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Chemodynamics of cypermethrin in eggplant agroecosystem in Bangladesh

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Abstract

A study was conducted in the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, which is situated at 24.04^{0} N latitude and 90.40^{0} E longitude with an elevation of 8.4 meter from the sea level and in the 28th Agro ecological Zone (AEZ) during November 2012 to April 2013. Field study was conducted to measure the application loss of insecticide through soil and air at different growth stages of eggplant crop. Fate of cypermethrin during application, consist of receiving insecticide by the eggplant and disseminating it to the other non target site mainly air and soil. The total highest loss of cypermethrin (82.3±4.2%) was recorded at 45 days after transplanting (DAT) and the loss was through air (5.2±0.3%) and soil (77.2±2.6%). The lowest plant height and canopy area was observed at 45 DAT in that time cypermethrin application loss was highest. Among the different treatments the lowest cypermethrin loss and maximum retention of cypermethrin in the plant (49.2%) was observed in T_3 treated plot which was started at 104 DAT when the plant height and canopy area was reached at a maximum level and obviously the environmental component was polluted at a minimum rate.

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Introduction

Eggplant is extensively damaged by the most destructive pest, eggplant fruit and shoot borer (ESFB) (*Leucinodes orbonalis*) which caused 31-86% fruit damage in Bangladesh (Alam *et al.,* 2003) reaching up to 90%, (Rahman, 1997) that making it totally unfit for human consumption. To overcome this loss, use of pyrethroid insecticides viz., Cypermethrin is very common used by the farmers of Bangladesh and they apply indiscriminately even at fruiting stage (Zafar *et al.,* 2011).

Chemodynamics means the study of the transport, conversion, and fate of chemical substances in air, water, or soil, including their movement from one medium to another (Thibodeaux, 1996). A survey of pesticide use in Bangladesh indicated that farmers sprayed chemical insecticides up to 180 times during a cropping season to protect their eggplant crop infested by the eggplant fruit and shoot borer, *Leucinodes orbonalis* (SUSVEG-Asia, 2007). Indiscriminate and haphazard use of these chemicals, particularly at fruiting stage, leads to its accumulation in the vegetables which consequently cause hazards to human beings through food chain (Nafees and Jan, 2009). This results serious contamination of different component of environment (surface waters, aquifers, soil, air etc) including human, wildlife and other organisms.

The poor method of application of pesticides practiced in Bangladesh lead to significant contamination. The consequences of such frequent application of pesticide cause serious contamination of environment through chemodynamics of pesticide. It is to be noted that only 10-20% of the applied pesticides reach the target site while the rest enter into the various environmental component including soil, air and water (Gill *et al*., 2008). So, it is very important to know about how much pesticide loss during application time before measure the residual status. Nevertheless, no study so far been conducted on such loss of pesticides in Bangladesh.

Therefore, the present study was undertaken to measure the application loss of cypermethrin insecticide through soil and air in eggplant agro-ecosystem at different growth stages of eggplant crop.

Materials and methods

Location

A study was conducted in the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706, during November 2012 to April 2013.

Design of Experiment

The field experiment comprising of four treatments with an untreated control was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were:

T_1 = Ripcord (cypermethrin) 10 EC at 1 ml/l of water sprayed at 45 DAT and repetition of the same at 7 days interval. T_2 = Ripcord (cypermethrin) 10 EC at 1 ml/l of water sprayed after initiation of 2% level of fruit infestation and repetition of the same at 15 days interval. T_3 = Ripcord (cypermethrin) 10 EC at 1 ml/l of water sprayed after observing 5% level of fruit infestation and repetition of the same at 15 days interval. T_4 = Ripcord (cypermethrin) 10 EC at 2 ml/l of water sprayed after observing 5% level of fruit infestation and repetition of the same at 15 days interval and T_5 = Untreated control.

Data Recording

The following parameters were considered for measuring the application loss of insecticides.
1. Weight of insecticide spray on foam sheet placed on ground (Application loss in soil). 2. Weight of insecticide spray on foam sheet placed over the plant canopy (Application loss in air). 3. Weight of insecticide on plant = {Total weight of spray volume (minus) - (1+2)}. 4. Height of plant (cm). 5. Area of plant canopy (cm^2).

Determination of Application Loss in Soil

For determining insecticide application loss in soil, a polythene sheet was initially placed in the 9 m^2 plot.

Then the foam sheet (1.25 cm thickness) of the same size (weighed) was placed on the polythene sheet to avoid loss of applied insecticide to the ground. Immediately after application of insecticide, the foam was weighed finally by electric balance. Insecticide application loss in soil was determined by subtracting the initial weight from the final weight of the foam sheet.

Determination of Application Loss in Air

The plots (3m X 3m) were housed by the polythene sheet. Underside of the roof of the house, a foam sheet (weighed) was placed. Immediately after application of insecticide, final weight of the foam sheet was taken by electrical balance and loss of insecticide in the air was measured from the difference between final and initial weight of foam sheet.

Measurement of Plant Height and Canopy

Plant height (cm) and canopy area (cm^2) were recorded at the time of each insecticidal application with the help of measuring scale. Canopy was measured at north-south (NS) and the east-west (EW) direction and area was calculated by using πr^2 formula.

Data analysis

All the collected and processed data as stated above were analyzed statistically after appropriate transformations. The analysis of variance (ANOVA) and multimode general linear model (GLM) of different parameters was done and the means were separated by using the Duncan's Multiple Range Test (DMRT) using SPSS software.

Results

Fate of Cypermethrin under Field Condition at Different Growth Stages of Eggplant

Fate of cypermethrin application on eggplant sprayed at 7 days interval at 1ml/l of water starting from 45 Days After Transplanting (DAT) is presented in Table 1. Results showed that deposition of cypermethrin on plants at different DAT showed significant difference ($F_{14,30} = 69.9$, $p < 0.001$). The highest percentage (49.4 ± 0.2%) of cypermethrin was received by the plant (target site) at 129 DAT which was statistically similar to that of 101 DAT to 143 DAT and the lowest (17.6 ± 2.6%) was received at 45 DAT which was statistically similar to 66 DAT. The results indicated that with the progress of growth stages the rate of cypermethrin deposit on the target site increased significantly.

Table 1. Fate ofcypermethrin application on eggplant sprayed at 7 days interval @ 1ml/l of water starting from 45 DAT till the last harvest (i.e., 143 DAT).

Days after transp-lanting (DAT)	Cypermethrin		
	Deposition	Loss	
	Plant (%) ± SE	in air (%) ± SE	in soil (%) ± SE
45	17.6 ± 2.6 ^{f}	5.2 ± 0.3 ^{ac}	77.2 ± 2.6 ^{a}
52	19.6 ± 2.7 ^{ef}	4.4 ± 0.7 ^{ad}	76.0 ± 2.8 ^{a}
59	22.3 ± 1.0 ^{ef}	3.8 ± 0.1 ^{d}	73.9 ± 1.1 ^{a}
66	23.1 ± 4.3 ^{ef}	3.7±1.2 ^{d}	73.2 ± 3.1 ^{a}
73	23.8 ± 3.4 ^{e}	3.7±0.1 ^{d}	72.6 ± 3.5 ^{a}
80	30.7 ± 0.3 ^{d}	3.6±0.3 ^{d}	65.7 ± 0.1 ^{b}
87	37.2 ± 0.1 ^{c}	3.9 ± 0.1 ^{cd}	58.8 ± 0.0 ^{c}
94	43.2 ± 0.8 ^{b}	4.1 ± 0.4 ^{bd}	52.8 ± 0.4 ^{d}
101	47.3 ± 0.1 ^{ab}	4.5 ± 0.1 ^{ad}	48.2 ± 0.1 ^{de}
108	48.3 ± 0.1 ^{ab}	4.8 ± 0.1 ^{ad}	46.9 ± 0.1 ^{e}
115	46.9 ± 0.9 ^{ab}	5.4 ± 0.2 ^{a}	47.6 ± 0.9 ^{e}
122	49.0 ± 0.6 ^{ab}	5.5 ± 0.1 ^{a}	45.4 ± 0.5 ^{e}
129	49.4 ± 0.2 ^{a}	5.3 ± 0.2 ^{ab}	45.3 ± 0.3 ^{e}
136	48.1 ± 0.8 ab	5.3 ± 0.2 ^{ab}	46.5 ± 0.7 ^{e}
143	48.5 ± 0.6 ^{ab}	5.5 ± 0.0 ^{a}	45.9 ± 0.5 ^{e}

Means within a column followed by same letter(s) are not significantly different (DMRT, $p \leq 0.05$).

During application cypermethrin was not only received by the plants but also it was drifted to other non target sites, mainly in the air and soil. Loss of applied cypermethrin through air at different DAT showed significant difference ($F_{14,30} = 3.4$, < p 0.01). Drifting in the air i.e., insecticide loss through air drifting was the highest at 143 and 122 DAT (5.5%) which was statistically similar to that of 136 DAT (5.3 ± 0.2%), 129 DAT (5.3 ± 0.02%), 115 DAT (5.4 ± 0.2%), 108 DAT (4.8±0.1%), 101 DAT (4.5 ± 0.1%), 52 DAT (4.4 ± 0.7%) and 45 DAT (5.2 ± 0.3%). Minimum loss was recorded at 80 DAT (3.6 ± 0.3%) which was statistically similar to that of 52 to 108 DAT (3.7% to 4.8%) (Table 1).

Loss of applied cypermethrin through drifting to the soil at different growth stages of eggplant showed significant difference ($F_{14,30} = 64.6$, $p < 0.001$). Loss of sprayed cypermethrin in soil through drifting was the highest at 45-73 DAT and it ranged from 72.6 ± 3.5% to 77.2 ± 2.6% and no significant difference was noticed among them. The second higher loss was obtained at 80 DAT (65.7 ± 0.1%) which was significantly different from those recorded at other DAT. The lowest loss of insecticide in soil through drifting was found at 129 DAT (45.3 ± 0.3%) which was statistically comparable to those recorded at 101 DAT to 143 DAT and value ranged from 45.9 ± 0.5% to 48.2 ± 0.1% (Table 1).

Fate of cypermethrin sprayed at 15 days interval at 1ml/l of water on eggplant starting at 2% fruit infestation level (101 to 146 DAT) is presented in Fig. 1A, B & C. Results showed that the fate of cypermethrin on plants at different DAT showed significant difference($F_{3,8} = 2.5$, $p < 0.05$).

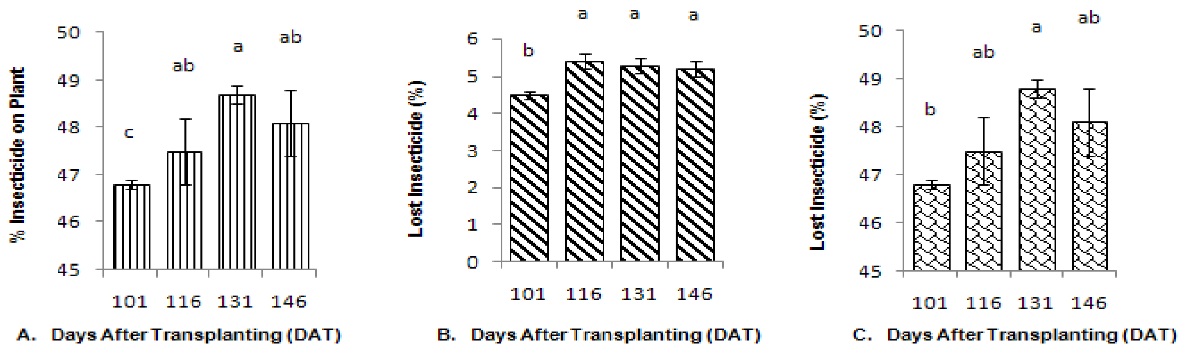

Fig. 1. Fate of cypermethrin application on eggplant sprayed at 15 days interval at 1ml/l of water at 2% level of fruit infestation starting from 101 DAT till the last harvest (i.e., 146 DAT). A. Percent retained on the plant, B. Percent lost in the air through drifting, C. Percent lost in the soil through drifting.

The highest (48.7 ± 0.2%) retention of cypermethrin was on the plant at 131 DAT which was statistically similar with 146 DAT (48.1%), and 116 DAT (47.5%). Significantly the lowest (46.8 ± 0.1%) of insecticide was retained on the plant at 101 DAT (Fig. 1A).

Loss of cypermethrin in the air through drifting was recorded (5.4 ± 0.1%) at 116 DAT followed by (5.3 ± 0.2%) at 131 DAT and (5.2 ± 0.2%) at 146 DAT and they were not significantly different from each other. Significantly the lowest percentage (4.5 ± 0.1%) of loss of cypermethrin in the air was observed at 101 DAT of plant growth (Fig. 1B).

Cypermethrin loss in soil through drifting in the eggplant field at 2% level of fruit infestation showed significant difference ($F_{3,8} = 2.5$, $p < 0.05$) (Fig. 1C). The highest (48.8 ± 0.2%) of cypermethrin loss was observed in the soil by drifting at 131 DAT followed by 146 DAT (48.1%) and 116 DAT (47.5%) which were statistically similar. The lowest percentage of loss in soil was found at 101 DAT (46.8 ± 0.1%) which was not significantly different from these of 116 DAT and 146 DAT

Fate of cypermethrin application on eggplant sprayed at 15 days interval at 1ml/l of water at 5% level of fruit infestation (i.e., 104 DAT to 149 DAT) is presented in Fig. 2A, B & C. Results presented in Fig. 2 indicated that the fate of cypermethrin on plant at different DAT showed none or less significant difference.

The highest retention (49.6%) of cypermethrin was on the eggplant at 134 DAT but this was not significantly different from those obtained at 104 DAT (49.2%), 119 DAT (49.3%) and 149 DAT (49.0%) (Fig. 2A).

The loss of cypermethrin in the air through drifting at 5% level of fruit infestation at 104 DAT (4.7%), 119 DAT (5.4%), 134 DAT (5.4%) and 149 DAT (5.5%) were not statistically different (Fig. 2B).

On the other hand, the loss of cypermethrin in the soil through drifting at 5% level of fruit infestation was the highest when applied at 104 DAT (46.1%) which was statistically identical to 149 DAT (45.5%). The minimum loss of the insecticide was recorded when applied at 134 DAT (45.0%) but this was statistically similar to that recorded at 119 DAT (45.2%) (Fig. 2C).

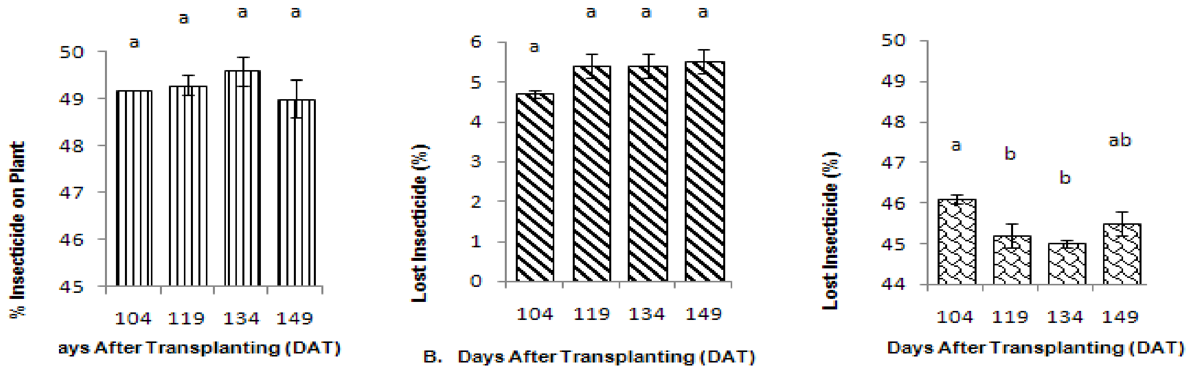

Fig. 2. Fate of cypermethrin application on eggplant sprayed at 15 days interval at 1ml/l of water at 5% level of fruit infestation starting from 104 DAT till the last harvest (i.e., 149 DAT). A. Percent retained on the plant, B. Percent lost in the air through drifting, C. Percent lost in the soil through drifting.

The fate of cypermethrin when sprayed at 15 days interval at 2ml/l of water at 5% level of fruit infestation of eggplant (104, 119, 134 and 149 DAT) under field condition is presented in Fig. 3A, B & C. Results showed that cypermethrin retained on plants ($F_{3,8}$ = 5.9, $p < 0.05$) had significant difference at different growth stages of eggplant. The highest quantity (50.1 ± 0.2%) of cypermethrin was retained on the plant after spraying at 104 DAT which was statistically similar to that obtained at 149 DAT (49.6%). The lowest percentage was retained on the plant at 134 DAT (48.7%) which was statistically comparable to that obtained at 119 DAT (49.2%) (Fig. 3A).

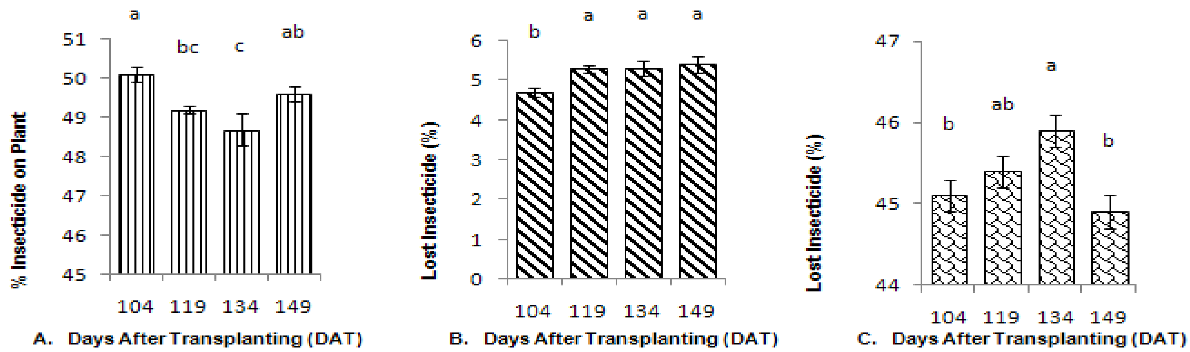

Fig. 3. Fate of cypermethrin application on eggplant sprayed at 15 days interval at 2ml/l of water at 5% level of fruit infestation starting from 104 DAT till the last harvest (i.e. 149 DAT). A. Percent retained on the plant, B. Percent lost in the air through drifting, C. Percent lost in the soil through drifting.

The loss of cypermethrin in the air through drifting at 5% level of fruit infestation was the highest (5.4%) when applied at 149 DAT which was not statistically different from that observed at 119 DAT (5.3%) and 134 DAT (5.3%). Significantly the lowest loss in the air was recorded at 104 DAT (4.7%) (Fig. 3B).

The loss of insecticide in the soil through drifting at 5% level of fruit infestation was the highest when applied at 134 DAT (45.9%) which was statistically similar to that of 119 DAT (45.4%). But the later one was not significantly different from those recorded at 104 DAT (45.1%) and 149 DAT (44.9%) (Fig. 3C).

Effect of Cypermethrin Loss in Relation to Plant height and Canopy area at Different Growth Stages of Eggplant

Plant height at different DAT had significant difference (GLM: $F_{14,45} = 5.1$, $P < 0.001$) (Table 2). The recorded plant height was ranged from 40.8 ± 3.4 to 60.1 ± 3.9 cm with the highest value of 60.1 cm at 143 DAT. But this was not significantly different from those recorded at 59 DAT to 136 DAT. Significantly the lowest plant height (40.8 cm) was recorded at 45 DAT.

Canopy area at different DAT showed significant difference (GLM: $F_{14,45} = 273.4$, $P < 0.001$). The canopy area of eggplant was significantly lowest (1863.7 cm^2) recorded at 45 DAT and it attained the highest (9943.4 cm^2) at 143 DAT, which was statistically identical with those obtained at 101 DAT to 136 DAT (Table 2).

Table 2. Relationship of plant height and canopy area with loss of cypermethrin at different growth stages of eggplant (mean±SD).

Days after transp-lanting (DAT)	Plant height (cm)	Canopy area (cm^2)	Cyperme-thrin loss
45	40.8 ± 3.4 ^{c}	1863.7 ± 200.2 ^{f}	82.3 ± 4.2 ^{a}
52	49.3 ± 4.6 ^{b}	2391.5 ± 376.2 ^{ef}	80.4 ± 4.7 ^{ab}
59	52.5 ± 3.7 ^{ab}	2628.7 ± 275.6 ^{de}	77.7 ± 1.8 ^{ab}
66	52.7 ± 4.8 ^{ab}	2695.2 ± 265.7 ^{de}	76.9 ± 7.4 ^{ab}
73	53.7 ± 4.5 ^{ab}	2820.1 ± 299.1 ^{de}	76.2 ± 5.9 ^{b}
80	56.5 ± 4.6 ^{ab}	3233.1 ± 342.0 ^{d}	69.3 ± 0.4 ^{c}
87	57.8 ± 4.6 ^{a}	4594.6 ± 410.9 ^{c}	62.8 ± 0.2 ^{d}
94	58.4 ± 4.6 ^{a}	7443.6 ± 360.8 ^{b}	56.8 ± 1.3 ^{e}
101	59.5 ± 4.2 ^{a}	9598.2 ± 376.6 ^{a}	52.7 ± 0.3 ^{ef}
108	60.1 ± 4.0 ^{a}	9854.8 ± 405.2 ^{a}	51.7 ± 0.2 ^{ef}
115	60.1 ± 3.9 ^{a}	9943.4 ± 432.9 ^{a}	53.0 ± 1.7 ^{ef}
122	60.1 ± 3.9 ^{a}	9943.4 ± 432.9 ^{a}	50.9 ± 1.0 ^{ef}
129	60.1±3.9 ^{a}	9943.4 ± 432.9 ^{a}	50.6 ± 0.3 ^{f}
136	60.1 ± 3.9 ^{a}	9943.4 ± 432.9 ^{a}	51.8 ± 1.4 ^{ef}
143	60.1 ± 3.9 ^{a}	9943.4 ± 432.9 ^{a}	51.8 ± 0.9 ^{ef}

Data were presented as Mean ± SD. General Linear Model (GLM). Means within a column followed by same letter(s) are not significantly different (DMRT, $p \leq 0.05$).

Loss of cypermethrin at different DAT showed significant difference (GLM: $F_{14,45} = 49.9$, $P < 0.001$).The highest (82.3 ± 4.2%) loss of cypermethrin was observed at 45 DAT which was statistically similar to those calculated at 52 DAT, 59 DAT and 66 DAT. and the lowest (50.6 ± 0.3%) loss of cypermethrin was recorded at 129 DAT which was statistically similar to those recorded at 101 DAT through 143 DAT.

Table 2 also indicated that the interaction effect of plant height and canopy area on the loss of cypermethrin at different DAT showed significant difference (GLM: $F_{1,45} = 7961.4$, $p < 0.0001$) where insecticide loss was reduced gradually with the increase of plant height and canopy area.

Discussion

Although the direct comparison of the present findings couldn't be made with the findings of other author(s) due to lack of references. But some workers have reported about the drifting loss of pesticide only. According to Gill *et al.* (2008), the pesticide losses in the air applied on the vine type of plant was ranged from 10% to 20% but the loss of insecticide in air of the present study was little more than 5%.

According to De Rudnicki and Ruelle (2010), pesticide loss depends upon the canopy coverage, shape, slope and the height of the plant and spray loss may be 14 to 45% in field depending on different spraying system. Up to 90 % spray losses of pesticide was commonly seen during a typical spray in the air and soil through drifting (Bodes, 2002). Different micro meteorological factors such as temperature, wind velocity, relative humidity etc. is also found to hamper the spray during application and causes the loss of pesticide (Hewitt *et al.,* 2002).

In this study we found that, the highest percentage of cypermethrin loss was recorded at 45 DAT (82.3 ± 4.2%) and the lowest percentage (50.6 ± 0.3%) was recorded at 129 DAT. With the increase the plant height and canopy area with increasing plant growth, the applied cypermethrin loss was gradually decreased. As a result it might be suggestions to the farmers use this pesticide start from around 104 DAT when plant height and canopy area attained a maximum level to keep our environment sound from indiscriminate application of cypermethrin insecticide.

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