J Agric. Res., 2018, Vol. 56(4):235-242
www.jar.com.pk
Agriculture Department
Government of Punjab

PLANT PROTECTION

INFLUENCE OF WEATHER FACTORS ON POPULATION DYNAMICS OF INSECT PESTS OF OKRA CROP

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ABSTRACT

A study was exercised to evaluate impact of weather factors on population dynamics of some of major insect pests of okra during crop season of year 2016. The study was laid out on a farmer field in Jhang district by sowing three okra varieties (OH-152, Sabz-pari, and Super-star) following RCBD. Observations were made on weekly interval basis. Maximum population of jassid (*Amrasca biguttula biguttula*) and whitefly (*Bemisia tabaci*) per leaf was recorded on 21st June and 7th June, respectively. More infestation of spotted borer (*Earias* spp.) on okra shoot and fruit was observed on 17th May and 7th June, respectively. Fruit borer (*Helicorerpa armigera)* attack was also higher on 7th June. The results indicate that population of jassid, whitefly, spotted borer and fruit borer were found positively correlated with temperature. However, infestation of *Earias* spp. on okra shoots was observed negatively correlated with the temperature. Population of these insect pests had also negative correlation with relative humidity. Rainfall had a positive effect on population of jassid and infestation of spotted borer on per leaf basis and on okra shoots, respectively. However, it had a negative effect on population of whitefly and infestation of spotted and fruit borer during fruiting phase of the crop. The study suggests that months of May and June are very critical to observe different insect pests infesting the okra crop. The study would provide guidelines for devising monitoring and pest management program against jassid, whitefly, spotted and fruit borers attack on okra crop by incorporating weather factors for having a sustainable crop production.

KEYWORDS: *Abelmoschus esculentus*; okra; insect pests; relative humidity; temperature; rainfall; correlation; Pakistan.

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Article received on: 05/09/2018
Accepted for publication: 10/12/2018

Okra, *Abelmoschus esculentus* L. (family: Malvaceae) is grown in tropic and sub-tropic regions of the world. This vegetable crop is an economically important in Pakistan being cultivated during summer season. Okra fruit crop in human diet (Kahlon *et al*., 2007; Saifullah *et al*., 2009) contains vitamin C, carbohydrates and proteins (Dilruba *et al*., 2009). Poor soil fertility, insect pests, diseases and varieties with low yield potential are main factors for low yield of okra (Dhaliwal, 2004) in Indian subcontinent including Pakistan. Okra is infested by as many as 72 insect pests (Srinivasa and Rajendran, 2003), resulting in destruction of the crop and producing inferior quality fruit. Among the insect pests of okra crop, include jassid (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), okra spotted (shoot and fruit) borer (*Earias vitella and E. insulana*) and okra fruit borer (*Helicoverpa armigera*). These insects are the most destructive pests of okra and cause significant yield damage in Pakistan which require the timely insecticidal control measures.

Jassid (*Amrasca biguttula biguttula*) is one of the major insect pests of okra (Dhandapani *et al*., 2003). It damages the crop in both nymph and adult phases of life by sucking the cell sap usually from the ventral surface of the leaves. During feeding it injects toxic saliva into plant tissues ultimately curling and turning the leaves in yellowish colour (Singh *et al*., 2008). The whitefly (*Bemisia tabaci*) not only damages the crop by sucking the cell sap and secreting the honeydew on leaves, but also it acts as a vector of okra yellow vein clearing mosaic virus disease (Kumar and Moorthy, 2000; Jose and Usha, 2003).

Both species of okra spotted borer feeding on shoot and fruit are considered as the most notorious pest of okra; firstly it causes direct damage to tender shoots and secondly it infests fruits resulting in both quantitative and qualitative losses upto 71% (Pareek and Bhargava, 2003). Caterpillars bore into the top shoot and feeds inside the shoot before fruit formation occurs. Severe infestations cause collapsing of stem and wilting of the leaves (Atwal and Dhaliwal, 2005). Later on, caterpillars bore into the fruits and feed inside. As a result of infestation, plant bears smaller and deformed pods, resulting upto loss of 49% pods

(Kanwar and Ameta, 2007) which leads to 36-90% loss in fruit yield of okra. Moreover, infested fruits remain unfit for human consumption.

Okra fruit borer (*Helicoverpa armigera*), is a polyphagous and widespread on many other crops (Reddy *et al*., 2004, Yu *et al*., 2008). Female of okra fruit borer prefers the okra crop for egg laying (Jallow *et al*., 2001); the hatching caterpillars from these eggs feed and cause worth losses in yield. Larvae bore into fruits and lower the market value of fruit, later on these holes become point of entry of different diseases or rotting in fruits (Kay, 2007).

Climatic factors such as temperature, relative humidity and rainfall are the prime factors for survival, development and reproductive capacity of insect pests as their life activities mostly depend on the weather conditions. Different levels of rainfall and humidity may decrease or increase the incidence of population of certain insect species (Prasad and Logiswaran, 1997). This effect on growth and development results in increase or decrease of population of certain insect pest species on host plants. Weather factors affect the life cycle and outbreaks of insects to such an extent that these are either completely or partially perish or compel the certain insect species to adapt the abrupt changes in climatic conditions in that particular area (Pedigo, 2004). Being the nature of cold blooded organism, there are possibilities that insect species may withstand the slight changes in the climatic factors. However, prolonged periods of high or low temperature and relative humidity adversely affect the growth and development of insects. Temperature is considered as a dominant factor affecting the abundance of insect species. However, species with a wide geographical range will tend to be less affected from the temperature (Bale *et al.*, 2002).Increase in temperature within the specified limits may increase the rate of metabolism and thus feeding or crop damage (Pedigo, 2002).

Studies on population dynamics are crucial for planning the management strategies in such a situation when complex of different insect pests infest the crop. The management strategy becomes rather impediment when pest pressure is severe due to more than one pest at a time. Moreover, studies on correlation of insect pests population with climatic factors are a dire need to formulate effective pest management strategies (Yadav *et al.*, 2007). These studies help in avoiding the haphazard use of pesticides generally applied to control the overlapping generations of insect pests.

Keeping in view the havoc caused by jassid, whitefly, shoot and fruit borers (*Earias* spp. and *Helicoverpa armigera*) on okra crop, the present study was carried out to evaluate population dynamics of insect pests and their correlation with maximum and minimum temperatures, relative humidity and rainfall.

MATERIALS AND METHODS

This study was exercised during 2016 at farmer's field in district Jhang (Punjab, Pakistan). Three okra varieties (OH-152, Sabz-pari and Super-star) were sown in a RCBD with three replications. Crop was sown in 1st week of March. Row to row distance was kept at 0.60 m and plant to plant 0.30 m in a plot size maintained at 9.5 × 9.5 m per treatment. Recommended agronomic practices were adopted during the crop season. Population of jassid, whitefly, okra shoot and fruit borers was recorded once in a week. Scouting for the insect pests started from 29th of March after three weeks of germination phase and observations were continued upto 12th of July near to maturity of the crop.

For the counts of jassid and whitefly population, 15 plants of each variety in each replication were selected randomly. For recording data one leaf at upper portion of the first plant, 2nd leaf in the middle portion from the second plant and 3rd leaf from the bottom portion of the third plant was observed. The data regarding shoot infestation by *Earias spp.* was noted by counting infested and un-infested shoots from randomly selected five plants of each replication of three varieties and so percentage shoot infestation was calculated. Fruit infestation by *Earias* spp. and *Helicoverpa armigera* were taken by counting the damaged and undamaged fruits from randomly selected five plants from each plot of each variety. Percentage fruit infestation was then calculated. Meteorological data, i.e. maximum and minimum temperature, relative humidity and rainfall were obtained on weekly basis in the Department of Pest Warning & Quality Control of Pesticides, District Jhang, Punjab, Pakistan.

Statistical analysis

Data regarding the insect pest population dynamics were analyzed using the analysis of variance (ANOVA). Tukey's honestly significance difference (HSD) test was used to compare the means. Simple correlation tests were carried out to determine the relationship of population of jassid, whitefly shoot and fruit borers with maximum and minimum temperature, relative humidity and rainfall.

RESULTS AND DISCUSSION

Population dynamics of jassid on okra plants

The results (Table 1) showed that the highest per leaf population of jassid (*Amrasca biguttula biguttula*) was observed on 21st of June on okra variety Sabz-pari (3.31±0.10) followed by Super-star (3.22±0.13) and OH-152 (2.95±0.12). After then population declined

Table 1. Per leaf population of jassid during the crop season of year 2016.

Dates	Varieties			ANOVA	
	OH-152	Sabz-pari	Super-star	F	P
29-Mar	0.24±0.08	0.53±0.10	0.44±0.06	2.74	0.17 ns
5-Apr	0.97±0.6	1.00±0.10	0.95± 0.02	0.08	0.92 ns
12-Apr	1.11±.012	1.13±.014	1.17±0.06	0.07	0.93 ns
19-Apr	1.62±0.16	1.73±0.08	1.78±0.08	0.34	0.73 ns
26-Apr	1.58±0.06	1.62±0.08	1.71±0.06	0.88	0.48 ns
3-May	1.34±0.18	1.51±0.15	1.56±0.08	0.64	0.57 ns
10-May	1.16±0.12	1.38±0.12	1.33±0.04	2.83	0.17 ns
17-May	1.24±0.12	1.25±0.10	1.53±0.10	19.90	0.008 ns
24-May	1.07±0.08	1.33±0.15	1.49±0.15	3.12	0.15 ns
31-May	1.17±0.06	1.33±0.04	1.25±0.10	1.24	0.38 ns
7-Jun	1.36±0.06	1.64±0.06	1.67±0.14	3.62	0.12 ns
14-Jun	2.04±0.08	2.38±0.12	2.33±0.23	1.25	0.37 ns
21-Jun	2.95±0.12	3.31±0.10	3.22±0.13	1.84	0.27 ns
28-Jun	2.20±0.10	2.33±0.08	2.38±0.06	1.01	0.44 ns
5-July	1.33±0.04	1.60±0.14	1.56±0.06	3.32	0.14 ns
12-July	0.77±0.08	0.80±0.20	0.82±0.24	0.02	0.97 ns
Seasonal mean	**1.39±0.01 B**	**1.56± 0.02 A**	**1.57± 0.02 A**	**44.59**	**0.001***

onward till 12th July on all these varieties. The seasonal means of per leaf population of jassid were noted significantly different (P = 0.001, Tukey HSD 0.05 = 0.07) on all three varieties i.e. Super-star (1.57 ± 0.02) followed by Sabz-pari (1.56 ± 0.02) and then at OH-152 (1.39±0.01). Mari (2013) also reported that infestation of jassid remained on okra plants throughout the crop season with maximum population of 7.87 insects/leaf. In contrast to this study, Rehman *et al.* (2015) recorded higher number of jassids per leaf on 2nd July and then population declined onward. However, Pathan and Bharpoda (2016) recorded the incidence of jassid during the 1st week of March and population reached at peak (7.45 per three leaves) during 4th week of March.

Population dynamics of whitefly on okra plants

Per leaf population of whitefly was noted maximum on 31th of May on okra variety Super-star (4.80±0.08) followed by Sabz-pari (4.76±0.08) and OH-152 (4.75±0.06) (Table 2). Seasonal mean per leaf population of whitefly was significantly different (P = 0.03, Tukey HSD 0.05 = 0.12) on all three varieties which was higher on Super-star (2.40 ± 0.03) followed by Sabz-pari (2.37 ± 0.03) and OH-152 (2.26 ± 0.01). Pathan and Bharpoda (2016) also observed that whitefly appeared in 2nd week of April and remained present on the okra plants throughout the crop season. However, Khan *et al*. (2015) recorded the highest population of whitefly (0.81 insects/leaf) on 30th of June with a decline afterward during the crop season. Akbar and Khan (2015) found overall 2.27 individuals/ leaf mean density of whitefly during the whole crop season of okra.

Table 2. Per leaf population of whitefly during the crop season of year 2016.

Dates	Varieties			ANOVA	
	OH-152	Sabz-pari	Super-star	F	P
29-Mar	-	-	-	-	-
5-Apr	0.29±0.08	0.33±0.08	0.37±0.06	1.59	0.30 ns
12-Apr	0.40±0.04	0.44±0.06	0.47±0.04	0.39	0.70 ns
19-Apr	0.69±0.10	0.86±0.12	0.84±0.06	0.94	0.46 ns
26-Apr	1.49±012	1.53±0.23	1.60±0.21	0.76	0.52 ns
3-May	1.89±0.08	2.13±0.12	2.26±020	1.33	0.36 ns
10-May	2.91±0.09	2.84±0.15	3.00±0.15	0.29	0.76 ns
17-May	3.47±0.17	3.56±0.15	3.60±0.31	0.12	0.88 ns
24-May	4.11±0.06	4.18±0.31	4.24±0.06	1.23	0.38 ns
31-May	4.75±0.06	4.76±0.08	4.80±0.08	0.09	0.91 ns
7-Jun	3.95±0.08	4.07±0.14	4.05±0.14	0.25	0.78 ns
14-Jun	3.40±0.21	3.62±0.21	3.69±0.06	0.53	0.62 ns
21-Jun	2.57±0.12	2.73±0.15	2.80±0.12	0.55	0.61 ns
28-Jun	2.13±0.28	2.37±0.15	2.29±0.15	0.28	0.76 ns
5-July	1.24±0.15	1.31±0.22	1.44±0.15	0.24	0.79 ns
12-July	0.55±0.06	0.75±0.06	0.69±0.12	1.03	0.43 ns
Seasonal mean	**2.26±0.01 B**	**2.37±0.03 AB**	**2.40± 0.03 A**	**9.13**	**0.03***

ns = non-significant at 0.05 Tukey HSD test; *significant at 0.05 Tukey HSD test

Infestation by spotted borer on okra shoots and fruits

Infestations of spotted borer, *Earias* spp. on okra shoot reached maximum on 17th May on all varieties (Super-star 21.33±4.81, on Sabz-pari 20±2.31 and OH-152 18.67±3.53) and then it declined onward upto the 7th June (Table-3). Seasonal means infestation of *Earias* spp. on okra shoot were recorded as non-significant (P= 0.34) among all three varieties i.e. Super-star (11.62±1.06) followed by Sabz-pari (10.47±1.06) and OH-152 (8.57±1.19). Infestation of *Earias* spp. on okra fruit was maximum on 7th June (Sabz-pari 23.16±2.15, Super-star 22.41±1.45, and OH-15221.82±2.78) and then it declined until 12th July (Table 4). Seasonal mean infestation of *Earias* spp. on okra fruit differed non-significantly (P = 0.51) i.e. Super-star (12.35±1.24), Sabz-pari (12.19±0.95) and OH-152 (10.65±0.32). In contradiction Aziz *et al*. (2011) reported the highest shoot and fruit infestations on 2nd week of June. However, Ali *et al.* (2016) reported maximum number of adults captured through light traps on 17th and 31st of May. Sharma (2010) recorded the highest number of larvae (7.5 larvae/10 plants) of *Earias* spp. during 42nd week of crop after sowing.

Table 3. Infestation (%) of *Earias* spp. on okra shoots during the crop season of year 2016.

Dates	Varieties			ANOVA	
	OH-152	Sabz-pari	Super-star	F	P
29-Mar	-	-	-	-	-
5-Apr	-	-	-	-	-
12-Apr	-	-	-	-	-
19-Apr	-	-	-	-	-
26-Apr	1.33±1.33	4±2.31	2.67±2.67	0.40	0.69 ns
3-May	6.67±2.67	8±2.31	10.67±3.53	0.40	0.69 ns
10-May	12.00±2.31	14.67±3.53	17.33±3.53	0.47	0.65 ns
17-May	18.67±3.53	20±2.31	21.33±4.81	0.09	0.91 ns
24-May	13.33±3.53	14.67±2.67	16±2.31	0.18	0.84 ns
31-May	5.33±1.33	10.67±2.67	9.33±1.33	1.86	0.26 ns
7-Jun	2.67±2.67	1.33±1.33	4±2.31	0.40	0.69 ns
14-Jun	-	-	-	-	-
21-Jun	-	-	-	-	-
28-Jun	-	-	-	-	-
5-July	-	-	-	-	-
12-July	-	-	-	-	-
Seasonal mean	**8.57±1.19**	**10.47±1.06**	**11.62±1.06**	**1.42**	**0.34 ns**

ns = non-significant at 0.05 Tukey HSD test

Table 4. Infestation (%) of *Earias* spp. on okra fruit during the crop season of year 2016.

Dates	Varieties			ANOVA	
	OH-152	Sabz-pari	Super-star	F	P
29-Mar	-	-	-	-	-
5-Apr	-	-	-	-	-
12-Apr	-	-	-	-	-
19-Apr	-	-	-	-	-
26-Apr	-	-	-	-	-
3-May	-	-	-	-	-
10-May	3.00±3.00	5.00±5.00	6.67±6.67	0.53	0.62 ns
17-May	5.57±2.81	7.04±3.53	5.78±2.89	0.04	0.95 ns
24-May	11.61±2.05	13.33±3.33	13.15±3.52	0.11	0.89 ns
31-May	18.48±3.68	20.20±3.02	20.39±2.56	0.10	0.90 ns
7-Jun	21.82±2.78	23.16±2.15	22.41±1.45	0.09	0.91 ns
14-Jun	16.81±2.34	18.85±1.78	18.11±1.11	0.39	0.69 ns
21-Jun	13.89±4.24	16.57±2.10	16.50±3.21	0.25	0.79 ns
28-Jun	8.67±0.88	10.47±2.46	9.86±1.21	0.94	0.46 ns
5-July	6.70±3.41	6.42±3.55	7.90±0.59	0.12	0.89 ns
12-July	0.00±0.00	2.33±2.33	2.78±2.78	0.41	0.69 ns
Seasonal mean	**10.65±0.32**	**12.19±0.95**	**12.35±1.24**	**0.80**	**0.51 ns**

ns = non-significant at 0.05 Tukey HSD test

Infestation by fruit borer on okra fruits

Fruit borer, *Helicoverpa* spp., infestation on okra fruits was observed from 10th May which reached at maximum on 7th June Super-star (19.78±2.67), Sabz-pari (19.46±1.77) and OH-152 (18.11±1.11). Afterwards it declined onward upto 28th of June (Table 5). Seasonal mean infestations of fruit borer differed non-significantly (P=0.35) i.e. Super-star (10.81±1.52), Sabz-pari (10.52±1.79) and OH-152 (9.60±1.43). Conversely to the present findings, Nath *et al.* (2011) recorded 1.20 to 1.0 per plant population of *H. armigera* on okra during 37th to 38th crop weeks in the year 2005 and 2006, respectively.

Table 5. Infestation (%) of fruit borer, *Helicoverpa armigera* on okra fruit during the crop season of year 2016.

Dates	Varieties			ANOVA	
	OH-152	Sabz-pari	Super-star	F	P
29-Mar	-	-	-	-	-
5-Apr	-	-	-	-	-
12-Apr	-	-	-	-	-
19-Apr	-	-	-	-	-
26-Apr	-	-	-	-	-
3-May	-	-	-	-	-
10-May	2.57±2.57	5.34±2.68	4.17±4.17	0.65	0.57 ns
17-May	5.78±2.89	6.33±3.18	6.11±3.09	0.01	0.99 ns
24-May	12.16±1.64	12.97±1.96	12.59±2.06	0.04	0.95 ns
31-May	15.88±2.25	16.57±0.83	17.85±1.34	0.55	0.61 ns
7-Jun	18.11±1.11	19.46±1.77	19.78±2.67	0.30	0.75 ns
14-Jun	11.99±2.04	12.42±1.90	12.91±1.28	0.05	0.95 ns
21-Jun	6.65±3.58	7.04±3.53	7.79±3.91	0.43	0.67 ns
28-Jun	3.70±0.70	4.08±1.08	5.34±2.68	0.54	0.61 ns
5-July	-	-	-	-	-
12-July	-	-	-	-	-
Seasonal mean	**9.60±1.43**	**10.52±1.79**	**10.81±1.52**	**1.34**	**0.35 ns**

ns = non-significant at 0.05 Tukey HSD test

Impact of weather factors on jassid *(Amrasca biguttula biguttula*)

Maximum population of jassid was observed on 21st June (Table 1). On this day temperature was maximum (40.11˚C) and night temperature was minimum (26˚C) while relative humidity was 57.5% and rainfall was 64 mm (Table 6). The correlation study of these factors with jassid population depicts that population of jassid was positively correlated with temperature and rainfall while negatively correlated with relative humidity (Table 7). Similar to present study, Iqbal *et al.* (2010) reported that temperature and rainfall showed significant and positive correlation effect on the population fluctuation of jassid. However, Nath *et al*. (2011) showed non-significant results of jassid activity with respect to environmental factors. The present study described a negative correlation effect of relative humidity with jassid population. These findings are in conformity to the findings of Pathan and Bharpoda (2016) who observed negative impact of relative humidity population fluctuation of jassid.

Impact of weather factors on whitefly (*Bemisia tabaci*)

Maximum population of whitefly per leaf was recorded on 7th June when there was a maximum temperature of 44.13˚C, minimum temperature as 26.39^{0}C and relative humidity as 37.36% with zero rainfall during that week (Table 6). Correlation study (Table 7) revealed that population dynamics of whitefly showed a positive correlation with temperature whereas a negative correlation with humidity and rainfall on okra crop. Siddartha *et al*. (2017) report similar findings that temperature had significantly positive effect on population fluctuation of sucking insect pests on okra crop. However, Singh *et al.* (2013) probed that maximum, minimum, mean temperature and maximum, minimum relative humidity exerted negative correlation while rainfall exerted positive correlation on population dynamics of whitefly.

Impact of weather factors on spotted borer (*Earias* spp.)

Higher infestation of spotted borer on okra shoot was noted on 17th May (Table 3) when there was a maximum temperature as 40.2˚C, minimum temperature as

Table 6. Metrological data during the crop season of year 2016.

Dates	Temperature (°C)		Relative humidity %	Rainfall (mm)
	Minimum	Maximum		
29-Mar	29.80	16.07	74.36	-
5-Apr	29.54	15.26	75.29	2.2
12-Apr	33.30	19.33	56.79	4.4
19-Apr	36.39	20.47	49.86	1.8
26-Apr	39.77	21.33	44.00	-
3-May	40.37	24.80	37.29	-
10-May	39.74	23.47	45.21	2.8
17-May	40.2	23.81	44.29	-
24-May	40.44	22.31	41.46	11
31-May	40.99	25.01	39.00	-
7-Jun	44.13	26.39	37.36	-
14-Jun	39.86	27.10	48.86	-
21-Jun	40.11	26.00	57.5	64
28-Jun	41.44	28.00	55.07	-
5-Jul	38.59	25.19	64.29	69
12-Jul	37.97	26.03	67.43	44

Table 7. Correlation of weather factors on population of different insect pests of okra crop during crop season during the year 2016.

Insect pests	Maximum temperature (˚C)	Minimum temperature (˚C)	Relative humidity %	Rainfall (mm)
Jassid (*Amrasca biguttula biguttula*)	0.52	0.589	-0.27	0.298
Whitefly (*Bemisia tabaci*)	0.75	0.52	-0.73	-0.22
Spotted borer (*Earias* spp.) on shoot	-0.48	-0.19	0.51	0.38
Spotted borer (*Earias* spp.) on fruit	0.73	0.26	-0.61	-0.31
Fruit borer (*Helicoverpa armigera*)	0.61	0.06	-0.69	-0.22

23.81 ˚C, relative humidity as 44.29% and no rainfall. The correlation study revealed that spotted borer infestation on okra shoot was positively correlated with relative humidity and rainfall while negatively correlated with maximum and minimum temperatures (Table 7). On okra fruit, the highest infestation of spotted borer was observed on 7th June (Table 4) when there was a maximum temperature of 44.13 ˚C, minimum temperature 26.39 ^{0}C, relative humidity 37.36% with no rainfall during the entire week. The correlation study showed that range of maximum and minimum temperature exerted positive correlation while relative humidity and rainfall exerted negative correlation on infestation of spotted borer on okra fruit (Table 7). Aziz *et al.* (2011) also reported a positive correlation of temperature whereas negative correlation of humidity and rainfall on shoot and fruit infestation of *Earias* spp. on cumulative basis of two years study. Conversely to the present findings, Ahmad *et al*. (2000) revealed that population dynamics of okra shoot and fruit borer positively correlated with minimum temperature and negatively correlated with maximum temperature. With the increase in temperature, the development rate of all stages of okra shoot and fruit borer also increased (Sabri and Shahzad 2002) and thus pest infested the crop greatly. Patel and Patel (2000) reported a negative correlation of *Earias* spp. with the rainfall and humidity.

Impact of weather factors on fruit borer (*Helicoverpa armigera*)

The highest infestation of fruit borer, on okra fruit was recorded on 7th June (Table 5) with maximum temperature of 44.13^{0}C, minimum temperature 26.39 ˚C and relative humidity 37.36% with no rainfall during that week (Table 6). The correlation study revealed that fruit borer infestation had a positive correlation with maximum and minimum temperature whereas a negative correlation with relative humidity and rainfall (Table 7). In conformity to the present findings, Raju *et al.* (2017) reported a positive correlation of larval population and fruit damage by *H. armigera* with maximum temperature and sunshine hours whereas a negative correlation with rainfall, relative humidity and minimum temperature. However, a positive correlation of fruit borer with minimum temperature was observed in the present study. Siddartha *et al.* (2017b) reported a non-significant impact of temperature and rainfall on the population dynamics of borer on okra crop during the cropping season.

CONCLUSION

Months of May and June are were important for the monitoring of insect pests of okra because maximum populations of jassid, whitefly and fruit borer infestation were recorded during these months. Infestations by spotted borer on shoot were observed maximum in the month of May. The higher number of jassid, whitefly and fruit borers showed positive correlations with the temperature while spotted borer infestation on shoot showed negative correlation with temperature. Relative humidity showed a negative correlation effect on all pests under study except spotted borer infestation on shoot which received a positive effect. Population of whitefly, shoot and fruit borers were positively correlated with the rainfall. Jassid population was negatively correlated with the rainfall.

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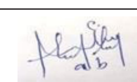
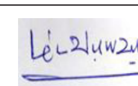
CONTRIBUTION OF AUTHORS

S. No.	Author name	Contribution	Signature
1.	Sarwat Zia	Conceived the research idea, set the study objectives and parameters, conducted the experiment and edited the manuscript	
2.	Muhammad Abdul ur Rehman	Assisted in layout the experiment, recorded and compiled the data	
3.	Noor Abid Saeed	Analyzed the data, wrote and discussed the results	
4.	Azhar Abbas Haidery	Assisted in writing the mansucript, reviewed the literature