Research Article

Population Dynamics of Sunflower Insect Pests and their Natural Enemies

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Abstract | A field study was carried out during 2008 and 2009 to evaluate the population fluctuation of insect pests and their predators in sunflower ecosystem. The data revealed that *B. tabaci* and *Empoasca* spp were present throughout the cropping season. Their average maximum populations (5.65 and 3.20 individuals / leaf) were recorded during 3-week of May 2009. *Aphis gossypii* was recorded during the month of March and its maximum population (28.3 individuals / leaf) was observed during 2-week of March 2009. Likewise, *Nysius inconspicuous* was observed during seeds development and its maximum population (126 individuals / head) was recorded during 4-week of April 2009. *Spodoptera spp*, *Thysanoplusia orichalcea* and *Heliothus* were also found but in small numbers. Among natural enemies, ladybeetles and spiders were found to be the putative predators with maximum population of 3.9 and 3.5 individuals/plant, respectively. Further, correlation study indicated that syrphids and chrysoperla had a significant positive correlation with *A. gossypii* and *T. orichalcea*, respectively. Likewise, spiders and lady beetles had significant positive relationship with *B. tabaci*, *N. inconspicuous* and *Empoasca* spp. Furthermore, temperature had a significant positive correlation with *B. tabaci*, *N. inconspicuous* and *Empoasca* spp, suggested increased in temperature also increased their population. In conclusion, *B. tabaci*, *Empoasca* spp and *N. inconspicuous* are major pests of sunflower which should be controlled by exploiting of spiders and lady beetles.

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Introduction

Pakistan is deficient in edible oil production and meets only 28% of its oil requirements through indigenous resources. The remaining 72% is being met through imports by spending billions of dollars each year (Mukhtar, 2009). The agro-climatic conditions of Pakistan are not conducive for cultivation of oil palm (Mukhtar, 2009). Sunflower and soyabeen are found to have the potential to raise the edible oil production in the country (Nasir, 2003).

Unlike soyabeen, sunflower crop has become fit-well in the local cropping system and it has become important cash crop in all parts of country (Mukhtar, 2009). Sunflower seeds contain 40 to 50% oil and 17 to 20% protein (Kakakhel et al., 2000a) and it is grown twice a year. Average yield of sunflower in Pa-

kistan is less than the other countries of the world. A number of factors can be attributed to the low yield such as poor agronomic practices, non availability of improved seeds and damaged caused by insect pests and diseases (Soomro et al., 2012). It is generally sandwiched between cotton crops in the Northern areas of Punjab, Pakistan. Cotton crop hosts a number of chewing and sucking insect pests and after its harvest, the pests move to the sunflower crop and vice versa. Broadley (1982) reported 45 insect pests attacking the crop in Australia whereas Sandhu et al. (1973) recorded 43 insects as pests of sunflower in India. In Pakistan, Hassan et al. (1984) listed 19 insect pests whereas Piracha (1989) stated *Bemisia tabaci* (Genn), *Amrasca devastans* (Dist), *Aphis gossypii* (Glover) and semi-looper attacking the sunflower crop.

Different insect pests cause various level of damage to the sunflower crop in different regions of Pakistan. For example, whitefly and jassid together can cause up to 44% loss of yield in Sindh, Pakistan (Lohar, 1987). Likewise, defoliating insect pests can reduce average yield of sunflower by 267.2 kg/ha whereas *Helicoverpa* alone can cause 120 kg/ha loss of seed in India (Panchabhavi and Karishnamoorhty, 1978). Control of the insect pests mainly depends upon the use of chemicals but cultural and biological control is more useful than chemical control. The main benefit of bio-control is its safety to human health and environment. Unlike chemical control, it does not cause the secondary pest out break (Flint and Dreistadt, 1998). The present study was designed to determine the relationship between insect pests and their predators along with their peak population period. The study was also aimed to find out the effect of abiotic factors on population fluctuation of insect pests.

Materials and Methods

Spring sunflower, hybrid Hysun-33, was sown on farmer field at Multan during 2008 and 2009. Experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The row to row and plant to plant distance was kept at 0.76 and 0.20-0.22 meters, respectively. Fertilizer applications and agronomic practices were used according to standard recommendations (Sattar et al., 1984; Ashfaq and Aslam, 2001). After fifteen days of germinations, data for the insect pests and predators were recorded on weekly basis till harvest of the crop. Sucking insect pests such as whitefly, green leaf hopper and aphid, were recorded from upper, middle and lower leaves of the plants. Total of 25 plants were observed. Chewing insect pests such as semi-looper, American bollworm and armyworm were recorded on whole plant basis, and total of 20 plants were observed. Dusky bug was recorded from 20 heads. For collection of the bug, sunflower heads were covered with muslin cloth bags and they were shaken vigorously. When all bugs were fallen, bags were removed, knotted the open ends properly and put into the freezer for 24h before counting insects. All natural enemies were recorded on whole plant basis.

Meteorological data, were taken from the Central Cotton Research Institute Multan. Simple correlation was worked out between insect pests and weather factors (T, RH), and their natural enemies. The significance level was set at $P < 0.01$.

Table 1: *Average insect pest (per plant) infestation on sunflower crop during 2008*

Date	Aphid	Whitefly	Leaf hopper	Dusky bug	Semi-looper	Armyworm	American bollworm
03-03-08	5.80±0.29	0.80±0.01	0.02±0.01	0±0	0±0	0±0	0±0
10-03-08	9.50±0.31	0.90±0.03	0.08±0.02	0±0	0±0	0±0	0±0
17-03-08	14.8±0.38	1.30±0.10	0.10±0.06	0±0	0.60±0.02	2.00±0.80	0±0
24-03-08	20.2±0.46	1.50±0.08	0.60±0.04	0±0	1.20±0.09	1.90±0.09	2.00±0.31
31-03-08	8.40±0.45	2.00±0.04	0.50±0.03	0±0	1.80±0.10	0±0	4.20±0.21
07-04-08	0.60±0.01	2.80±0.03	0.90±0.09	0±0	2.80±0.15	0±0	1.40±0.13
14-04-08	0±0	2.80±0.08	0.95±0.03	0±0	6.00±0.26	0±0	0±0
21-04-08	0±0	1.50±0.09	1.45±0.04	0±0	6.40±0.31	0±0	0±0
28-04-08	0±0	1.55±0.07	1.85±0.07	0.10±0.07	1.36±0.06	0±0	0±0
05-05-08	0±0	2.90±0.04	2.60±0.08	7.50±0.35	0.48±0.10	0±0	0±0
12-05-08	0±0	3.70±0.08	2.80±0.35	25.5±0.40	0±0	0±0	0±0
19-05-08	0±0	3.80±0.03	2.85±0.19	56.4±0.36	0±0	0±0	0±0
26-05-08	0±0	2.80±0.10	1.85±0.08	103±1.25	0±0	0±0	0±0

Aphid, Aphis gossypii; Whitefly, Bemisia tabaci; leaf hopper, Empoasca spp; Dusky bug, Nysius inconspicuous, Semi-looper; Thysanoplusia orichalcea; Armyworm, Spodoptera spp; American bollworm, Helicoverpa armigera

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Table 2: *Average insect pest (per plant) infestation on sunflower crop during 2009*

Date	Aphid	Whitefly	Leaf hopper	Dusky bug	Semi-looper	Armyworm	American bollworm
03-03-09	15.4±1.41	0.01±0.07	0.02±0.01	0±0	0±0	0±0	0±0
10-03-09	28.3±1.56	0.23±0.09	0.12±0.02	0±0	0±0	0±0	0±0
17-03-09	12.4±1.41	1.56±0.07	0.15±0.01	0±0	0.46±0.01	0.21±0.01	0±0
24-03-09	2.38±0.96	0.53±0.04	0.43±0.03	0±0	2.74±0.04	0.15±0.05	0.13±0.06
31-03-09	0.56±0.04	1.46±0.03	0.70±0.10	0±0	6.56±0.68	0.18±0.04	0.26±0.13
07-04-09	0±0	2.60±0.81	0.80±0.04	0±0	4.46±0.70	0±0	0.43±0.06
14-04-09	0±0	2.21±0.09	1.26±0.03	0±0	3.20±0.20	0±0	0±0
21-04-09	0±0	2.70±0.82	1.27±0.04	0±0	2.25±0.33	0±0	0±0
28-04-09	0±0	3.30±0.51	2.06±0.01	2.44±0.81	0.26±0.03	0±0	0±0
04-05-09	0±0	3.50±0.70	2.48±0.09	15.5±0.97	0±0	0±0	0±0
11-05-09	0±0	4.58±0.71	2.63±0.25	45.8±1.48	0±0	0±0	0±0
18-05-09	0±0	5.65±0.51	3.20±0.20	90.4±2.01	0±0	0±0	0±0
25-05-09	0±0	1.37±0.04	2.50±0.10	126±4.08	0±0	0±0	0±0

Aphid, Aphis gossypii; Whitefly, Bemisia tabaci; leaf hopper, Empoasca spp; Dusky bug, Nysius inconspicuous, Semi-looper; Thysanoplusia orichalcea; Armyworm, Spodoptera spp; American bollworm, Helicoverpa armigera

Results and Discussion

Sucking insect pests

Green leaf hopper's (*Empoasca* spp.) attack on sunflower has been previously reported by Kakakhel et al. (2000a) and Ashfaq and Aslam (2001). In the present study, green hopper was observed throughout cropping season but its population remained low. Initially its population (0.02±0.01 individuals/plant) was observed during first week of March 2008 and 2009. Then its population increased gradually and maximum population (2.85±0.19 and 3.20±0.20 individuals/plant) was recorded during third week of April 2008 and 2009, respectively (Table 3 and 4). Then its population started to decline but remained active till harvest of the crop.

Table 3: *Average population of predators (per plant) on sunflower crop during 2008*

Date	Syrphids	Lady beetles	Green lace wing	Spiders
03-03-08	0±0	0.15±0.03	0±0	0±0
10-03-08	2.00±0.07	1.26±0.04	0±0	0.12±0.04
17-03-08	3.25±0.06	1.50±0.06	0±0	0.20±0.03
24-03-08	2.25±0.09	1.70±0.03	0±0	0.25±0.03
31-03-08	0.30±0.06	1.60±0.06	0.13±0.03	0.25±0.06
07-04-08	0±0	1.90±0.03	0.06±0.02	0.40±0.06
14-04-08	0±0	1.71±0.09	0.20±0.03	0.60±0.04
21-04-08	0±0	1.60±0.07	0.25±0.04	0.05±0.03
28-04-08	0±0	2.16±0.12	0.10±0.05	1.25±0.06
05-05-08	0±0	2.40±0.06	0±0	1.50±0.09
12-05-08	0±0	3.03±0.09	0±0	2.75±0.08
19-05-08	0±0	3.75±0.03	0±0	3.10±0.06
26-05-08	0±0	4.05±0.08	0±0	3.25±0.07

Aphid, *Aphis gossypii* (Glover) is also an important sucking insect pest of sunflower. Aslam et al. (2000) reported its infestation and damage previously. It appeared on the crop during vegetative growth during first week of March 2008 and 2009. Its maximum population (20.2±0.46 and 28.3±1.56) was recorded during fourth week of March 2008 and 2009, respectively. As reproductive stage started with rise in temperature, its population disappeared. Minimum population (0.60±0.01 and 0.56±0.04) was observed during first week of April 2008 and fifth week of March 2009, respectively. Data suggest that aphid is a major pest of spring sunflower crop during vegetative growth.

Table 4: *Average population of predators (per plant) on sunflower crop during 2009*

Date	Syrphids	Lady beetles	Green lace wing	Spiders
03-03-09	0±0	0.60±0.01	0±0	0±0
10-03-09	2.55±0.09	0.38±0.03	0±0	0±0
17-03-09	1.93±0.03	0.15±0.06	0±0	0.08±0.07
24-03-09	1.76± 0.02	0.38±0.09	0±0	0.16±0.08
31-03-09	0.66±0.07	0.70±0.08	0.08±0.04	0.83±0.04
07-04-09	0±0	1.29±0.04	0.12±0.07	0.91±0.05
14-04-09	0±0	1.33±0.04	0.24±0.06	0.95±0.08
21-04-09	0±0	1.24±0.07	0.29±0.04	0.99±0.04
28-04-09	0±0	3.87±0.07	0.16±0.04	1.24±0.07
04-05-09	0±0	3.99±0.08	0±0	1.58±0.11
11-05-09	0±0	3.91±0.04	0±0	2.08±0.11
18-05-09	0±0	3.95±0.11	0±0	3.08±0.09
25-05-09	0±0	3.90±0.09	0±0	3.54±0.07

Dusky bug, *Nysius inconspicuous* (Distant) is a major pest of sunflower head and reduces grain yield, oil contents and seed germination percentage (Kakakhel et al., 2000b). In the present study, its maximum population (103±1.25 and 126±4.08) was recorded dur-

ing fourth week of April 2008 and 2009, respectively (Table 3 and 4). These findings are in line with those of Kakakhel et al. (1997, 2000b) and Du plessis et al. (2007).

Bemisia tabaci is a polyphagous insect pest feeding on a number of economically important crops. Its infestation on sunflower crop has been reported in Israel (Melamed- Madjar et al., 1989), India (Sethi et al., 1978) and Pakistan (Aslam et al., 2000; Kakakhel et al., 2000). In the present study, *B.tabaci* infestation occurred throughout the crop season and its population continuously increased until harvest of the crop. Its maximum population (3.80±0.03 and 5.65±0.51 individuals/leaf) was recorded during third week of April 2008, 2009, respectively. *B. tabaci* is an important polyphagous insect pest and a vector of about 111 plant viruses (Mugiira et al., 2008). It causes crop losses in hundreds of millions of US dollars each year in diverse agricultural systems (Menn, 1996). After sunflower harvest, it moves to cotton crop and spread Cotton Leaf Curl Virus. It is a main pest that should be controlled on sunflower before it moves to cotton.

Chewing insect pests

Armyworm, *Spodoptera spp* and semi-looper, *Thysanoplusia orichalcea* are polyphagous insect pests that feed on plant leaves. Armyworm is a major pest of cotton and cabbage in Pakistan. The results indicated that its attack on sunflower occurred during March 2008 and 2009. Its maximum population (2±0.80 larvae/plant) was recorded during third week of March 2008. In contrast, *T. orichalcea* started infesting the crop from 17 March and its maximum population (6.56±0.68 larvae/plant) was recorded during fourth week of March 2009. Then its population started to decline and minimum population (0.26±0.03 larvae/plant) was observed during fourth week of April 2009. The data indicated that *T. orichalcea* might become a primary pest of sunflower in future. These finding are in agreement with those of Piracha (1989).

Helicoverpa armigera is also a polyphagous insect pest feeding on a number of economically important crops like cotton, chickpea, tomato and sunflower. It damages sunflower crop at bud stage by eating head and developing seeds. Infestation of *H. armigera* on sunflower has already been reported in India by Sing et al. (1977) and Bhosale et al. (1990). Makhdoomi et al. (1984) and Hassan et al. (1984), previously reported its damage to sunflower crop in Pakistan. In the present study, its maximum population (4.20±0.21 larvae/plant) was recorded during fourth week of March 2008. *H. armigera* infested the crop for 2 – 3 weeks only during March and afterward it was disappeared.

Predators

Predators recorded on the spring sunflower were: Syrphus spp, Lacewings, Coccinalids and Spiders. Larvae of syrphid feed on soft bodied insects particularly aphids. They are common predators in the field crops and vegetable, and play an important role in suppressing aphids. Syrphids were recorded during month of March 2008 and 2009. Maximum population (3.25±0.06 and 3.53±0.08) was observed on third and first week of March 2008 and 2009, respectively (Table 2 and 3).

Likewise, larvae of green lacewing are also feed on soft bodied insects, primarily aphids. Larvae are voracious feeder of insect while adults feed on nectars and pollens. Green lacewing was observed in small number and its maximum population (0.25±0.04 and0.29±0.04) was recorded during third week of April 2008 and 2009, respectively (Table 1 and 2). The data suggest that it is not a putative predator on spring sunflowers.

Spiders are general predators feeding mainly on insects, and are the most abundant in terrestrial agro-ecosystem. Under favorable conditions, their population density might be as high as 1000 individuals /m^2 and play a crucial role in regulating pest population (Nyffeler, 2000). In the present study, they were observed during the whole crop season. Their maximum population (3.25±0.07 and 3.54±0.07) were recorded during fourth week of April 2008 and 2009.

Similarly, coccinellids were also found throughout the crop season. They feed on a number of insect pests like aphids, whitefly and eggs and early stage larvae of lepidopteron (Basappa, 2011). Coccinellids maximum population (4.05±0.08 and 3.99±0.08) was recorded during fourth and first week of April 2008 and 2009, respectively (Table 3 and 4). Spiders and coccinellids were found to be the putative predators on spring sunflower. These findings are in line with those of Basappa (2011).

Correlation studies

Syrphids had a significant negative correlation ($r = -0.66$, $P < 0.05$) with whitefly and jassids ($r = -0.76$, p

< 0.01). In contrast, it had a highly significant positive correlation (r = 0.93, p < 0.001) with aphids. It suggested that increased in population of aphids also increased the population of syrphids and vice versa (Table 5). Similarly, *chrysoperla* also had a significant and positive relationship with semi-looper (r = 0.79, P < 0.01). Likewise, spiders and lady beetles had significant positive correlation with whitefly, jassid and dusky bug. In contrast, spiders had a negative correlation with aphid (Table 5). These results suggest that lady beetles and spiders are major predators of sunflower insect pests and play a critical role in their regulation.

Table 5: *Correlation coefficients of insect pests with predators*

Insect	Cumulative			
	Syrphids	*Chrysoperla*	Spiders	Lady beetles
Whitefly	-0.66*	0.12	0.62*	0.72*
Jassid	-0.76*	-0.10	0.89*	0.85*
Aphid	0.86*	-0.33	-0.54*	-0.49
Dusky bug	-0.37	-0.33	0.86*	0.67*
Semilooper	-0.28	0.79*	-0.18	-0.17
Armyworm	0.05	-0.05	-0.25	-0.23
American bollworm	0.25	0.32	-0.13	-0.27

**Significant at P < 0.01*

Table 6: *Correlation coefficients of temperature and relative humidity with insect pests*

Insect	Cumulative			
	Min Temp.	Max Temp.	Av Temp.	%RH
Aphid	-0.63*	-0.51*	-0.50*	0.46
Whitefly	0.69*	0.76*	0.69*	-0.57*
Jassid	0.93*	0.91*	0.94*	-0.85*
Dusky bug	0.77*	0.63*	0.71*	-0.47
Semi-looper	-0.08	-0.02	-0.05	-0.11
Armyworm	-0.08	-0.02	-0.28	0.33
American bollworm	-0.06	-0.01	-0.04	-0.01

**Significant at P < 0.01*

Role of abiotic factors in regulation of insect pests population is fundamental. For instance, temperature (T) affects insect behavior, distribution, survival and reproduction (Gogoi et al., 2000; Murugan and Uthamasamy, 2001; Panicker and patel, 2001; Bale et al., 2002). Insect's life stages can be calculated using degree days from a base T and biofix point. It has been estimated that with a 2°C rise in T, insects might experience one to five additional life cycles per season. Present study indicated that aphid had a significant negative correlation with Temp. (r = -0.50, P < 0.01) (Table 6). It suggest increase in aphid population with decrease in Temp and vice versa.

In contrast, whitefly, leaf hopper and dusky bug had a significant positive correlation with Temp (r = 0.69, P < 0.01; r = 0.94, P < 0.01; r = 0.71, P < 0.01), suggesting increase in their population with rise in temp (Table 6). Semilooper, armyworm and American bollworm had not significant correlation with temp and humidity (Table 6).

Conclusion

Whitefly, jassid and dusky bug are the key insect pests that are destructive to the sunflower crop. Spiders and lady beetles which are the major predators of sunflower ecosystem, should be exploited for the control of insect pest of sunflower and other crops. Bio-control agents not only control the insect pest but also solve the problem of environmental pollution and secondary pest outbreaks.

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Author's contribution

MB and SS conceived and designed the experiment. MB performed the experiment, analyzed the data and wrote initial draft. SS and RZ contributed inputs/analysis tools. MB and MS Revised and edited the article.

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