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Population Trend of Canola Aphid, Lipaphis Erysimi (Kalt.) (Homoptera: Aphididae) and its Associated Natural Enemies in Different Brassica Lines along with the Effect of Gamma Radiation on Their Population

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***Abstract*—**Studies regarding the determination of population trend of *Lipaphis erysimi* (kalt.) and its associated natural enemies in different Brassica lines along with the effect of gamma radiation on their population were conducted at Agricultural Research Farm, Malakandher, Khyber Pakhtunkhwa Agricultural University Peshawar during spring 2006. Three different Brassica lines F6B3, F6B6 and F6B7 were used, which were replicated four times in Randomized Complete Block Design. The data revealed that aphid infestation invariably stated in all three varieties during last week of February 2006 (1st observation). The peak population of 4.39 aphids leaf^{-1} was s recorded during 2nd week of March and lowest population of 1.02 aphids leaf^{-1} was recorded during 5th week of March. The species of lady bird beetle (*Coccinella septempunctata*) and Syrphid fly (*Syrphus balteatus*) first appeared on 24th February with a mean number of 0.40 lady bird beetle leaf^{-1} and 0.87 Syrphid fly leaf^{-1}, respectively. At the time when aphid population started to increase the peak population of *C. septempunctata* (0.70 lady bird beetle leaf^{-1}) and *S. balteatus* (1.04 syrphid fly leaf^{-1}) was recorded on the 2nd week of March. *Chrysoperla carnea* appeared in the 1st week of March and their peak population was recorded during the 3rd week of March with mean population of 1.46 *C. carnea* leaf^{-1}. Among all the Brassica lines, F6B7 showed comparatively more resistance as compared to F6B3 F6B6. F6B3 showed least resistance against *L. erysimi*, which was found to be the most susceptible cultivar. F6B7 was also found superior in terms of natural enemies. Maximum number of all natural enemies was recorded on this variety followed by F6B6. Lowest number of natural enemies was recorded in F6B3. No significant effect was recorded for the effect of gamma radiation on the population of aphids, natural enemies and on the varieties.

***Keywords*—**Canola aphid, *Lipaphis erysimi*, natural enemies, brassica lines, gamma radiation.

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I. Introduction

THE name canola refers to cultivars of those species that produce seed with lower level of glucosinolates and erucic acid than rapeseed cultivars. In Pakistan, "canola" (*Brassica napus* L and *B. compestris* L.) is attaining the status of leading oilseed crop, both as a source of edible oil for human and protein supplement of animals. It is cultivated throughout the country. Pakistan is the seventh most populous country of the world with estimated population of 140.50 million, which is still multiplying at 2.10 percent per annum. It is a matter of deep concern to meet the edible oil needs of such a big population due to existing huge gap between population and consumption. The total area under canola is 265.8 thousand acres and its total production of is about 221.0 thousand tons oilseed which is lower than the other oil producing countries [5]. So it warrants increasing area as well as production of oilseed crops.

Among different factors which are responsible for the low yield of canola crop is the attack of aphids. Canola crop is heavily attacked by different species of aphids, which results in poor growth and low yield. Under favorable conditions, aphids populations multiply very rapidly and they form dense colonies on plants. Aphids also transmit plant viral diseases, like turnip mosaic virus, which can be only managed by effective control of aphids. Aphids are the most important insect pests, causing 70-80% losses in yield [3].

The mustard aphid, *Lipaphis erysimi* (Kalt.) is one of the serious pests of rape and mustard crop. Its population reaches its peak when the crop is about 70 days old. Both adults and nymphs feed on leaves, inflorescence and pods, which results in pale and curled leaves and consequently plant growth and development of flowers and pods are adversely affected. This aphid has become one of the primary pests of fall and spring seeded canola. The feeding just prior to and during bloom, results in aborts flower buds, deformed developing pods and generally decreases vigor in plant growth resulting in yield losses of up to 40 percent in untreated fields [2].

There are different methods which are used for the management of aphids include use of pesticides, bio-control agents, resistant varieties and Gamma Radiation. Secondary pest outbreaks, pesticide resistance, more stringent pesticide regulation, and concern about human health and environmental quality have renewed the interest in Integrated Pest Management programs that emphasize biological control. Biological control is very effective pest management strategy. The safety of biological control is outstanding as many natural enemies are restricted to their host and hence no effect on non- targets species. Before application and use of natural enemies in an IPM program the proper identification and determination of their population dynamics/tend is it's pre-requisite. The screening of varieties/lines and determination of resistance in different varieties against aphids is the key component of an IPM package. The host plant resistance can easily be combined with other IPM techniques for having a best IPM package. Also use of host plat resistance having no adverse effects like the use of pesticides. Gamma radiation has also been used in different IPM programs against different insect pests.

No work has been conducted on the population density of *L. erysimi* and its proper identified natural enemies on the different brassica lines along with the effect of Gamma Radiation on their population. The present study was therefore conducted to evaluate population density/trend of *L.erysimi* and there associated natural enemies. Also to determine the comparative resistance in different brassica lines against *L. erysimi* and their response toward its associated natural enemies. The response of Gamma radiation was also studied on all these parameters.

II. Materials and Methods

An experiment was conducted to determine the population trends of *L. erysimi* and its associated natural enemies in different Brassica lines (F6B3, F6B6 and F6B7) along with the effect of gamma radiations on their population at Agricultural Research Farm, Malakandher, Khyber Pakhtunkhwa Agricultural University Peshawar.

Parameters

1. Population density/trend of *L. erysim.*
2. Population density/trend of natural enemies.
3. Identification of their associated natural enemies.
   a. Ladybird beetle (*Coccinella septempunctata),*
   b. Syrphid fly (*Syrphis balteatus*)
   c. Green lacewing (*Chrysoperla carnea*).
4. Effect of gamma radiation on *L. erysimi* population, its associated natural enemies and on brassica lines.

1) Seed Irradiation and Sowing

Seeds of all Brassica lines were irradiated with a dose of 0.8 and 1 kGy (KiloGray, radation unit of measure) each with gamma rays from Co60 (Cobalt 60 radiation source at the Nuclear Institute for Food and Agriculture (NIFA) Tarnab, Peshawar. The irradiated seeds along with parental lines were sown at the Newly Developed Farm near institute of Biotechnology and Genetic Engineering Khyber Pakhtunkhwa Agricultural University Peshawar on 29/10/2006. There were total 24 sub-plots. Each sub plot was having 10 rows.

2) Population density/trend of L. erysimi

In order to study the population densities of *L. erysimi,* three different Brassica lines including F6B3, F6B6 and F6B7 were sown in different sub plots. All these Brassica lines were replicated four times. Number of aphids was counted on the three leaves, top, middle and lower region of 4 randomly selected plants in each variety in each replication avoiding the boarder rows from each plot. Data were collected at weekly intervals.

3) Population trend of Natural Enemies

In order to study the population trend of natural enemies in three different Brassica lines F6B3, F6B6 and F6B7 were sown in different sub-plots. All these Brassica lines were replicated four times. The numbers of natural enemies i.e. Syrphid fly, green lacewing and ladybird beetle were counted on 4 randomly selected plants from each variety, from each replication. Data were collected at weekly intervals and specimens were identified by the Plant Protection Department, Pakhtunkhwa Agricultural University Peshawar.

4) Identification of Natural enemies

The species of natural enemies, which were found in the field, were collected and identified in the lab. of Plant Protection Department, Khyber Pakhtunkhwa Agricultural University Peshawar. The species were:

a. Ladybird beetle (*Coccinella septempunctata),*

b. Syrphid fly (*Syrphis balteatus*)

c. Green lacewing (*Chrysoperla carnea*).

5) Effect of gamma radiation on L. erysimi *population and their associated natural enemies*

Aphid number and their associated natural enemies were counted on three leaves, top, middle, and lower region of the plant. All these Brassica lines were replicated four times. The numbers of aphids and natural enemies were counted on 4 randomly selected plants from each variety in each replication in the irradiated plots as well as in the control plots. Data were collected at weekly interval.

Data were taken at weekly intervals from each plot from the last week of February 2007 to the fourth week of March. Data were analyzed by M-State-C computer package, using Randomized Complete Block Design. The means were separated by Duncan's Multiple Range Test (DMR-T) [9].

III. Results

A. Population density/trend of aphid, L. erysimi *in different Brassica lines*

Table I, shows the effect of interaction of Brassica lines × radiation × time intervals (weeks) on the mean population of aphid *L. erysimi*. Mean value of the data indicated that, initially the mean aphid population was found low, with the passage of time the aphid population increased and peak population (3.07 aphid leaf^{-1}) was recorded on week 3rd (2nd week of March). After week 3rd the population started to decline and low population (1.15 aphid leaf^{-1}) was recorded on week 5 (4th week of March).

The interaction of Brassica lines × radiation × time interval (weeks) shows a significant response towards the mean aphid population. In most of the cases non-significant results were recorded for the effect of radiation, when we compare it with the treated Brassica lines (Table I).

The interaction of Brassica lines × radiation × time interval (weeks) shows that in almost all cases initially the population was found less, with the passage of time the aphid population increased. Generally maximum number of aphids was recorded in the interaction of F6B6 × D1 × Week 3rd. Peak population (4.39 aphid's leaf^{-1}) was recorded on week 3rd (2nd week of March). After week 3rd the population started to decline. The lowest population (1.02 aphids leaf $^{-1}$) was recorded in the interaction of F6B6 × D0 × Week 5th (Table I).

Non-significant response was recorded for the interaction of Brassica lines × radiation (Table I).

Table II, shows the effect of the interaction of Brassica lines × time interval (weeks) on the mean number of *L. erysimi* leaf^{-1} of Brassica plants. Mean value of data revealed that interaction between Brassica lines × weeks significantly effect the aphid population. In the interaction of Brassica lines × weeks, maximum number of aphids (2.18 aphids leaf^{-1}) was recorded in the F6B3 line, followed by F6B6 (1.80 aphids leaf^{-1}), the lowest mean population (1.66 leaf^{-1}) was recorded in line F6B7.Among the weeks, highest average population was recorded in week 3rd (3.07 aphids leaf^{-1}), followed by week 2nd (2.18 aphid leaf^{-1}) and week 1st (1.56 aphid leaf^{-1}), least mean number of aphids (1.15 aphid leaf^{-1}) was recorded during the last week (week 5). Maximum aphid population (3.99 aphid leaf^{-1}) was recorded at 3rd week (2nd week of March) for F6B3, followed by F6B3 (2.74 aphid leaf^{-1}) in 2nd week of March while minimum number of aphids (1.05 aphid leaf^{-1}) was recorded for F6B7 in 5th week (4th week of March).

B. Green lacewing population in different Brassica lines

Table III, shows the effect of interaction of Brassica lines × radiation × time intervals (weeks), on the mean population of green lacewing. Mean value of time interval revealed that initially the mean green lacewing population was recorded in lower number, with the passage of time green lacewing population increased and maximum population (1.46 green lacewing leaf $^{-1}$) was observed in week 4 (3rd week of March). After this the population started to decline.

The interaction of Brassica lines × radiation × time intervals (weeks), and the interaction of Brassica lines × radiation shows non-significant response to mean green lacewing population (Table III).

Table IV, shows the effect of interaction of Brassica lines × time interval (weeks) on the mean number of green lacewing population. Among the Brassica lines, maximum green lacewing population of (0.92 green lacewing leaf^{-1}) per leaf was recorded on F6B7, followed by (0.69 green lacewing leaf^{-1}), while the lowest number of (0.52 green lacewing leaf^{-1}) green lacewing population was observed in F6B3.

In the interaction of Brassica lines x time interval (weeks) initially in almost all cases aphid population was recorded lower as compared with the onward observation. Peak population was recorded in week 4, after that decline was started. Among all interactions high number (1.65 green lacewing leaf^{-1}) of green lacewing was recorded for F6B7 x week 4 (Table IV).

C. Ladybird Beetle Population in Different Brassica Lines

Table V, shows the interaction of Brassica lines × radiations × time intervals (weeks). The interaction was found non-significant ($P > 0.05$). Almost in all the cases mean ladybird beetle population was found lower initially and increased with the passage of time. Peak population (0.90 ladybird beetle leaf $^{-1}$) was recorded in the interaction of F6B6 × D0 × week 3. In most of the cases high number of ladybird beetle were recorded during week 3, after that decline of the ladybird beetle was recorded.

Among the different time intervals, highest average population (0.70 ladybird beetle leaf^{-1}) was recorded during week 3 ($P < 0.05$), followed by week 4 (0.55 ladybird beetle leaf^{-1}), the lowest population was recorded in week 1 ($P < 0.05$) (Table V).

Table VI, shows that among the Brassica lines x time intervals (weeks), brassica line F6B7 was found superior where maximum number of ladybird beetle population (0.69 ladybird beetle leaf^{-1}) was recorded, followed by F6B6 (0.50 ladybird beetle leaf^{-1}), the least mean numbers were recorded on F6B3 (0.35 ladybird beetle leaf^{-1}).

Among the time intervals (weeks) initially the mean number of ladybird beetle population was found lower, with the passage of time it increased and highest average population (0.70 ladybird beetle leaf^{-1}) was recorded during week 3, after that the decline was started (Table VI).

Among the interaction in almost all cases initially the population was found lower, with the passage of time the population increased. In most of the cases the highest number were recorded during week 3. After that decline was recorded. Highest numbers (0.91 ladybird beetle leaf^{-1}) was recorded in the interaction of F6B7 x week 3 (Table VI).

D. Syrphid fly population in different Brassica lines

Table VII, shows non-significant response for the interaction of Brassica lines × radiation × time intervals and also for the response of the interaction of Brassica line x radiation ($P > 0.05$). The time intervals show positive response

on the total average population of Syrphid fly, like other natural enemies Syrphid fly population was also found lower initially, with the passage of time it increased. Peak population (1.04 Syrphid fly leaf^{-1}) and (0.97 Syrphid fly leaf^{-1}) was recorded during week 3 and week 2 respectively, It was followed by (0.89 Syrphid fly leaf^{-1}) which was recorded during week 4 and week 5.The least numbers (0.87 Syrphid fly leaf^{-1}) was recorded during week 1.

Table VIII, shows that among the interaction of Brassica lines × time intervals (weeks), brassica line F6B7 was found superior where maximum number of Syrphid fly population (1.12 Syrphid fly leaf^{-1}) was recorded, followed by F6B6 (0.97 Syrphid fly leaf^{-1}), the least mean numbers were recorded on F6B3 (0.70 Syrphid fly leaf^{-1}).

Among the time intervals (weeks) initially the mean number of Syrphid fly population was found lower, with the passage of time it increased and highest average population (1.04 Syrphid fly leaf^{-1}) was recorded during week 3, after that the decline was started (Table VIII).

Among the interaction in almost all cases initially the population was found lower, with the passage of time the population increased. In most of the cases the highest number were recorded during week 3. After that decline was recorded. Highest numbers (1.15 Syrphid fly leaf^{-1}) was recorded in the interaction of F6B7 × week3 (Table VIII).

TABLE I
EFFECT OF THE INTERACTION OF THE GAMMA RADIATION × BRASSICA LINES × TIME INTERVAL (WEEKS) ON THE MEAN NUMBER OF LIPAPHIS ERYSIMI (KALT.) PER LEAF OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING 2007

Time Interval (weeks)							Total Mean
Brassica Lines	Radiation	W1 24/2/07	W2 31/2/07	W3 7/3/07	W4 14/3/07	W5 21/3/07	
F6B3	0	1.75g	2.40de	3.59b	1.74g	1.27i-m	2.15 ns
	1	1.58g-i	2.1ef	2.98c	1.43g-l	1.10 lm	1.84
F6B6	0	1.41g-l	2.1f	2.48d	1.27i-m	1.02m	1.65
	1	1.63gh	2.3d-f	4.39a	1.56g-j	1.26j-m	2.21
F6B7	0	1.54g-j	2.1ef	2.50d	1.41g-l	1.14k-m	1.75
	1	1.46j-k	2.1ef	2.49d	1.20h-m	1.10lm	1.69
Total Mean		1.56c	2.18b	3.07a	1.44c	1.15d	

LSD for weeks = 0.12
ns = non significant

TABLE II
EFFECT OF THE INTERACTION OF THE BRASSICA LINES × TIME INTERVALS (WEEKS) ON THE MEAN NUMBER OF LIPAPHIS ERYSIMI (KALT.) LEAF $^{-1}$ OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING 2007

Brassica Lines	Time interval (Weeks)					Total Mean
	W1	W2	W3	W4	W5	
F6B3	1.69e	2.34c	3.99a	1.64ef	1.25g-i	2.18a
F6B6	1.56ef	2.12d	2.74b	1.42fg	1.12hi	1.80b
F6B7	1.43fg	2.08d	2.48c	1.28gh	1.05i	1.66c
Total Mean	1.56c	2.18b	3.07a	1.44c	1.15d	

LSD for weeks = 0.12
LSD for varieties = 0.92
LSD for interaction = 0.20
Means followed by different letters in columns and rows are significantly different at 5 % of probability.

TABLE III
EFFECT OF THE INTERACTION OF THE GAMMA RADIATION × BRASSICA LINES × TIME INTERVAL (WEEKS) ON THE MEAN NUMBER OF GREEN LACEWING PER LEAF OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING 2007

Time Interval (weeks)							Total Mean
Brassica Lines	Radiation	W1 24/2/07	W2 31/2/07	W3 7/3/07	W4 14/3/07	W5 21/3/07	
F6B3	0 1	0.00 ns 0.00	0.37 0.52	0.60 0.98	1.31 1.42	0.33 0.50	0.52 ns 0.68
F6B6	0 1	0.00 0.00	0.79 0.43	1.29 0.58	1.72 1.29	0.75 0.31	0.91 0.52
F6B7	0 1	0.00 0.00	0.54 0.90	1.02 1.42	1.42 1.58	0.54 0.73	0.70 0.93
Total Mean		0.00e	0.59c	0.98b	1.46a	0.53d	

LSD for weeks= 0.04
ns = non significant

TABLE IV
EFFECT OF THE INTERACTION OF THE BRASSICA LINES × TIME INTERVAL (WEEKS) ON THE MEAN NUMBER OF GREEN LACEWING PER LEAF OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING 2007

Brassica Lines	Time interval (Weeks)					Total Mean
	W1	W2	W3	W4	W5	
F6B3	0.00j	0.40h	0.59g	1.30c	0.32i	0.52c
F6B6	0.00j	0.53g	1.00d	1.42b	0.52g	0.69b
F6B7	0.00j	0.85e	1.35bc	1.65a	0.74f	0.92a
Total Mean	0.00e	0.59c	0.98b	1.45a	0.53d	

LSD for varieties =0.034
LSD for weeks= 0.04
LSD for interaction =0.08
Means followed by different letters in columns and rows are significantly different at 5 % of probability.

TABLE V
EFFECT OF THE INTERACTION OF THE GAMMA RADIATION × BRASSICA LINES ×TIME INTERVAL (WEEKS) ON THE MEAN NUMBER OF LADYBIRD BEETLE PER LEAF OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING 2007

Time Interval (weeks)							Total Mean
Brassica Lines	Radiation	W1 24/2/07	W2 31/2/07	W3 7/3/07	W4 14/3/07	W5 21/3/07	
F6B3	0 1	0.27 ns 0.35	0.33 0.43	0.45 0.71	0.37 0.54	0.29 0.46	0.34 ns 0.50
F6B6	0 1	0.60 0.27	0.62 0.35	0.90 0.50	0.73 0.40	0.64 0.33	0.70 0.37
F6B7	0 1	0.37 0.55	0.39 0.62	0.71 0.92	0.54 0.71	0.46 0.62	0.49 0.68
Total Mean		0.40d	0.46c	0.70a	0.55b	0.47c	

LSD for Weeks = 0.04
ns = non significant

TABLE VI
EFFECT OF THE INTERACTION OF THE BRASSICA LINES × TIME INTERVAL (WEEKS) ON THE MEAN NUMBER OF LADYBIRD BEETLE PER LEAF OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING 2007

Brassica Lines	Time interval (Weeks)					Total Mean
	W1	W2	W3	W4	W5	
F6B3	0.27i	0.34gh	0.47e	0.38fg	0.31hi	0.35c
F6B6	0.36f-h	0.41ef	0.71b	0.54d	0.46e	0.50b
F6B7	0.57cd	0.62c	0.91a	0.72b	0.63c	0.69a
Total Mean	0.40d	0.46c	0.70a	0.55b	0.47c	

LSD for Weeks = 0.04
LSD for varieties = 0.03
LSD for interaction = 0.06
Means followed by different letters in columns and rows are significantly different at 5 % of probability.

TABLE VII
EFFECT OF THE INTERACTION OF THE GAMMA RADIATION × BRASSICA LINES × TIME INTERVAL (WEEKS) ON THE MEAN NUMBER OF SYRPHID FLY PER LEAF OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING 2007

Brassica Lines	Radiation	Time Interval (weeks) W1 24/2/07	W2 31/2/07	W3 7/3/07	W4 14/3/07	W5 21/3/07	Total Mean
F6B3	0	0.64 ns	0.73	0.88	0.70	0.58	0.71 ns
	1	0.90	1.10	1.23	0.92	0.77	0.98
F6B6	0	1.10	1.17	1.14	1.02	1.20	1.13
	1	0.58	0.75	0.80	0.67	0.68	0.70
F6B7	0	0.96	0.94	1.03	1.00	0.91	0.97
	1	1.08	1.15	1.17	1.02	1.21	1.13
Total Mean		0.87 c	0.97ab	1.04a	0.89bc	0.89bc	

LSD value for weeks = 0.085
ns = non significant

TABLE VIII
EFFECT OF THE INTERACTION OF THE BRASSICA LINES × TIME INTERVAL (WEEKS) ON THE MEAN NUMBER OF SYRPHID FLY PER LEAF OF BRASSICA PLANT (N=16) AT AGRICULTURAL UNIVERSITY RESEARCH FARM, PESHAWAR DURING SPRING, 2007

Brassica Lines	Time interval (Weeks)					Total Mean
	W1	W2	W3	W4	W5	
F6B3	0.61 ns	0.74	0.84	0.69	0.63	0.70c
F6B6	0.92	1.02	1.13	0.96	0.84	0.97b
F6B7	1.09	1.16	1.15	1.02	1.20	1.12a
Total Mean	0.87c	0.97ab	1.04a	0.89bc	0.89bc	

LSD value for Varieties = 0.65
LSD value for weeks = 0.085
LSD for interaction =0.065
ns = non significant
Means followed by different letters in columns and rows are significantly different at 5 % of probability.

IV. Discussion

L. erysimi is the most serious pest of *Brassica* spp. and causes maximum yield losses in Brassica so it is very important to study its population trends and thus to control or at least minimize their losses. It is reported that canola crop is heavily infested by aphids under favorable environmental conditions and reduced its yield drastically [6] [10].

Brassica lines, gamma radiation and different time intervals (weeks) on the population of aphid, *L. erysimi*, showed significantly large F values ($P < 0.05$) for the Brassica lines, time intervals (weeks), interaction of weeks × Brassica lines and interaction of week × radiation × Brassica lines. In the first week the mean aphid population was low, with the passage of time the aphid population increased and peak population was recorded on week 3 (2^{nd} week of March). After week 3 the population started at decline and low population was recorded on week 5 (4^{th} week of March). Similar results were reported by Rana (2006) who stated that the population started multiplying and reached to a peak during the 3rd and 4^{th} weeks of March. After week 3 the population started to decline and low population was recorded on week 5 (4^{th} week of March).

The Brassica line (F6B7) showed best response in reducing the aphids population. No literature is available to confirm these findings.

In the present study the population of green lacewing are significantly different for Brassica lines, time interval (weeks), while the interaction between Brassica lines and time interval (weeks), radiation and weeks, interaction between Brassica lines, weeks and radiation had non-significant effect on population of green lacewing. At the beginning the mean green lacewing population was lower but with the passage of time, green lacewing population increased and maximum population was observed in week 4 (3^{rd} week of March), while minimum population was found in week 1st (last week of February). Among the Brassica lines, maximum green lacewing population was recorded on F6B7 while minimum green lacewing population was observed in F6B3. Our results are in conformity with [8].

Seven spot ladybird beetles, (*C. septempunctata*) were a predominant predator in brassica spp. Mustard aphid and *C. septempunctata* appeared simultaneously in early march, reported by [1].

In the present study Brassica lines, time interval (weeks), interaction between Brassica lines and time interval (weeks) significantly affected mean ladybird beetle population, while the effect of radiation, effect of interaction of brassica lines, weeks and radiation, interaction between radiation and brassica lines and interaction between radiation and time interval was non significant on mean lady bird beetle population. Mean ladybird beetle population increased with the passage of time and maximum population was recorded in week 3rd (2^{ND} of March), after that population declined and minimum number of population observed in week 1 (last week of Feb). Among Brassica lines maximum population of ladybird beetle per leaf was recorded on F6B7 while minimum of ladybird beetle was observed on F6B3. Our results are in conformity with [7] who reported that *C. septempunctata* appeared in variably late in February during the studies of three consecutive years in Brassica crops.

In the present study Brassica lines, time interval (weeks), interaction between Brassica lines and time interval (weeks) showed significant response in terms of mean Syrphid fly population, while the effect of radiation, effect of interaction of brassica lines, weeks and radiation, interaction between radiation and brassica lines and interaction between radiation and time interval was non significant on mean Syrphid fly population. Mean Syrphid fly population increased with the passage of time and maximum population was recorded in week 3rd (2^{nd} of March), after that population declined and minimum number of Syrphid fly population observed in week 1 (last week of Feb). Among Brassica lines maximum population of Syrphid fly per leaf was recorded on F6B7 while minimum was observed on F6B3. Our results supports the findings of [4] who reported late build up of population of *C. carnea*.

In the present study it was found that peak population of aphids was observed during week 3. F6B7 was found best in reducing the aphid population. In case of natural enemies, in all cases same trend was observed and peak population was recorded during week 3, after that decline was recorded. Gamma radiations had no significant effect in terms of reducing aphid population.

V. Conclusion and Recommendations

The peak population of 3.07-aphids $leaf^{-1}$ attained during 2^{nd} week of March and lowest population of 1.15 aphid $leaf^{-1}$ observed during 4^{th} week of March. *L. erysimi* attacked more on F6B3 because of its susceptible nature, while F6B7 showed comparatively more resistance against its attack. The initial population of natural enemies started in the last week of February attained peak on 2^{nd} week of March and then declined. Ladybird beetle, Syrphid fly and *C. carnea* were the main natural enemies observed in the study sites. Ladybird beetle and Syrphid fly were recorded at the beginning of the season while Green Lace Wing population was observed during late season. The major species of natural enemies that were observed in the field were Ladybird beetle (*Coccinella septempunctata)*, Syrphid fly (*Syrphis balteatus*) and Green lacewing (*Chrysoperla carnea*).

The Brassica line F6B7 should be used for cultivation in Peshawar, because of the least preference by the *L. erysimi.* Mass production and rearing of *C. septempunctata* is recommended for the management of *L. erysimi*. Population. *C. carnea* comes late and may not be successful in Peshawar.

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