



ISSN (E): 2277-7695
 ISSN (P): 2349-8242
 NAAS Rating: 5.23
 TPI 2023; SP-12(11): 93-97
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www.thepharmajournal.com

Received: 22-08-2023

Accepted: 25-09-2023

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Bio-efficacy of chlorpyrifos 20 EC against woolly apple aphid, *Eriosoma lanigerum* on apple in Kashmir (J&K)

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Abstract

Bioefficacy studies of test molecule Chlorpyrifos 20 EC against Woolly apple aphid (WAA) (*Eriosoma lanigerum*) in apple orchards were conducted during 2020 and 2021 at two different locations in district Baramulla of Jammu and Kashmir. The test molecule Chlorpyrifos 20 EC at the dosages of 0.75, 1.00, 1.25 and 1.50 ml along with standard check Chlorpyrifos 20 EC (Trade name other than the test molecule) at 1.00 ml per litre of water were evaluated against *Eriosoma lanigerum*. After 21 days of spray, maximum WAA mortality as 81.43 and 80.30 percent was obtained from test insecticide Chlorpyrifos 20 EC @ 1.50 ml and 1.25 ml, respectively at location Singhpora Pattan, Baramulla; whereas, at another location Rafiabad, Baramulla, highest WAA mortality of 78.77 and 76.58 percent was recorded from test molecule Chlorpyrifos 20 EC @ 1.50 ml and 1.25 ml, respectively. At location Singhpora Pattan, Baramulla, the least mortality of parasitoid, *Aphelinus mali* as 17.27 and 19.25 percent was recorded from molecule Chlorpyrifos 20 EC @ 0.75 ml and 1.00 ml, respectively; whereas, highest mortality of 28.85 and 21.63 was recorded with test molecule @ 1.50 ml and 1.25 ml, respectively. Similarly, at location Rafiabad, Baramulla the least mortality of parasitoid, *Aphelinus mali* as 16.94 and 23.12 percent was recorded with the test molecule Chlorpyrifos 20 EC @ 0.75 ml and 1.00 ml, respectively; whereas, highest mortality of 36.86 and 29.50 was recorded with test molecule @ 1.50 ml and 1.25 ml, respectively. The highest yield of apples was recorded with application of test molecule Chlorpyrifos 20 EC @ 1.50 ml at both the locations.

Keywords: Apple, chlorpyrifos 20 EC, efficacy, *Eriosoma lanigerum*, parasitoid, mortality

Introduction

The apple (*Malus × domestica* Borkh.) is a significant, lucrative crop farmed across the temperate parts of the world and belongs to Rosaceae family, which includes more than 300 species (Hanke *et al.*, 2020) [17]. The cultivated apple is native to South-West Asia (Korban and Skirvin, 1984) having basic chromosome number of 17 (Brown and Janick, 1992) [2]. The apple is revered as the king of all temperate fruits and is mostly grown in temperate and subtropical countries, including India (Ghanbari, 2014) [5]. A total of 86.44 million tonnes of apples are produced worldwide from an area of 4.62 million hectares, with China being the world's top apple producer (Manzoor *et al.*, 2023) [13]. The U.T. of Jammu and Kashmir has an area of 164 thousand hectare under apple with an annual production of 2.02 million tons (Directorate of Horticulture, 2019-2020).

The apple is the most significant fruit crop grown in Jammu & Kashmir. Kashmir is known as "The Apple Bowl of India," and apples from the area have gained recognition among consumers worldwide for their distinctive yet delectable flavor (Paray *et al.*, 2014) [12]. India's entire apple production is primarily sourced from Kashmir. Besides Kashmir, Himachal Pradesh and Uttarakhand are other states where apples are cultivated. The common man now has a lot of labor opportunities in apple fields from planting to harvest, making apple production not only a lucrative crop for growers but also a source of income for them (Riyaz *et al.*, 2018) [16]. However, the production and quality of apple is poor because of several factors including insect pests. The major insect pests attacking this crop are San Jose scale (*Quadraspidiotus perniciosus*), European red mite (*Panonychus ulmi*), Woolly apple aphid (*Eriosoma lanigerum*) etc (Sherwani *et al.*, 2016) [17]. The damage is caused by sucking the sap from branches, twigs and fruits, which weakens the plant and the fruit is rendered unfit and unmarketable.

The woolly apple aphid, *Eriosoma lanigerum* (Hausmann) (Hemiptera: Aphididae), is indigenous to America and is distributed globally, with the exception of hotter tropical regions.

In India, it was first recorded in 1889 at Connoor (Tamil Nadu) damaging young apple trees (Misra, 1920) [14]. The pest feeds on apple, crab apple, almond, hawthorn, pear, and quince and is active all year long. The term "woolly aphid" comes from the waxy filaments that the nymphs exude all over their bodies. It attacks trunk, branches, stem, twigs, leaf petioles, and fruit stalks; predominantly targets the underground roots. Upward and downward migrations are accentuated during hottest and coldest seasons, respectively (Lal and Singh, 1947) [11]. Due to the drainage of sap by feeding, affected trees present a sickly appearance; lose vigor and the growth and also their fruiting capacity is adversely affected. In case of young trees, the roots disintegrate to such an extent that these trees are easily blown over by even moderately strong winds. The fruits from heavily infested trees are of poor quality being undersized, malformed and insipid in taste (Sherwani *et al.*, 2016) [17].

Materials and Methods

Field trials were laid at two different locations of district Baramulla at SinghPura, Pattan and Rafiabad. The test molecule Chlorpyrifos 20 EC @ 0.75, 1.0, 1.25 and 1.5 ml per litre and Standard check Chlorpyrifos 20 EC @ 1.0 ml per litre were evaluated against Woolly Apple Aphid (WAA), infesting 18-20 years old apple trees. The pesticides molecule were sprayed with help of motorized sprayer and total number of WAA colonies were counted from one branch (including small and side branches) one day prior to spray as pre-treatment count and at subsequent intervals on 1, 3, 5, 7, 10, 14 and 21 days as post count. Similarly, the observations on natural enemies were also recorded 1 day before spraying and 1, 3, and 7 days after spray. The phytotoxicity data on chlorosis, necrosis, wilting, scorching, hyponasty and epinasty were also recorded, besides yield was calculated on the basis of A-Grade Apple boxes/ tree at time of crop harvest.

The experiment was laid in Randomised Block Design with six treatments each replicated thrice; and one tree represented as one replicate. Percent mortality was worked out by computing the difference between pre and post treatment population of the pest. The data was subjected to analysis of variance and critical difference at 5% level of significance was worked out.

Results and Discussion

The highest mortality of Woolly apple aphid (WAA) as 92.0 and 92.08 percent was recorded with the application of test molecule Chlorpyrifos 20 EC @ 1.50 ml/ lit of water; which was closely followed by aphid mortality of 91.73 and 91.88 percent at a dosage of 1.25 and a recommended dose of 1.0 ml/ lit of water after 21 days of spray treatment during the year, 2020 and 2021, respectively at location Singhpora, Pattan, Baramulla. The least WAA mortality of 87.29 and 88.34 percent was recorded with test molecule Chlorpyrifos 20 EC @ 0.75 ml and standard check Chlorpyrifos 20 EC @ 1.0 ml/ lit of water (Table 1). In another location, Rafiabad, Baramulla, the maximum WAA mortality as 89.10 and 90.93 percent was registered with spray application of test molecule Chlorpyrifos 20 EC @ 1.5 ml/ lit of water during both the respective years. The standard check Chlorpyrifos 20 EC @ 1.0 ml per litre of water recorded least WAA mortality of 85.44 and 84.47 percent after 21 days of spray application at both the respective locations (Table 2). Though, all the treatments were statistically significant from the control

which registered mean mortality of WAA as 20.80 and 22.50 percent at location, Singhpora, Pattan, Baramulla; and 17.23 and 17.04 percent at Rafiabad, Baramulla in both the respective years. However, the cumulative mean highest mortality of *Eriosoma lanigerum* for all the observation levels at Singhpora, Pattan, Baramulla during the year 2020 was 81.43 percent and in the succeeding year, the maximum WAA mortality was 78.77 percent at another location, Rafiabad, Baramulla. The application of Chlorpyrifos 20 EC (both as test (coded) molecule and standard check) at recommended dosage of 1.0 ml per lit of water registered 74.39 and 74.16 percent aphid mortalities at Singhpora, Pattan; and 71.10 and 71.44 percent at Rafiabad, Baramulla (Table 3). The present results are more or less corroborated with the findings of Gupta *et al.* (2015) [4] who reported that Chlorpyrifos (0.05%) and Phosphamidon (0.03%) offered good resistance of WAA at 3rd day after treatment application by reducing aphid colonies upto 93.18 and 80.28 percent, respectively which considerably increased during 10 and 30 days after treatment and finally led to aphid mortalities up to 96.23 and 91.55 percent respectively. Thakur and Gupta (1998) [18]. Too opined that Chlorpyrifos (0.05%), and Fenitrothion (0.05%) provide good control of woolly apple aphids for 30 days. Penman and Chapman (1980) [15] also reported woolly apple aphids to be highly susceptible to foliar application of chlorpyrifos (0.05%). Also in Poland, chlorpyrifos (0.1%) and demeton S methyl (0.05%) were reported to give good control of aerial population of woolly apple population (Badowska and Pala, 1990) [1]. However, Joginder and Sushma (2018) [8] while evaluating different insecticides (Spirotetramat, Flupyradifurone, Thiamethoxam, Flonicamid) in comparison to Chlorpyrifos revealed that all the insecticides were superior, and 21 days after spray, chlorpyrifos and thiamethoxam were the best with zero infestation.

The natural enemy associated with *Eriosoma lanigerum* at both the locations was parasitoid *Aphelinus mali* during both the consecutive years of study. The least mortality of parasitoid was 17.27 and 16.94 percent with spray application of test molecule Chlorpyrifos 20 EC @ 0.75 ml/lit of water at both the location Singhpora, Pattan and Rafiabad, Baramulla, respectively. However, test molecule Chlorpyrifos 20 EC @ 1.50 ml/lit of water was highly toxic to parasitoid, *Aphelinus mali* in recording highest mortality of 28.85 and 36.86 percent at both the respective locations (Table 4). The test molecule Chlorpyrifos 20 EC at all the concentrations doesn't caused any phytotoxicity during both the years at both the locations. The highest yield of apple fruit was computed with treatment application of test molecule @ 1.50 ml followed by the fruit yield obtained with test molecule Chlorpyrifos 20 EC @ 1.50 ml per litre of water. The results are more or less in consonance with the findings of Cohen *et al.* (1999) [3] reported that Chlorpyrifos was found to be highly toxic to the adult wasps of *A. mali*. Gloria (1982) [6] reported that Vamidothion was highly detrimental to the early developing stages of *A. mali*. The findings further supported with the work of Khajuria *et al.* (2010) [9] who reported higher toxicity of Chlorpyrifos against *Aphelinus mali* (Haldemann) in apple orchards of Himachal Pradesh (Kullu valley). Khajuria *et al.* (2010) [9] reported that the insecticides viz; carbosulfan, chlorpyrifos, profenophos and thiamethoxam proved safe to the apple plants as there were no phytotoxic symptoms.

Table 1: Bio-efficacy of Chlorpyrifos 20 EC against Woolly Apple Aphid (*Eriosoma lanigerum*) (WAA) on Red Delicious apple cultivar at SinghPura, Pattan, Baramulla during 2020-2021

S. No.	Chemical	Dosage (ml per lit. of water)	Pre treatment count	Percent mortality of Woolly Apple Aphid Days after spray (DAS)													
				1 st		3 rd		5 th		7 th		10 th		14 th		21 st	
				2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
1.	Chlorpyrifos 20 EC (Test molecule)	0.75	14.67	46.53* (43.03)**	43.14* (41.07)	61.14 (51.46)	61.34 (51.57)	79.17 (62.87)	77.30 (61.57)	81.32 (64.42)	79.50 (63.10)	84.10 (66.53)	84.11 (66.54)	86.19 (68.21)	81.79 (64.77)	87.29 (69.14)	88.61 (70.31)
2.	Chlorpyrifos 20 EC (Test molecule)	1.0	13.33	54.77 (47.76)	51.34 (45.79)	68.42 (55.83)	62.12 (52.03)	83.65 (66.18)	78.34 (62.29)	86.04 (68.09)	83.78 (66.28)	87.16 (69.03)	86.45 (68.43)	88.66 (70.35)	89.21 (70.85)	90.18 (71.77)	91.88 (73.47)
3.	Chlorpyrifos 20 EC (Test molecule)	1.25	15.0	55.39 (48.11)	57.80 (49.51)	67.87 (55.49)	64.47 (53.43)	85.13 (67.35)	77.80 (61.92)	89.07 (70.72)	86.67 (68.61)	87.43 (69.26)	88.87 (70.54)	89.83 (71.43)	91.13 (72.70)	91.73 (73.32)	91.13 (72.70)
4.	Chlorpyrifos 20 EC (Test molecule)	1.50	13.67	55.47 (48.16)	56.10 (48.52)	69.56 (56.54)	65.84 (54.26)	86.79 (68.72)	85.36 (67.53)	89.37 (71.00)	87.78 (69.57)	89.72 (71.33)	87.79 (69.58)	91.37 (72.95)	90.27 (71.85)	92.00 (73.60)	92.08 (73.60)
5.	Chlorpyrifos 20 EC (Standard Check)	1.0	14.33	43.18 (41.10)	41.87 (40.34)	62.07 (52.01)	65.11 (53.82)	76.74 (61.19)	74.39 (59.62)	82.71 (65.46)	76.76 (61.20)	85.18 (67.39)	81.37 (64.46)	87.08 (68.96)	83.74 (66.25)	89.78 (71.39)	88.34 (70.06)
6.	Check	Water	12.33	09.43 (17.89)	09.97 (18.41)	11.25 (19.60)	12.45 (20.67)	13.65 (21.69)	15.0 (22.79)	16.11 (23.67)	17.48 (24.72)	15.73 (23.37)	17.48 (24.72)	18.43 (25.43)	19.95 (26.54)	20.80 (27.14)	22.50 (28.33)
C.D ($p \leq 0.05$)				(2.19)	(3.24)	(2.07)	(3.76)	(2.78)	(2.52)	(2.50)	(4.06)	(4.01)	(2.23)	(5.46)	(2.84)	(4.37)	(2.62)

Table 2: Bio-efficacy of Chlorpyrifos 20 EC against Woolly Apple Aphid (*Eriosoma lanigerum*) (WAA) on Red Delicious apple cultivar at Rafiabad, Baramulla during 2020-2021

S. No.	Chemical	Dosage (ml per lit. of water)	Pre-treatment count	Percent mortality of Woolly Apple Aphid Days after spray (DAS)													
				1 st		3 rd		5 th		7 th		10 th		14 th		21 st	
				2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
1.	Chlorpyrifos 20 EC (Test molecule)	0.75	14.67	43.73* (41.41)**	45.66* (42.53)**	57.40 (49.27)	56.49 (48.75)	71.28 (57.62)	69.60 (56.56)	78.53 (62.42)	78.27 (62.24)	81.17 (64.31)	80.43 (63.77)	81.79 (64.77)	82.58 (65.36)	84.35 (66.72)	84.30 (66.69)
2.	Chlorpyrifos 20 EC (Test molecule)	1.0	13.33	49.57 (44.77)	51.21 (45.71)	62.57 (52.30)	58.52 (49.93)	79.46 (63.08)	75.57 (60.40)	81.61 (64.63)	80.47 (63.80)	83.35 (65.95)	82.95 (65.64)	86.42 (68.40)	85.37 (67.54)	85.59 (67.72)	87.78 (69.57)
3.	Chlorpyrifos 20 EC (Test molecule)	1.25	15.0	52.19 (46.27)	52.36 (46.37)	63.41 (52.80)	57.14 (49.12)	80.57 (63.87)	78.57 (62.45)	83.77 (66.27)	83.35 (65.95)	86.11 (68.15)	85.71 (67.82)	87.26 (69.12)	85.71 (67.82)	87.94 (69.71)	88.07 (69.82)
4.	Chlorpyrifos 20 EC (Test molecule)	1.50	13.67	52.87 (46.66)	54.53 (47.62)	64.51 (53.46)	61.35 (51.58)	82.37 (65.20)	79.55 (63.14)	86.48 (68.46)	86.37 (68.36)	86.92 (68.83)	88.61 (70.31)	88.27 (70.00)	90.93 (72.50)	89.10 (70.75)	90.93 (72.50)
5.	Chlorpyrifos 20 EC (Standard Check)	1.0	14.33	41.58 (40.17)	44.46 (41.83)	59.74 (50.64)	60.0 (50.79)	72.68 (58.51)	71.13 (57.52)	79.57 (63.15)	75.53 (60.38)	80.84 (64.07)	80.0 (63.46)	82.63 (65.40)	82.20 (65.07)	85.44 (67.60)	84.47 (66.82)
6.	Check	Water	12.33	07.13 (15.49)	08.48 (16.93)	09.34 (17.80)	10.65 (19.05)	11.33 (19.67)	12.76 (20.93)	14.18 (22.13)	14.93 (22.74)	15.15 (22.91)	15.15 (22.91)	16.81 (24.21)	17.04 (24.39)	17.23 (24.53)	17.04 (24.39)
C.D ($p \leq 0.05$)				(3.83)	(3.17)	(2.44)	(2.87)	(2.77)	(3.17)	(2.12)	(3.18)	(3.32)	(3.72)	(3.37)	(3.07)	(2.97)	(3.67)

* Each value is mean of three replications** Figures in parenthesis are Arcsine transformed values

Table 3: Bio-efficacy of Chlorpyrifos 20 EC against Woolly Apple Aphid (*Eriosoma lanigerum*) (WAA) on Red Delicious apple cultivar at SinghPora, Pattan and Rafiabad, Baramulla (Pooled data)

S. No.	Chemical	Dosage (ml per lit. of water)	Percent Cumulative Mean Mortality of Woolly apple aphid					
			Singh Pora, Pattan, Baramulla			Rafiabad, Baramulla		
			2020	2021	Cumulative Mean	2020	2021	Cumulative Mean
1.	Chlorpyrifos 20 EC (Test molecule)	0.75	75.10	73.68	74.39	71.17	71.04	71.10
2.	Chlorpyrifos 20 EC (Test molecule)	1.0	79.84	77.59	78.71	75.51	74.55	75.03
3.	Chlorpyrifos 20 EC (Test molecule)	1.25	80.92	79.69	80.30	77.32	75.84	76.58
4.	Chlorpyrifos 20 EC (Test molecule)	1.50	82.04	80.83	81.43	78.64	78.90	78.77
5.	Chlorpyrifos 20 EC (Standard Check)	1.0	75.24	73.08	74.16	71.78	71.11	71.44
6.	Check	Water	15.06	16.40	15.73	13.02	13.72	13.37

* Each value is mean of three replications** Figures in parenthesis are Arcsine transformed value

Table 4: Toxicity of Chlorpyrifos 20 EC against natural enemies of Woolly Aphid on apple cv. Red Delicious at SinghPora, Pattan, Baramulla and Rafiabad, Baramulla (Two years pooled data)

S. No.	Code/ Chemical	Dosage (ml per lit. of water)	Percent Cumulative Mean Mortality of Parasitoid (<i>Aphelinus mali</i>)					
			Singh Pora, Pattan, Baramulla			Rafiabad, Baramulla		
			2020	2021	Cumulative Mean	2020	2021	Cumulative Mean
1.	Chlorpyrifos 20 EC (Test molecule)	0.75	16.36	18.18	17.27	16.06	17.82	16.94
2.	Chlorpyrifos 20 EC (Test molecule)	1.0	20.25	18.25	19.25	23.21	23.03	23.12
3.	Chlorpyrifos 20 EC (Test molecule)	1.25	23.19	20.07	21.63	34.08	24.93	29.50
4.	Chlorpyrifos 20 EC (Test molecule)	1.50	36.53	21.18	28.85	43.38	30.35	36.86
5.	Chlorpyrifos 20 EC (Standard Check)	1.0	27.0	23.23	25.11	26.91	24.87	25.89
6.	Check	Water	0.00	0.00	0.00	0.00	0.00	0.00

Table 5: Effect of Chlorpyrifos 20 EC on yield (Number of boxes) variety red Delicious infested with Woolly Apple Aphid (*Eriosoma lanigerum*) in Singhpora, Pattan, during 2020 and 2021

Treatment/ Chemical	Dosage (ml per lit. of water)	Yield of A grade Apples/tree (Number of boxes per plant)					
		Singh Pora, Pattan, Baramulla			Rafiabad, Baramulla		
		2020	2021	Cumulative mean	2020	2021	Cumulative mean
Chlorpyrifos 20 EC (Test molecule)	0.75	3.67	3.33	3.50	4.33	4.0	4.16
Chlorpyrifos 20 EC (Test molecule)	1.0	5.67	5.0	5.33	6.00	5.67	5.83
Chlorpyrifos 20 EC (Test molecule)	1.25	6.00	6.00	6.00	6.67	6.33	6.50
Chlorpyrifos 20 EC (Test molecule)	1.50	6.33	6.33	6.33	7.00	6.67	6.83
Chlorpyrifos 20 EC (Standard Check)	1.0	4.67	4.33	4.50	5.33	5.33	5.33
Check (Water spray)	-----	2.67	2.67	2.67	3.67	3.33	3.50

Conclusion

The highest mortality of Woolly apple aphid (WAA) as 92.00 and 92.08 percent was recorded with the application of test molecule Chlorpyrifos 20 EC @ 1.50 ml/ lit of water during the year, 2020 and 2021, respectively at location Singhpora, Pattan, Baramulla. In another location, Rafiabad, Baramulla, the maximum WAA mortality as 89.10 and 90.93 percent was registered with spray application of test molecule Chlorpyrifos 20 EC @ 1.5 ml/ lit of water during both the respective years. The highest yield of apple fruit was computed with treatment application of test molecule Chlorpyrifos @ 1.50 ml/lit of water.

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