Influence of different nozzle on residual toxicity of insecticides against larvae of Cabbage butterfly (*Pieris brassicae* Linn.)

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Abstract

A study was undertaken to evaluate the Influence of nozzle on residual toxicity of insecticides against larvae of Cabbage butterfly (*Pieris brassicae* linn.) under temperate conditions of SKUAST-Kashmir, Shalimar. Three insecticides at different concentrations were evaluated in treatment @ 0.1, 0.05 and 0.025% for Dichlorvos, 0.14, 0.07 and 0.035% for Malathion and 0.07, 0.035 and 0.0175% for Quinalphos. Influence of nozzle in context to efficacy of each insecticide based on median lethal time (LT_{50}), median lethal concentration (LC_{50}), persistent toxicity (PT) and relative residual toxicity (RRT) of each insecticide was determined. The value of persistent toxicity was recorded highest (540.36) after the treatment of Dichlorvos 76 EC @ 0.10% followed by spray of Quinalphos 25 EC @ 0.07%, (430.10) sprayed whereas the lowest value (154.00) was recorded by treatment of Malathion 50 EC @ 0.035% sprayed. The relative residual toxicity was observed highest (3.34) in case of Dichlorvos 76 EC @ 0.10% sprayed followed by spray of Quinalphos 25 EC @ 0.07%, (2.77) were as the lowest (1.00) observed in case of Malathion 50 EC @ 0.035% sprayed. Dichlorvos recorded to be relatively more toxic than Quinalphos and Malathion. Malathion proved to be least toxic to the larvae of cabbage butterfly, and followed by quinalphos and Dichlorvos, as it is evident from the value of persistent toxicity and relative residual toxicity of each insecticide with respective concentrations.

Keywords: malathion, quinalphos, residues, cabbage, persistence, waiting period

Introduction

Cole vegetables grown mostly in winter season occupy an important position in meeting the dietary requirements of most of the people all over the world. Among the winter vegetables, cabbage *Brassica oleracea* var. *capitata* (Linn) is a popular and extensively cultivated crop because of its nutritional and economical values (Anonymous, 2019) [4]. Cabbage (*Brassica oleracea* var. capitata L.) is an important Cole crops and major vegetable produced and consumed in India. This is widely cultivated throughout the sub-tropical parts of north India, with annual production of 3.39 million tons (Anonymous, 2019) [4]. It is grown for its edible enlarged terminal buds, which is a rich source of Ca, P, Na, K, S, vitamin A, vitamin C and dietary fiber. India is the second largest producer of cabbage in the world after China producing 68.70 lakh tones in an area of 3.1 lakh hectares with a productivity of 22.20 MT/ha (Anonymous, 2009) [3]. Among the total land under vegetable production cabbage occupies 4.4% and west Bengal is the highest producer of cabbage with 2179.20 tones (APEDA, 2012) [5]. Insecticide application against the larval stage is the primary method of control of *P. brassicae* (Linn.), but high tolerance to most insecticides and associated environmental problems may jeopardize their continued use (Grisakova *et al*., 2006) [10]. Long-term use of broad-spectrum pesticides may result in outbreaks of insect pests by destruction of their natural enemies. Frequent uses of insecticides have led to the development of resistance in many species of insect pests and also have negative effects on the survival and adaptation of natural enemies (Hossain and Poehling, 2006) [11]. Cabbage is heavily attacked by many insect pests, resulting in severe loss of quality and production. The major insect pests responsible for crop losses are stem borer (*Hellula undalis*), diamondback moth (*Plutella xylostella*), leaf eating caterpillars and aphids. A number of organochlorine, organophosphate, carbamate and pyrethroid insecticides have beenecommended against various insect pests of cabbage. Quinalphos, O, O-diethyl-Oquinoxalin-2-yl-phosphorothioate is a selective insecticide, intensively used by the farmers in many parts of India as a crop protection measure. It is solid at low temperature having melting point 31.5 °C and is very toxic to mammals (LD_{50}-71 mg kg1) (Younas *et al*., 2004) [19].

The majority of chemicals used in vegetable production are delivered in the form of droplets produced from different types of nozzles and spray booms. To maximize spray efficiency, spray droplets must be uniformly distributed on a target surface with minimum losses due to drift, evaporation and run-off (Smith and Wilkes, 1977) [16]. A choice must be made between high volume sprayer, low volume sprayer and ultra-low volume sprayer (Srivastava *et al*., 1994) [17]. Insecticides sprays might be indispensable for crop protection but number of applications can certainly be reduced and the beneficial natural fauna can be saved if proper nozzle type is selected. The most important factors in reducing drift in the size of the droplets produced by the nozzle. Droplets with a diameter of 150 µ and smaller are susceptible to drift due to wind, temperature, relative humidity and release height. Droplet of 200 µ or larger in diameter are less prone to drift influencing factor (Bode, 1984) [8]. Pesticides, although play fundamental role in the current agricultural production system, have been the subject of growing concern because of their potential environmental risk (Barcellos *et al*., 1998) [6]. In practice, the dose of pesticide used is much higher than required (Fernandes, 1997). Keeping in view of drift loss and its hazard on environment and farmers an attempt has been made to investigate the extent of drift loss and efficacy of different insecticides with different types of nozzles against 2nd instar larvae of Cabbage butterfly (*Pieris brassicae* linn.).

Material and method

Experiment was conducted on cabbage butterfly to study Comparative efficacy of Malathion, Dichlorovos and Quinalphos on 2nd instar larvae of Cabbage butterfly (*Pieris brassicae* linn.) in the year 2014-15 at the laboratory in department of Entomology, Sher-e-Kashmir University of agricultural science and technology, Shalimar.

The egg masses and caterpillar of cabbage butterfly were collected from the field and taken to the laboratory and placed in Petri plates and transferred to the B.O.D. incubator at 28±1°C and 70% RH. After hatching the first instar larvae was taken out from B.O.D. incubator and placed on potted cabbage plants. The cabbage variety was Golden Acre, which had been raised through standard package of practices. 2nd instar larvae of cabbage butterfly, *Pieris brassicae* (Linn.) was used in present study. The egg masses and caterpillar of cabbage butterfly were collected from the field and taken to the laboratory and placed in petri plates and transferred to the B.O.D. incubator at 28±1°C and 70% RH. After hatching the first instar larvae was taken out from B.O.D. incubator and placed on potted cabbage plants. The cabbage variety was Golden Acre, which had been raised through standard package of practices. 2nd instar larvae of cabbage butterfly, *Pieris brassicae* (Linn.) was used in present study. Water was sprayed with each nozzle. About 2-3 treated leaves was plucked from the potted plant and kept in petri plates 100 mm. diameter and about 15 larvae of cabbage butterfly were released at an interval of 1, 6 and subsequently every 24 hours after the treatment till the mortality was observed. Leaves from different treatment were collected daily (from 1st day to 15th day after). The insecticides sprayed leaves were then placed in thoroughly cleaned Petri plates of diameter 100 mm then 15 number of 2nd Instar larvae of cabbage butterfly of nearly uniform age and size were placed in Petri plates. The uncovered Petri plate was covered with muslin cloth held in the position by rubber bands and kept in B.O.D. Incubator at 28±1°C and 70% RH, for assessment of residual toxic effect.

Calculation of persistent toxicity (PT) and residual toxicity

Persistent and residual toxicity was determined by the method of Sarup *et al.* (1970) [15]. The average persistent toxicity (T) was determined by adding the values of corrected percentage mortalities of each observation and dividing the total by the total number of observations. Mortality was calculated by Abotts (1925) [1]. The persistent toxicity (PT) was calculated by multiplying the average toxicity (T) by the period for which the toxicity persisted. On the basis of persistent toxicity (PT) values the orders of relative efficacy of each treatment were determined. For comparing the residual toxicity of different insecticides, relative residual toxicity (RRT) was worked out by taking the persistent toxicity (PT) value of least toxic insecticide as unity.

Result and discussion

Relative efficacy of insecticides based on LT_{50} values

Relative efficacy of each insecticide based on LT_{50} and persistent toxicity (PT) values of each insecticide were determined by probit analysis (Finney, 1972) [9]. LT_{50} values were determined by transforming percentage larval mortalities to probits and plotting these against log transformed time values. Relative persistent and residual toxicity of each insecticide was determined as per Pradhan and Venkatraman (1962) by taking the LT_{50} values of least toxic insecticide as unity, was as the lowest (1.00) observed in case of Malathion 50 EC @ 0.035% sprayed by full cone nozzle. The relative residual toxicity in case of hollow cone nozzle was recorded to be highest (3.31) in case of Dichlorvos 76 EC @ 0.10% by treatment with hollow cone nozzle, followed by Quinalphos 25 EC @ 0.07% (2.73) sprayed by hollow cone nozzle and lowest (163) was recorded by treatment of Malathion 50 EC @ 0.035% sprayed by hollow cone nozzle. Result reveals that Dichlorvos 76 EC @ 0.10% persisted longer duration and found on par with Malathion 50 EC and Quinalphos 25 EC. Dichlorvos recorded to be relatively more toxic than Quinalphos and Malathion. Table-1 also reveals that Dichlorvos 76 EC @ 0.10% persisted for longer duration than Quinalphos 25 EC and Malathion 50 EC. It is clear that in both the type of nozzle used in spray, Dichlorvos recorded to be more toxic.

Order of relative efficacy

Relative efficacy of various insecticides was found to be significantly affected by persistent toxicity and LT_{50} values. The order of relative efficacy of each insecticide at three different doses against 2nd instar larvae of cabbage butterfly *P. brassicae* (Linn.) at various intervals sprayed with hollow cone nozzle was recorded highest (1) by the treatment of Dichlorvos 76 EC @ 0.10%, followed by Quinalphos 25 EC @ 0.07% (2), and lowest (9) was recorded in Malathion 50 EC @ 0.035% were as the order of relative efficacy in case of full cone nozzle was found highest (1) by the treatment of Dichlorvos 76 EC @ 0.10%, followed by Quinalphos 25 EC @ 0.07% (2), and lowest (9) was recorded in Malathion 50 EC @ 0.035%.

Persistence of residual toxicity

Median lethal concentration (LC_{50})

Significantly maximum LC_{50} value of 0.0862 per cent was recorded in Malathion sprayed with full cone nozzle and lowest 0.0372 per cent was recorded in Dichlorvos sprayed with hollow cone nozzle. This may be due to highest per cent of mortality was observed in Dichlorvos under hollow cone nozzle as it produces less droplet sizes making the more surface area of the toxicant and hence more mortality. It is clear from the data (Table-2) Dichlorvos was proved more toxic against 2nd instar larvae of cabbage butterfly, *Pieris brassicae* (Linn) than Quinalphos and Malathion. This result is in line with the result obtained from Saler and Saglam (2005) who reported lower LC_{50} value of Dichlorvos (DDVP) in water flea *Daphinia magna* (Stratus) verses time.

Relative toxicity of various insecticides based on median lethal (LC_{50}) value was ordered as Dichlorvos > Quinalphos > Malathion. Malathion was proved to be least toxic followed by

Quinalphos and Dichlorvos was highly toxic against 2nd Instar larvae of cabbage butterfly *P. brassicae* (Linn).

Median lethal time (LT_{50})

$LT_{50}$was found significantly affected by spray with different types of insecticides at different concentration under different nozzles. The observation was recorded on the basis of temporal response of 2nd instar larvae of *P. brassicae* (Linn.) exposed to different insecticide at different concentrations and mortality was recorded after every 24 hour and the data was subjected to probit analysis (Finney, 1972) [9] for calculation of LT_{50} values of each insecticides at each concentration under different nozzles. Significantly maximum LT_{50} (110.86 hours) was recorded by the treatment of Dichlorvos 76 EC @ 0.10% sprayed with hollow cone nozzle, followed by Dichlorvos 76 EC @ 0.10% sprayed with full cone nozzle (100.12 hours) and minimum (38.82 hours) was recorded after the treatment of Malathion 50EC @ 0.035% sprayed with full cone nozzle.

The reason for significantly maximum and minimum value of Dichlorvos and Malathion may be due to the droplet size produced by hollow cone nozzle which are high penetrating, more persistent and quality of spray was more uniform, and proved to be more effective as compared to full cone nozzle. This result is in accordance with Klein (2011) [12] who reported that for the application of insecticide in field crops hollow cone nozzle provide better foliage penetration and complete coverage of the leaf surface. The same observation gets support from the finding of Nair *et al* (2010) [13] who reported the LT_{50} value of quinalphos 25 EC was 2.437 days where as endosulfan 35% EC LT_{50} value was 5.313 days and and for cypermethrin 10% EC the LT_{50} value was 2.659 days against looper, *Hyposidra infixaria* (Walk.).

Persistent toxicity (P.T)

Persistent toxicity was significantly affected by treatment of different insecticides with different concentration sprayed by various types of nozzle. The value of persistent toxicity was recorded highest (540.36) after the treatment of Dichlorvos 76 EC @ 0.10% sprayed by hollow cone nozzle and 5.6% mortality was observed on 12th day after the treatment, followed by the treatment of Dichlorvos 76 EC @ 0.10% (517.00) and 5.1% mortality was seen on 12th day after the treatment sprayed by full cone nozzle, whereas the lowest value (154.00) was recorded by treatment of Malathion 50 EC @ 0.035% sprayed by full cone nozzle and 6.1% mortality was seen on 5th day after the treatment.

The persistent toxicity value was recorded highest in hollow cone nozzle treatment than full cone nozzle might be due to effective droplet size of insecticide and uniform coverage after the spray by hollow cone nozzle, were as due to larger droplet size produced by full cone nozzle there might be less amount of deposition and more run off and less uniformity in coverage proved less persistent. These results are in accordance with the result of Bandral (2007) [7] who reported that among the four insecticides namely Cypermethrin, Dimethoate, Malathion and Methyl demeton, significantly maximum persistent toxicity value was recorded in Dimethoate (821.25) and minimum persistent toxicity value was recorded in Malathion (140.42), due to higher concentration of insecticide, chemical nature and sensitivity against the neonate larvae of *P. brassicae*.

Relative residual toxicity (R.R.T)

The relative residual toxicity was observed highest (3.34) in case of Dichlorvos 76 EC @ 0.10% sprayed by full cone nozzle followed by spray of Quinalphos 25 EC @ 0.07% (2.77) by full cone nozzle, were as the lowest (1.00) observed in case of Malathion 50 EC @ 0.035% sprayed by full cone nozzle. The relative residual toxicity in case of hollow cone nozzle was recorded to be highest (3.31) in case of Dichlorvos 76 EC @ 0.10% by treatment with hollow cone nozzle, followed by Quinalphos 25 EC @ 0.07% (2.73) sprayed by hollow cone nozzle and lowest (163) was recorded by treatment of Malathion 50 EC @ 0.035% sprayed by hollow cone nozzle.

This may be due to relatively high toxic nature of dichlorvos, more mortality has been observed as compared to quinalphos and Malathion. The death rate of the larvae was more during initial days due to more concentration of insecticides during early days, high mortality of early instars (Ahmad *et al.* 2007) [2]. These results are in accordance with the result of Bandran (2007) [7] who reported that among the four different insecticide. Malathion was proved least persistent and relative residual toxicity of Malalthion was lowest (1.00). Nair *et al* 2010 [13] reported that the relative residual toxicity of Quinalphos 25 EC @ 0.0625% was found to be 1.10.

Order of relative efficacy

The order of relative efficacy of each insecticide at three different doses against 2nd instar larvae of cabbage butterfly *P. brassicae* (Linn.) at various intervals sprayed with hollow cone nozzle was recorded highest (1) by the treatment of Dichlorvos 76 EC @ 0.10%, followed by Quinalphos 25 EC @ 0.07% (2), and lowest (9) was recorded in Malathion 50 EC @ 0.035% were as the order of relative efficacy in case of full cone nozzle was found highest (1) by the treatment of Dichlorvos 76 EC @ 0.10%, followed by Quinalphos 25 EC @ 0.07% (2), and lowest (9) was recorded in Malathion 50 EC @ 0.035%. The relative efficacy of insecticides was found to be significantly affected by RRT values and LT_{50}. This may be due to the reason that the order of relative efficacy was based on RRT value and it was arranged in descending order. The highest RRT value (3.34) was ordered as 1 in Dichlorvos and lowest RRT (1.00) was ordered as 9 in Malathion. These results are in accordance with the result of Bandran (2007) [7] who reported that among the four different insecticides viz. cypermethrin (0.01%), dimethoate (0.03%), malathion (0.05%) and methyl demeton (0.025%), the order of relative efficacy of malathion was found least (1.00). Comparison between the tested insecticides on the basis of relative efficacy against *P. brassicae* (Linn) shows that the most toxic insecticide by unit weight of active ingredient was dichlorvos, followed by pirimicarb, thiamethoxam, pirimiphos-methyl and least toxic was malathion (Tawfiq *et al.*, 2010) [18].

Table 1: Relative toxicity of various insecticides based on PT values sprays under two different nozzles

Insecticides	Dose (a.i/ha)	Persistent toxicity (PT)		Relative residual toxicity (RRT)		Order Of Relative residual toxicity (RRT)	
		Hollow cone nozzle	Full cone nozzle	Hollow cone nozzle	Full cone nozzle	Hollow cone nozzle	Full cone nozzle
Dichlorvos	250	288.54	285.04	1.77	1.84	6	6
	500	287.27	376.92	2.37	2.43	3	3
	1000	540.36	517.68	3.31	3.34	1	1
Quinalphos	175	197.40	191.88	1.21	1.23	8	8
	350	363.70	306.90	2.23	1.98	4	5
	700	445.94	430.10	2.73	2.77	2	2
Malathion	350	163.00	154.90	1.00	1.00	9	9
	700	285.04	270.00	1.74	1.70	7	7
	1400	356.22	342.90	2.18	2.21	5	4

PT = Index of persistent toxicity (P = Period for which toxicity was observed X T = Average residual toxicity), RRT = Relative residual toxicity

Table 2: LC_{50} and LT_{50} Values of various Insecticides against 2nd instar larvae of *Pieris brassicae* (Linn.) sprayed with full cone nozzles and hollow cone nozzles

Insecticide	Nozzle type	LT_{50} Value	LC_{50} Value	Order of relative toxicity (ORE)
Malathion	Full cone	38.82	0.0862	1
Quinalphos	Full cone	42.66	0.0598	3
Dichlorvos	Full cone	52.12	0.0399	5
Malathion	Hollow cone	81.22	0.0810	2
Quinalphos	Hollow cone	91.24	0.0561	4
Dichlorvos	Hollow cone	110.86	0.0372	6

ORE = Order of relative efficacy based on PT values

Conclusion

Keeping in view of safety period and consumption, Malathion is relatively safe followed by quinalphos and dichlorvos, due to less persistence of Malathion and more of Dichlorvos. Regarding the median lethal concentration (LC_{50}) and median lethal time (LT_{50}) among the efficacy of three insecticides, Dichlorvos 76 EC sprayed with hollow cone nozzle was best to control the 2nd instar larvae of cabbage butterfly *Pieris brassicae* (Linn). On the basis of persistent toxicity also Dichlorvos 76% EC @ 0.10% persisted for longer duration and Malathion 50% EC @ 0.0175% persisted for shorter time. Persistent toxicity of all the three insecticides was more in hollow cone nozzle as compared to full cone nozzle.

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