Pakistan J. Zool., vol. 50(1), pp 317-323, 2018. **DOI**: http://dx.doi.org/10.17582/journal.pjz/2018.50.1.317.323

Occurrence of *Chilo partellus* on Maize in Major Maize Growing Areas of Punjab, Pakistan

Muhammad Nabeel,[1,*] Humayun Javed[1] and Tariq Mukhtar[2]

[1]*Department of Entomology, PMAS Arid Agriculture University, Rawalpindi*
[2]*Department of Plant Pathology, PMAS Arid Agriculture University, Rawalpindi*

ABSTRACT

Maize (*Zea mays* L.) is one of the most important nutritious crops in the world. In Pakistan, this is the 3rd largest cultivated crop. The yield of maize is greatly affected by many insect pests and maize borer (*Chilo partellus* Swinhoe) has been identified as one of the major limiting factors to maize production throughout the world. As the information regarding its distribution is lacking therefore, its incidence and prevalence was determined in seven major maize growing districts of Punjab during 2016. The maximum overall incidence of maize borer (12%) was recorded in Khanewal district followed by Multan (6%) while it was the minimum (1%) in district Okara. On the other hand, maximum prevalence of maize borer was observed in district Vehari (100%) followed by districts of Khanewal and Multan (73%) while minimum prevalence of 33% was recorded in district Sahiwal. As regards cultivars, maximum incidence of maize borer (13%) was recorded on cultivar 8621 followed by C1543 (10%) and the minimum was found on cultivar 71R88 and Desi. No infestation of the borer was observed on cultivars 88R88, 30T87 and 15P43. It is concluded that maize borer has been found fairly distributed in the major growing districts of Punjab; hence strict control measures should be adopted to minimize its damage. Some cultivars were found resistant to the borer infestation and are recommended for cultivation.

Article Information
Received 21 August 2017
Revised 26 September 2017
Accepted 17 October 2017
Available online 15 January 2018

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

Key words
Incidence, Prevalence, Maize borer, Infestation, *Zea mays*.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops, cultivated on 17% of the cultivated land worldwide with 24% grain production in the world (Abid, 1983). In Pakistan, maize is cultivated on 1169 thousand hectares with 4944 thousand tons annual production (Anonymous, 2015). Maize crop is used for multiple purposes such as fuel, food for human, fodder for livestock and feed for poultry. Successfully cultivated throughout Pakistan and mostly concentrated in Punjab and NWFP, it contributes about 98% of total country's production. Maize yield per hectare has not been increasing even in the presence of high yielding cultivars mainly due to a large number of biotic factors like fungi (Iqbal and Mukhtar, 2014; Iqbal *et al*., 2014), bacteria (Shahbaz *et al*., 2015; Aslam *et al*., 2017a, b), nematodes (Hussain *et al*., 2014; 2016; Kayani *et al*., 2017; Khan *et al*., 2017; Mukhtar *et al*., 2014, 2017a, b; Tariq-Khan *et al*., 2017), viruses (Ashfaq *et al*., 2014a, b, 2015, 2017) and insect pests (Ahmed *et al*., 2002, 2003; Naz *et al*., 2003). Maize is attacked by 140 different insect species with their different level of damage percentage. Out of 140 species of insect pests, only 12 species are the serious pests of maize causing damage from sowing to the harvesting and also in the storage conditions (Siddiqui and Marwaha, 1993). Maize crop is attacked by insects (army worm, stem borer, thrips, aphids, termites, white grub, seed corn maggots, root worms, Indian meal moth, grain borer and grain weevil) during their storage. Maize crop can be attacked at any stage of their life even after harvesting. The severity of pest attack depends upon the cultivars, cultivation practices, mode of storage and environmental conditions (Arabjafari and Jalai, 2007). A wide variety of insect pests attack maize crop resulting in heavy losses annually. Among these pests, *Chilo partellus* (Lepidoptera: Pyralidae) is one of the most dangerous pests and causes tremendous damage to maize crop (Kavita *et al*., 2016; Yonow *et al*., 2017). It has been reported to cause damage to the extent of 42.29% (Dejen *et al*., 2014). In case of severe damage, it can cause yield reduction up to 75% (Sharma and Gautam, 2010). In Africa and Asia, *C. partellus* is economically the most notorious pest of sorghum and maize (Bosque-Perez and Schulthess, 1998). In different agro-climatic regions of India, *C. partellus* has caused damage of 26.7-80.4% to sorghum (Sethuraman and Narayanan, 2010). It is the principal pest in lowland areas (Yonow *et al*., 2017). *C. partellus* takes 30-40 days to complete its life cycle. The larvae appreciably grow more rapidly and 4th instar larva consumes more food than others. Pupal period passes

* Corresponding author: nabeelmushtaq7@gmail.com
0030-9923/2018/0001-0317 $ 9.00/0

within 7-10 days and eggs hatch in 5-6 days (Panchal and Kachole, 2013). Larval stages are the most destructive and make tunnels inside the stem or stalk after hatching from eggs (Yonow *et al*., 2017). Increased structural damage results in crop lodging and there is less ear formation. It may also lead to rottening of ears resultantly phytotoxins are produced (Nderitu, 2000). The borer causes injury to maize by feeding on leaves, making tunnels in the stalks, disrupting the flow of nutrients to ears and finally causing deadhearts. The larvae move from one plant to other through the holes made at the lower nodes of the plant and pupate in the stem (Lella and Srivastav, 2013).

In Pakistan this pest causes significant yield losses. As information on the incidence and prevalence is lacking in the major maize growing areas of the Punjab province, therefore, the objective of the present studies was to determine its incidence and prevalence in seven major districts and on different maize cultivars.

MATERIALS AND METHODS

To record the incidence of maize borer, fields were randomly selected from seven major maize growing districts (Khanewal, Multan, Okara, Pakpattan, Sahiwal, Vehari and Toba Tek Singh) of the Punjab province. A total of 103 fields were visited and from each district 10-15 fields were randomly selected. Fields were visited only once during the survey. Hundred plants from each field were selected randomly by simple random sampling method to record the maize borer infestation. The incidence in each field was determined by the method described by Mukhtar *et al*. (2017b). During surveys different factors *i.e.* age of crop, variety cultivated, area under cultivation, date of sowing, number of irrigations, fertilizers and pesticides were also recorded. Similarly, incidence in each field of each district was recorded and the individual incidence of each district was calculated. The prevalence of maize borer in each district was determined as described by Fateh *et al*. (2017). The incidence on each cultivar in each district and overall incidence on each cultivar was also calculated. All the graphs were made in Microsoft Excel 2007.

RESULTS

The maximum overall incidence of maize borer (12%) was recorded in Khanewal district followed by Multan (6%) while it was the minimum (1%) in district Okara. On the other hand, maximum prevalence of maize borer was observed in district Vehari (100%) followed by districts of Khanewal and Multan (73%) while minimum prevalence of 33% was recorded in district Sahiwal. The individual incidence and prevalence of the insect pest have been shown in Figure 1.

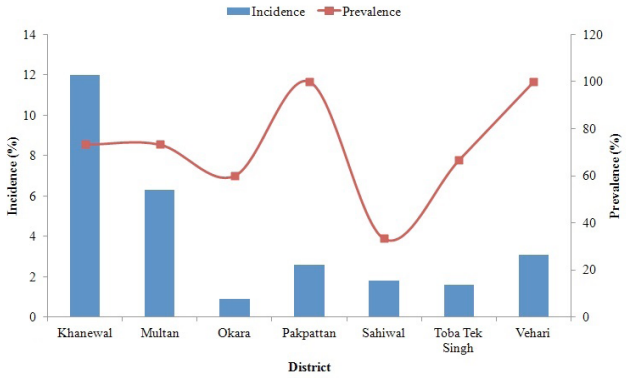

Fig. 1. Overall incidence and prevalence of maize borer in seven districts of Punjab.

As regards cultivars, maximum incidence of maize borer (13%) was recorded on cultivar 8621 followed by C1543 (10%) and the minimum was found on cultivar 71R88 and Desi. No infestation of the borer was observed on cultivars 88R88, 30T87 and 15P43. The individual incidence of maize borer on each cultivar has been given in Figure 2. The individual incidence on each of the cultivars in each district is given in Figure 3. In district Khanewal maximum incidence was recorded on cultivar 31R88 while the minimum was on the cultivar 302287 (Fig. 3A). In district Multan the incidence was the maximum on cultivar C1543 while it was the minimum on C1574 (Fig. 3B). The incidence of the borer was found to be the maximum on cultivar S7720 and the minimum on cultivar 30Y87 in district Okara. Cultivars 15P46, 6417, 6789 and 81R88 were found free of the infestation (Fig. 3C). As regards district Pakpattan, the maximum incidence (27%) of borer was recorded on cultivar NK6654 while the rest of the cultivars showed incidence up to 4% (Fig. 3D).

In district Toba Tek Singh, the maximum incidence was found on Cultivar 31R88 and the minimum was observed on cultivars Desi and 7720 while the cultivars 6714 and 30T60 did not show infestation of the borer (Fig. 3E). In district Vehari all the cultivars were found infested with the borer. The maximum incidence was recorded on cultivars 30T60 and 31R88 while the minimum incidence of 5% was found on cultivars 6789, 339 and 71R88 as shown in Figure 3F. Similarly, in district Sahiwal, infestation of the borer was recorded on four cultivars while the remaining four cultivars did not show infestation of the pest (Fig. 3G).

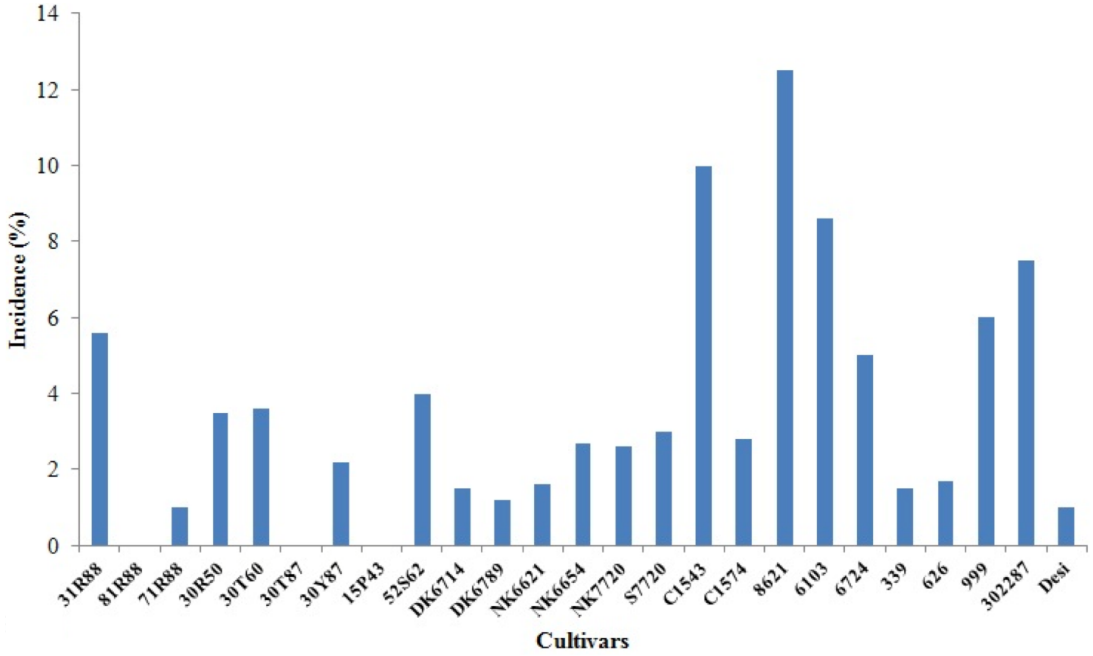

Fig. 2. Overall incidence of maize borer on each cultivar of maize.

DISCUSSION

In the present study, differences in the incidence and prevalence of maize borer were recorded in seven major maize growing districts of the Punjab province of Pakistan. Similarly, variations in the infestation of maize borer were also observed on various cultivars grown in these districts. Different researchers have reported incidence of maize borer in different countries. Naz *et al*. (2003) reported that *C. partellus* was one of the serious maize pests causing 24.5% damage with varying incidence. Dejen *et al*. (2014) found 1-100% incidence of maize borer in different localities of the North-eastern Ethiopia. Similarly, 2-62% damage was recorded in the North Wollo. The damage was also recorded as 84-99% by *C. partellus* in the Oromia zone. Mashwani *et al*. (2015) showed that the highest infestation of 27% was recorded from the Palo area while the lowest damage was recorded as 15% from Badder region.

The differences in the incidence are due to different abiotic factors prevailing in these districts. Incidence and infestation of maize borer has been found affected by irrigation (Kumar and Asino, 1994), fertilizers (Arshad *et al*., 2013) and applications of pesticides. It has been observed that over irrigation cause lodging of plants. Plants have more watery and juicy contents and become soft which help *C. partellus* to bore easily into the stem of plants and cause more damage. Fertilizers are beneficial for plants to fulfill their nutrients demands for their better growth, development and health. A healthy plant can withstand or face the adverse factors of environment. But the excessive use of fertilizers makes the plants more susceptible for the pest attack. By the use of excessive nitrogen, the plants show excessive growth of foliage and become lush green which attract the insect pests and increase the incidence of the borer. On the other hand, application of pesticides reduces the incidence and infestation of maize borer (Khan and Amjad, 2000; Koul *et al*., 2013). Different environmental conditions also affect the incidence of maize borer. It was found that temperature, relative humidity and their interaction significantly affected the developmental time, adult longevity and potential fecundity of the pest. Developmental time was inversely related to temperature (Tamiru *et al*., 2012).

The pest status of *C. partellus* is also influenced by survival and dispersal of first- and second-instar larvae (Chapman *et al*., 1983; Bernays *et al*., 1985), larval behaviour and host-plant resistance (Woodhead and Taneja, 1987), larval movements, feeding and development (Ampofo and Kidiavai, 1987; Alghali and Saxena, 1988), larval infestations (Rensburg *et al*., 1988), ovipositional responses (Kumar, 1988) and maize floral initiation and infestation (Sharma and Sharma, 1987). Crop stage also affects the infestation of maize borer. At early stage the plants being tenderer are more frequently attacked by the borer as compared to older ones which show resistance towards the insect pests. Biological control agents have also been reported to lower the incidence of insect pests (Rahoo *et al*., 2017).

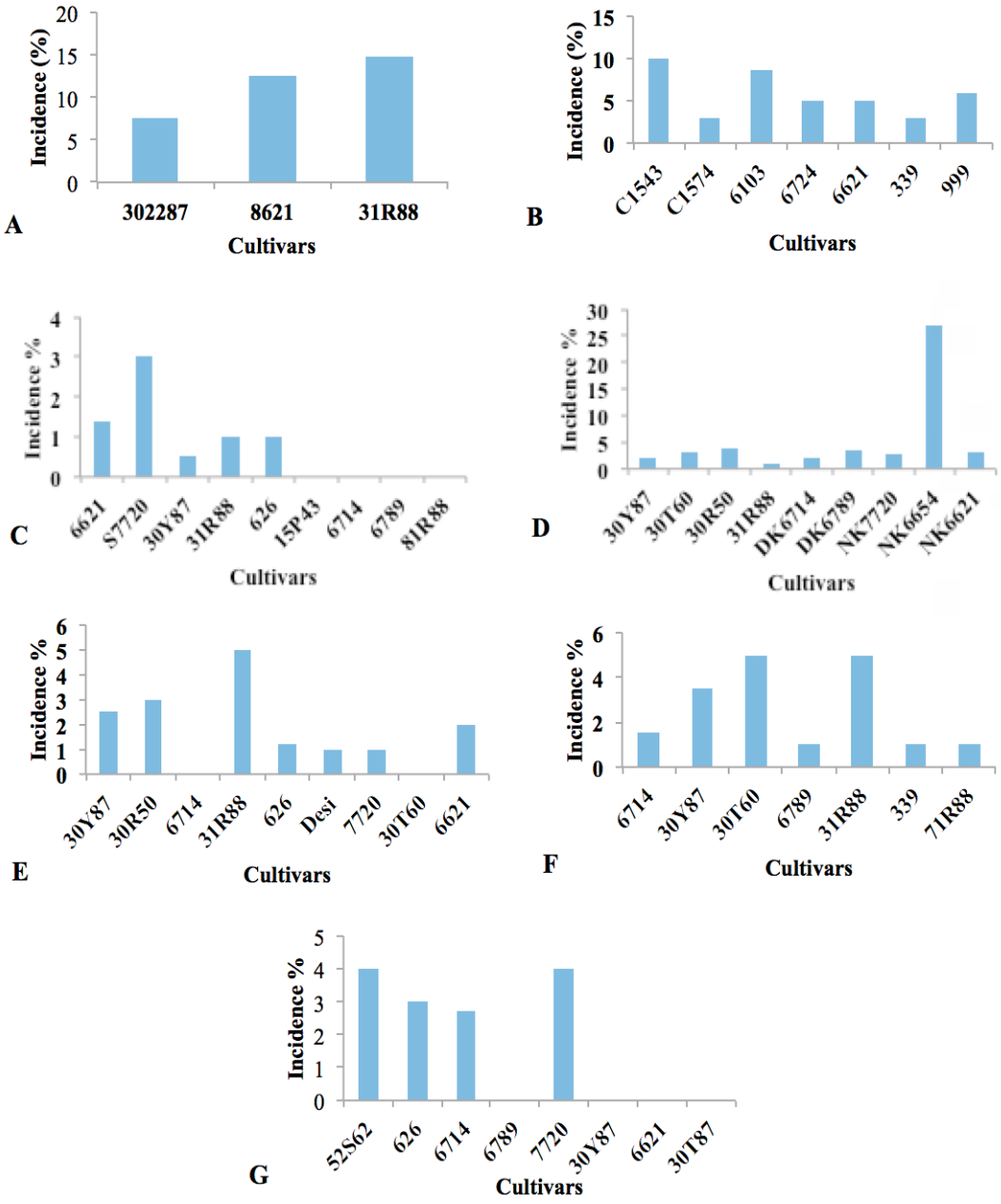

Fig. 3. Variety wise incidence of maize borer in district Khanewal (A), Multan (B), Okara (C), Pakpattan (D), Toba Tek Singh (E), Vehari (F) and Sahiwal (G).

The results of the present survey revealed that the maximum incidence of maize borer was found in Khanewal district, the incidence was intermediate in Multan district while the minimum incidence was observed in the Okara district. Maximum incidence of maize borer in Khanewal was due to over irritation as compared to the crop age and in Multan the irrigation is little higher while in Okara district the irrigation was according to the crop age. In district Khanewal, fertilizers were applied four times till the age of 7.5 weeks, in district Multan same number of fertilizer applications was made to the 9 weeks age crop while in Okara district four fertilizer applications were given to the 9.5 weeks crop age which affected incidence of maize borer. Four-time pesticide was applied in both Khanewal and Multan districts while in Okara district pesticides were applied only two times.

CONCLUSION

It is concluded from the present studies that maize borer is fairly distributed in the major growing districts of Punjab and warrant strict control measures. Some cultivars were found free from the borer infestation and are recommended for cultivation.

Statement of conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

REFERENCES

Abid, A.K., 1983. *Resistance of different varieties of maize stem borer*. M.Sc. (Hons.) thesis, Faculty of Agriculture University, Peshawar, Pakistan.

Ahmed, S., Saleem, M.A. and Rauf, I., 2002. Field efficacy of some bio-insecticides against maize and jowar stem borer, *Chilo partellus* (Pyralidae: Lepidoptera). *Int. J. Agric. Biol*., **4**: 332-334.

Ahmed, S., Shahzad, A., Naeem, M. and Ashraf, M.Y., 2003. Determination of efficacy of cypermethrin, regent and carbofuran against *Chilo partellus* Swin. and biochemical changes following application of these insecticides in maize plants. *Int. J. Agric. Biol*., **5**: 30-35.

Alghali, A.M. and Saxena, K.N., 1988. Larval movement, feeding and development of *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) on two sorghum cultivars. *Insect Sci. Appl*., **9**: 7-11. https://doi.org/10.1017/S1742758400009942

Ampofo, J.K.O. and Kidiavai, E.L., 1987. *Chilo partellus* (Swinhoe) (Lepid., Pyralidae) larval movement and growth on maize plants in relation to plant age and resistance or susceptibility. *J. appl. Ent*., **103**: 483-488. https://doi.org/10.1111/j.1439-0418.1987.tb01012.x

Anonymous, 2015. *Pakistan economic survey*. Ministry of Food, Agriculture and Livestock Federation Bureau Stat., Islamabad, pp. 21-23.

Arabjafari, K.H. and Jalai, S.K., 2007. Identification and analysis of host plant resistance in leading maize genotypes against spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). *Pak. J. biol. Sci*., **10**: 1885-1895. https://doi.org/10.3923/pjbs.2007.1885.1895

Arshad, M.J., Freed, S., Akbar, S., Akmal, M. and Gul, H.T., 2013. Nitrogen fertilizer application in maize and its impact on the development of *Chilo partellus* (Lepidoptera: Pyralidae). *Pakistan J. Zool*., **45**: 141-147.

Ashfaq, M., Iqbal, S., Mukhtar, T. and Shah, H., 2014a. Screening for resistance to cucumber mosaic cucumovirus in chilli pepper. *J. Anim. Pl. Sci*., **24**: 791-795.

Ashfaq, M., Khan, M.A., Mukhtar, T. and Sahi S.T., 2014b. Role of mineral metabolism and some physiological factors in resistance against urdbean leaf crinkle virus in blackgram genotypes. *Int. J. Agric. Biol*., **16**: 189-194.

Ashfaq, M., Saeed, U., Mukhtar, T. and Haq, M.I., 2015. First report of zucchini yellow mosaic virus in ridge gourd in Pakistan. *Pl. Dis*., **99**: 1870. https://doi.org/10.1094/PDIS-05-15-0553-PDN

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. Sci*., **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

Bernays, E., Woodhead, S. and Haines, L., 1985. Climbing by newly hatched larvae of the spotted stalk borer *Chilo partellu*s to the top of sorghum plants. *Ent. Exp. Appl*., **39**: 73-79. https://doi.org/10.1111/j.1570-7458.1985.tb03544.x

Bosque-Perez, N.A. and Schulthess, F., 1998. *Maize in west and central Africa. African cereal stem borers: economic importance, taxonomy, natural enemies and control*. CAB International, Wallingford, UK, pp. 11-24.

Chapman, R.F., Woodhead, S. and Bernays, E.A., 1983. Survival and dispersal of young larvae of *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) in two cultivars of sorghum. *Bull. entomol. Res*., **73**: 65-74. https://doi.org/10.1017/S0007485300013808

Dejen, A., Getu, E., Azerefegne, F. and Ayalew, A., 2014. Distribution and impact of *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) in Northeastern Ethiopia. *J. Ent. Nematol*., **6**: 1-13. https://doi.org/10.5897/JEN2013.0078

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**: 913.

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

Iqbal, U. and Mukhtar, T., 2014. Morphological and pathogenic variability among Macrophomina phaseolina isolates associated with mungbean (*Vigna radiata* L.) Wilczek from Pakistan. *Sci. World J.,* **2014**: Article ID 950175. https://doi.org/10.1155/2014/950175

Iqbal, U., Mukhtar, T. and Iqbal, S.M., 2014. *In vitro* and *in vivo* evaluation of antifungal activities of some antagonistic plants against charcoal rot causing fungus, *Macrophomina phaseolina*. *Pak. J. agric. Sci*., **51**: 689-694.

Kavita, H., Manjunatha, M., Adarsha, S. and Sharanabasappa, K., 2016. Management of *chilo partellus* (Swinhoe) and *Sesamia inferens* (Walker) through different intercropping systems and organic manures in maize ecosystem. *Int. J. agric. Sci*., **8**: 1053-1056.

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

Khan, A.R., Javed, N., Sahi, S.T., Mukhtar, T., Khan, S.A. and Ashraf, W., 2017. *Glomus mosseae* (Gerd and 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

Khan, S.M. and Amjad, M., 2000. Chemical control of maize stem borer (*Chilo partellus* Swin.). *Pak. J. biol. Sci*., **3**: 2116-2118. https://doi.org/10.3923/pjbs.2000.2116.2118

Koul, O., Singh, R., Kaur, B. and Kanda, D., 2013. Comparative study on the behavioural response and acute toxicity of some essential oil compounds and their binary mixtures to larvae of *Helicoverpa armigera, Spodoptera litura* and *Chilo partellus*. *Ind. Crop Prod*., **49**: 428-436. https://doi.org/10.1016/j.indcrop.2013.05.032

Kumar, H. and Asino, G.O., 1994. Grain yield losses in maize (*Zea mays* L.) genotypes in relation to their resistance against *Chilo partellus* (Swinhoe) infestation at anthesis. *Crop Prot*., **13**: 136-140. https://doi.org/10.1016/0261-2194(94)90164-3

Kumar, H., 1988. Oviposition and larval behaviour of stalk borer *Chilo partellus* on susceptible and resistant varieties of maize, *Zea mays* L. *Ind. J. agric. Sci*., **58**: 918-921.

Lella, R. and Srivastav, C.P., 2013. Screening of maize genotypes against stem borer *C. partellus* in kharif season. *Int. J. appl. Biol. Pharmaceutical Technol*., **4**: 394-403.

Mashwani, M.A., Ullah, F., Ahmad, S., Sohail, K., Shah, S.F. and Usman, M., 2015. Infestation of maize stem borer, *Chilo partellus* (Swinhoe) in maize stubbles and stalks. *J. Biol. environ. Sci*., **7**: 180-185.

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 twelve 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

Naz, F., Hussain, M., Faridullah and Din, M., 2003. Insect pest of maize and their losses. *Asian J. Pl. Sci*., **2**: 412-414. https://doi.org/10.3923/ajps.2003.412.414

Nderitu, C. 2000. *Agricultural biotechnology and the poor proceedings of an international conference, Washington, D.C.* Consultative Group on International Agricultural Research, pp. 109-114.

Panchal, B.M. and Kachole, M.S., 2013. Life cycle of *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) on an artificial diet. *Int. J. Pl. Anim. environ. Sci*., **3**: 19-22.

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

Rensburg, J.B.J., Walters, M.C. and Giliomee, J.H., 1988. The comparative abundance and in-season distribution of larval infestations of *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) on

maize. *J. entomol. Soc. S. Afr*., **51**: 138-140

Sethuraman, V. and Narayanan, K., 2010. Biological activity of nucleo-polyhedro virus isolated from *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) in India. *Asian J. exp. biol. Sci*., **1**: 325-330.

Shahbaz, M.U., Mukhtar, T., Haque, M.I. and Begum, N., 2015. Biochemical and serological characterization of *Ralstonia solanacearum* associated with chilli seeds from Pakistan. *Int. J. Agric. Biol*., **17**: 31-40.

Shahzaman, S., Inam-ul-Haq, M., Mukhtar, T. and Naeem, M., 2015. Isolation, identification of antagonistic rhizobacterial strains obtained from chickpea (*Cicer arietinum* L.) field and their in-vitro evaluation against fungal root pathogens. *Pak. J. Bot*., **47**: 1553-1558.

Sharma, A.N. and Sharma, V.K., 1987. The stage of maize, with respect to floral initiation, most vulnerable to infestation by stem borer, *Chilo partellus* (Swinhoe) in India. *Trop. Pest Manage*., **33**: 139-141. https://doi.org/10.1080/09670878709371134

Sharma, P.N. and Gautam, P., 2010. Assessment of yield loss in maize due to attack by the maize borer, *Chilo partellus* (Swinhoe). *Nepal J. Sci. Technol*., **11**: 25-30.

Siddiqui, K.H. and Marwaha, K.K., 1993. *The vistas of maize entomology in India*. Kalyani Publishers, Ludhiana.

Tamiru, A., Getu, E., Jembere, B. and Bruce, T., 2012. Effect of temperature and relative humidity on the development and fecundity of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae). *Bull. entomol. Res*., **102**: 9-15. https://doi.org/10.1017/S0007485311000307

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

Woodhead, S. and Taneja, S.L., 1987. The importance of the behaviour of young larvae in sorghum resistance to *Chilo partellus*. *Ent. Exp. Appl*., **45**: 47-54. https://doi.org/10.1111/j.1570-7458.1987.tb02254.x

Yonow, T., Kriticos, D.J., Ota, N., Berg, J.V.D. and Hutchison, W.D., 2017. The potential global distribution of *Chilo partellus*, including consideration of irrigation and cropping patterns. *J. Pest Sci*., **90**: 459-477. https://doi.org/10.1007/s10340-016-0801-4