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Evaluating the Safety of β-Cyfluthrin Insecticide for Usage in Eggplant (*Solanum melongena* L.) Crop

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β - Cyfluthrin, a recent introduction to the synthetic pyrethroid family, is a mixture of four active stereoisomers of the parent compound cyfluthrin (Leicht, 1996). It is enriched with 67% of the *Trans* isomer, which is more insecticidal in nature than the *Cis* form and is a contact and stomach poison with a fast knock down effect. Synthetic pyrethroids are recommended against *Lepidopteran* pests affecting *Solanaceous* crops (Agnihotri *et al.*, 1990). Eggplant (*Solanum melongena* L.) is one of the major vegetable crops grown in India year round, and the fruit is consumed as vegetable; however high insect infestation of eggplant is the main problem of its cultivation. *Leucinodes orbonalis* or eggplant shoot and fruit borer is the major insect pest. The larvae cause the damage, when it bores into the fruit and makes it unconsumable (Bose and Some, 1990). Various studies under Indian conditions prove that synthetic pyrethroids are more efficient in controlling this pest menace. β - cyfluthrin insecticide had been tested against various pests of okra, cotton, cabbage and mustard (Gopal *et al.,* 2001), but its efficacy has not been studied against shoot and fruit borer of eggplant.

For safety evaluation of a new compound, actual field studies are essential. As literature on the persistence of β - cyfluthrin on various crops is very scanty, a study was therefore undertaken to develop an analytical method for estimation of its residues and study the persistence of β - cyfluthrin in / on eggplant fruits.

MATERIALS AND METHODS

Eggplant crop (variety Pusa Kranti) was raised in 360 m^2 plot (sub plot size 4.0 m x 3.0 m) in experimental farms of Indian Agricultural Research Institute, New Delhi during winter season. The plantation density was 18333 plants/ha. The average maximum and minimum daily temperature was 28.8^0C and 17.3^0C respectively. During the experiment, average relative humidity was 66% with 5.5-h sunshine hour and 65.8 mm of total rainfall. The analytical standard (98.7% pure) and formulation (Bulldock® 2.5 % a.i.) of β - cyfluthrin were procured from Bayer India Ltd. The crop was sprayed with β - cyfluthrin (formulation Bulldock® 025 SC) @ 12.5 g a.i./ha for normal dose and 25.0 g a.i./ha for double dose in 600 L of water. A control plot having no insecticide application was also maintained.

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Spraying was done at the flowering stage using a high volume paddle compressor sprayer. Each treatment was replicated thrice in randomized block design.

For bioefficacy study, all the eggplant fruits having holes visible from outside were plucked and discarded before the application of insecticide. Only small sized fruits, free from borer infestation were allowed to grow on the plant. After spraying the insecticide, extent of borer infestation was counted on 0, 7, 15 and 30 days for both the treatments as well as for the control. For pesticide residue analysis, tender fruit samples (2 kg) were collected from each replicate of both the treatments on 0 (1 hour after sampling), 1, 3, 5, 7, 10 and 15 days after spraying. Immediately after plucking the fruit, samples were put into polythene bag and transported to the laboratory. Analytical grade solvents namely acetone, hexane and dichloromethane were used for analysis. Sodium chloride, sodium sulfate, alumina (neutral and acidic) and Florisil were purchased from the BDH and used as such. A Hewlett-Packard Model 5890 series II gas chromatograph having an electron capture detector (ECD ^{63} Ni) with a glass column (2 m x 2 mm i.d.) containing 3% SE-30 coated on 80-100 mesh Chromosorb W.H.P. was used for residue analysis. Its injector temperature was set at 275 ^{0}C, while the column and detector temperature were 250 ^{0}C and 300 ^{0} C, respectively. Nitrogen was used as carrier gas, which was passed through the column at the rate of 30 ml / min.

Recovery experiments were conducted first before the field level analysis. Fresh eggplant fruits, which were not treated with pesticides, were cut into small pieces and 50 g of the samples were transferred into glass jars. These were then spiked separately with 1 ml of 5 ppm and 10 ppm β - cyfluthrin standard solution to obtain 0.1 mg/kg and 0.2 mg/kg β - cyfluthrin deposit on eggplant fruits. Distilled acetone was poured to submerge all the cut pieces of eggplant and left overnight (20 h). Dichloromethane was used for liquid-liquid partitioning of the pesticide from its aqueous extract and four different adsorbents namely silica gel, neutral alumina, acidic alumina and Florisil were used for column chromatographic cleanup. Hexane – acetone mixture (9:1,V/V) was used as eluting solvent in all the cases. For field level analysis, a representative sample of 50 g of eggplant fruits was taken after quartering and was extracted with acetone (thrice with 100 ml) in a Ramie Waring Blender for 3 minutes. The contents were filtered through a Buchner funnel fitted with a Whatman No.1 filter paper. The extracts were concentrated under reduced pressure and partitioned in a 250 ml separatory funnel with dichloromethane (3 x 30 ml) in the presence of 50 ml of 5% (V/V) saline water. The dichloromethane was passed through anhydrous sodium sulfate and was concentrated in a rotary evaporator. Thereafter the residue left was dissolved in hexane and was poured into a glass column (20 mm i.d.) packed sequentially with cotton, 2 g anhydrous sodium sulfate, 5 g neutral alumina and 2 g anhydrous sodium sulfate. It was eluted with 100 ml of hexane – acetone mixture (9:1, V/V). Colorless elute thus obtained was taken in a round bottomed flask and was evaporated completely. The flask was finally rinsed with hexane-acetone (9:1, V/V) mixture and the volume was made up to 10 ml and 3 µl of the solution was injected into the ECD-GLC.

Efforts were made to decontaminate the initial pesticide residues, present on eggplant fruits by employing some simple and feasible culinary processes, such as washing the fruits in running water and soaking in lime-water. For the former, the eggplant fruits were drawn on 0 (2 hr after spraying), 1 and 3 days after spraying from the plots treated with the normal and double dose of the insecticide. A representative sample of 50 g each was drawn after quartering and they were washed in running water along with mild rubbing with hand. Then they were air-dried and processed for residue analysis. In case of lime-water soaking treatments the representative samples (50 g each) were dipped in 1% calcium hydroxide solution for five minutes along with intermittent mild rubbing and thereafter they were taken out and subsequently washed in running water for one minutes. They were then air-dried and processed for residue estimation.

RESULTS AND DISCUSSION

Both the treatments were found effective in suppressing the insect population up to 15 days but the higher dose (25 g a.i./ha) was more efficient than the lower dose (12.5 g a.i./ha). The results are given in Table 1.

Table 1. Bioefficacy of β - cyfluthrin against the eggplant shoot and fruit borer.

Treatments	Borer infestation (% of total fruits)		
	7 day	15 day	30 day
T_1 (12.5 g a. i./ha)	15.19 (22.81)	17.84 (24.95)	37.68 (37.84)
T_2 (25.0 g a. i./ha)	8.37 (16.67)	11.32 (19.43)	23.88 (29.22)
Control	34.96 (36.24)	30.45 (33.41)	51.85 (46.06)
S. Error	0.4381	0.551	0.386
CD at 1%	1.966	3.493	1.730

Figures in parenthesis show the angular transformed value.

Among the adsorbents, Florisil gave highest recovery (87.55%) followed by neutral alumina (80.35%), but due to the higher cost effectiveness of neutral alumina, it was selected for the cleanup of samples. The results are given in Table 2. The eggplant fruits were analyzed periodically after the application of insecticide at two doses. The data of the residues are presented in Table 3.

About 88-90 % of initial β - cyfluthrin concentration dissipated from the eggplant fruits within 15 days after application following first order reaction kinetics. The regression equation for the single dose and double doses were Y= - 0.8532 - 0.0627 X and Y= - 0.5299 – 0.0648 X, respectively where 'Y' represents log of residues in mg/kg and 'X' time in days. The half-life of the insecticide was 4.80 days for normal dose and 4.65 days for double dose. It seems that β - cyfluthrin

has a moderate persistence on eggplant fruits. The results are quite comparable with the persistence of other synthetic pyrethroids on eggplant. Mukherjee and Gopal (1992) reported that the half-lives of lambda-cyhalothrin, tau-fluvalinate and fenvalerate on eggplant were 3.0, 5.5 and 6.0 days, respectively. Singh and Kalra (1992) also got similar results when they applied another synthetic pyrethroid cypermethrin on eggplant fruits during the autumn season. It was found to have a half-life of 2.2-2.9 days.

Table 2. Recovery of β – cyfluthrin from fortified eggplant fruits.

Adsorbent used	Amount added (mg x10^{-3})	Amount recovered (mg x 10^{-3})				Per cent recovery	Average recovery (%)
		R_1	R_2	R_3	Mean		
Silica gel	5.0	0.83	0.92	1.12	0.96	18.0	18.25
	10.0	2.66	2.29	2.58	2.51	18.5	
Alumina (Neutral)	5.0	3.71	4.10	3.88	3.89	77.9	80.35
	10.0	8.00	8.40	8.47	8.29	82.9	
Alumina (Acidic)	5.0	2.80	3.09	3.31	3.06	61.3	60.42
	10.0	6.29	5.77	5.81	5.95	59.5	
Florisil	5.0	4.49	4.17	4.24	4.30	86.0	87.55
	10.0	9.29	8.31	9.13	8.91	89.1	

Table 3. Residues of β - cyfluthrin on eggplant fruits.

Days after application	Treatments (g a.i./ ha)	Residues (mg / kg)				σ_{n-1}	% loss
		R_1	R_2	R_3	Mean		
0	12.5	0.141	0.148	0.136	0.142	0.006	-
	25.0	0.324	0.288	0.298	0.303	0.018	-
1	12.5	0.107	0.128	0.115	0.116	0.011	18.30
	25.0	0.225	0.208	0.222	0.232	0.028	23.43
3	12.5	0.106	0.082	0.091	0.093	0.012	34.51
	25.0	0.187	0.153	0.209	0.183	0.028	39.60
5	12.5	0.066	0.061	0.075	0.067	0.004	52.58
	25.0	0.164	0.155	0.152	0.157	0.006	48.48
7	12.5	0.052	0.055	0.047	0.051	0.004	63.85
	25.0	0.109	0.109	0.118	0.112	0.005	63.04
10	12.5	0.039	0.035	0.029	0.034	0.005	75.82
	25.0	0.064	0.052	0.067	0.061	0.007	79.87
15	12.5	0.015	0.017	0.015	0.016	0.001	88.97
	25.0	0.031	0.039	0.024	0.031	0.007	89.66

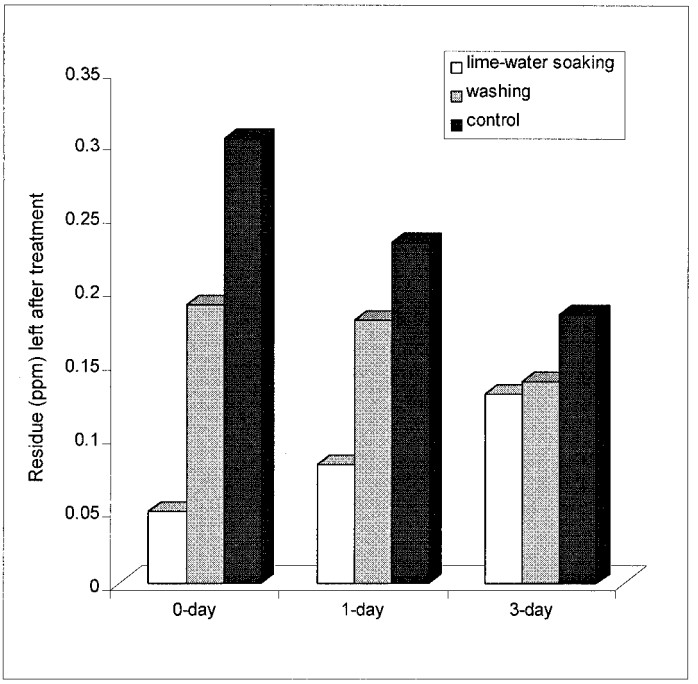

Figure 1. Ability of different decontamination methods to dislodge β – cyfluthrin residue from eggplant fruits.

The acceptable daily intake (ADI) of β - cyfluthrin is 0.02 mg / kg body weight (Tomlin, 1994). Taking the body weight of an average Indian person as 55 kg, the maximum permissible intake (MPI) of β - cyfluthrin is calculated out by multiplying it with the ADI (Gopal and Mukherjee, 1995), which was found to be 1.1 mg / person. An average Indian person consumes 1.5 - kg food per day of which vegetable constitutes 0.285 kg. Therefore, the food factor for the vegetable was 0.19. The maximum amount of residue obtained on the eggplant fruits during the experiments was 0.324 mg / kg (0 day, double dose). Thus the Theoretical Maximum Residue Contribution (TMRC) for β - cyfluthrin was 0.324 mg/ kg x 0.19 x 1.5 kg / person / day = 0.092 mg/ person/ day. As the theoretical maximum residue contribution value (TMRC) was found less than the toxicologically estimated MPI value, it can be concluded that the rate of application of β - cyfluthrin at both of the doses could be taken as safe from the point of view of crop protection and environmental pollution, but more field trials are required to confirm this finding.

Since the eggplant fruits are plucked almost everyday, there is a need for reducing the level of residues in these fruits below its maximum residue limit (MRL). Since the MRL of β - cyfluthrin is not yet available from FAO/ WHO, MRL of a similar synthetic pyrethroid cypermethrin was used (0.1 ppm). It was worthwhile to study

whether the residue of β- cyfluthrin can be reduced below this level by decontamination. Simple culinary processes were tested for this purpose and the results are given in Figure 1.

These results show that simple culinary processes are quite efficient in reducing the pesticide residues from eggplant fruits. The lime-water soaking was found better for decontamination of eggplant fruits than simple washing with tap water. This is due to the alkaline nature of the calcium hydroxide, which helps in degrading the ester linkage of β - cyfluthrin. This facilitates in removal of the pesticide from the eggplant fruits as the level of pesticide residues in eggplant fruits was found to be less than 0.1 ppm after lime-water soaking. This process was however more effective for the 0 day and 1 day samples. In the later stages, these treatments were found not very effective, as the insecticide might have penetrated in the skin of eggplant fruit.

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