Research article

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MEASURING THE LOSS OF PYRETHROID INSECTICIDE AFTER SPRAY IN BRINJAL ECOSYSTEM IN BANGLADESH

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ABSTRACT

The field study was undertaken to estimate the application loss of synthetic pyrethroid (Cypermethrin 10EC) insecticide through soil and air at different days after transplanting of brinjal. The study was conducted in the experimental farm of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during summer season (February to June 2016). Cypermethrin sprayed at 10 days interval @ 1 ml l^{-1} of water was highly deposited on the brinjal plant at 100 days after transplanting (DAT) (53.20±3.20%) and the lowest deposition was at 30 DAT (26.90 ± 2.69 %). The drift loss of cypermethrin was ranged from 3.40±0.24 % at 50 DAT to 5.60± 0.34% at 120 DAT in air on the other hand 41.70± 2.92% at 100 DAT to 69.60± 6.96% at 30 DAT in soil. While cypermethrin sprayed @ 2 ml l^{-1} of water at 15 days interval, the same results were observed i.e., 1 ml l^{-1} of water applied at 10 days interval and 2 ml l^{-1} of water at 15 days interval showed the almost similar results. The loss of cypermethrin was reduced day by day as the brinjal plant canopy and the plant height increased with the time. The highest drift loss was 73.10±7.31% at 30 DAT and the lowest was 46.80±3.28% at 100 DAT as the brinjal plant height and canopy increased.

Keywords: Estimation, drifting loss, cypermethrin 10EC, *Solanum melongena* L.

INTRODUCTION

Brinjal (*Solanum melongena* L.) is one of the major and important vegetables in Bangladesh. Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) is the most destructive pest of brinjal, which caused 31-86% fruit damage in Bangladesh (Alam *et al.* 2003) reaching up to 90% (Raman 1997). In India it was 37-63%

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(Dhankar 1988) and in Pakistan 50-70% (Saeed and Khan 1997). To overcome this loss, use of pyrethroid insecticides viz., Cypermethrin is very commonly used by the farmers of Bangladesh and they apply indiscriminately even at fruiting stage (Zafar *et al.* 2011). Choudhury *et al.* (2018) reported only 4.28-8.57% shoot infestation in Cypermethrin 10EC treated brinjal field in Bangladesh. Shivalingaswamy *et al.* (2005) reported that for controlling BSFB, Quinalphos (55.68%) Cypermethrin (40%) and endosulphan (35.22%) are the most preferred insecticides to the brinjal growers of Eastern Uttar Pradesh of India.

Cypermethrin is a synthetic pyrethroid used as an insecticide in large-scale commercial agriculture applications as well as in consumer products for domestic purposes. Choudhury *et al.* (2019) stated that cypermethrin 10 EC increased healthy fruits and reduced infested fruits of brinjal over untreated control (79.24% and 51.66%, respectively). Synthethic pyrethroid insecticides has unique properties, such as greater photo stability, effectiveness at low concentrations, low environmental persistence, and easy breakdown as compared to organochlorine and organophosphorus insecticides (Pang *et al*. 1994). It constitute approximately 25% of worldwide insecticide market for plant protection and have been in use for more than 40 years (Shafer *et al*. 2005).

Farmers of Bangladesh particularly in intensive brinjal growing areas like Jessore district apply insecticides 84-140 times in a brinjal growing season (AVRDC 2003). This over-use, misuse and indiscriminate use of insecticides cause drifting loss to the nearest crop and in the atmosphere, which resulted in resistance to pest species, because pest resurgence & secondary pest outbreak stimulate the reproductive rate in certain pests, resulted in mortality of beneficial insects and finally environmental pollution. The poor method of application of pesticides practiced in Bangladesh lead to significant contamination. 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 necessary to apply pesticides following good agricultural practice (GAP). There is very scanty information on measuring insecticide (Cypermethrin 10 EC) drifting loss in air and soil in brinjal field of Bangladesh. Therefore, considering the above background, the present research was undertaken to estimate the application loss of sprayed cypermethrin 10 EC in soil and air at different days after transplanting (DAT) of brinjal plant in the field.

MATERIALS AND METHODS

The study was conducted in the experimental farm of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, during summer (February to June 2016). The crop was grown following the recommended practices as described by Rashid (1999).

Design and layout of the experiment: Experiment was arranged in randomized complete block design (RCBD) with three replications. The whole field was divided into three blocks of equal size having 2 m space between the blocks and 1.5 m between the plots. The unit plot size was 3 m × 3 m accommodating 15 pits per plot. The distance between rows was 1 m and that between plants 60 cm. Every unit plot had 3 rows with 5 plants at each row. The total number of plants per plot was 15.

Seedling raising and transplantation: Seeds of brinjal variety BARI Begun-8 were collected from the Horticulture Research Center (HRC) of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh. A small seed bed measuring 5 m × 1 m was prepared and seeds were sown in the nursery bed at BSMRAU, Entomology field on 1, January 2016. The plots were lightly irrigated regularly for ensuring proper germination and growth of the seedlings. Thirty days old seedlings were transplanted in the well-prepared experimental plots. A total of 135 seedlings were planted in 9 plots @ 15 seedlings per plot. Light irrigation was applied on newly transplanted seedling. Gap filling was done with fresh and healthy seedling. Supplementary irrigation was applied at an interval of 7 days.

Treatments: The present study was composed of three treatments including an untreated control and these were Rambo10 EC (Cypermethrin) @ 1 ml L^{-1} of water sprayed at first initiation of BSFB infestation (during 30 DAT to 120 DAT i.e., crop age of 60 to 150 days) at 10 days interval. And Rambo10EC (Cypermethrin) @ 2 ml L^{-1} of water sprayed at first initiation of BSFB infestation (during 30 DAT to 120 DAT i.e., crop age of 60 to 150 days) at 15 days interval and control

Data recording: The following parameters were considered for measuring the loss of insecticide after application.

1. Weight (before & after application) of insecticide spray on foam sheet placed on ground (application loss in soil)
2. Weight (before & after application) 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 – (1+2)]
4. Height of plant (cm)
5. Area of canopy (cm^2)

Weight of spray material: Spray material with insecticide (Cypermethrin 10 EC) was weighed by electronic balance and applied in the field by knapsack sprayer.

Determination of application loss in soil: For determining insecticide application loss in soil, initially polythene sheet was placed in each plot (3 m x 3 m) encircling the base of each brinjal plant. In the same manner foam sheet was placed on the polythene sheet after taking its weight in electronic balance. Immediately after application of insecticide, the wet foam was collected from the plot carefully and weighed. 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: Randomly chosen three plots (3 m × 3 m) were housed using polythene sheet. Underside of the roof of the house, foam sheet was placed after weighing. Immediately after application of insecticide, final weight of the foam sheet was taken by electronic balance and loss of insecticide in the air was determined from the difference between final and initial weight of foam sheet.

Determination of quantity of insecticide retained on plant canopy: How much insecticide retained on the target plant canopy was determined by subtracting the quantity of insecticide lost in the soil + quantity lost in the air from the total quantity of insecticide applied.

Measurement of plant height and canopy: Plant height (cm) and canopy area (cm^2) were recorded before the insecticidal application with the help of measuring tape. Maximum circumference of a brinjal plant was measured and then diameter and subsequently the radius (r) of circumference were determined. Finally, canopy was measured by using formula πr^2 (cm^2).

Statistical analysis: Data were analyzed by MSTAT software for interpretation. The data recorded on different parameters were subjected to analysis of variance (ANOVA) and the means were separated by Duncan Multiple Range Test (DMRT) at 5 % level of significance.

RESULTS AND DISCUSSION

Loss observation of cypermethrin sprayed at 10 days interval @ 1ml l^{-1} of water: Fate of cypermethrin application on brinjal plant sprayed at 10 days interval @ 1ml l^{-1} of water starting from 30 DAT (Days after transplanting) to 120 DAT is presented in Table 1. Results showed that deposition of cypermethrin on plants at different DAT showed significant difference from each other. The highest percentage (53.20±3.20 %) of cypermethrin was received by the plant (target site) at 100 DAT which was statistically similar to that of 60 DAT to 120 DAT and the lowest (26.90 ± 2.69 %) was received at 30 DAT which was statistically comparable to 40 DAT (27.60± 3.04%) and followed by 50 DAT (34.50±3.10%). The results indicated that with the progress of growth stages the rate of cypermethrin deposition on the target site increased significantly. Consequently, the loss of insecticide during initial stage of plant growth was maximum but reduced with the increasing growth of the plant.

Table 1. Loss measurement of cypermethrin application on brinjal plant sprayed at 10 days interval @ 1ml l^{-1} of water starting from 30 DAT to 120 DAT during summer (February to June) season

Days after transplanting (DAT	Cypermethrin deposited on	Cypermethrin lost	
	Plant (%) ±SE	in air (%) ±SE	in soil (%) ±SE
30	26.90 ± 2.69 c	3.50±0.18 e	69.60± 6.96 a
40	27.60± 3.04 c	3.44± 0.30 e	69.00± 7.59 a
50	34.50±3.10 b	3.40±0.24 e	62.13± 5.55 a
60	47.00± 3.76 a	3.90±0.32de	49.21± 3.95 b
70	51.10± 3.58 a	4.30±0.39 cd	44.60± 3.12 b
80	52.10± 3.13 a	4.60±0.46 bc	43.30± 2.60 b
90	51.76±4.30a	5.29±0.48 a	41.80± 2.09 b
100	53.20±3.20 a	5.09±0.41 ab	41.70± 2.92 b
110	52.30±3.67 a	5.30±0.37 a	42.30± 3.38 b
120	51.60± 4.13 a	5.60± 0.34 a	42.60± 4.15 b
LSD	5.95	0.61	8.11
CV (%)	7.75	8.07	9.35

Means within the same letter (s) within a column do not differ significantly (P=0.05) according to DMRT.

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. Drifting in the air i.e., insecticide loss through air drifting was the highest at 120 DAT (5.60± 0.34%) and which was statistically comparable to that of 110 DAT (5.30±0.37 %), 90 DAT (5.29±0.48 %) and 100 DAT (5.09±0.41 %). Minimum loss was recorded at 50 DAT (3.40±0.24 %) which was statistically identical to that of 40 DAT (3.44± 0.30 %) and 30 DAT (3.50±0.18%) (Table 1).

Fate of cypermethrin sprayed at 15 days interval @ 2ml l^{-1} of water: Results revealed that the fate of cypermethrin on plants at different DAT showed significant difference.

Insecticide on plant: The highest (53.95%) retention of cypermethrin was on the plant at 105 DAT which was followed by 90 DAT (52.20 %), 75 DAT (51.93 %), 120 DAT (51.80 %) and 60 DAT (49.05 %) and they were statistically similar. The lowest (27.30%) of insecticide was retained on the plant at 30 DAT and it was identical to 45 DAT (31.05%) (Fig. 1).

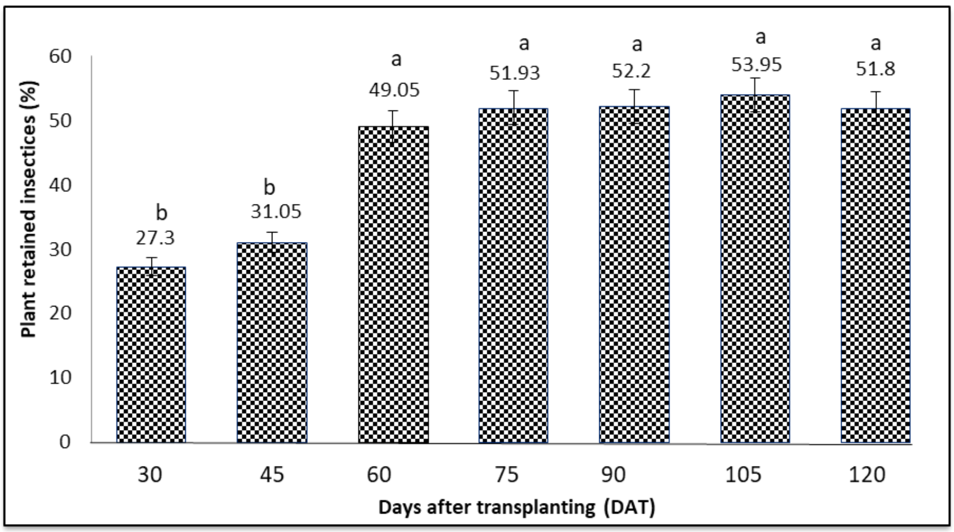

Fig. 1. Percent retained of cypermethrin on the target site (brinjal plant) sprayed at 15 days interval @ 2ml l^{-1} of water at 30, 45, 60, 75, 90, 105 and 120 DAT

Loss of cypermethrin in the air: The drift loss of cypermethrin in the air ranged from 3.42 to 5.62%. The highest drifting was recorded (5.62 %) at 120 DAT and it was identical to that of 105 DAT (5.45%). The second highest loss was observed at 90 DAT (5.10 %) followed by at 75 DAT (4.95 %), 60 DAT (4.10%) and at 30 DAT (3.90%) and they were significantly different from each other. The lowest percentage (3.42 %) of loss of cypermethrin in the air was observed at 45 DAT and significant different from all other DATs. The loss was sporadic; no pattern was found (Fig. 2).

Loss of cypermethrin in the soil: The drift loss of cypermethrin in soil ranged from 40.60 to 68.80%. The highest drifting was recorded (68.80 %) at 30 DAT and it was identical to that of 45 DAT (65.56 %). The lowest percentage (40.60 %) of loss of cypermethrin in the soil was observed at 105 DAT which was followed by 120 DAT (42.58 %), 90 DAT (42.70 %), 75 DAT (43.12 %) and 60 DAT (46.91 %) and they were statistically similar (Fig. 3).

The present study is supported by Rahman *et al.* (2015) who studied the fate of cypermethrin sprayed at 15 days interval @ 2 ml l^{-1} of water at 5% level of fruit infestation of brinjal plant under field condition. Results showed that the cypermethrin retained on plants had significant difference at different growth stages of brinjal plant. 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%). They found the lowest percent retained on the plant at 134 DAT (48.7%) which was statistically comparable to that obtained at 119 DAT (49.2%). In case of 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%).

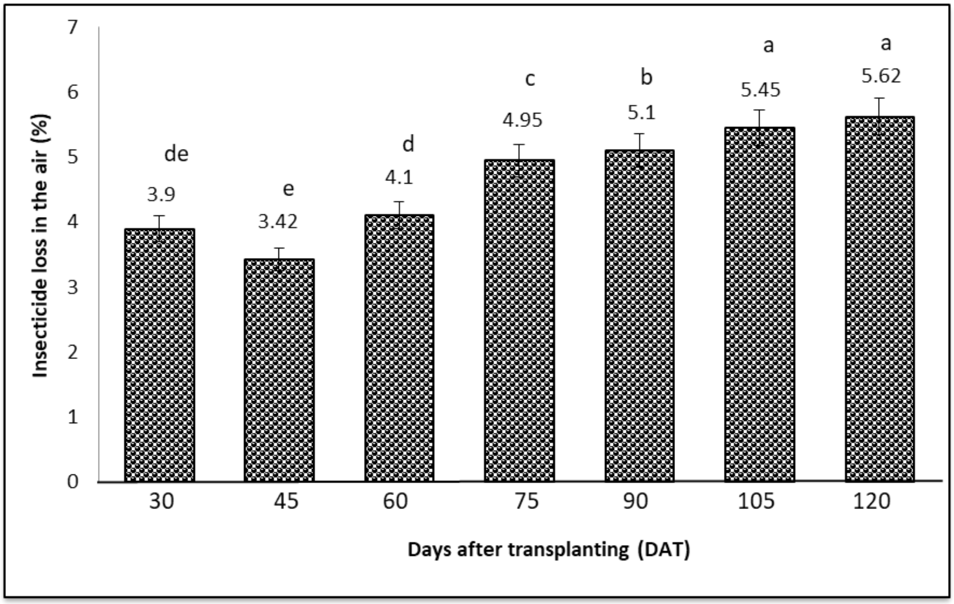

Fig. 2. Percent loss of cypermethrin in the air (through drifting) sprayed at 15 days interval @ 2ml l^{-1} of water at 30, 45, 60, 75, 90, 105 and 120 DAT

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%). On the other hand, accordingly the pesticide losses in the air when applied on the vine type of plant was ranged from 10% to 20% (Gill *et al*. 2008) but the loss of insecticide in air of the present study was little more than 5%. The present finding also partially is in agreement with Paul *et al*. (2016) who recorded the loss of cypermethrin in soil and air ranged from 35.9±0.0 to 47.3±2.6% and 3.9±0.3 to 7.1±0.1%, respectively and target site deposited insecticide was observed 48.8±2.6% to 59.7±3.4% in country bean treated field.

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

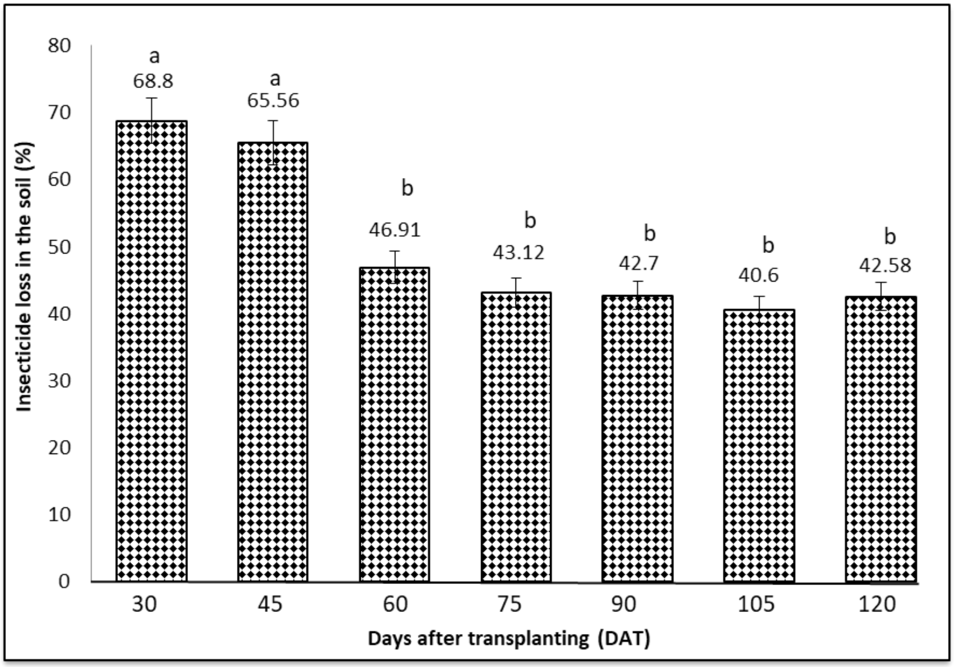

Fig. 3. Percent loss of cypermethrin in the soil (through drifting) sprayed at 15 days interval @ 2ml l^{-1} of water at 30, 45, 60, 75, 90, 105 and 120 DAT

Effect of cypermethrin loss in relation to plant height and canopy area at different DAT (growth stages) of brinjal plant

Plant height (cm): Plant height at different days after transplanting (DAT) had significant difference (Table 2). The recorded plant height was ranged from 53.75±5.38 to 64.68±2.89 cm with the highest value of 64.68 cm at 110 DAT which was statistically different from all other DATs. But the height at 50 DAT (57.75±5.20 cm) to 100 DAT (61.35±4.30cm) and at 120 DAT (61.33±5.50) were statistically comparable. The lowest plant height (53.75±5.38 cm) was recorded at 30 DAT and it was statistically identical to 50 DAT (54.95±6.05) (Table 2).

Plant canopy area (cm^2): Canopy area at different DAT showed significant difference. The canopy area of brinjal plant was significantly lowest (2785.40±278.50 cm^2) when recorded at 30 DAT and it was statistically identical to 40 DAT (2977.10±267.93 cm^2) and 50 DAT (3390.20±271.20 cm^2). The highest canopy area was observed (10100.30±909 cm^2) at 120 DAT, which was statistically identical with those obtained at 70 DAT (9755.10±585.30 cm^2) to 110 DAT (10100.30±808.00 cm^2). The second highest canopy area was obtained at 60 DAT (7600.20±532.00 cm^2) (Table 2).

Table 2. Relationship of brinjal plant height and canopy area with loss of cypermethrin at different days after transplanting (DAT) (growth stages) of brinjal plant (Mean±SD)

Days after Transplanting (DAT)	Plant height (cm) Mean±SD	Canopy area (cm^2) Mean±SD	Cypermethrin loss (%) Mean±SD
30	53.75±5.38 b	2785.40±278.50 c	73.10±7.31 a
40	54.95±6.05 b	2977.10±267.93 c	72.50±6.53 a
50	57.75±5.20 ab	3390.20±271.20 c	65.50±5.24 a
60	59.65±4.77 ab	7600.20±532.00 b	53.10±3.72 b
70	60.75±4.25 ab	9755.10±585.30 a	48.90±3.94 b
80	61.35±3.68 ab	10100.30±505.00 a	47.90±2.40 b
90	61.35±3.07 ab	10100.30±606.00 a	47.10±2.83 b
100	61.35±4.30 ab	10100.30±707.00 a	46.80±3.28 b
110	64.68±2.89 a	10100.30±808.00 a	47.60±3.85 b
120	61.33±5.50 ab	10100.30±909.00 a	48.40±4.11 b
LSD	6.83	995.60	7.95
CV (%)	6.67	7.54	8.42

Means within the same letter (s) within a column do not differ significantly (P=0.05) according to DMRT.

Loss of cypermethrin at different plant ages: Loss of cypermethrin at different DAT showed statistically significant. The highest (73.10±7.31%) loss of cypermethrin was measured at 30 DAT which was statistically similar to that at 40 DAT (72.50±6.53%) and 50 DAT (65.50±5.24%). The lowest (46.80±3.28 %) loss of cypermethrin was recorded at 100 DAT which was statistically similar to those recorded at 60 DAT (53.10±3.72%) to 120 DAT (48.40±4.11%) (Table 2).

The finding of this present study indicated that the interaction effect of plant height and canopy area on the loss of cypermethrin at different DAT showed significant difference where insecticide loss was reduced gradually with the increase of plant height and canopy area. The present finding is supported by Rahman *et al.* (2015) who reported that the insecticide losses reduced gradually with the increase of plant height and canopy area.

According to De Rudnicki (2010), pesticide loss depends upon the canopy coverage, shape, slope and the height of the plant and spray loss may be 14-45% in field depending on different spraying method. Up to 90 % spray losses of pesticide was commonly seen in the air and soil through drifting during a typical spray. 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).

CONCLUSION

The present study revealed that the highest percent loss of cypermethrin was found at 30 DAT (73.10±7.31 %) and the lowest percentage (46.80±3.28%) was recorded at 100 DAT. With the increase of the plant height and canopy area i.e., increasing of plant growth, the applied cypermethrin loss was gradually reduced. Therefore plant growth has an important role to reduce the drifting loss of insecticides.

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