Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(4): 1445-1448

Received: 12-05-2020
Accepted: 14-06-2020

Akhtar Ali Khan
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

Corresponding Author:
Akhtar Ali Khan
Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India

Bio-efficacy of botanical pesticides against green apple aphid (*Aphis pomi*) and biosafety against its natural enemies in apple orchard of Kashmir

Akhtar Ali Khan

Abstract
Two concentrations of Neem oil (2% and 3%), castor oil (2% and 3%), Artemisia leaf extract (2% and 3%), Neem seed kernel extract (NSKE) @ 4% and 5% and Azadirachtin (0.2% and 0.3%) compared with the treated check Dimethoate (1ml/L) with untreated check for their bio-efficacy against green apple aphid. The highest mean per cent mortality of 68.91 was recorded against Azadirachtin (0.3%) followed by 65.06% against same pesticide of 0.2% concentration while as least mean mortality of 34.32% was exhibited against castor oil (1%). Maximum percent reduction of green apple aphid population *viz*., nymph, alate and apterous were recorded 77.0%, 68.29% and 61.76% against Azadirachtin (0.3%) while as least mortality of above three stages of green apple aphid were recorded as 43.19%, 23.94% and 30.88% against Castor oil (2%), respectively. The bio-safety of botanical pesticides were evaluated against natural enemies associated with green apple aphid. The highest predator mortality (39.04%) was recorded against Azadirachtin (0.3%) which was significantly lower (72.00%) than treated check (Dimethoate, 1ml/L) while as lowest (24.25%) against Neem oil (2%). Among all treatments, the mortality of Chrysoperla was recorded highest followed by syrphid fly larva. The maximum mortality of coccinellids (40.00%) was recorded against NSKE (5%) while as, maximum mortality of larvae of syrphid fly (42.85%) and Chrysoperla (45.00%) were recorded against Azadirachtin (0.3%) as compared with treated check was 72.22%, 74.28% and 67.50% of coccinellids, syrphid fly and Chrysoperla larva, respectively. All botanical pesticides are safer against parasitoids of aphids and not found any significant effect while as treated check (Dimethoate @ 1ml/L) was given significantly more mortality of parasitoids.

Keywords: Bio-efficacy, green apple aphid, biosafety of natural enemies, botanical pesticides

Introduction
Aphids are an extremely successful group of insects which occur throughout the world, with the greatest number of species in the temperate regions [1]. Out of 4702 known aphid species [2] about 1015 species occur in oriental region and about 750 species belonging to 208 genera represent India Aphididae [3]. In Jammu and Kashmir State, the previous works on aphid species have been summarised by Bhagat [4] and Khan and Shah [5]. The green apple aphid, *A. pomi* is an important pests of temperate fruits Damage in horticultural crops caused by aphids is very dreaded problem because one aphid is enough to profound damage for large crop area by transmitting the viral diseases. It is especially harmful in nurseries and young orchards [6]. The apple aphid, *Aphis pomi* is an economically important pest of apple throughout the world [7]. A common strategy to control *A. pomi* in conventional apple orchards in Kashmir is based on one or more than one application of insecticides [8]. On the other hand, application of wide-spectrum insecticides upsets natural biodiversity and effects population abundance of predators [9, 10, 11] which has a reverse negative effect on production sustainability and inevitability of repeated treatments [12, 13]. The present study aimed to investigate the possibility of effective control of *A. pomi* on apple trees by botanical treatments as well as bio-safety of an autochthonous predator and parasitoid population in apple orchard of Kashmir.

Materials and methods
Field trials were laid out at apple orchards of Srinagar to evaluate the bioefficacy of botanical pesticide against green apple aphid and biosafety against their natural enemies. Two concentration of Neem oil (2% and 3%), castor oil (2% and 3%), Artemisia leaf extract (2% and 3%), Neem seed kernel extract (NSKE) @ 5% and 6% and Azadirachtin (0.2% and 0.3%)

Compared with the treated check Dimethoate (Roger) @ 1% concentration with untreated check for their bio-efficacy against green apple aphid and bio-safety against natural enemies. Each concentration was replicated five times. Pre-treatment count was taken one day before treatment and post treatment count was taken after 1,7 and 15 days after treatment by taking a random sample of per 10 cm top of the twigs. Similarly, the observation of natural enemies was also recorded one day before treatment and 1,7 and 15 days after treatment by taking a random sample of total of 10 twigs of 10cm top of twigs.

The trails were laid out in randomized block design apple trees of variety Red delicious 15-20 years of uniform age. Percent reduction (mortality was workout by computing the differences between pre and post treatment population of green apple aphid and their natural enemies by applying Abbot's formula. The data was subjected to analysis of variance and critical differences at 5% level of significance was work out.

Results and Discussion

Bio-efficacy of botanical pesticides on green apple aphid (*Aphis pomi*) and bio-safety of on their natural enemies were studied at Srinagar are presented in Table 1 and 2.

Bio-efficacy of botanical pesticides against Green apple aphids

Perusal of data of Table 1 revealed that highest total mean % mortality of 68.91 was recorded against Azadirachtin @ 0.3% concentration followed by 65.06% against same botanical pesticide of 0.2% concentration while as least mean mortality of 34.32% was exhibited by castor oil @ 1% concentration. The total mean mortality of other botanicals of 2% concentration was recorded 33.33%, 43.33% and 48.76% against Neem oil, castor oil and Artemisia leaf extract, respectively. Higher concentration (3%) of Neem oil, Castor and Artemisia were showed 54.10%, 39.38% and 42.47% mortality of green apple aphid, respectively, while as NSKE 4% and 5% were given 44.40% and 48.85% mortality, respectively as compared with treated check (Roger@ 1ml/lit) which revealed 68.91% mortality of green apple aphid and was significantly similar to Azadirachtin (0.3%).

First day after treatment, highest mortality (reduction) of nymph, alate and apterous green apple aphid were recorded 62.03% against Azadirachtin@ 0.3% concentration which was statistically similar to treated check (Roger@ 1ml/L), while at least 28.63% against Castor oil (2%) which differed significantly with other. The highest mortality of alate and apterus aphid of green apple aphid at one day after treatment was recorded highest 50.00% and 45.56% against Azadirachtin (0.3%) while as lowest 14.08% and 11.76% against Castor oil (2%).

Maximum percent reduction of green apple aphid population *viz*., nymph, alate and apterous were recorded 77.0%, 68.29% and 61.76% against Azadirachtin@ 0.3% while as least mortality of above three stages of green apple aphid was recorded 43.19%, 23.94% and 30.88% against Castor oil (2%), respectively. The higher concentration of Neem oil, Castor oil and Artemisia leaf extract @ 3% were given nymph mortality of 59.80%, 27.58% and 39.97%, apterous aphid mortality of 53.078%, 34.17% and 48.48%, respectively. Mortality of green apple aphid (Nymph, alate and apterous stages) at 15th days after treatment showed similar trend of mortality with gradually increasing trend which was significantly high and differed from the mortality of 7th day after treatments.

Cumulative mean mortality of nymph, alate, and apterous of green apple aphid were recorded highest 73.79%, 62.60% and 58.81%, respectively against Azadirachtin@ 0.3% which were statistically similar to treated check of nymph, alate and apterous green apple aphid respectively. Lowest cumulative mean mortality of nymph, alate and apterous green apple aphid 43.34%, 25.81% and 33.82%, respectively which were statistically lower than other botanical oils of same concentration. A common strategy to control *Aphis pomi* in apple orchids is based on one or more than one application of insecticides (Khan 2009; 2012). Least information is available for comparing the impact of botanical pesticides against *Aphis pomi* as well as their natural enemies. The toxicity of pesticides on *Aphis pomi* was studied by few workers like Hardman *et al.* [14]; Martenz-Villar *et al*. [15] and Khan and Riyaz [11].

Table 1: Bio-efficacy of Botanical pesticides against green apple aphid *Aphis pomi* in apple orchard of Kashmir

Treatment	Conc.	Pre-treatment count (aphid/ 10cm of twig)			Mean	Post treatment count (Mean Population of *A.pomi*/ 10 cm of twigs DAT)									Cumulative Mean			Total (Mean % reduction)
						1			7			15						
		N	A	Ap		N	A	Ap	N	A	Ap	N	A	Ap	N	A	Ap	
Neem oil	2%	35.2	15.4	17.4	68.0	18.2 (48.29)	11.6 (24.67)	12.2 (29.88)	15.4 (56.25)	7.4 (51.94)	9.6 (44.82)	10.8 (69.31)	8.4 (45.45)	6.4 (63.21)	14.8 (57.95)	9.13 (40.68)	9.4 (45.97)	33.33 (48.20)
	3%	40.8	17.2	16.2	74.2	20.2 (50.49)	11.6 (32.55)	10.8 (33.33)	16.4 (59.80)	8.0 (53.48)	7.6 (53.08)	9.8 (75.98)	6.6 (61.62)	5.4 (66.66)	15.4 (62.09)	8.73 (49.21)	7.93 (51.02)	32.06 (54.10)
Castor oil	2%	42.6	14.2	13.6	70.4	30.4 (28.63)	12.2 (14.08)	12.0 (11.76)	24.2 (43.19)	10.8 (23.94)	9.4 (30.88)	17.8 (58.21)	8.6 (39.43)	5.6 (58.82)	24.13 (43.34)	10.2 (25.81)	9.0 (33.82)	43.33 (34.32)
	3%	57.4	17.4	15.8	90.6	35.6 (37.97)	14.2 (18.39)	13.2 (16.45)	27.2 (52.61)	12.6 (27.58)	10.4 (34.17)	20.6 (64.11)	9.8 (43.67)	6.4 (59.49)	27.8 (51.56)	12.20 (29.88)	10.33 (36.70)	50.33 (39.38)
Artemisia leaf extract	2%	55.2	16.2	14.4	85.8	38.8 (29.71)	13.4 (17.29)	11.6 (19.44)	32.2 (41.66)	10.2 (37.03)	8.4 (41.66)	26.2 (52.53)	8.8 (45.67)	5.2 (59.72)	32.4 (41.30)	7.4 (33.32)	8.46 (40.27)	48.76 (38.29)
	3%	40.8	15.6	13.4	69.8	28.2 (30.88)	11.2 (21.79)	10.6 (20.89)	21.6 (47.05)	9.4 (39.97)	7.4 (44.77)	15.4 (62.25)	7.4 (52.56)	5.2 (62.12)	21.73 (46.72)	9.33 (38.10)	7.73 (42.59)	38.79 (42.47)
NSKE	4%	43.2	11.8	13.2	68.2	27.8 (35.64)	9.2 (22.03)	10.4 (21.21)	21.6 (50.00)	6.6 (44.06)	6.8 (48.48)	15.8 (63.42)	5.4 (54.23)	5.2 (60.60)	21.73 (49.68)	7.06 (40.10)	7.8 (43.43)	36.25 (44.40)
	5%	41.6	10.6	12.8	65.0	24.8 (40.38)	7.6 (28.30)	7.8 (26.41)	19.4 (53.36)	5.2 (50.94)	6.2 (51.56)	14.2 (65.86)	4.2 (60.37)	4.8 (62.50)	19.46 (53.20)	5.66 (46.53)	6.26 (46.82)	31.38 (48.85)
Azadirachtin	0.2%	45.2	18.2	15.4	78.8	20.0 (55.75)	10.8 (40.65)	9.4 (38.96)	12.2 (73.00)	7.2 (60.43)	6.4 (58.44)	8.6 (80.97)	7.6 (58.24)	5.2 (66.23)	13.6 (69.90)	8.53 (53.10)	7.0 (54.54)	29.13 (59.21)
	0.3%	37.4	16.4	13.6	67.4	14.2 (62.03)	8.2 (50.00)	7.4 (45.56)	8.6 (77.00)	5.2 (68.29)	5.2 (61.76)	6.6 (82.35)	5.0 (69.51)	4.2 (69.11)	9.8 (73.79)	6.13 (62.60)	5.6 (58.81)	21.53 (65.06)
Treated	1ml/L	53.6	16.4	17.2	87.2	20.6	6.2	8.4	13.6	4.0	6.4	11.4	3.6	4.2	15.20	4.6	6.33	26.13

check (Dimethoate 30EC)						(61.56)	(62.19)	(51.16)	(74.62)	(75.60)	(62.79)	(78.73)	(78.04)	(75.58)	(71.63)	(71.94)	(63.17)	(68.91)
Control	Use Water only	55.4	16.8	15.4	87.6	56.2 (-1.44)	16.8 (0.0)	15.6 (-1.29)	57.4 (-3.61)	17.2 (-2.38)	16.2 (-5.19)	58.8 (-10.0)	17.8 (-5.95)	17.0 (-10.4)	57.4 (-3.61)	17.26 (-2.77)	16.26 (-5.58)	90.92 (-3.98)
CD(P=0.05)		4.15	1.27	1.98	2.85	1.54	1.31	1.04	1.21	0.94	0.81	1.17	0.59	0.67	-	-	-	-

Mean of 5 replications
Figure in parenthesis indicates mean % reduction of aphid population
N= nymph, Al= Alate, Ap= Apterus
DAT= days after treatment

Bio-safety of botanical pesticides against their natural enemies of green apple aphid

The bio-safety of botanical pesticides were evaluated against three predatory natural enemies associated with green apple aphid in the valley as coccinellids, syrphid fly and Chrysoperla larva and Parasitization of green apple aphid was also evaluated (Table 2). The highest total predatory natural enemies mean mortality 39.04% was recorded against Azadirachtin (0.3%) which was significantly lower (72.00%) than treated check (Dimethoate@ 1ml/L) while as lowest (24.25%) against Neem oil (2%). Among three predatory natural enemies, the cumulative mean mortality of coccinellids was recorded lowest in all treatment except Artemisia leaf extract (2%) was 28.50% was higher than Chrysoperla (26.42). Among all treatments, the mortality of Chrysoperla was recorded highest followed by syrphid fly larva. The maximum mortality of coccinellids (40.00%) was recorded against NSKE (5%) while as, maximum mortality of syrphid fly (42.85%) and Chrysoperla (45.00%) were recorded against Azadirachtin (0.3%) and Artemisia leaf extract (3%), respectively. Under treated check (Dimethoate @ 1ml/L) was given higher cumulative mean mortality of 72.22%, 74.28% and 67.50% of coccinellids, syrphid fly and Chrysoperla larva, respectively which was significantly higher than all botanical pesticides. All botanical pesticides are safer against parasitization of aphids and not found any significant effect while as treated check (Dimethoate @ 1ml/L) was given significantly more mortality of parasitoids (mummified aphids) (Table 2).

First day after spray, highest mortality of 25.00% of coccinellids against Artemisia leaf extract (3%); 28.57% mortality of syrphid fly against Azadirachtin (0.3%) and 33.30% mortality of Chrysoperla larvae against castor oil (3%) and Artemisia leaf extract (3%) which was significantly lower to untreated check (Dimethoate @ 1ml/L) showed 66.66% mortality of coccinellids, 71.42% mortality of syrphid fly and 62.50% mortality of Chrysoperla larvae (Table 2).

Maximum per cent mortality of predatory natural enemies of 40.00% of coccinellids against Artemisia leaf extract (3%) and Azadirachtin (0.3%) were recorded at 7th day after treatment and least against Castor oil (2%) was 14.28%.

In case of syrphid fly larvae it was highest (43.85%) against Azadirachtin (0.3%) and least 22.20% against Neem oil (3%) at 7th DAT. The mortality of Chrysoperla was recorded highest (50.00%) against NSKE (5%) and lowest (25.00%) against Castor oil (2%) at 7th DAT. At 15th DAT the maximum mortality (60.00%) of coccinellids was recorded against NSKE (5%) and least 28.57% against Castor oil (2%), in case of syrphid fly it was highest (57.14%) against Azadirachtin (0.3%) and least (35.71%) against castor oil (2%). The maximum mortality of Chrysoperla was recorded highest 50.0% against higher concentration of botanical pesticides which was significantly lower than treated check (Roger@ 1ml/L) and was 75.00% while as least mortality (33.30%) was recorded against Neem oil (2%) at 15th DAT. Lest information was recorded against effect of botanicals pesticides on natural enemies population of green apple aphids, Khan [16, 17] reported some oils for the biosafety of natural enemies of green apple aphids of Kashmir.

We can conclude that Azadirachtin @ 0.3% exhibited best performance on the basis of mortality of green apple aphid (68.91%) and safer for natural enemies; hence, Azadirachtin @ 0.3% can be considered potential botanical pesticides for the management of green apple aphid in Kashmir.

Table 2: Bio-safety of Botanical pesticides against natural enemies of green aphid (*Aphis pomi*) in apple orchard of Kashmir

Treatment	Conc.	Pre-treatment count			Mean	P (%)	Post treatment count (Mean population of Natural Enemies DAT)												Cumulative mean			Total (Mean % reduction)	Mean (% P)
							1				7				15								
		C.	S.	Ch.			C.	S.	Ch.	P (%)	C.	S.	Ch.	P (%)	C.	S.	Ch.	P (%)	C.	S.	Ch.		
Neem oil	2%	1.8	1.6	0.6	4.0	12.2	1.6 (11.11)	1.4 (12.50)	0.5 (16.6)	10.0	1.4 (22.20)	1.2 (25.00)	0.4 (33.30)	9.6	1.2 (33.30)	1.0 (37.50)	0.4 (33.30)	9.4	1.4 (22.2)	1.2 (25.00)	0.43 (28.30)	3.03 (24.25)	9.6
	3%	2.4	1.8	0.8	5.0	9.8	2.2 (16.67)	1.5 (16.70)	0.6 (25.0)	9.5	1.8 (25.00)	1.4 (22.20)	0.5 (37.50)	8.2	1.5 (37.50)	1.1 (38.80)	0.4 (50.00)	7.9	1.76 (26.66)	1.33 (26.11)	0.50 (37.50)	3.59 (28.20)	8.5
Castor oil	2%	1.4	2.8	0.4	4.6	9.0	1.3 (7.14)	2.4 (14.28)	0.3 (25.0)	8.6	1.2 (14.28)	2.0 (28.57)	0.3 (25.00)	8.4	1.0 (28.57)	1.8 (35.71)	0.2 (50.00)	6.0	1.16 (17.14)	2.06 (26.42)	0.26 (35.00)	3.48 (24.34)	7.6
	3%	2.2	1.6	1.2	5.0	9.2	7.8 (18.80)	1.2 (25.00)	0.8 (33.30)	8.2	1.6 (27.27)	1.0 (37.50)	0.7 (41.60)	7.4	2.0 (39.91)	0.8 (45.45)	0.6 (50.00)	7.2	1.53 (30.45)	1.0 (37.50)	0.70 (41.66)	3.23 (35.40)	7.6
Artemisia leaf extract	2%	2.0	1.4	1.4	4.8	10.4	1.6 (20.00)	1.1 (21.43)	1.2 (14.28)	8.2	1.4 (30.00)	1.0 (28.57)	1.0 (28.57)	6.8	1.3 (35.00)	0.8 (42.85)	0.9 (35.72)	6.6	1.43 (28.50)	0.96 (31.42)	1.03 (26.42)	3.42 (28.75)	7.2
	3%	1.6	2.4	0.6	4.6	8.2	7.2 (25.00)	2.0 (16.66)	0.4 (33.30)	7.6	1.0 (37.50)	1.8 (33.33)	0.3 (53.00)	12.2	0.9 (43.75)	1.4 (41.66)	0.3 (50.00)	6.4	1.0 (35.02)	1.73 (27.91)	0.33 (45.00)	3.09 (32.38)	7.4
NSKE	4%	1.4	1.8	1.2	4.4	9.4	1.2 (14.28)	1.4 (22.20)	1.0 (16.60)	7.8	1.0 (28.57)	1.2 (33.33)	0.8 (33.30)	7.3	0.8 (42.85)	1.0 (44.40)	0.7 (41.60)	6.7	1.0 (28.57)	1.2 (33.30)	0.83 (30.83)	3.03 (31.14)	7.3
	5%	1.0	1.6	0.8	3.4	10.6	0.8 (20.00)	1.2 (25.00)	0.6 (25.0)	9.4	0.6 (40.00)	1.0 (37.50)	0.4 (50.00)	8.6	0.4 (60.00)	0.8 (50.00)	0.4 (50.0)	7.4	0.6 (40.00)	1.0 (37.50)	0.46 (42.50)	2.06 (39.41)	8.46
Azadirachtin	0.2%	1.5	2.0	0.6	4.1	10.4	1.2 (20.00)	1.6 (20.00)	0.5 (16.60)	9.2	1.1 (26.60)	1.4 (30.00)	0.4 (33.30)	9.0	1.0 (33.30)	1.2 (40.00)	0.3 (50.00)	8.6	1.1 (26.67)	1.4 (30.00)	0.40 (33.30)	2.90 (29.26)	8.9

	0.3%	2.0	1.4	0.8	4.2	11.2	1.6 (20.00)	1.0 (28.57)	0.6 (25.00)	9.4	1.2 (40.00)	0.8 (43.85)	0.5 (37.50)	8.4	1.0 (50.00)	0.6 (57.14)	0.4 (50.00)	8.2	1.26 (37.00)	0.8 (42.85)	0.50 (37.50)	2.56 (39.04)	9.0
Treated check (Dimethoate 30EC)	1ml/L	1.8	1.4	0.8	4.0	12.0	0.6 (66.60)	0.4 (71.42)	0.3 (62.50)	10.6	0.5 (72.22)	0.4 (71.42)	0.3 (62.50)	6.8	0.4 (77.70)	0.3 (78.50)	0.2 (75.00)	5.0	0.5 (72.22)	0.36 (74.28)	0.26 (67.50)	1.12 (72.00)	7.4
Control	Use water only	1.6	1.4	0.8	3.8	10.2	1.8 (-12.5)	1.4 (0.0)	0.8 (0.0)	10.6	1.7 (6.25)	1.5 (-7.14)	0.8 (0.0)	12.3	1.9 (-18.75)	1.5 (-7.14)	0.9 (-12.50)	12.6	1.8 (-12.50)	1.46 (-4.28)	0.83 (-3.75)	4.05 (-6.57)	11.83
CD(P=0.05)		0.23	0.14	0.09	0.49	1.2	0.72	0.33	0.29	1.30	0.23	0.38	0.17	1.9	0.18	0.21	0.09	1.73	-	-	-	-	-

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 twigs.

Acknowledgements
This work was funded by Department of Science and Technology (DST), New Delhi, GOI under the project entitled "Biodiversity and management of aphid fauna of temperate horticulture ecosystem of Kashmir". The authors are thankful to DST for the financial assistance.

References

1. Blackman RL, Eastop VF. Taxonomic Issues. In: Aphids as Crop Pests. (Eds. H.F. van Emden and R. Harrington). CABI, Cambridge, UK, 2007, 1-22.
2. Remaudiere G, Remaudiere M. Catalogue of World's Aphididae: Homoptera- Aphidoidea. Inra Edition: Route de France, 1997, 478.
3. Ghosh AK, Ghosh LK. The Fauna of India and Adjacent Countries: Homoptera, Aphidoidea, Part. Zoological Survey of India, Calcutta. 2006; 7(1):244.
4. Bhagat RC. Aphids (Insecta) of agricultural importance in J&K state, India: a checklist and biodiversity. International Journal of Food, Agriculture and Veterinary Sciences. 2012; 2(3):116-125.
5. Khan AA, Shah MA. Records of aphids 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.
6. Haley EAC, Allen WR. The green apple aphid, *Aphis pomi* De Geer (Homoptera: Aphididae), and its predators in a young apple orchard. Crop Protection. 1990; 9:225-230.
7. Woolhouse MEJ, Harmsen R. Population dynamics of Aphis pomi: A transition matrix approach. *Ecological Model*. 1991; 55:103-111.
8. 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.
9. Shah MA, Khan AA. Functional response- a function of predator and prey species. *The Bioscan*, 2013; 8:751-758.
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. Khan AA, Riyaz S. Bioefficacy of pesticides against green apple aphid Aphis pomi De Geer and biosafety to natural enemies in apple orchard. Indian Journal of Entomology. 2018; 80(2):315-319.
12. Jansen JP, Defrance T, Warnier AM. Effect of organic farming compatible insecticides on four aphid natural enemy species. Pest Management Science. 2010; 66:650-656.
13. Milenkovic S, Marcic Ruzicic L. Control of Green Apple Aphid (Aphis pomi De Geer) in Organic Apple Production. Journal of Pesticides and Phytomedicine. 2013; 28(4):281-285.
14. Hardman JM, Franklin JI, Moreau DI, Bostaman NJ. An index for selective toxicity of miticides to phytophagous mires and their predators based on orchard trails. Pest Management Science. 2003; 59:1324-1332.
15. Martizen-Villar E, Saenz-De-Cabezon FJ, Moreno-Grijaiba F, Marco V, Perez-Moreno I. Effect of azadirechtin on two spotted spider mite, Tetranychus urticae (Acari: Tetranychidae). Experimental and Applied Acarology. 2005; 35(3):215-222.
16. Khan AA. Relative toxicity of pesticides for safety of predatory coccinellids. Annals of Plant Protection Sciences. 2009; 17(2):307-311.
17. Khan AA. Comparison of spider diversity in relation to pesticide use in apple orchards of Kashmir. Journal of Biological Control. 2012; 26(1):1-10.