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Bio-efficacy of insecticides against mealy cabbage aphid (*Brevicoryne brassicae* L.) and bio-safety against its natural enemies in cruciferous vegetable ecosystem of Kashmir

Akhtar Ali Khan

Abstract
Three dosages of insecticides *viz*., Imdaclorpid (17.8SL) @ 0.17, 0.28, and 0.58ml/L; Dimethoate 30EC @ 1.0, 1.5 and 2.0ml/L; Thioclorpid (21.7SC) @ 0.1ml, 0.2ml and 0.4ml/L; Cypermethrin (25EC) @1.0,1.5, and 2.0ml/L; Chlorpyriphos (20EC) @ 1ml, 1.5ml and 2 ml/L of water were compared with the treated check (Diclorovas) @ 1ml/L of water with untreated control for their efficacy against mealy cabbage aphid and biosafety of their natural enemies were evaluated. The bioefficacy of Imdaclorpid (17.8SL) @ 0.28ml/liter of water exhibited best performance on the basis of reduction of cabbage aphid mortality (85.89%) with less mortality (71.56%) of predatory fauna and with 4.4 % parasitization of mealy cabbage aphids which was statistically similar to other insecticides caused less mortality of natural enemies can be considered as potential insecticides against cabbage aphid in Cole crop of Kashmir.

Keywords: cabbage aphid, *Brevicoryne brassicae* L., bio-safety, natural enemies

Introduction

The cabbage aphid, *Brevicoryne brassicae* L. (Hemiptera: Aphididae), is one of the major insect pests of cruciferous crops worldwide [1] and also an important insect pest of cruciferous vegetable crops in Kashmir [2, 3]. It is native to Europe and widely distributed throughout all the temperate and warm temperate parts of the world [4]. In temperate areas, the cabbage aphid has a holocyclic life-cycle without change of host plant and during the growing season, the wingless, parthenogenetic, viviparous females (apterae) are the predominant form [5, 6]. In order to produce nymphs as fast as possible, they exploit the food supply to the limit [7]. The cabbage aphid damages leaves and flowers directly by sucking the sap and resulting in distorted, wrinkled and chlorotic leaves [8, 9, 10]. In addition, the cabbage aphid is a vector of about 20 plant viruses, including mosaic potyvirus, cauliflower mosaic caulimovirus, radish mosaic comovirus and turnip mosaic potyvirus [11, 12].

Natural enemies, such as predators [13, 14], parasites [15] and entomopathogenic fungi [16] are of paramount importance in suppressing the abundance of cabbage aphids [17, 18, 19]. Predaceous species attacking the aphids are principally coccinellids [20, 21, 22], chrysopids 23, 24, 25], syrphids [26, 27] and spiders [28, 29, 30]. Modification of the environment or habitat management can be seen as a conservation practice, which focuses on manipulating habitats within agricultural landscapes to make them more hospitable to natural enemies [31, 32, 33]. This can be done by providing resources to the natural enemies such as nectar, honeydew, shelter and alternative prey or hosts [34]. The frequent use of insecticides (particularly broad spectrum insecticides) in crop production systems strongly limits the effectiveness of natural enemies [35, 36]. Therefore, beside habitat management, Conservation Biological Control stresses the importance of selective insecticides and the appropriate timing of insecticide use to minimize their negative impact on natural enemies [37, 38]. Moreover, the strong reliance on pesticides created negative side-effects including pesticide resistance, pest resurgence, secondary pest outbreaks and the negative effects on the survival and adaptation of natural enemies [39].

Consequently, Assessment of bio-efficacy of insecticides on mealy cabbage aphid and its predators has been recognized as one of the main pre-requisites for the establishment of effective integrated pest management programme [40, 41]. Keeping in view, the study was conducted to evaluate the bio-efficacy of insecticides against mealy cabbage aphid (*Brevicoryne brassicae* L.) and bio-safety against its natural enemies in cruciferous vegetable ecosystem of Kashmir.

Materials and Methods

Field experiments were carried out to find the toxicity of chemical pesticides on cabbage aphid and their natural enemies during in cabbage field of cruciferous vegetable in District Srinagar of Kashmir valley. Three treatments of different chemical pesticides *viz*., Imdaclorpid (17.8SL)@0.17, 0.28, and 0.58ml/L. Dimethoate 30EC@ 1.0, 1.5 and 2.0ml/L; Thioclorpid (21.7SC)@ 0.1ml, 0.2ml and 0.4ml/L; Cypermethrin (25EC)1.0,1.5, and 2.0ml/L; chlorpyriphos (20EC) @ 1ml, 1.5ml and 2 ml/L of water were compared with the treated check (Diclorovas)@ 1ml/L of water with untreated control for their efficacy against cabbage aphid and their natural enemies. Each concentration was replicated 5 times. Ten liter spray volume was sprayed per plant. Pre- treatment count was taken one day before treatment and post treatment count was taken after 1st, 7th and 15th days after treatment by taking random sample of per leaf of cabbage plant. Similarly, the observations of natural enemies were also recorded one day before treatment and 1, 7 and 15th days after treatment on the basis of 10 leaves of cabbage plant. The trails were laid out in randomized block design on cabbage of uniform age. Percent mortality was worked out by computing the differences between pre and post treatment population of cabbage aphid and natural enemies by applying Abbot's formula. The data was subject to analysis of variance and critical difference at 5% level of significance was work out.

Results and Discussion

Bio-efficacy of insecticides against mealy cabbage aphid

Bio-efficacy of chemical pesticides on the reduction of cabbage aphid was studied under field condition in Srinagar and presented in Table 1. The data revealed that highest total mean mortality of 89.80% was recorded against Imdaclorpid (17.8SL) @ 0.56ml/liter of water which was statistically similar to imdaclorpid (17.8SL) @ 0.28ml/liter of water (85.89%) and least (66.93%) was recorded against Chlorpyriphos (20EC) @ 1.0ml/liter of water. Other pesticide and their concentration *viz*., Imdaclorpid (17.8SL) @0.17ml; Dimeothate 30EC @ 1.0ml, 1.5ml and 2.0ml; Thioclorpid (21.7SL) @0.1ml, 0.2ml, and 0.4ml; Cypermethrin (25EC) @ 1.0ml/L,1.5ml and 2.0ml; Chlorpyriphos (20EC) @1.5ml and 2.0ml/liter of water were given maximum total mortality of 80.85%; 73.53%,75.62%, and 81.47%; 73.21%,78.33%, and 85.67%; 71.49%, 76.09%, and 83.43%; 73.26%, and 74.51% mortality of cabbage aphid, respectively as compared to treated check ((Dichlorovas76 EC @ 1.0ml/L of water) and was recorded 74.51% reduction of cabbage aphid

Maximum Cumulative mean mortality of nymph of cabbage aphid was recorded highest (93.08%) against Imdaclorpid (17.8SL) @0.56ml/liter of water which was statistically similar to same pesticide when used the concentration of 0.28ml/liter of water and was recorded 90.53% while as least (67.92%) recorded against chlorpyriphos (20EC) @1.0ml/liter of water. Thioclorpid (21.7SL) @ 0.4ml/liter of water also gave 91.14% reduction of cabbage aphid which was statistically at par to Imdaclorpid (17.8SL) @ 0.28ml/liter of water. The highest cumulative mean mortality 89.88% and 73.52% of alateand apterous cabbage aphid against Imdaclorpid (17.8SL) @ 0.56ml/liter of water followed by Imdaclorpid (17.8SL) @ 0.28ml/liter of water were 80.65% and 77.56% respectively which were statistically higher than treated check (Dichlorovas) @ 1.0ml/L of water, recorded as 63.08% and 61.86%, respectively.

Maximum reduction of cabbage aphid population of nymph (90.46%) was recorded at 1stdays after treatment against Imdaclorpid (17.8SL) @ 0.56ml/L of water which was statistically quite similar to Imdaclorpid (17.8SL) @ 0.28ml/L of water (87.79%) while as least reduction (57.69%) was recorded against Chlorpyriphos (20EC) @1.0ml/L of water. The highest reduction of alate cabbage aphid was recorded 86.81% against Imdaclorpid (17.8SL) @ 0.56ml/L of water while as least reduction (57.81%) was recorded against Chlorpyriphos (20EC) @1.0ml/L of water.In case of apterous aphid it was highest (70.39% and 66.35%)against Imdaclorpid (17.8SL) @ 0.56ml/L and 0.28ml/ L of water at 1st day after treatment and least (52.89%) against Dimethoate 30EC @ 1.0ml/liter of water and in treated check (Diclorovas) @ 1.0ml/L of water Cypermethrin (25EC) @ 1.0ml/L of water. In treated check (Diclorovas) @ 1.0ml/L of water, the reduction of cabbage aphid nymph, alate, apterous aphid were 72.21%, 55.41% and 52.89%, recorded respectively.

The mortality of all stages of cabbage aphid was increased at Seventh days of treatment against all chemical pesticides and showed similar trends as found at1st day after treatment. At 15th days after treatments, the reduction of cabbage aphids increased and the trend was also similar to 7th day after treatments and highest mortality of nymph, alate, and apterous aphid were recorded against Imdaclorpid (17.8SL) @ 0.56mkl/L of water which were statistically quite similar to Imdaclorpid (17.8SL) @ 0.28ml/L of water (Table 1). Little informations are available for comparing the impact of insecticides against meal cabbage aphid as well as their natural enemies. The toxicity of pesticides both chemical as well as botanicals were evaluated on green apple aphid (*Aphis pomi*) and their natural enemies was studied by Khan [40,42] and similarly Khan [43] worked on bioefficacy of botanical pesticides against cabbage aphid and biosafety against its natural enemies and result was quite similar to present findings.

Bio-safety of insecticides against natural enemies of mealy cabbage aphid

The bio-safety of chemical pesticides were evaluated against three predatory natural enemies associated with green cabbage aphid in the valley as coccinellids, syrphid fly and Chrysoperla larva and parasitization of cabbage aphid was also evaluated and depicted in Table 2. Impact on chemical pesticides on the mortality of cabbage aphid was studied under field condition during 2014 in Kashmir. The total highest mean mortality of predatory natural enemies was recorded 75.22% against Imdaclorpid (17.8SL) @ 0.56ml/L of water which was statistically similar to Thioclorpid (21.7SC) @ 0.40ml/L of water (72.73%). While as least mortality (50.33%) was recorded against Chlorpyriphos (20EC) @1.0ml/L of water as compared to treated check (Diclorovas) @ 1.0ml/liter of water and was recorded (69.46%) reduction of cabbage aphid natural enemies population which was statistically similar to reduction of Imdaclorpid (17.8SL)@ 0.28ml/liter of water. The lowest post- treatment total mean parasitization (4.2%) followed by 3.46% was recorded against Thioclorpid (27.7SC) @ 0.4ml/liter of water and Imdaclorpid (17.8SL) @ 0.28ml/liter which were 9.4% and 8.0% at the time of pre-treatments.

At 1st DAT, the mean mortality of coccinellids was recorded highest (61.11%),syrphid fly larvae (66.66%) and Chrysoperla larvae (66.66%) was recorded against

Chlorpyriphos (20EC) @ 2.0ml/liter, Dimethoate 30EC @ 2.0ml/liter and Imdaclorpid (17.8SL) @0.58ml/liter of water, respectively while as lowest were recorded 36.36%, 43.75% against Chlorpyriphos (20EC) @ 1.0ml/L of coccinellids and syrphid fly larvae and 40.00% of Chrysoperla larva was recorded against Thioclorpid (21.7SL) @ 0.1ml/liter of water. In the treated check (Dichlorovas) @ 1.0ml/ liter of water), the mortality was recorded as 68.42%, 58.82%, and 60.00% of coccinellids, syrphid fly larvae and Chrysoperla larvae, respectively at 1st DAT of treatments.

Maximum mortality at 7th day after treatment of Coccinellids (75.00%) and syrphid fly (77.77%) were recorded against Imdaclorpid 17.8 SL @ 0.58ml/liter of water and highest mortality of Chrysoperla larva (76.92%) was recorded against Thioclorpid 21.7SC @ 0.4ml/liter of water. Both pesticides *viz*., Imdaclorpid 17.8 SL @ 0.58ml/liter and Thioclorpid 21.7SC @ 0.4ml/liter of water showed statistically similar result as compared with other pesticides including treated check (Diclorvas 76EC @ 1.0ml/liter of water) against predatory natural enemies. All concentration of Chlorpyriphos 20EC @ 1.0ml, 1.5ml and 2.0ml/liter of water showed least mortality of predatory natural enemies at 7th DAT (Table 2).

At 15th day after treatment, highest mortality of predatory Coccinellids, syrphid fly larvae and Chrysoperla larvae were recorded as 84.21%, 82.35% and 84.64% against Thioclorpid 21.7SC @ 0.4ml/liter of water which were statistically similar to the Imdaclorpid 17.8 SL @ 0.58ml/liter and was detrimental for natural enemies of cabbage aphids. Least mortality of natural enemies was also recorded against chlorpyriphos 20EC @ 1.0ml, 1.5ml and 2.0ml/liter of water at 15th day after treatment.

The highest Cumulative mean mortality of predatory natural enemies were recorded (72.91%) of Coccinellids, 77.77% of syrphid fly larvae and 74.99% of Chrysoperla larvae against higher concentration of Imdaclorpid (17.8SL) @0.56ml/liter of water followed by Thioclorpid (21.7SL) @ 0.4ml/liter of water were recorded as 71.92%, 74.50% and 71.79% mortality of Coccinellids, syrphid fly larva and Chrysoperla larva, respectively and both were found statistically similar while as least against Chlorpyriphos 20EC @ 1.0ml/liter of water were 45.45% of coccinellids, 50.00% of syrphid fly larvae and 55.55% of Chrysoperla larvae.

The associated biodiversity is conserved in the organic fields as well as unsprayed field by avoiding chemical pesticide sprays [44]. A common strategy to control this pest in cruciferous vegetable ecosystem of Kashmir is the use of one or more application of insecticides. But a wide spectrum insecticide upsets natural biodiversity and affects population abundance of predators [10, 41, 42, 43]. In today's context conservation of natural enemies is very important deploying safer pesticides in vegetable ecosystem.

Table 1: Bio-efficacy of insecticides against mealy cabbage aphid (*Brevicoryne brassicae)* in Cabbage field of Kashmir

Treatment	Conc. (ml/L)	Pre-treatment count			Total	Post treatment count (Mean Population of *Brevicoryne brassicae*/ leaf DAT)									Cumulative Mean			Total (mean % reduction)
						1			7			15						
		N	A	Ap		N	A	Ap	N	A	Ap	N	A	Ap	N	A	Ap	
Imdaclorpid (17.8 SL)	0.17 ml	37.6	18.2	16.6	72.4	6.4 (86.72)	4.2 (72.31)	6.6 (55.58)	5.4 (88.80)	3.6 (65.57)	5.2 (65.0)	4.2 (91.28)	2.4 (84.17)	3.6 (75.77)	5.33 (88.93)	3.4 (74.01)	5.13 (65.45)	13.86 (80.85)
	0.28 ml	43.8	16.4	15.8	76.0	5.8 (87.79)	3.6 (76.26)	4.4 (70.39)	4.2 (91.28)	3.0 (78.90)	3.2 (78.46)	3.6 (92.53)	2.0 (86.81)	2.4 (83.84)	4.53 (90.53)	2.86 (80.65)	3.33 (77.56)	10.72 (85.89)
	0.56 ml	50.4	14.6	14.4	79.4	4.6 (90.46)	2.0 (86.81)	5.0 (66.35)	3.0 (93.77)	1.6 (89.45)	4.4 (70.39)	2.4 (95.02)	1.0 (93.40)	2.4 (83.84)	3.33 (93.08)	1.53 (89.88)	3.23 (73.52)	8.09 (89.80)
Dimethoate (30 EC)	1ml	46.6	17.2	15.0	78.8	13.6 (71.79)	5.4 (64.40)	7.0 (52.89)	10.2 (78.84)	4.2 (72.31)	6.2 (58.27)	8.4 (82.57)	2.6 (82.86)	5.0 (66.35)	10.73 (77.73)	4.06 (73.18)	6.06 (59.17)	20.85 (73.53)
	1.5ml	45.2	15.6	17.4	78.2	10.4 (78.43)	6.0 (60.44)	7.6 (48.85)	8.6 (82.16)	4.6 (69.67)	5.2 (65.0)	6.8 (85.89)	3.2 (78.90)	4.8 (67.69)	8.6 (82.16)	4.6 (69.67)	5.86 (60.51)	19.06 (75.62)
	2ml	53.4	16.2	12.8	82.4	9.2 (80.92)	5.4 (64.40)	4.6 (69.04)	7.4 (84.65)	4.0 (73.63)	3.8 (74.42)	5.6 (88.38)	3.2 (78.90)	2.6 (82.50)	7.4 (84.65)	4.2 (72.31)	3.66 (75.32)	15.26 (81.47)
Thioclorpid (21.7 SC)	0.1ml	57.2	17.4	15.2	89.8	16.2 (66.40)	8.2 (45.94)	5.4 (63.66)	12.4 (74.28)	7.0 (53.85)	4.0 (73.08)	10.6 (78.01)	5.6 (63.08)	2.8 (81.15)	13.06 (72.89)	6.93 (54.29)	4.06 (72.63)	24.05 (73.21)
	0.2ml	53.8	13.8	17.0	84.6	10.4 (78.43)	5.8 (61.76)	7.6 (48.85)	8.6 (82.16)	4.2 (72.31)	5.4 (63.66)	6.2 (87.14)	3.6 (65.57)	3.2 (78.46)	8.4 (82.57)	4.53 (66.54)	5.4 (63.65)	18.33 (78.33)
	0.4ml	48.6	14.2	15.8	78.6	5.0 (89.63)	3.8 (74.95)	5.2 (65.0)	4.2 (91.28)	3.4 (77.58)	3.0 (79.81)	3.6 (92.28)	3.0 (80.22)	2.6 (82.50)	4.26 (91.14)	3.4 (77.58)	3.6 (75.77)	11.26 (85.67)
Cypermethrin (25EC)	1ml	37.4	12.4	12.6	62.4	11.6 (75.94)	5.2 (65.57)	4.6 (69.04)	9.8 (79.67)	4.2 (72.31)	3.8 (74.42)	7.2 (85.06)	4.6 (69.67)	2.6 (82.50)	9.53 (80.22)	4.6 (69.18)	3.6 (75.32)	17.73 (71.49)
	1.5ml	46.2	13.6	15.2	75.0	9.6 (80.09)	5.4 (64.40)	6.4 (56.93)	7.4 (84.65)	4.2 (72.31)	5.4 (63.66)	5.8 (87.79)	3.8 (74.95)	5.0 (66.35)	7.6 (84.17)	5.13 (70.55)	5.2 (62.31)	17.93 (76.09)
	2ml	51.4	16.4	11.8	79.6	5.6 (88.38)	3.0 (80.22)	7.2 (51.54)	4.2 (91.28)	2.8 (81.54)	6.4 (56.93)	3.2 (93.36)	2.0 (86.81)	5.2 (65.0)	4.33 (91.0)	2.6 (82.85)	6.26 (57.82)	13.19 (83.42)
Chlorpyriphos (20EC)	1ml	54.6	11.2	13.4	79.2	20.4 (57.69)	6.4 (57. 81)	7.2 (51.54)	16.2 (66.40)	4.6 (69.67)	5.2 (65.0)	9.8 (79.67)	4.2 (72.31)	4.6 (69.04)	15.46 (67.92)	5.06 (66.59)	5.66 (61.86)	26.18 (66.93)
	1.5ml	46.2	15.4	16.2	77.8	16.6 (65.57)	6.2 (59.12)	6.6 (55.58)	11.4 (76.35)	4.2 (72.31)	3.6 (75.77)	7.6 (84.23)	3.4 (77.58)	2.8 (81.15)	11.86 (75.38)	4.6 (69.67)	4.33 (70.83)	20.79 (73.26)
	2ml	42.8	13.8	15.6	72.2	10.4 (78.43)	5.4 (64.40)	6.2 (58.27)	7.2 (85.06)	3.6 (65.57)	5.4 (63.66)	5.8 (87.97)	3.2 (78.90)	4.2 (71.73)	7.8 (83.82)	4.06 (69.62)	5.26 (64.55)	17.12 (76.28)
Treated check (Dichlorovas76 EC)	1ml	56.4	16.4	13.0	85.8	13.4 (72.21)	6.8 (55.41)	7.0 (52.89)	10.8 (77.60)	5.4 (64.40)	5.2 (65.0)	7.6 (84.23)	4.6 (69.67)	4.8 (67.69)	10.6 (78.01)	5.6 (63.08)	5.66 (61.86)	21.86 (74.51)
Control	water	54.2	16.6	13.2	84.0	56.2 (-3.69)	16.8 (-1.20)	13.6 (-3.03)	56.4 (-4.05)	17.2 (-3.61)	13.8 (-4.54)	57.6 (-6.27)	17.4 (-4.81)	14.4 (-9.09)	56.7 (-4.61)	17.13 (-3.19)	14.0 (-6.06)	87.83 (-4.56)
CD(P=0.05)		4.25	1.97	1.57	6.64	2.01	1.24	1.32	1.57	1.04	0.98	0.68	0.37	0.56	-	-	-	-

Mean of 5 replications, Figure in parenthesis indicates mean % reduction of aphid population, N= nymph, Al= Alate, Ap= Apterus, DAT= days after treatment, Population of *Brevicoryne brassicae* count on the basis of per leaf

Table 2: Bio-safety of insecticides against natural enemies of mealy cabbage aphid (*Brevicoryne brassicae)* in cabbage field of Kashmir

Treatment	Conc. (ml/L)	Pre-treatment count			Mean	P (%)	Post treatment count (Mean population of Natural Enemies/10 leaves DAT) 1				7				15				Cumulative mean			Total (Mean % reduction)	Mean (% P)
		C.	S.	Ch.			C.	S.	Ch.	P (%)	C.	S.	Ch.	P (%)	C.	S.	Ch.	P (%)	C.	S.	Ch.		
Imdaclorpid (17.8SL)	0.17 ml	2.0	1.2	1.0	4.2	8.4	1.0 (50.00)	0.6 (50.00)	0.4 (60.00)	6.6	0.6 (70.00)	0.4 (66.66)	0.3 (70.00)	6.0	0.4 (80.00)	0.3 (75.00)	0.2 (80.00)	5.6	0.66 (66.66)	0.43 (63.88)	0.30 (70.00)	1.39 (66.84)	6.06
	0.28 ml	1.6	1.8	1.2	4.6	8.6	0.8 (55.55)	0.5 (64.28)	0.6 (62.50)	5.2	0.5 (72.22)	0.4 (71.42)	0.4 (75.00)	4.4	0.3 (83.33)	0.3 (78.57)	0.3 (81.25)	4.0	0.53 (70.36)	0.40 (71.42)	0.43 (72.91)	1.36 (71.56)	4.4
	0.56 ml	1.8	1.4	1.6	4.8	8.0	0.7 (56.25)	0.6 (66.66)	0.4 (66.66)	4.0	0.4 (75.00)	0.4 (77.77)	0.3 (75.00)	3.8	0.2 (87.50)	0.2 (88.88)	0.2 (83.33)	2.6	0.43 (72.91)	0.40 (77.77)	0.30 (74.99)	1.13 (75.22)	3.46
Diamethoate (30 EC)	1.0 ml	1.8	1.0	1.4	4.2	9.6	1.1 (38.88)	0.5 (50.00)	0.8 (55.55)	6.4	0.8 (55.50)	0.4 (60.00)	0.6 (57.14)	5.8	0.6 (66.66)	0.3 (70.00)	0.5 (64.28)	5.0	0.83 (53.68)	0.40 (60.00)	0.63 (58.99)	1.86 (57.55)	5.73
	1.5 ml	1.7	1.5	1.4	4.6	9.2	0.8 (52.94)	0.6 (60.00)	0.6 (57.14)	5.2	0.7 (58.82)	0.5 (66.66)	0.5 (64.28)	4.0	0.5 (70.58)	0.4 (73.33)	0.4 (71.42)	3.0	0.66 (60.78)	0.50 (66.66)	0.50 (64.28)	1.66 (66.28)	4.06
	2.0 ml	2.0	1.8	1.2	5.0	8.4	0.8 (60.00)	0.6 (66.66)	0.5 (58.33)	4.2	0.7 (65.00)	0.5 (72.22)	0.4 (66.66)	4.0	0.5 (72.22)	0.4 (77.77)	0.3 (75.00)	2.6	0.66 (65.74)	0.50 (72.21)	0.40 (66.66)	1.56 (68.20)	3.6
Thioclorpid 21.7 SC	0.1ml	1.8	1.6	1.0	4.4	8.8	1.0 (44.44)	0.8 (50.00)	0.6 (40.00)	7.2	0.6 (66.66)	0.6 (62.50)	0.4 (60.00)	7.0	0.4 (77.77)	0.4 (75.00)	0.3 (70.00)	6.8	0.66 (62.95)	0.60 (62.50)	0.43 (56.66)	1.69 (60.70)	7.00
	0.2ml	2.0	1.6	1.0	4.6	10.2	0.9 (55.00)	0.7 (56.25)	0.5 (50.00)	7.4	0.6 (70.00)	0.5 (68.75)	0.3 (70.00)	5.0	0.4 (80.00)	0.3 (81.25)	0.2 (80.00)	4.6	0.63 (68.33)	0.50 (68.75)	0.33 (66.66)	1.46 (67.91)	5.66
	0.4ml	1.9	1.7	1.3	4.9	9.4	0.8 (57.89)	0.6 (64.70)	0.6 (53.84)	4.6	0.5 (73.68)	0.4 (76.47)	0.3 (76.92)	4.2	0.3 (84.21)	0.3 (82.35)	0.2 (84.61)	3.8	0.53 (71.92)	0.43 (74.50)	0.36 (71.79)	1.32 (72.73)	4.2
Cypermethrin (25EC)	1.0 ml	2.0	1.7	0.9	4.6	11.2	0.8 (40.00)	0.9 (47.05)	0.5 (44.44)	7.4	0.7 (65.00)	0.7 (58.82)	0.4 (55.55)	5.8	0.6 (70.00)	0.5 (70.58)	0.3 (66.66)	5.0	0.70 (58.33)	0.70 (58.81)	0.40 (55.55)	1.8 (57.56)	6.06
	1.5 ml	1.8	1.5	1.1	4.4	10.4	0.8 (55.55)	0.6 (60.00)	0.6 (45.45)	5.2	0.6 (66.66)	0.5 (66.66)	0.4 (63.63)	4.4	0.5 (72.22)	0.4 (73.33)	0.3 (72.72)	4.0	0.63 (64.81)	0.50 (66.66)	0.43 (60.60)	1.56 (64.02)	4.53
	2.0 ml	1.9	1.6	1.3	4.8	9.6	0.8 (57.89)	0.6 (62.50)	0.6 (53.84)	5.0	0.6 (68.42)	0.5 (68.75)	0.4 (69.23)	4.2	0.5 (73.68)	0.4 (75.00)	0.3 (76.92)	4.0	0.63 (66.66)	0.50 (68.75)	0.43 (66.66)	1.56 (67.35)	4.40
Chlorpyriphos (20EC)	1.0 ml	2.2	1.6	1.8	5.6	8.8	1.4 (36.36)	0.9 (43.75)	0.9 (50.00)	7.4	1.2 (45.45)	0.8 (50.00)	0.8 (55.55)	5.8	1.0 (54.54)	0.7 (56.25)	0.7 (61.11)	5.2	1.20 (45.45)	0.8 (50.00)	0.80 (55.55)	2.8 (50.33)	6.13
	1.5 ml	1.5	1.8	1.6	4.9	8.2	0.8 (46.66)	0.8 (55.55)	0.7 (56.25)	6.2	0.7 (53.33)	0.7 (61.11)	0.6 (62.25)	4.4	0.6 (60.00)	0.6 (66.66)	0.5 (68.75)	4.0	1.40 (53.33)	0.70 (61.10)	0.60 (62.41)	2.7 (58.94)	4.86
	2.0 ml	1.8	1.6	1.2	4.6	8.0	0.7 (61.11)	0.7 (56.25)	0.5 (58.33)	5.0	0.6 (66.66)	0.6 (62.50)	0.4 (66.66)	3.6	0.5 (72.22)	0.5 (68.75)	0.3 (75.00)	3.8	0.6 (66.66)	0.6 (62.50)	0.4 (66.66)	1.6 (65.27)	4.13
Treated check (Dichlorvas 76 EC)	1.0 ml	1.9	1.7	1.0	4.6	8.4	0.6 (68.42)	0.7 (58.82)	0.4 (60.00)	5.6	0.5 (73.68)	0.6 (64.70)	0.3 (70.00)	4.8	0.4 (78.94)	0.5 (70.58)	0.2 (80.00)	4.4	0.50 (73.68)	0.60 (64.70)	0.30 (70.00)	1.40 (69.46)	4.93
Control	Use water only	2.1	1.7	1.2	5.0	9.0	2.2 (-4.76)	1.8 (-5.88)	1.1 (8.33)	8.4	2.1 (0.0)	1.6 (5.88)	1.2 (0.0)	9.2	1.8 (14.28)	1.3 (23.52)	1.1 (8.33)	10.8	2.03 (3.33)	1.56 (8.23)	1.13 (5.55)	4.72 (5.60)	9.46
CD(P=0.05)		0.68	0.54	0.47	-	1.34	0.12	0.14	0.20	0.84	0.15	0.17	0.13	0.71	0.13	0.11	0.15	0.56	-	-	-	-	-

Mean of 5 replications, Figure in parenthesis indicates mean % reduction of natural enemies, C= Coccinellids, S= Syrphid fly larva, Ch. = Chrysoperla, P= parasitized aphid (mummified), DAT= days after treatment, *Natural enemies count on the basis of 10 leaves.

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References

1. Geiger F, Bianchi FJJA. Wäckers FL. Winter ecology of the cabbage aphid *Brevicoryne brassicae* (L.) (Homoptera: Aphididae) and its parasitoid *Diaeretiella rapae* (McIntosh) (Hym, Braconidae: Aphidiidae). Journal of Applied Entomology 2005;129:563-566.
2. Khan AA. Report of Department of Science and Technology on Biodiversity and management of aphid in temperate horticulture ecosystem of Kashmir. Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences & Technology, Shalimar Campus Srinagar190025, India, 2015, 123.
3. Khan AA, Kundoo AA, Khan ZH, Husain K. Identification of potential and suitable natural enemies of arthropod pests for conservation biological control in vegetable ecosystem of Kashmir. Journal of Entomology and Zoology Studies 2020;8(5):2251-2255.
4. Blackman RL, Eastop VF. Aphids on the world's crops; An identification and information guide. Wiley & Sons, Chichester, U.K, 2000.
5. Dixon AFG. Aphid Ecology: Life Cycles, Polymorphism, and Population Regulation. Annual Review of Ecology and Systematics 1977;8(1):329-353.
6. Shah MA, Khan AA. Aphid in agro-ecosystem and their management. In: Hill Agriculture: Prospects, Constraints and Mitigations, edited by Dr. Shahid Ahamad, 04/2013: pages 314-330; Daya Publishing House, New Delhi 2013. ISBN: 978-81-7035-859-6.
7. Kant R, Minor MA, Trewick SA. Fitness gain in a koinobiont parasitoid *Diaeretiella rapae* (Hymenoptera: Aphidiidae) by parasitising hosts of different ages. Journal of Asia-Pacific Entomology 2011;15(1):83-87.
8. Hughes RD. Population dynamics of the cabbage aphid, *Brevicoryne brassicae* (L.). Journal of Animal Ecology 1963;32(3):393-424.
9. Khan AA, Shah MA. Population dynamics of green apple aphid *Aphis pomi* De Geer (Homoptera: Aphididae) and its natural enemies in apple orchard of Kashmir. Indian Journal of Entomology 2018;80(2):320-329.
10. Shah MA, Khan AA. Qualitative and quantitative prey requirements of two aphidophagous coccinellids, *Adalia tetraspilota* and *Hippodamia variegata*. J Insect Sci 2014, 14(72). Available online: http://www.insectscience.org/14.72.
11. Ulusoy MR, Ölmez-Bayhan S. Effect of certain Brassica plants on biology of the cabbage aphid *Brevicoryne brassicae* under laboratory conditions. Phytoparasitica 2006;34(2):133-138.
12. Shah MA, Khan AA, Juniad JM, Majid S, Mohi-ud-din S. Aphid Vectored Viral Diseases and their Management, In book: Insect Pest of Fruit Crops and their

Management, Chapter: 27, Publisher: Biotech Books. Ansari Road, Darya Ganj, New Delhi-110 002, Editors: A. K. Pandey and Promod Mall (ISBN 978-81-7622-358-4) 2016, 511-554.
13. Khan AA. Functional response of *Adalia tetraspilota* (Hope) (Coleoptera: Coccinellidae) on cabbage aphid, *Brevicoryne brassicae* (L.) (Homoptera: Aphididae). Journal of Biological Control 2009;23:243-248.
14. Khan AA, Kundoo AA, Nissar M, Rasool I. Sucking pests of temperate Vegetables. (Book Chapter). Sucking pests of crops (eds): Omkar., Springer Nature Singapore, 2019, 341-367. https://doi.org/10.1007/978-981-15-6149-8_11.
15. Bacci L, Picanco MC, Rosado JF, Silva, GA, Crespo ALB, Pereira EJG *et al*. Conservation of natural enemies in brassica crops: Comparative selectivity of insecticides in the management of *Brevicoryne brassicae* (Hemiptera: Sternorrhyncha: Aphididae). Applied Entomology and Zoology 2009;44(1):103-113.
16. Jankowska B. The effect of cruciferous vegetables on occurrence of Cecidomyiidae, Coccinellidae and Chrysopidae predators in colonies of cabbage aphid (*Brevicoryne brassicae* L.). Journal of Plant Protection Research 2005;45(4):302-308.
17. Dey D, Akhtar S. Diversity of natural Enemies of Aphids belonging to Aphidiinae (Hymenoptera: Braconidae) in India. Journal of Asia-Pacific Entomology 2007;10(4):281-296.
18. Khan AA, Shah MS. Records of aphid and their natural enemies in agro-ecosystem with special reference to horticultural ecosystem of Kashmir. Journal of Entomology and Zoology Studies 2017;5(4):189-203.
19. Khan AA, Zaki FA, Khan ZH, Mir RA. Biodiversity of predacious ladybird beetles (Coleoptera: Coccinellidae) in Kashmir. Journal of Biological Control 2009;23:43-47.
20. Khan AA. Intra-specific and intra-guild predation of two coccinellids. Annals of Plant Protection Science 2012;20:369-374.
21. Bhagat RC, Lone MA. New records and host range of predators of aphids (Aphididae: Homoptera) in Kashmir Valley, India. Science & Culture 1984;50(12):333-372.
22. Hodek I, Honek A. Ecology of Coccinellidae. Kluwer Academic Publishers, 1996.
23. Mushtaq T, Khan AA. Functional Response of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) to different densities of *Aphis craccivora* Koch and Aphis pomi De Geer (Homopetera: Aphididae). Indian Journal of Agriculture Sciences 2010a;80:93-95.
24. Mushtaq T, Khan AA. Functional and aggregation response of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) to different densities of *Bravicoryne brassicae* (Homopetera: Aphididae). Journal of Biological Control 2010b;24:28-34.
25. Khan AA, Zaki FA. Predatory responses of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) on Euonymus aphid, Aphis *fabae solanella* Theobald (Homoptera: Aphididae) in Kashmir. Journal of Biological Control 2008;22(1):149-154.
26. Khan AA. Effect of insecticides on biodiversity of aphidophagous syrphid flies in fruit ecosystem of Kashmir. Journal of Entomology and Zoology Studies 2017;5(4):117-125.
27. Khan AA. Effect of insecticides on distribution, relative abundance, species diversity and richness of syrphid flies in vegetable ecosystem of Kashmir. Journal of Entomology and Zoology Studies 1017;5:808-817.14.
28. Khan AA. Comparison of spider biodiversity in relation to pesticide use in apple orchards of Kashmir. Journal of Biological Control 2012;26(1):1-10
29. Khan AA, Khan ZH. Spider fauna (Arachnida: Araneae) in horticultural ecosystem of Kashmir (Chapter 17) "Animal Diversity, Natural History and Conservation" (eds): Dr. V.K. Gupta and Dr. A. K. Verma. Daya Publishing House, New Delhi, India, 2011; I: 313-338. [ISBN: 978- 81-7035-751-3(Series), ISBN: 978-81-7035-752.
30. Khan AA. Spider fauna (Arachnida: Araneae) of temperate vegetable ecosystem of Kashmir. D Prasad and DP. Ray (edited) Book: Biotechnological Approaches in Crop Protection: Published by: Biotech books, New Delhi 2013;29:400-414. (ISBN: 978-81-7622-285-3).
31. Gurr GM, Wratten SD, Altieri MA. Ecological engineering for pest management - Advances in habitat manipulation for arthropods. CSIRO Publishing, Melbourne, Australia, 2004.
32. Vattala HD, Wratten SD, Phillips CB. Wackers FL. The influence of flower morphology and nectar quality on the longevity of a parasitoid biological control agent. Biological Control 2006;39(2):179-185.
33. Khan AA, Kundoo AA, Khan ZH. Identification of the most conservative plant species for promising natural enemies of arthropods pests of Vegetable crops. Journal of Entomology and Zoology Studies 2020;8(5):2244-2250.
34. Geiger F, Wäckers FL, Bianchi FJJA. Hibernation of predatory arthropods in semi-natura habitats. Biocontrol 2009;54(4):529-535.
35. Khan AA. Distribution, Relative Abundance, Species Diversity and Richness of Syrphid Flies in Floricultural Ecosystem of Kashmir, India. International Journal of Current Microbiology and Applied Sciences 2017;6:1539-1552.
36. Shah MA, Khan AA. Assessment of coccinellid biodiversity under pesticide pressure in Horticulture ecosystems. Indian Journal of Entomology 2014;76(2):107-116.
37. Landis DA, Wratten SD, Gurr GM. Habitat management to conserve natural enemies of arthropod pests in agriculture. Annual Review of Entomology 2000;45:175-201.
38. Ahmad M, Akhtar S. Development of insecticide resistance in field populations of *Brevicoryne brassicae* (Hemiptera: Aphididae) in Pakistan. Journal of Economic Entomology. 2013; 106:954-958.
39. Thomson LJ, Hofmann AA. Ecologically Sustainable Chemical Recommendations for Agricultural Pest Control? Journal of Economic Entomology 2007;100(6):1741-1750.4
40. Khan AA. Bio-efficacy of botanical pesticides against green apple aphid (*Aphis pomi*) and biosafety against its natural enemies in apple orchard of Kashmir. Journal of Entomology and Zoology Studies 2020;8(4):1445-1448.
41. Khan AA. Relative toxicity of pesticides for safety of predatory coccinellids. Annals of Plant Protection Sciences 2009;17(2):307-311.
42. Khan AA, Reyaz S. Bioefficacy of pesticides against

green apple aphid *Aphis pomi* De Geer and biosafety to natural enemies in apple orchards. Indian Journal of Entomology 2018;80(2): 315-319.

43. Khan AA. Bio-efficacy of botanical pesticides against mealy cabbage aphid (*Brevicoryne brassicae* L.) and biosafety against its natural enemies in cruciferous vegetable ecosystem of Kashmir. Journal of Entomology and Zoology Studies 2021;9(2):1332-1336.
44. Kristiansen P. Overview of organic agriculture. In: Organic agriculture: A global perspective (Eds. Kristiansen, P., Taji, A., and Reganold, J.). Collingwood, Australia: CSIRO Publishing, 2006.