trichoplusia ni Hubner)* and leaf miner (*Liriomyza* spp.) have been found to attack the exotic vegetables (Lim *et al.,* 1997).

Pesticides are widely used in production of such horticultural crops to combat insects and diseases. In Ghana, λ-cyhalothrin, cypermethrin, dimethoate and endosulfan were sprayed on lettuce, okra, egg-plant, cabbage, tomato and pepper for pest management (Ntow *et al.,* 2006). Cypermethrin was the most commonly used pesticide followed by malathion, alpha cypermethrin, dimethoate, chlorpyriphos, mancozeb, methomyl, dicofol and carbaryl on brassicas in Botswana (Obopile *et al.,* 2008). Newer molecules like flubendiamide, spinosad, emamectin, chlorantraniliprole and indoxacarb were used against *S. exigua* and *T. ni* in lettuce grown in Arizona (Palumbo *et al.,* 2009). In Malaysia, Thailand and Indonesia, cabbage farmers followed 12 to 16 sprays with 3 to 5 days interval (Amit *et al.*, 2001). Tyagi *et al.* (2015) reported that more than 70 per cent farmers sprayed more than four times on cauliflower and tomato grown in India. There has been a growing interest in detecting and quantifying pesticide residues that may remain on vegetable crops following pesticide application in agricultural and horticultural produce which are intended for human consumption. With increased concern over pesticide residues in food commodities, there is strict regulation of Maximum Residue Limits (MRLs) in international trade (Hassanzadeh *et al.,* 2009).

Pan *et al.* (2017) formulated a method for estimation of pyrethrins in leaf lettuce. The initial concentration of pyrethrins in greenhouse was found higher (0.57 mg kg^{-1}) than in open field conditions (0.25 mg kg^{-1}) and the half-life of pyrethrin residues in field lettuce (0.7 days) was comparatively lower than that of greenhouse grown lettuce (1.1 days). Several factors such as solar radiation, rainfall, wind speed, and crop growth rate influenced and ended up in these results. Final residues in leaf lettuce were much lower than the MRLs (1 mg kg^{-1} established by the

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European Union (EU), Australia, Korea, and Japan). In another study conducted by Mohapatra *et al.* (2010), the initial deposits of flubendiamide on cabbage when applied @ 24 and 48 g a.i.ha^{-1} were 0.33 and 0.49 mg kg^{-1} respectively. Residues dissipated to BDL of 0.01 mg kg^{-1} at 15 days after last application, with half-life values of 3.9 and 4.45 days. In exotic vegetables like lettuce, broccoli, celery, red cabbage and parsley, insecticides are applied indiscriminately to avoid even minimal pests because of the high value of such vegetables in the market. Hence, this study was undertaken to analyze the knowledge level of farmers on the usage of insecticides, insecticide residues, disposal of insecticide containers and usage of biopesticides and traps. The data will help the scientists and extension workers in ensuring food safety and environmental health and policy matters.

Material and Methods

Selection of study area

The Nilgiris, major exotic vegetables growing district of Tamil Nadu was selected. Within the district, block (one) and village (one) were selected based on personal communication with the State Department of Horticulture located at Nilgiris district.

Nature and source of data

The information on pest status and pesticide usage pattern was collected from 20 selected progressive exotic vegetables growing farmers in Kukkalthorai village of Kotagiri block, Nilgiris district. The objectives and scope of the study were first explained to farmers for their mutual support. Data collection was done by interviewing the farmers individually.

An interview schedule consisting of information on the general information about farmer; major pests and pesticides used (Name of pest, stage of infestation, pesticides sprayed and use of biopesticides and traps); and pesticide usage pattern (source of information on recommended pesticides, application technique, waiting period followed, spray intervals, dosage of insecticides, number of sprays, handling and disposal of pesticide containers) was prepared. In Tamil Nadu, Meenambigai *et al.* (2017) conducted a survey on pesticide usage pattern on okra with the help of a questionnaire.

Sample collection for residue analysis

Farm gate samples

Iceberg lettuce (two) and red leaf lettuce (one) farm gate samples were collected from Kukkalthorai village during October, 2017.

Market samples

Exotic vegetable samples were collected from vegetable markets in Coimbatore during November and December, 2017 and January and February, 2018. Totally twenty eight samples of exotic vegetables were collected for insecticide residue monitoring.

Clean-up, extraction and final determination

Samples were processed according to the modified QuEChERS method (Anastassiades *et al.,* 2003). A representative sample of 10 g of the finely ground sample was transferred into a 50 ml centrifuge tube, to which 20 ml of acetonitrile was added and thoroughly mixed using a vortexer for one min. About four grams of anhydrous $MgSO_4$ and one gram of NaCl were subsequently added and again shaken well by vortexer, then centrifuged at 6000 rpm for 10 min. After centrifuging, nine ml of clear supernatant solution was transferred to test tube containing anhydrous Sodium Sulphate (Na_2SO_4). From the supernatant solution, six ml was pipetted into a 15 ml centrifuge tube containing salts *viz*., 100 mg Primary Secondary Amine (PSA), 600 mg anhydrous Magnesium Sulphate ($MgSO_4$) and 10 mg Graphitized Carbon Black (GCB). The mixture was vortexed again for one min. and then centrifuged for 10 min. at 3000 rpm. From the centrifuged sample, 4 ml of the upper extract was taken and filtered using a 0.2µm syringe filter to remove the salts, if any. The filtered extract was then transferred into a glass tube and concentrated to near dryness using nitrogen in a turbovap evaporator at 40 ˚C for 30 min. Finally, the sample was reconstituted to about one ml with acetonitrile and transferred into a 1.5 ml glass auto sampler vial for LC-MS/MS analysis.

Results and Discussion

Crop production information

The results of the survey revealed that each farmer had 1000 sq m. (25 cents) of farm land growing mostly iceberg lettuce and rarely broccoli and red cabbage. Crop duration of iceberg lettuce was 50 - 55 days (80%) with a spacing of 30×20 cm (75%). The duration of broccoli and red cabbage was 90 days and the spacing followed was 60×45 cm and 30×30 cm respectively. Ninety per cent of the farmers followed multiple cropping (lettuce alternated with potato, carrot and beetroot) and 10 per cent of farmers followed mono cropping system (Table 1). Results revealed that most of the exotic vegetable growing farmers (90 per cent) are small farmers and raise short duration crops like lettuce, broccoli and red cabbage in alternation with other crops like potato, carrot and beet root. The production practices of exotic vegetables have been popularized among the small farmers by a private producer organization.

Survey on pests of exotic vegetables in The Nilgiris district

The survey revealed that *S. litura* and *Agrotis ipsilon* (Hufnagel) (95%) were the predominant pests followed by green peach aphids, *M. persicae* (75%), leaf miner, *L. trifoli* (60%), snail, *Helix aspersa* (Muller) (50%), mirid bug, *Nesidiocoris tenuis* (Reuter) (40%) and cabbage looper, *T. ni* (30%) in iceberg lettuce. Diamondback moth, *P. xylostella* (90%) and aphids, *M. persicae* (65%) were major pests in broccoli. *P. xylostella* (75%) was the predominant pest followed by aphids, *M. persicae* (60%), snail, *H. aspersa* (45%)

and cabbage looper, *T. ni* (25%) in red cabbage (Table 2). Apart from major pests of cole crops, mirid bug was also reported as a serious pest by 40% of lettuce farmers, which was a new information gathered in this study.

Table 1. Crop production information of farmers of Kotagiri block of The Nilgiris

Particulars		No. of respondents	Percentage
Size of holding = 1000 sq m (25 cents)		20	100
Cropping pattern	Monocropping	2	10
	Multiple cropping	18	90
Spacing- Lettuce	30 × 20 cm	15	75
(Variety: Iceberg lettuce)	30 × 15 cm	5	25
Crop duration- Lettuce	50-55 days	16	80
	55-60 days	4	20
Spacing - Broccoli (Variety: Bejo)	60 × 45 cm	20	100
Crop duration – Broccoli	90 days	20	100
Spacing - Red cabbage (Variety: Tokito)	30 × 30 cm	20	100
Crop duration - Red cabbage	90 days	20	100

Sample size: Total number of farmers was 20.

Sulvai *et al.* (2016) also reported cutworm, *A. ipsilon* as a serious pest on lettuce in a field study conducted in Mozambique, South Africa. Kift *et al.* (2004) reported aphid, *Nasonovia ribisnigri* (Mosley) as a major pest of lettuce. *P. xylostella* was reported to be the most destructive insect pest of cultivated cruciferous crops (including broccoli) throughout the world (Abro *et al.,* 2013; Obopile *et al.,* 2008; Sarfraz *et al.,* 2006; Shelton, 2001). Hooks *et al.* (2002) also reported *P. xylostella* and *T. ni* as potentially serious lepidopteran pests of brassicaceous plants in Japan. Because of the presence of alternate hosts like cabbage, cauliflower and potato, pests of exotic vegetables were recurring during every season, which forces the farmers to use more of pesticides. As inferred from earlier studies and the present study, the pest that is newly found in lettuce ecosystem in Tamil Nadu and gaining importance is the mirid bug, *N. tenuis.* Ahirwar *et al.* (2009), El-Dessouki *et al.* (1976) and Patel (1980) also reported *N. tenius* as a pest on sesame, tomato and tobacco respectively.

Table 2. Pest scenario of exotic vegetables in surveyed area

Crop	Name of the insect	No. of respondents	Percentage (%)
Lettuce	Tobacco caterpillar, *S. litura* Cutworm, *A. ipsilon*	19	95
	Aphids, *M. persicae*	15	75
	Leaf miner, *L. trifoli*	12	60
	Snail, *H. aspersa*	10	50
	Mirid bug, *N. tenuis*	8	40
	Cabbage looper, *T. ni*	6	30
Broccoli	Diamondback moth, *P. xylostella*	18	90
	Aphids, *M. persicae*	13	65
Red cabbage	Diamond back moth, *P. xylostella*	15	75
	Aphids, *M. persicae*	12	60
	Snail, *H. aspersa*	9	45
	Cabbage looper, *T. ni*	5	25

Sample size: Total number of farmers was 20.

Pesticides used against exotic vegetables pests

In the study area, most of the farmers were aware of newer insecticide molecules and applied insecticides like flubendiamide (95%), spinosad (75%) and chlorantraniliprole (60%) to manage *S. litura, A. ipsilon, P. xylostella* and *T. ni* on exotic vegetables. Predominantly, imidacloprid (90%) and acephate (70%) were used for the management of sucking pests (Table 3). Earlier workers also reported the usage of flubendiamide, spinosad, emamectin benzoate, chlorantraniliprole and indoxacarb against *S. exigua*, *P. xylostella* and *T. ni* in lettuce and cruciferous crops from seedling to harvest, across the world (Palumbo *et al.,* 2009; Amit *et al.,* 2001; Chen *et al.,* 2014 and Mohapatra *et al.,* 2010). Singh *et al.* (2016) conducted a study on broccoli in Himachal

Pradesh and found that malathion was mostly used followed by chlorpyriphos and cypermethrin, which is in contrast with the present study.

Pesticides usage pattern on exotic vegetables

In the survey area, 80% of farmers followed five sprays each with 5 days interval on iceberg lettuce and 65% of farmers applied seventimes at an interval of 6 days on broccoli. In red cabbage, 75% of farmers followed sevennumber of sprays with 6 days interval. Most of the farmers used hand operated knapsack sprayer for pesticide application (Table 3). In spite of frequent spraying, the dose applied was not scrupulously adopted as per the recommendation given by State Dept. of Horticulture or Tamil Nadu Agricultural University. Of the three major exotic vegetables grown, lettuce was the crop with shortest duration and received pesticide application once in 5 days as reported by 80% of the farmers. In broccoli and red cabbage, 7 days interval was followed by majority of the farmers. Similarly, Amit *et al.* (2001) also reported that for every 3-5 days, farmers applied the insecticides to manage cabbage pests. Results are in collaborative with Tyagi *et al*. (2015) who reported that more than 70 per cent farmers sprayed more than four times on cauliflower and tomato grown in India. In Ghana, Ntow *et al.* (2006) observed that farmers had sprayed the pesticides 6 to 12 times with an interval of 7 days in tomato and 12 sprays with 7 days interval in brinjal. Obopile *et al.* (2008) reported that 93.8% of farmers were using knapsack sprayer for pesticide application to control the pests of vegetables (including brassica crops) in Botswana.

Table 3. Insecticides used against pests of exotic vegetables

Name of the pests	Pesticides used	No. of respondents	Percentage
S. litura	Flubendiamide 39.35% SC	19	95
A. ipsilon	Spinosad 2.5% SC	15	75
P. xylostella	Chlorantraniliprole 18.5% SC	12	60
	Thiodicarb 75% WP	8	40
M. persicae	Imidacloprid 70% WG	18	90
	Acephate 75% SP	14	70
	Beta-cyfluthrin 8.49% + Imidacloprid 19.81% W/W	12	60
	Acetamiprid 20% SP	9	45
L. trifoli	Neemazal 1% EC	15	75

Sample size: Total number of farmers was 20

Figures in parentheses indicate percentage of respondents to total farmers (20 farmers).

Source of information on pesticide recommendation

The major sources of information pertaining to the recommendation of pesticides were private producer organization (50%), Department of Horticulture (35%), fellow farmers (5%), TNAU (5%) and pesticide retailers (5%). As the farmers in the survey area followed contract farming with the Green Earth Fresh Produce (GEFP) Company, the advisory given by them was the major source of information on pesticide recommendation (Table 4). In Nepal, 60 per cent of the vegetable farmers (including broccoli) followed the advice from neighbours to manage the pests (Rijal *et al.,* 2006), which was quite different from the present study. In another survey, farmers took advice from Agricultural Extension Officers (34.6%), fellow farmers (13.7%) and pesticide dealers (11.9%) in Ghana (Ntow *et al.,* 2006). Print and television media were not found to influence any of the agricultural operations including pest management in the study area.

Knowledge levels of farmers on pesticide residues

Survey among 20 farmers of exotic vegetables showed that 50 per cent of farmers were aware of pesticide residues in exotic vegetables and followed safe harvest interval of 3-4 days between last spray and harvest. In the survey area, 10 per cent of farmers followed the safety measures like use of protective dress while spraying and bathing after spraying pesticides. Bottle caps were used by 35 percent of farmers for the measurement of pesticide quantity for spraying and the remaining farmers followed approximate quantity. Only 20 per cent of farmers used stick for mixing the chemical. Rest of the farmers mixed the pesticide solution with hand. Survey showed that pesticide containers were buried in soil by 10 per cent and thrown in neglected area by 90 per cent of the farmers. None of the farmer was using biopesticides and/or traps for exotic vegetable pest management (Table 5). Similarly, in a survey conducted by Ntow *et al.* (2006), 80.2 per cent of the farmers were found to throw the empty pesticide containers in the field and 60 per cent of the farms were found with these empty bottles. About 83.2 per cent of the farmers were using knapsack sprayer for pesticide application in Ghana. In a survey conducted by Singh *et al.* (2016), 20.67 per cent of cabbage and tomato farmers were found to throw the empty pesticide containers in field and 39.33 per cent of farmers used mask or hand gloves while spraying in Himachal Pradesh. Contrast to the Indian farmers, 60 per cent of the vegetable (including broccoli) farmers

of Nepal were found wearing protective masks while spraying the pesticides (Rijal *et al.,* 2006), which was quite different from the present study. Contrast to the present study, 16per cent farmers spray even during harvesting and 37per cent of farmers followed safe harvest interval of 11 days to two weeks in cauliflower (Tyagi *et al.,* 2015).

Table 4. Source of information on insecticide recommendation

Particulars	No. of respondents	Percentage of respondents
Department of Horticulture	7	35
Private producer organisation	10	50
Fellow farmers	1	5
Pesticide retailers	1	5
TNAU	1	5

Sample size: Total number of farmers was 20.

In Kukkalthorai village, iceberg lettuce was mostly cultivated. Aphids were the epidemic pest during cooler season (July -October). The pesticides such as beta-cyfluthrin 8.49% + imidacloprid 19.81% W/W @ 30ml/10 L, imidacloprid 70% WG @ 3g/10 L, acetamiprid 20% SP @ 8g/10 L and acephate 75% SP @ 50g/10 L were used for the management of these pests. Mostly imidacloprid and acephate were used for the management of aphids. Each pesticide was applied only once, and the gap between two sprayings was about five days. *Helicoverpa* spp. and *Spodoptera* spp. were the endemic pests during summer season (March –June) on iceberg lettuce. Pesticides like thiodicarb 75% WP @ 30g/10 L, spinosad 2.5% SC @ 30ml/10 L, flubendiamide 39.35% SC @ 3ml/10 L and chlorantraniliprole 18.5% SC @ 5ml/10 L were used for its management. Leaf miner was a pest of iceberg lettuce upto 20 days after transplanting; Neemazal 1% EC @ 40ml/ 10 L is being applied for its management.

Table 5. Knowledge level of farmerson pesticide residues

Particulars		No. of respondents	Percentage
Pesticide residues		10	50
Harvest interval		10	50
Mixing of chemical by stick		4	20
Safety precautions while spraying		2	10
Disposal of pesticide container	Burial in soil	2	10
	Throwing in neglected area	18	90
Measuring pesticide for spraying using bottle cap		7	35
Approximate measurement		13	65
Biopesticides		0	0
Traps		0	0

Sample size: Total number of farmers was 20.

Diamondback moth (DBM) was an important pest in broccoli, and the pesticides used for the management were thiodicarb 75% WP @ 30g/10 L, spinosad 2.5% SC @ 30ml/10 L, flubendiamide 39.35% SC @ 3ml/10 L and chlorantraniliprole 18.5% SC @ 5ml/10 L. For management of aphids in broccoli, beta-cyfluthrin 8.49% + imidacloprid 19.81% W/W @ 30ml/10 L, imidacloprid 70% WG @ 3g/10 L, acetamiprid 20% SP @ 8g/10 L and acephate 75% SP @ 50g/10 L were used.

Monitoring of residues in market and farmgate samples

Totally, three farm gate lettuce samples (October, 2017) and twenty eight market samples of exotic vegetables (November, 2017 to February, 2018) including lettuce, broccoli, red cabbage, parsley and celery were analysed by using LC-MS/MS considering lettuce as the representative matrix. Flubendiamide residue was not detected in any of the samples tested. Since, the half life of flubendiamide on lettuce and other vegetables was very less (0.69 to 3.57 days), there is a meagre chance of detecting the residues in market samples. The loss of residues might have occurred in the field itself during the harvest interval or during supply chain process. Residues might have been lost due to growth dilution also. Shane (2006) also reported non-detectable residues of flubendiamide in key crops like cabbage, chilli and tomato. Quicker dissipation of flubendiamide on vegetable crops was also reported by Parmar *et al.* (2012); Sahoo *et al*. (2009) and Takkar *et al*. (2009).

Conclusion

Iceberg lettuce was the mostly grown exotic vegetable in the study area. Tobacco caterpillar, cutworm and aphids were major pests. Insecticides like flubendiamide (39.35% SC), spinosad (2.5% SC), chlorantraniliprole (18.5% SC), imidacloprid (70% WG) and acephate (75% SP) were mostly used by farmers on exotic vegetables for controlling the pests, as per the recommendations given by private company with which the farmers were engaged in contract farming. Farmers' knowledge on pesticide recommendation, dosage, safe harvest interval, label claim, personnel protection during sprayoperation was found to be squat. Thus, government has to encourage farmers to adopt sustainable pest management approach. Extension activities must be extended to spread awareness on pesticide residues caused due to indiscriminate usage and their hazards to the environment, which is to be considered seriously under resource poor small and medium holding systems.

References

Abro, G. H., Syed, T. S., Kalhoro, A. N., Sheikh, G. H., Awan, M. S., Jessar, R. D., and A. M. Shelton. 2013. Insecticides for control of the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) in Pakistan and factors that affect their Toxicity. *Crop Protection*, **52**: 91-96.

Ahirwar, R. M., Banerjee, S., and M. P. Gupta. 2009. Seasonal incidence of insect pests of sesame in

relation to abiotic factors. *Annals of Plant Protection Sciences*, **17(2)**: 351-356.

Amit, S., Thompson, G., and P. Downard. 2001. Challenges in implementing spinosad diamond back moth resistance management strategies in intensive vegetable growing areas in Asia. InThe management of diamond back moth and other crucifer pests, In: Proc. of the fourth international workshop. pp. 26-29.

Anastassiades, M., Lehotay, S. J., Stajnbaher, D., and F. J. Schenck. 2003. Fast and easy multiresidue method employing acetonitrile extraction/partitioning and "dispersive solid-phase extraction" for the determination of pesticide residues in produce. *Journal of AOAC international*, **86(2)**: 412-431.

Chen, X. J., Wang, P., Meng, Z. Y., Chen, S., Gu, H. T., and X. L. Sha. 2014. Degradation Dynamics and Residue Analysis of Flubendiamide in Cabbage and Soil by Liquid Chromatography–Tandem Mass Spectrometry with Dispersive Solid Phase Extraction. *Agricultural Sciences*, **5**: 850-857.

El-Dessouki, S. A., El-Kifl, A. H., and H. A. Helal. 1976. Life cycle, host plants and symptoms of damage of the tomato bug, *Nesidiocoris tenuis* Reut. (Hemiptera: Miridae), in Egypt. *Journal of Plant Diseases and Protection*, **83(4)**: 204-220.

Hassanzadeh, N., Bahramifar, N., Esmaili-Sari, A., and F. Saberfar. 2010. Dissipation of ethion applied on greenhouse cucumbers by duration of a pre-harvest interval (PHI). *Int. J. Agric., Environ. Biotechnol.,* **3(2)**: 179-183.

Hooks, C. R. R., and M. W. Johnson. 2002. Lepidopteran pest populations and crop yields in row intercropped broccoli. *Agricultural and forest entomology,* **4(2)**: 117-125.

Kift, N. B., Mead, A., Reynolds, K., Sime, S., Barber, M. D., Denholm, I., and G. M. Tatchell. 2004. The impact of insecticide resistance in the currant-lettuce aphid, *Nasonovia ribisnigri*, on pest management in lettuce. *Agricultural and Forest Entomology*, **6(4)**: 295–309.

Lim, G. S., Sivapragasam, A., and W. H. Loke. 1997. Crucifer insect pest problems: trends, issues and management strategies. The management of diamondback moth and other crucifer pests, In: proc. The Management of Diamondback Moth and Other Crucifer Pests. pp. 3-16.

Meenambigai, C., Bhuvaneswari, K., Mohan Kumar, K., and R. Sangavi. 2017. Pesticides usage pattern of okra, *Abelmoschus esculentus* (L) Moench in Tamil Nadu. *Journal of Entomology and Zoology Studies*, **5(6)**: 1760-1765.

Mohapatra, S., Ahuja, A. K., Deepa, M., Sharma, D., Jagadish, G. K., and N. Rashmi. 2010. Persistence and dissipation of flubendiamide and des-iodoflubendiamide in cabbage (*Brassica oleracea* Linne) and soil. *Bulletin of Environmental Contamination and Toxicology*, **85(9)**: 352–356.

Ntow, W. J., Gijzen, H. J., Kelderman, P., and P. Drechsel. 2006. Farmer perceptions and pesticide use practices in vegetable production in Ghana. *Pest management science,* **62(4)**: 356-365.

Obopile, M., Munthali, D. C., and B. Matilo. 2008. Farmers' knowledge, perceptions and management of vegetable pests and diseases in Botswana. *Crop Protection*, **27(8)**: 1220-1224.

Palumbo, J. C., and S. J. Castle. 2009. IPM for fresh-market lettuce production in the desert southwest: the produce paradox. *Pest Manag. Sci.,* **65**: 1311–1320.

Pan, L., Feng, X., and H. Zhang. 2017. Dissipation and Residues of Pyrethrins in Leaf Lettuce under Greenhouse and Open Field Conditions. *Int. J. Environ. Res. Public Health*, **14(7)**: 822.

Parmar, K. D., Singh, S., Shah, P. G., Joshi, M. N., Panchal, R. R., and A. R. Patel. 2012. Persistence of Flubendiamide and Thiacloprid in/on Chilli under Middle Gujarat Condition. *Pesticide Research Journal,* **24(1)**: 51-54.

Patel, N. G. 1980. The bionomics and control measures of tobacco bug *Nesidiocoris tenuis* Reuter (Miridae: Hemiptera). *Gujarat Agricultural University Research Journal*, **5(2)**: 60.

Rao, C. C., and V. M. Sasanka. 2015. Exotic Veggies: A Practical utility of innovation-lured by the easy returns. *International Journal of Applied Research*, **1(12)**: 1038-1041.

Rijal, J. P., Malla, R. K., Rawat, P. R., Tiwari, S., and Y. D. Gc. 2006. A preliminary study on the practices of insect pest management at Sukranagar VDC, Chitwan: A case study, In: proc. of National IPM Workshop of Plant Protection Society of Nepal. pp. 25-26.

Sahoo, S. K., Sharma, R. K., Battu, R. S., and B. Singh. 2009. Dissipation kinetics of flubendiamide on chili and soil. *Bulletin of environmental contamination and toxicology,* **83(3)**: 384-387.

Sarfraz, M., Dosdall, L. M, and B. A. Keddie. 2006. Diamondback moth- host plant interactions: implications for pest management. *Crop Prot.,* **25(7)**: 625-639.

Shane, H. 2006. Flubendiamide: the next generation in lepidopteran pest management. In annual meetingof the Entomological Society of America (ESA) held at research Triangle Park, NC, December.

Shelton, A. M. 2001. Managementof the diamondback moth: deja vu all over again. In The management of Diamondback moth and other crucifer pests, In: proc. of the fourth international workshop. pp. 26-29.

Singh, G., Dubey, J. K., and S. K. Patyal. 2016. A study on farmers' knowledge, perception and intensity of approved pesticide use practices/patterns in tomato and cabbage in Himachal Pradesh. *International Journal of Farm Sciences,* **6(3)**: 77-83.

Sulvai, F., Chauque, B. J. M., and D. L. P. Macuvele. 2016. Intercropping of lettuce and onion controls caterpillar thread, *Agrotis ipsilon* major insect pest of lettuce. *Chemical and Biological Technologies in Agriculture,* **3(1)**: 28.

Takkar, R., Sahoo, S. K., Singh, G., Battu, R. S., and B. Singh. 2012. Dissipation pattern of flubendiamide in/on brinjal (*Solanum melongena* L.). *Environmental monitoring and assessment,* **184(8)**: 5077-5083.

Tyagi, H., Gautam, T., and P. Prashar. 2015. Survey of pesticide use patterns and farmers' perceptions: a case study from cauliflower and tomato cultivating areas of district Faridabad, Haryana, India. *International Journal of MediPharm Research*, **1(3)**:139-146.

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