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Full Research Article

Seasonal Abundance of Mustard Aphid, *Lipaphis Erysimi* (Kalt.) and Saw Fly, *Athalia Lugens Proxima* (Klug) in Relation to Abiotic Factors and their Eco-Friendly Management

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Abstract

Effect of weather on abundance of mustard aphid and sawfly and their eco-friendly management was studied during 2011-13. Mustard aphid, *Lipaphis erysimi* appeared first in 49th and 50th standard week and reached maximum in 2nd standard week (49.07 and 63.48 aphids 10 cm^{-1} central inflorescence during 2011-12 and 2012-13, respectively). Sawfly appeared in 45th and 46th standard week and attained maximum in 47th standard week (1.57 and 1.42 larvae $plant^{-1}$ during 2011-12 and 2012-13, respectively). The correlation study revealed that minimum and maximum temperature had significant negative influence on aphid population (r=-0.64 to -0.83 during 2011-12 and 2012-13) whereas saw fly population was influenced positively by both temperature (r=0.62 to 0.67 in both the periods). Of 14 germplasm of rapeseed-mustard screened against mustard aphid and sawfly, Sikkim Toria-2, Sikkim Sarson Yellow-1, Sikkim Sarson Yellow-3 and TS-38 were found promising. Among the biopesticides evaluated against mustard aphid and sawfly, *Bacillus thuringiensis* @ 2 g l^{-1} was found to be effective for management of sawfly population (68.60 % larval reduction over control) while petroleum agro-spray @ 10 ml l^{-1} and neem oil 0.15EC @ 3 ml l^{-1} were most effective for controlling of aphid population. Among treatments the highest yield (7.8 q ha^{-1}) was recorded in the plot treated with petroleum agro-spray followed by neem oil (7.6 q ha^{-1}) and were on par with check oxydemeton methyl 25EC @ 1 ml l^{-1}. *Coccinella septempunctata* and *Menochilus sexmaculata* were recorded more (0.35-0.70 nos. $plant^{-1}$) with higher predatory efficiency (8.4-12.6 aphids day^{-1}) in comparison to syrphid fly.

1. Introduction

Rapeseed-mustard is an important oleiferous crop and constitutes major source of edible oil for the human consumption and feed as cake for livestock. In Sikkim, the total cultivated area under this crop is around 4380 ha producing 3500 t with an average yield of 779 kg ha^{-1} (Avasthe et al., 2014). More than three dozen of pests are known to be associated with various phenological stages of rapeseed-mustard crops in India (Bakhetia and Sekhon, 1989). Among these insect pests, mustard aphid is the most serious and destructive pest and major limiting factor for mustard cultivation (Begum, 1995; Biswas and Das, 2000; Kumar et al., 2007). The colonies of mustard aphids, both nymphs and adults, suck the cell sap from the new shoots, inflorescence and leaves. This pest may reduce about 30-90% yield of mustard without an intervention of any control measure (Rouf and Kabir, 1997). In case of severe attack of sawfly the crop is completely devastated while in severe aphid attack the entire plant gets densely covered with aphids resulting in stunted growth and poor pod with negligible seeds.Weather conditions play the most favourable role for rapid multiplication of aphids and saw fly (Sinha et al., 1989; Rana et al., 1993; Singh and Malik, 1998). It has become absolutely imperative to study the population buildup of aphids and saw fly in relation to abiotic factors to determine the effective eco-friendly management strategies. Such study will provide an opportunity to address the pest challenge by manipulating the manageable ecological parameters in the form of planting or harvesting time adjustment, varietal selection, correct time of pesticide application, etc. Predators also play pivotal role for management of mustard aphid. Seven different species of ladybird beetle have been recorded by Hossain et al. (2001) in Pakistan. So, Coccinellid beetles may be utilized to a great extent for the biological control of mustard aphid as they aphidivorus (Sheikh et al., 1993).

The biological control is one of the most effective means of achieving insect control (Pedigo, 2004). Therefore, the present

investigation was undertaken with few objectives viz., to study the effect of abiotic factors on the population buildup of mustard aphid and saw fly, determine the potential natural enemies, find out some tolerant resistant^{-1} germplasm and evaluate some biopesticides against these insect pests.

2. Materials and Methods

2.1. Effect of abiotic factors on the population buildup of mustard aphid and saw fly

Mustard crop (var-M-27) was grown in 400 m^2 to study the effect of abiotic factors on the population build up of mustard aphid and saw fly. Whole plot was divided into four equal plots. The crop was sown late on 28th October in both the years at ICAR Farm, Tadong at 1350 m msl. During experimentation all the recommended cultural operations were followed except the plant protection measures. In case of mustard saw fly the number of larvae plant^{-1} was recordedat weekly interval from randomly selected 10 plants from each plot. Data on the population of aphids per 10 cm inflorescence from central shoot was recorded at weekly interval by randomly selecting 10 tillers from each plot. The meteorological data were collected regularly.

2.2. Study on species composition of aphids associated with mustard

Hundred colonies of aphids were collected randomly from the field and identified taxonomically and the composition of different species of aphids infest mustard crop was determined.

2.3. Identification of potential natural enemies

The population of natural enemies was recorded from central inflorescence of randomly selected 10 plants from each plot at weekly interval. The rate of predation of different natural enemies was studied in the laboratory. Fifty numbers of aphids were retained along with the inflorescence of mustard crop inside a cage and an adult of *Coccinella septempunctata* was released into the cage. Same method was followed for *Menochilus sexmaculata* and in case of Syrphid fly a larva was released and replicated ten times. Aphid population was counted after 24 hours. The predatory efficiency i.e., no. of aphids consumed per individual day^{-1} was calculated afterwards.

2.4. Screening of germplasm

Fourteen different germplasm of mustard and rapeseed suitable for Sikkim were grown in the field to identify germplasm the resistant or tolerant against mustard aphid and saw fly, during 2011-12 and 2012-13. The experiment was conducted in RBD and each treatment (germplasm) was replicated thrice. The population of saw fly was recorded at vegetative stage at 20 and 30 days after sowing and mustard aphid was recorded at 25% and 50 % flowering stage of the crop.

2.5. Evaluation of biopesticides

Six different biopesticides viz., neem oil 0.03 EC @ 3 ml l^{-1}, neem oil 0.15 EC @ 3 ml l^{-1}, *Beauveria bassiana* 7 g l^{-1}, *Bacillus thuringiensis,* @ 2 g l^{-1}, *Verticillium lecanii* @ 3 ml l^{-1}, petroleum agro-spray @ 10 ml l^{-1} were tested against insect pests of mustard aphid and saw fly by taking Oxydemeton methyl @ 1 ml l^{-1} as check and an untreated control. The experiment was conducted in RBD and the treatments were replicated thrice. The first application of treatments was done at vegetative stage when the population of saw fly was observed. Second spray was given when mustard aphid population was observed at the flowering stage and third spray at 15 days interval. The population of mustard aphid and saw fly was recorded before treatment and 7 and 14 days after treatment. The yield of each plot was recorded separately.

3. Results and Discussion

3.1. Impact of abiotic factors on mustard aphid and saw fly

Effect of abiotic factors on the population build up of mustard aphid and saw fly was studied during 2011-12 and 2012-13. It was found from the study that the appearance of aphid was noticed first in the 49th and 50th standard week during 2011-12 and 2012-13, respectively and the aphid population reached maximum in the 2nd standard week (49.07 and 63.48 aphids 10 cm^{-1} central inflorescence) in both the years and started declining (Table 1). Saw fly appeared earlier than aphid on 45th and 46th standard week during 2011-12 and 2012-13, respectively and attained maximum on 47th standard week (1.57 and 1.42 larvae plant^{-1}) in both the years and there after started declining (Table 1). The peak aphid population was found at minimum and maximum temperatures of 6.58 and 13.80 °C during 2011-12 and 5.34 and 14.12 °C during 2012-13, respectively. The population of saw fly reached a peak when minimum and maximum temperatures were 10.44 and 19.72 °C during 2011-12 and 10.12 and 19.18 °C during 2012-13, respectively. The correlation coefficient analysis of the data on aphid population with prevailing abiotic factors indicated a negative association with the maximum temperature (r =-0.67 and -0.64 during 2011-12 and 2012-13, respectively) and minimum temperature (r= -0.68 and -0.83 during 2011-12 and 2012-13, respectively) whereas saw fly was influenced positively by maximum temperature (r=0.62 and 0.67during 2011-12 and 2012-13, respectively) and minimum temperature (r=0.64 and 0.68during 2011-12 and 2012-13, respectively) in both the years (Table 2). Gami et al. (2002); Hasan and Singh (2010) also observed that aphid population registered significant negative correlation with maximum and minimum temperatures. The population of natural enemies viz., lady bird

Table 1: Study on effect of abiotic factors on population of mustard aphid and saw fly

Mustard aphid population						Sawfly population					
2011-12			2012-13			2011-12			2012-13		
Observation date	Standard week	Aphids 10 cm^{-1} central shoot	Date of observation	Standard week	Aphids10 cm^{-1} central shoot	Observation date	Standard week	Saw fly $plant^{-1}$	Date of observation	Standard week	Saw fly $plant^{-1}$
05.12.11	49	8.47	15.12.12	50	12.47	07.11.11	45	0.32	17.11.12	46	0.68
12.12.11	50	12.67	22.12.12	51	27.15	14.11.11	46	0.75	24.11.12	47	1.42
19.12.11	51	18.2	29.12.12	52	34.92	21.11.11	47	1.57	01.12.12	48	1.36
26.12.11	52	25.22	05.01.13	01	46.32	28.11.11	48	1.37	08.12.12	49	1.18
02.01.12	01	37.35	12.01.13	02	63.48	05.12.11	49	1.10	15.12.12	50	0.92
09.01.12	02	49.07	19.01.13	03	54.62	12.12.11	50	0.72	22.12.12	51	0.64
16.01.12	03	41.65	26.01.13	04	50.76	19.12.11	51	0.30	29.12.12	52	0.82
23.01.12	04	28.07	02.02.13	05	44.14	26.12.11	52	0.47	05.01.13	01	0.78
30.01.12	05	11.55	09.02.13	06	39.26	02.01.12	01	0.54	12.01.13	02	0.38
06.02.12	06	6.0	16.02.12	07	23.86	09.01.12	02	0.10	19.01.13	03	0.30
-	-	-	23.02.13	08	14.20	-	-	-	26.01.13	04	0.12

Table 2: Correlation between population of mustard aphid and saw fly and abiotic factors

Abiotic factors/ population of insect	Aphids		Sawfly	
	2011-12	2012-13	2011-12	2012-13
Maximum temperature °C	-0.67*	-0.64*	+0.62*	+0.67*
Minimum temperature °C	-0.68*	-0.83*	+0.64*	+0.68*
Maximum humidity %	-0.19	-0.22	+0.10	+0.16
Minimum humidity %	-0.11	-0.14	+0.12	+0.20
Rainfall (mm)	+0.30	+0.12	+0.18	+0.16
BSSH (hrs)	+0.02	+0.28	+0.52	+0.46

*Significant at (0.05)

beetles, *Coccinella septempunctata, Coccinella transversalis* and *Menochilus sexmaculata* and Syrphid fly was noticed first during flowering stage of the crop and existed till maturity of the crop. Amongst them the occurrence of *C. Septempunctata* (0.22 to 0.70 beetles $plant^{-1}$) and *Menochilus sexmaculata* (0.32 to 0.52 beetles $plant^{-1}$) are more in comparison to syrphid fly (0.0.08 to 0.35 larva $plant^{-1}$) and *C. transversalis* (0.03 to 0.16 beetles $plant^{-1}$) (Table 3). From the laboratory study it was found that the predatory efficiency of *C. Septempunctata* (12.6 aphids day^{-1}) was recorded higher than *M. sexmaculata* (8.4 aphids day^{-1}) and syrphid fly (4.6 aphids day^{-1}) (Figure 1). Chowdhury et al., 2008 reported that the total number of bean aphid consumed by each larva during its total larval development period from 38 to 58 aphids with an average of 48.60±2.04 aphids during their entire larval period. They also reported that the predation efficiency of male and female adults were 1003.27±104.35 and 1216.40±22.89 aphids, respectively in entire life period. The feeding rate of predatory stage of *C. septempunctata* decreased at increased prey and predator densities (Omkar and Srivastava, 2003). Three different species of aphids are associated with mustard crop in Sikkim besides mustard aphid, *Lipaphis erysimi*. It is revealed from the Figure 2 that mustard aphid, *Lipaphis erysimi* (89.00%) is the most dominant species in mustard crop. Other species are Cabbage aphid, *Brevicoryne brassicae* (6.00%), *Brachycaudus helichrysi* (3.00%) and bean aphid, *Aphis craccivora* (2.00%).

3.2. Screening of germplasm for resistance/tolerance

Fourteen different germplasm of rapeseed and mustard viz., Sikkim Sarson Yellow-1, Sikkim Sarson Yellow-2, Sikkim Toria-1, Sikkim Toria-2, Sikkim Sarson Brown-2, Yellow Sarson IC-385, Sikkim Sarson Yellow-3, Yellow Sarson Jhumka, Yellow Sarson IC-398652, Sikkim Sarson Brown-1, TS-36, TS-38, TS-46, and M-27 were screened against mustard aphid and saw fly during 2011-12 and 2012-13. Amongst them in Sikkim Toria-2, Sikkim Sarson Yellow-1, Sikkim Sarson Yellow-3 and TS-38 the infestation of mustard aphid and saw fly was recorded significantly less in comparison to others. The average aphid and saw fly population ranged from 21.00 to 24.93 aphids 10 cm^{-1} central inflorescence and 0.70 to 0.90 larvae $plant^{-1}$, respectively in these four germplasms whereas maximum infestation of mustard aphid and sawfly was

Table 3: Population build up of natural enemies in rapeseed and mustard

Date of observation	Adult larval^{-1} predators plant^{-1}							
	Adult *C. septempunctata*		Adult *M. sexmaculata*		Adult *C. transversalis*		Adult Syrphid fly	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
05.12.11	0.35	0.22	0.36	0.34	0.08	0.06	0.20	0.22
12.12.11	0.46	0.36	0.37	0.38	0.12	0.08	0.22	0.20
19.12.11	0.48	0.45	0.40	0.42	0.14	0.10	0.24	0.26
26.12.11	0.49	0.52	0.42	0.45	0.09	0.14	0.28	0.25
02.01.12	0.58	0.54	0.44	0.48	0.13	0.14	0.24	0.28
09.01.12	0.70	0.68	0.52	0.49	0.15	0.16	0.35	0.34
16.01.12	0.60	0.55	0.47	0.44	0.16	0.12	0.32	0.30
23.01.12	0.53	0.46	0.43	0.37	0.08	0.08	0.18	0.20
30.01.12	0.47	0.42	0.37	0.34	0.12	0.07	0.12	0.14
06.02.12	0.46	0.38	0.35	0.32	0.08	0.03	0.08	0.10

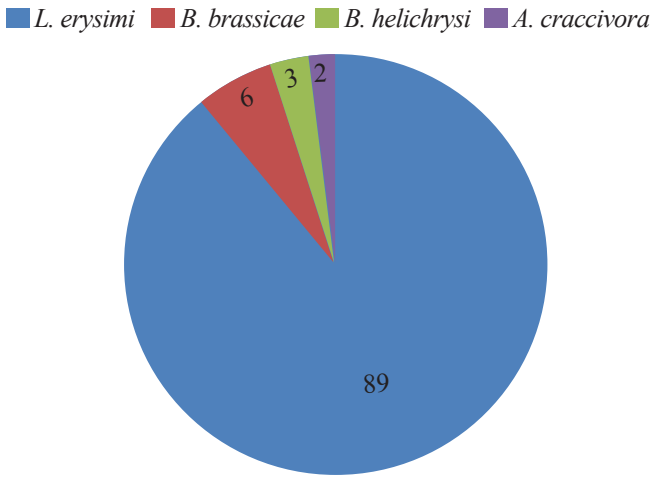

Figure 1: Species composition of aphids in mustard

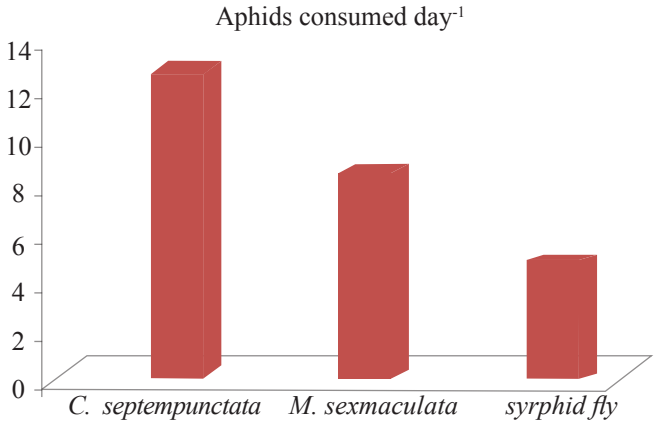

Figure 2: Predatory efficiency of different natural enemies

recorded in M-27 (56.20 aphids 10 cm^{-1} central inflorescence and 1.46 larvae plant^{-1}) (Table 4). Ali and Rizvi (2011) screened 65 rapeseed-mustard cultivars against mustard aphid, *Lipaphis erysimi* and found Kranti, Maya, MYSL-203, PCR-7 and Pusa Agrani (Indian mustard); Pusa Swarnim (Kiran rai) and NDYS-2, YST-151 (yellow sarson) were highly resistant to mustard aphid. Kumar et al., 2011 recorded *Brassica fruticulosa* and *Brassica montana* most promising while a diverse array of wild and weedy crucifers was screened under laboratory conditions for their resistance to *Lipaphis erysimi*. They also suggested the possibility of high concentration of lectins to be associated with low aphid infestation in *B. fruticulosa.*

3.3. Evaluation of biopesticides against mustard aphid and saw fly

The pre-treatment aphid and sawfly population during 2012-13 crop season was 55.13 to 57.80 aphids 10 cm^{-1} central inflorescence and 1.93 to 2.23 larvae plant^{-1} (Table 5). This variation in aphid and sawfly population was non-significant indicating homogenous distribution of these pests in the experimental field. It was observed from the study that all the treatments reduced the population of mustard aphid and saw fly significantly over control. The maximum reduction of population of both the pests was achieved in the plots treated with oxydemeton methyl 25 EC @ 1 ml l^{-1} (86.02% reduction of aphid population over control). Among the biopesticides, *Bacillus thuringiensis* @ 2 g l^{-1} was found to be effective for management of sawfly population (68.60% larval reduction over control after 14 days of treatment). Two sprays of petroleum agro-spray @ 10 ml l^{-1} were found to be the most effective for controlling aphid population (72.51% reduction of aphid population over control) followed by neem oil 0.15EC @ 3 ml l^{-1} (71.46% reduction of aphid population over control). Similar trend of result was reported by Kalita et al., 2010 in case of citrus aphid in Sikkim mandarin nursery. Baxendale and Johnson (1989) reported that spraying of horticultural

Table 4: Screening of germplasms of mustard/rapeseed

Sl. no.	Name of variety	No. of sawfly larvae plant^{-1}			No. of aphids 10 cm^{-1} central inflorescence		
	Name of variety	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean
1.	Sikkim Sarson Yellow-1	0.96	0.84	0.90	23.44	26.42	24.93
2.	Sikkim Sarson Yellow-2	1.28	1.18	1.23	36.85	37.62	37.23
3.	Sikkim Toria-1	1.32	1.20	1.26	41.78	39.14	40.46
4.	Sikkim Toria-2	0.84	0.92	0.88	25.70	23.82	24.76
5.	Sikkim Sarson Brown-2	1.27	1.28	1.27	42.40	43.76	43.08
6.	Sikkim Sarson IC-385	1.24	1.32	1.28	38.34	40.24	39.29
7.	Yellow Sarson Yellow-3	0.68	0.72	0.70	20.34	22.16	21.25
8.	Yellow Sarson Jhumka	1.36	1.24	1.30	40.92	42.94	41.93
9.	Yellow Sarson IC-398652	1.34	1.26	1.30	37.68	39.28	38.48
10.	Sikkim Sarson Brown-1	1.30	1.19	1.24	35.64	36.18	35.91
11.	TS-36	1.36	1.38	1.37	39.42	37.24	38.33
12.	TS-38	0.74	0.84	0.79	21.86	20.14	21.00
13.	TS-46	1.18	1.22	1.20	34.36	35.36	34.86
14.	M-27	1.40	1.52	1.46	54.14	58.26	56.20
	CD (p=0.05)	0.20	0.24	0.14	8.12	8.42	3.13

Table 5: Efficacy of different biopesticides against mustard aphid and saw fly (during 2013-14)

Treatments	No. of larvae plants^{-1} after spray			No. of aphids 10 cm^{-1} shoot after first spray			No. of aphids 10 cm^{-1} shoot after 2nd spray		% reduction of aphids over control	Yield (q ha^{-1})
	PTC	7 DAT	14 DAT	PTC	7 DAT	14 DAT	7 DAT	14 DAT		
Neem oil 0.03 EC @ 3 ml l^{-1}	2.10	0.83	1.30	56.23	28.16	41.03	18.30	21.76	70.47	7.0
Neem oil 0.15 EC @ 3 ml l^{-1}	1.93	0.76	1.16	57.80	23.76	35.50	16.26	21.03	71.46	7.6
Beauveria bassiana 7 g l^{-1}	2.10	0.70	0.93	57.16	37.70	50.80	25.70	32.26	56.22	6.0
Bacillus thuringiensis @ 2 g l^{-1}	1.93	0.40	0.70	55.34	43.10	52.6	30.50	37.13	49.62	6.2
Verticillium lecanii @ 3 ml l^{-1}	2.20	0.80	1.23	55.13	26.70	35.5	20.36	27.86	62.19	6.4
Petroleum Agrospray @ 10 ml l^{-1}	2.23	0.60	0.80	56.80	24.86	35.33	15.13	20.26	72.51	7.8
Oxydemeton methyl 1 ml l^{-1} (Check)	2.03	0.20	0.43	56.30	12.16	22.43	6.20	10.30	86.02	8.4
Control	2.00	2.13	2.23	57.86	58.03	61.06	62.46	73.70	-	4.8
CD (p=0.05)	NS	0.43	0.68	NS	13.76	12.26	7.85	8.94		0.85

PTC: Pre-treatment count; DAT: Days after treatment; NS: Non-significant

oil was effective for management of several aphid species in different crops. Shannag et al., 2014 indicated that the neem oil was highly effective in suppressing peach aphid population. The maximum yield was obtained in oxydemeton methyl 25 EC @ 1 ml l^{-1} treated plot (8.4 q ha^{-1}). Among biopesticides petroleum agro-spray @ 10 ml l^{-1} recorded highest yield (7.8 q ha^{-1}) followed by neem oil 0.15EC @ 3 ml l^{-1} (7.6 q ha^{-1}) and were on par with check oxydemeton methyl 25 EC @ 1 ml l^{-1} (Table 5).

4. Conclusion

Temperature has significant effect on aphid and sawfly population. *Coccinella septempunctata*, *Menochilus sexmaculata* and Syrphid fly play important role to reduce

aphid population. Sikkim Toria-2, Sikkim Sarson Yellow-1, Sikkim Sarson Yellow-3 and TS-38 are found promising for Sikkim to avoid aphid and sawfly. One spray of *Bacillus thuringiensis* @ 2 g l^{-1} at early vegetative stage and two sprays of petroleum agro-spray @ 10 ml l^{-1} or neem oil 0.15EC @ 3 ml l^{-1} during flowering period can manage saw fly and mustard aphid.

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