Pakistan J. Zool., vol. 51(3), pp 835-841, 2019. **DOI**: http://dx.doi.org/10.17582/journal.pjz/2019.51.3.835.841

Relationship of Physico-Morphic Characters of Okra Cultivars with their Resistance to *Helicoverpa armigera*

Ajmal Khan Kassi[1,*], Humayun Javed[1] and Tariq Mukhtar[2]

[1]*Department of Entomology, Pir Mehr Ali Shah-Arid Agriculture University Rawalpindi*
[2]*Department of Plant Pathology, Pir Mehr Ali Shah-Arid Agriculture University, Rawalpindi*

ABSTRACT

Resistance to plants is often attributed to physical, morphological, physiological, biochemical, molecular and genetic characteristics of the plants. As the information about the relationship between physico-morphic characteristics of commercially grown okra cultivars and resistance or susceptibility to *Helicoverpa armigera* is lacking, therefore, in the present study relationship between physico-morphic characteristics and resistance or susceptibility of okra cultivars to *H. armigera* was evaluated. The heights and stem girths of comparatively resistant varieties were statistically greater as compared to intermediate resistant and comparatively susceptible varieties. Contrarily, hair densities on leaf midrib and leaf lamina were comparatively less in case of comparatively resistant varieties as compared to intermediate resistant and comparatively susceptible varieties. With one exception in each category, no significant differences were observed regarding area, moisture, thickness of leaves and fruit length of okra varieties. The leaf area was slightly greater in comparatively resistant varieties. Similarly, fruit was found to be significantly more in case of comparatively resistant varieties as compared to intermediate resistant and comparatively susceptible varieties. It was also observed that fruit and shoot infestation was the maximum on comparatively susceptible cultivars while infestation was significantly lower on comparatively resistant cultivars. Similarly, the pest produced significantly more eggs and larvae on comparatively susceptible cultivars as compared to comparatively resistant ones. As comparatively resistant okra varieties viz. Bhindi Punjab Selection, Arka Anamika and Bhindi Sabazpari suffered less damage and yielded more and are therefore, recommended for cultivation to avoid damage by *Helicoverpa armigera*.

Article Information
Received 17 July 2018
Revised 15 August 2018
Accepted 21 August 2018
Available online 15 March 2019

Authors' Contribution
AKK, HJ and TM designed the study, executed experimental work and analyzed the data. HJ supervised the work. TM helped in preparation of the manuscript.

Key words
Okra, American boll worm, Resistance, Susceptibility, Physico-morphic characteristics.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.), is one of the popular nutritious vegetables of North-East Africa and South Asia including Pakistan. Okra is highly cultivated vegetable in Pakistan (Javed *et al*., 2009). The total okra production in the world is 4.8 million tons, where India contributes 70%, Nigeria 15%, Pakistan 2%, Ghana 2%, Egypt 1.7% and Iraq 1.7% (Gulsen *et al*., 2007). There is a progressive increase in the cultivation of okra in Pakistan, with the cultivated area of about 14.47 thousand hectares and annual production of 109.24 thousand tons (Anonymous, 2006).

Successful production of okra is threatened by many biotic factors including plant pathogens (Ashfaq *et al*., 2017; Aslam *et al*., 2017a, b; Kayani *et al*., 2017, 2018; Kayani and Mukhtar, 2018; Khan *et al*., 2017; Mukhtar, 2018; Mukhtar *et al*., 2017a, b, 2018; Tariq-Khan *et al*., 2017) and particularly the insect pests (Javed *et al*., 2017a; Kassi *et al*., 2018; Nabeel *et al*., 2018). Among insect pests, fruit borer, *Helicoverpa armigera* is the major pest of different crops and vegetables all over the world (Jallow *et al*., 2004; Reddy *et al*., 2004; Mironidis *et al*., 2008; Yu *et al*., 2008). The larval stage directly causes damage to flowers, buds and fruits leading to heavy yield losses in various crops. Annual losses worth US$ 2 billion have been estimated in semiarid tropics even though US$ 500 million worth pesticides have been applied to control the pest (Sharma and Ortiz, 2002).

Synthetic pesticides are extensively used for controlling this insect pest especially in Pakistan. These pesticides have dreadful side effects and resulted in resurgence of secondary pests, environmental pollution, elimination of beneficial fauna, pest resistance to specific insecticides and various human health problems. To do away with these side effects, alternative approaches must be adopted to reduce dependency on these lethal pesticides. One of such approaches for controlling this pest is the use of resistant cultivars which are economically feasible, environmentally benign and secure. The resistant cultivars can minimize yield losses and can also be used as a constituent of integrated pest management programs along with other control strategies (Rahoo *et al*., 2017, 2018a, b, 2019).

Resistance to plants is often attributed to physical,

* Corresponding author: a_k_kasi@yahoo.com
0030-9923/2019/0003-0835 $ 9.00/0

morphological, physiological, biochemical, molecular and genetic characteristics of the plants. As the information about the relationship between physico-morphic characteristics of commercially grown okra cultivars and resistance or susceptibility to *H. armigera* is lacking, therefore, in the present study effects of some physico-morphic characteristics were investigated in imparting resistance to the insect pest.

MATERIALS AND METHODS

Okra varieties

Nine okra varieties were tested to evaluate the physico-morphic characters imparting resistance or susceptibility to *H. armigera*. These included three comparatively resistant (Arka Anamika, Bhindi Punjab Selection and Bhindi Sabazpari), three intermediate resistant (Rama Krishna, NS-810 and Baharti Kaspori) and three comparatively susceptible cultivars (RK-516, OH-152 and Tarnab Nargis).

Evaluation of okra varieties

The experiment was conducted at the University Research Farm Koont of Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, Pakistan. Randomized Complete Block Design was used to evaluate okra varieties. Plot measuring 40′ × 10′ was used for each variety with three replications. The overnight-presoaked seeds were sown in each plot with plant to plant and row to row distances of 60 and 75 cm, respectively. Irrigation was applied as per requirement. Data regarding number of eggs, larval population, shoot infestation and fruit infestations were recorded as described previously (Fateh *et al*., 2017; Javed *et al*., 2017b).

Physico-morphic characters of okra

Following physico-morphic characters were studied to investigate their role against infestation of *H. armigera*.

Plant height

Height of ten randomly selected plants from each replicate of each treatment was measured with the help of meter rod at an interval of 40, 90 and 140 days after emergence of okra plants and finally their averages were computed.

Stem girth

The stem girth was recorded from randomly selected ten plants from each experimental unit with the help of measuring tape at an interval of 40, 90 and 140 days after emergence.

Number of primary branches

Total primary branches arising from the basal node were counted from randomly selected ten plants in each plot and their average was worked out.

Hair density on leaf midrib and leaf vein

Three top leaves from randomly selected five plants from each plot were taken and hair density was noted under stereoscopic microscope from leaf midrib (cm^{-1}) and leaf vein (cm^{-1}).

Hair density of leaf lamina

Three pieces of leaf lamina each of one cm^2 area was cut from each top, middle and lower portion leaves from ten randomly selected plants from each experimental unit. Number of hair/cm^2 of each piece was counted under microscope and their averages were worked out.

Table I.- Number of eggs, larval population, fruit and shoot infestation of *Helicoverpa armigera* on different okra varieties.

Variety	Number of eggs	Larval population	Fruit Infestation	Shoot infestation	Reaction
Arka Anamika	0.03 b	0.04 f	3.26 i	7.88 c	CR
Bhindi Punjab Selection	0.04 b	0.04 f	4.05 hi	6.73 c	CR
Bhindi Sabazpari	0.03 b	0.03 f	4.83 gh	6.39 c	CR
Rama Krishna	0.07 a	0.09 a	7.25 f	11.79 b	IR
NS-810	0.06 ab	0.07 cd	8.34 e	15.24 a	IR
Baharti Kaspori	0.05 ab	0.08 bcd	9.98 d	14.86 a	IR
RK-516	0.05 ab	0.09 a	12.06 ab	13.99 a	CS
OH-152	0.05 ab	0.07 de	12.34 a	11.69 b	CS
Tarnab Nargis	0.04 b	0.09 ab	11.56 abc	15.09 a	CS
LSD	0.016	0.01	0.69	1.296	

Mean sharing similar letters are not significantly different by LSD Test at p=0.05. CS, comparatively susceptible; IR, intermediate resistant; CR, comparatively resistant.

Hair density on fruits

Three fruits from five randomly selected plants of each entry were taken and their hair density (cm^2) was noted under stereomicroscope.

Leaf area

Three leaves each from upper, middle and lower portion of the selected ten plants from each test entry were selected and brought in the laboratory. Leaf area (cm^2) was measured with the help of leaf area meter at an interval of 40, 90, and140 days after emergence.

Thickness of leaf lamina

Three top leaves each from randomly selected five plants per plot were taken. Cross section of the leaves was cut with the help of a fine razor and thickness of lamina was determined with the help of an ocular micrometer under binocular microscope.

Moisture percentage in leaves

Three samples each of 10 g leaves from top portions of different plants were taken from every plot. All the leaves were cleaned with muslin cloth, weighed and kept into drying oven at 100 ± 5°C for 12 h. The dry matter of leaves were weighed and kept back into oven at the same temperature for another six hours. After the weight of the dry material becomes constant, the moisture percentage was calculated.

Fruit length and width

Three full-grown edible fruits were taken from five randomly selected plants of each test entry, their length and width were determined by meter scale and averages were worked out.

Statistical analysis

The data regarding fruit and shoot infestation percentage, physico-morphic characters of different varieties were subjected to statistical analysis by COSTATC package and their means were compared according to DMR-Test at 5% level of probability. The data were then processed for simple correlation analysis to determine their impact on fruit infestation caused by *H. armigera*.

RESULTS AND DISCUSSION

Response of okra varieties to H. armigera

It is evident from Table I, that maximum fruit and shoot infestation was recorded on comparatively susceptible cultivars while infestation was significantly lower on comparatively resistant cultivars. Similarly, the pest produced significantly more eggs and larvae on comparatively susceptible cultivars as compared to comparatively resistant ones. Numbers of eggs, larval population, fruit and shoot infestation on each variety have been shown in Table I.

Many researchers have evaluated different okra varieties under varying climatic conditions in different okra producing countries. In the present studies okra varieties showed variable infestations of *H. armigera* on fruit and shoot. The minimum fruit infestation was observed on Arka Anamika (3.26%) fallowed by Bhindi Punjab Selection (4.05%) and Bhindi Sabazpari (4.83%). The findings are to some extent similar to those observed by Aziz *et al*. (2012), Mastoi *et al*. (2013) and Afzal *et al*. (2015) who have reported 9.42% fruit infestation on Sabzpari. The variety Rama Krishna with 5.51% fruit infestation showed intermediate resistance against

Table II.- Hair density on leaf midrib, fruit, leaf lamina and leaf veins on selected okra varieties.

Variety	Hair density on leaf midrib/cm	Hair density on fruit (cm^2)	Hair density of leaf lamina (cm^2)	Hair density of leaf veins (cm^2)
Arka Anamika	34.91 d	309.73 a	20.17 g	10.67 f
Bhindi Punjab Selection	52.53 b	315.08 a	24.84 f	11.17 f
Bhindi Sabazpari	42.99 c	283.97 b	30.61 e	17.13 d
Rama Krishna	64.24 a	215.59 cd	35.26 d	18.42 c
NS-810	51.59 b	208.13 e	52.66 b	17.99 cd
Baharti Kaspori	64.59 a	199.39 f	55.16 b	21.49 b
RK-516	61.24 a	212.24 de	45.09 c	14.93 e
OH-152	65.01 a	219.73 c	55.09 b	17.55 cd
Tarnab Nargis	55.03 b	210.35 de	64.68 a	22.71 a
LSD	2.02	3.18	1.40	0.50

Mean sharing similar letters are not significantly different by LSD Test at P=0.05.

H. armigera. The findings are not similar to the results observed by Javed *et al*. (2009) on Rama Krishna with 9.42% fruit infestation. This variation in infestation might be due to differences in temperature, humidity and rainfall. Arka Anamika and Bhindi Punjab Selection were found comparatively resistant varieties with 3.26 and 4.05% fruit infestations, respectively. The findings are in accordance with those of Akhter *et al*. (2014) who also found that Punjab Selection was moderately resistant against *H. armigera*.

Height, stem girth and number of primary branches

Significant variations were observed in plant heights and stem girths among nine okra varieties belonging to different groups of resistance. The heights and stem girths of comparatively resistant varieties were statistically greater as compared to intermediate resistant and comparatively susceptible varieties. However, with few exceptions these parameters were statistically similar in intermediate resistant and comparatively susceptible varieties. On the other hand, no significant difference was observed in number of primary branches among the three categories of okra varieties as shown in Figure 1.

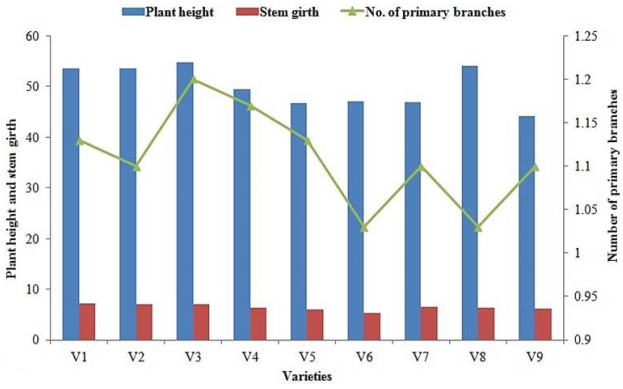

Fig. 1. Plant height, stem girth and number of primary branches of selected okra varieties. V1, Arka Anamika; V2, Bhindi Punjab Selection; V3, Bhindi Sabazpari; V4, Rama Krishna; V5, NS-810; V6, Baharti Kaspori; V7, RK-516; V8, OH-152; V9, Tarnab Nargis. LSD for Plant height = 1.77, Stem girth = 0.11 and No. of primary branches = 0.09.

Hair density

Okra varieties showed significant variations in hair density on leaf midrib, fruit, leaf lamina and leaf veins as shown in Table II. Hair density on leaf midrib was comparatively less in case of comparatively resistant varieties as compared to intermediate resistant and comparatively susceptible varieties. Similar is the case regarding hair density on leaf lamina and leaf veins. On the contrary, hair density on fruit was more on comparatively resistant varieties as compared to intermediate resistant and comparatively susceptible varieties.

Leaf area, thickness and moisture

With one exception in each category, no significant differences were observed rgarding area, moisture and thickness of leaves of okra varieties. The leaf area was slightly greater in comparatively resistant varieties as shown in Figure 2.

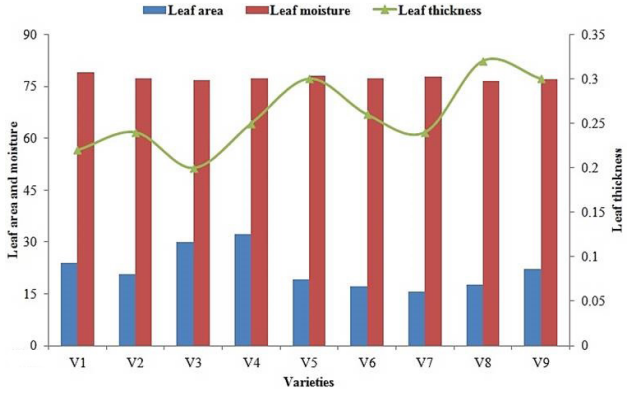

Fig. 2. Fruit width and length of selected okra varieties. LSD for Fruit width = 0.17 and Fruit length = 0.36. For abbreviations, see Figure 1.

Fruit length and width

With few exceptions no significant differences were observed regarding fruit length among all the nine varieties, although fruit length was found to be more in case of comparatively resistant varieties. Similarly, fruit was found to be significantly more in case of comparatively resistant varieties as compared to intermediate resistant and comparatively susceptible varieties. Minimum fruit weight was recorded in case of comparatively susceptible varieties as shown in Figure 3.

Earlier many researchers have studied different physico-morphic characters of different okra cultivars and reported variations in them (Hussain *et al*., 2014, 2016; Mukhtar *et al*., 2014). In the present study, fruit width and length of Arka Anamika was different from those obtained by Farooq *et al*. (2002) in an earlier study. Similarly, Singh *et al*. (2015) has also reported differences in fruit length and width at marketable stage (four days after anthesis) in different okra varieties. Farooq *et al*. (2002) has also reported that variations in fruit length and width were due to varietal differences. Makhadmeh *et al*. (2004) has shown wide variations in number of pods per plant (17 to 31) in different genotypes.

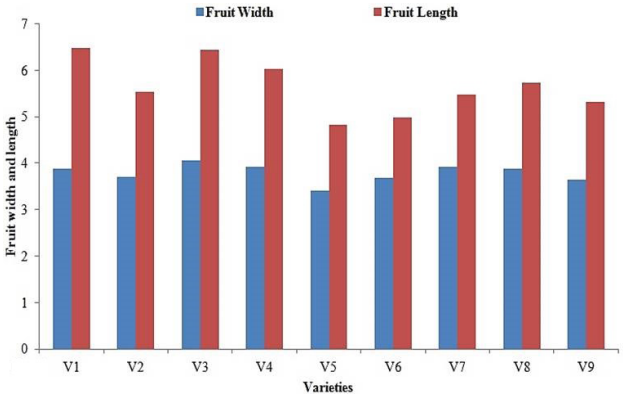

Fig. 3. Leaf area, moisture and thickness of selected okra varieties. LSD for Leaf area = 3.23, leaf moisture = 0.45 and Leaf thickness = 0.01. For abbreviations, see Figure 1.

Similarly, density of hairs on crown leaves (Agarwal and Katiyar, 1974) and leaf hairiness (Sharma and Agarwal, 1983) had a significant effect on the selection of oviposition sites by *Earias vittella* (Fab.). Conversely, several workers have reported that okra varieties showing greater fruit infestation had more hair density and soft skin (Teli and Dalaya, 1981). Chaudhuri *et al*. (1981) has also reported that fruit damage by *E. vittella* larvae was higher in open pollinated varieties than hybrids.

The relationship between fruit characteristics and okra yield has been investigated by some scientists. There are some reports which describe that more productive plants had greater fruit lengths. More yields were obtained from varieties having greater ability to bear fruits on lateral branches (Blennerhassett and El-Zeftawi, 1986). The findings of present research are in agreement with those of Aryo *et al.* (1987) who revealed that fruit weight, fruit length, fruit width, and numbers of branches per plant had significant correlation with fruit yield per plant.

CONCLUSION

Okra varieties belonging to different groups of resistance showed significant variations in physico-morphic characters. It was also observed that fruit and shoot infestation was the maximum on comparatively susceptible cultivars while infestation was significantly lower on comparatively resistant cultivars. Similarly, the pest produced significantly more eggs and larvae on comparatively susceptible cultivars as compared to comparatively resistant ones. Similarly, fruit was found to be significantly more in case of comparatively resistant varieties as compared to intermediate resistant and comparatively susceptible varieties. As comparatively resistant okra varieties *viz*. Bhindi Punjab Selection, Arka Anamika and Bhindi Sabazpari suffered less damage and yielded more and are therefore, recommended for cultivation to avoid damage by *Helicoverpa armigera*.

Statement of conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

Afzal, M., Mukhtar, K.M., Tahir, H.M., Ibrar-ul-haq, Babar, M.H. and Sherawat, S.M., 2015. Screening of different okra genotypes against fruit borer (*Earias* spp.) (Lepidoptera: Noctuidae) on okra crop. *Pakistan J. Zool*., **47**: 1631-1635.

Agarwal, R.A. and Katiyar, K.N., 1974. Ovipositional preference and damage by spotted bollworm (*Earias fabia*) in cotton. *Cotton Develop.*, **4**: 28-30.

Akhter, M., Jabeen, F., Sultana, S., Sultana, T., Hussain, D. and Ali, A., 2014. Selection of different okra genotypes against *Earias* spp. (Lepidoptera: Noctuidae). *J. Ent. Zool. Stud*., **2**: 138-141.

Anonymous, 2006. *Fruit, vegetables and condiments statistics of Pakistan*. Ministry of Food, Agriculture and Livestock (Econ. Unit), Govt. of Pakistan, Islamabad, pp. 68.

Aryo, O.J., Aken'ova, M.E. and Fatokun, C.A., 1987. Plant character correlation and path analysis of pod yield in okra (*Abelmoschus esculentus*). *Euphytica*, **36**: 677-686. https://doi.org/10.1007/BF00041518

Ashfaq, M., Saleem, A., Waqas, M. and Mukhtar, T., 2017. Natural occurrence and host range studies of Cucumber Mosaic Virus (CMV) infecting ornamental species in Rawalpindi-Islamabad area of Pakistan. *Philipp. Agric. Scient*., **100**: 55-61.

Aslam, M.N., Mukhtar, T., Ashfaq, M. and Hussain, M.A., 2017a. Evaluation of chili germplasm for resistance to bacterial wilt caused by *Ralstonia solanacearum*. *Australas. Pl. Pathol*., **46**: 289-292 https://doi.org/10.1007/s13313-017-0491-2.

Aslam, M.N., Mukhtar, T., Hussain, M.A. and Raheel M., 2017b. Assessment of resistance to bacterial wilt incited by *Ralstonia solanacearum* in tomato germplasm. *J. Pl. Dis. Prot*., **124**: 585-590. https://doi.org/10.1007/s41348-017-0100-1

Aziz, M.A., Hasan, M., Ali, A. and Iqbal, J., 2012. Comparative efficacy of different strategies for management of spotted bollworms, *Earias* spp. on okra, *Abelmoschus esculentus* (L). Moench. *Pakistan J. Zool*., **44**: 1203-1208.

Blennerhassett, R.M. and El-Zeftawi, B.M., 1986. Productivity and growth of six okra varieties. *Aust.*

J. exp. Agric., **26**: 625-629. https://doi.org/10.1071/EA9860625

Chaudhuri, N., Pal, S. and Senapati, S.K., 1981. Fruit damage potential of *Earias vittella* (Fab.) as influenced by physical characters of okra fruit. *Indian J. Ent*., **66**: 372-374.

Farooq, A.K., Jalal-Ud-Din, Ghaffoor, A. and Khan, K.W., 2002. Evaluation of different varieties of 'okra' (*Abelmoscus esculentus* L.) under the agro-climatic conditions of Dera Ismail Khan. *Asian J. Pl. Sci*., **1**: 663-664. https://doi.org/10.3923/ajps.2002.663.664

Fateh, F.S., Mukhtar, T., Kazmi, M.R., Abbassi, N.A. and Arif, A.M., 2017. Prevalence of citrus decline in district Sargodha. *Pak. J. agric. Sci*., **54**: 9-13. https://doi.org/10.21162/PAKJAS/17.5643

Gulsen, O., Karagul, S. and Abak, K., 2007. Diversity and relationships among Turkish okra germplasm by SRAP and phenotypic marker polymorphism. *Biol. Bratisl*., **62**: 41-45. https://doi.org/10.2478/s11756-007-0010-y

Hussain, M.A., Mukhtar, T. and Kayani, M.Z., 2014. Characterization of susceptibility and resistance responses to root-knot nematode (*Meloidogyne incognita*) infection in okra germplasm. *Pak. J. agric. Sci*., **51**: 319-324.

Hussain, M.A., Mukhtar, T. and Kayani, M.Z., 2016. Reproduction of *Meloidogyne incognita* on resistant and susceptible okra cultivars. *Pak. J. agric. Sci*., **53**: 371-375. https://doi.org/10.21162/PAKJAS/16.4175

Jallow, M.F.A., Cunningham, J.P. and Zalucki, M.P., 2004. Intra-specific variation for host plant use in *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae): Implications for management. *Crop Prot*., **23**: 955-964. https://doi.org/10.1016/j.cropro.2004.02.008

Javed, H., Aziz, M.A. and Leghari, R.A.K., 2009. Resistance in different okra varieties against American bollworm (*Helicoverpa armigera* Hub.). *J. agric. Res*., **47**: 433-438.

Javed, H., Hussain, S.S., Javed, K., Mukhtar, T. and Abbasi, N.A., 2017a. Comparative infestation of brinjal stem borer (*Euzophera perticella*) on six aubergine cultivars and correlation with some morphological characters. *Pak. J. agric. Sci*., **54**: 763-768.

Javed, H., Mukhtar, T., Javed, K. and Mohsin, A., 2017b. Management of eggplant shoot and fruit borer (*Leucinodes orbonalis* guenee) by integrating different non-chemical approaches. *Pak. J. agric. Sci*., **54**: 65-70. https://doi.org/10.21162/PAKJAS/17.5282

Kassi, A.K., Javed, H. and Mukhtar, T., 2018. Screening of okra cultivars for resistance against *Helicoverpa armigera*. *Pakistan J. Zool*., **50**: 91-95.

Kayani, M.Z. and Mukhtar, T., 2018. Reproductivity of *Meloidogyne incognita* on fifteen cucumber cultivars. *Pakistan J. Zool*., **50**: 1717-1722. https://doi.org/10.17582/journal.pjz/2018.50.5.1717.1722

Kayani, M.Z., Mukhtar, T. and Hussain, M.A., 2017. Effects of southern root knot nematode population densities and plant age on growth and yield parameters of cucumber. *Crop Prot*., **92**: 207-212. https://doi.org/10.1016/j.cropro.2016.09.007

Kayani, M.Z., Mukhtar, T. and Hussain, M.A., 2018. Interaction between nematode inoculum density and plant age on growth and yield of cucumber and reproduction of *Meloidogyne incognita*. *Pakistan J. Zool*., **50**: 897-902. https://doi.org/10.17582/journal.pjz/2018.50.3.897.902

Khan, A.R., Javed, N., Sahi, S.T., Mukhtar, T., Khan, S.A. and Ashraf, W., 2017. *Glomus mosseae* (Gerd&Trappe) and neemex reduce invasion and development of *Meloidogyne incognita*. *Pakistan J. Zool*., **49**: 841-847. https://doi.org/10.17582/journal.pjz/2017.49.3.841.847

Makhadmeh, I.M. and Khalil, I.E., 2004. Geometric characteristics and chemical composition of okra (*Abelmoschus esculentus* L.) grown under semi-arid conditions. *Int. J. Fd. Prop*., **7**: 83-90. https://doi.org/10.1081/JFP-120022983

Mastoi, A.H., Memon, S.A. and Haq, W., 2013. Varietal resistance of okra against whitefly (*Bemisia tabaci*) and fruit borer (*Earias* spp.). *Schol. J. agric. Vet. Sci*., **3**: 78-82.

Mironidis, G.K. and Savopoulou-Soultani, M., 2008. Development, survivorship and reproduction of *Helicoverpa armigera* (Lepidoptera: Noctuidae) under constant and alternating temperatures. *Environ. Ent*., **37**: 16-28. https://doi.org/10.1603/0046-225X(2008)37[16:DSAROH]2.0.CO;2 https://doi.org/10.1093/ee/37.1.16

Mukhtar, T., 2018. Management of root-knot nematode, *Meloidogyne incognita*, in tomato with two *Trichoderma* species. *Pakistan J. Zool*., **50**: 1589-1592. https://doi.org/10.17582/journal.pjz/2018.50.4.sc15

Mukhtar, T., Arooj, M., Ashfaq, M. and Gulzar, A., 2017a. Resistance evaluation and host status of selected green gram genotypes against *Meloidogyne incognita*. *Crop Prot*., **92**: 198-202. https://doi.org/10.1016/j.cropro.2016.10.004

Mukhtar, T., Hussain, M.A. and Kayani, M.Z.,

2017b. Yield responses of 12 okra cultivars to southern root-knot nematode (*Meloidogyne incognita*). *Bragantia*, **75**: 108-112. https://doi.org/10.1590/1678-4499.005

Mukhtar, T., Hussain, M.A., Kayani, M.Z. and Aslam, M.N., 2014. Evaluation of resistance to root-knot nematode (*Meloidogyne incognita*) in okra cultivars. *Crop Prot*., **56**: 25-30. https://doi.org/10.1016/j.cropro.2013.10.019

Mukhtar, T., Jabbar, A., Raja, M.U. and Javed, H., 2018. Re-emergence of wheat seed gall nematode (*Anguina tritici*) in Punjab, Pakistan. *Pakistan J. Zool*., **50**: 1195-1198. https://doi.org/10.17582/journal.pjz/2018.50.3.sc4

Nabeel, M., Javed, H. and Mukhtar, T., 2018. Occurrence of *Chilo partellus* on maize in major maize growing areas of Punjab, Pakistan. *Pakistan J. Zool.*, **50**: 317-323. https://doi.org/10.17582/journal.pjz/2018.50.1.317.323

Rahoo, A.M., Mukhtar, T., Gowen, S.R., Rahoo, R.K. and Abro, S.I., 2017. Infectivity and searching ability of entomopathogenic nematode, *Steinernema feltiae*. *Pakistan J. Zool*., **49**: 229-234. https://doi.org/10.17582/journal.pjz/2017.49.1.229.234

Rahoo, A.M., Mukhtar, T., Jakhar, A.M. and Rahoo, R.K., 2018a. Inoculum doses and exposure periods affect recovery of *Steinernema feltiae* and *Heterorhabditis bacteriophora* from *Tenebrio molitor*. *Pakistan J. Zool*., **50**: 983-987. https://doi.org/10.17582/journal.pjz/2018.50.3.983.987

Rahoo, A.M., Mukhtar, T., Abro, S.I., Bughio, B.A. and Rahoo, R.K., 2018b. Comparing the productivity of five entomopathogenic nematodes in *Galleria mellonella*. *Pakistan J. Zool*., **50**: 679-684. https://doi.org/10.17582/journal.pjz/2018.50.2.679.684

Rahoo, A.M., Mukhtar, T., Bughio, B.A. and Rahoo, R.K., 2019. Relationship between the size of *Galleria mellonella* larvae and the production of Steinernema feltiae and Heterorhabditis bacteriophora. *Pakistan J. Zool*., **50**: 79-84. http://dx.doi.org/10.17582/journal.pjz/2019.51.1.79.84

Reddy, K.S., Rao, G.R., Rao, P.A. and Rajasekhar, P., 2004. Life table studies of the Capitulum Borer, *Helicoverpa armigera* (Hübner) infesting sunflower. *J. entomol. Res*., **28**: 13-18.

Sharma, H.C. and Agarwal, R.A., 1983. Ovipositional behaviour of spotted bollworm *Earias vittella* (Fab.) on some cotton genotypes. *Insect Sci. Applic.*, **4**: 373-376.

Sharma, H.C. and Ortiz, R., 2002. Host plant resistance to insects: An eco-friendly approach for pest management and environment conservation. *J. environ. Biol*., **23**: 11-35.

Singh, B., Chaubey, T., Upadhyay, D.K., Aastik, J.H.A., Pandey, S.D. and Sanwal, S.K., 2015. Indian Council of Agricultural Research, New Delhi, India. *Indian J. agric. Sci*., **85**: 1192-1200.

Tariq-Khan, M., Munir, A., Mukhtar, T., Hallmann, J. and Heuer, H., 2017. Distribution of root-knot nematode species and their virulence on vegetables in northern temperate agro-ecosystems of the Pakistani-administered territories of Azad Jammu and Kashmir. *J. Pl. Dis. Prot*., **124**: 201-212. https://doi.org/10.1007/s41348-016-0045-9

Teli, V.S. and Dalaya, V.P., 1981. Studies on varietal resistance in okra (*Abelmoschus esculentus* (Linn.) Moench) to the shoot and fruit borer, *Earias vittella* Fabricius. *South Indian Hort*., **29**: 54-60.

Yu, F.L., Wu, G., Liu, T.J., Zhai, B.P. and Chen, F.J., 2008. Effects of irrigation on the performance of cotton bollworm, *Helicoverpa armigera* (Hübner) during different pupal stages. *Int. J. Pest Manage*., **54**: 137-142. https://doi.org/10.1080/09670870701766038