Pak. J. Agri. Sci., Vol. 60(4), 637-642; 2023
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI:10.21162/PAKJAS/23.70
http://www.pakjas.com.pk

Comparative efficacy of some granular insecticides against maize stem borer, *Chilo partellus* (Swinhoe) under high efficiency irrigation system

Shehbaz Sharif[1,*], Muhammad Ali[1], Muhammad Ashfaq[2] and Habib ur Rehman[3]

[1]Department of Entomology, Faculty of agricultural sciences, University of the Punjab, Lahore, Pakistan; [2]Department of Plant Breeding and Genetics, Faculty of agricultural sciences, University of the Punjab, Lahore, Pakistan; [3]Water Management Research Farm, Okara, Pakistan.
*Corresponding author's e-mail: Shehbazsherawat@gmail.com

Maize crop is being attacked by numerous insect pests including borers which result in yield losses. Repeated use of similar insecticides resulted in resistance development in maize stem borer. The current research trial was executed to find out the lethal impacts of Chlorantraniliprole 0.4% G, Carbofuran 3 G, Fipronil 0.3% G, Cartap hydrochloride 4%G, Thimet and Monomehypo against *Chilo partellus* (S.). Results of insect pest infestation showed that maximum infestation (25.87%) was noted in check plot whereas lowest (2.93%) was recorded in case of Chlorantraniliprole 0.4% G, Carbofuran 3 G was the next effective one (6.17%) followed by Fipronil 0.3% G (8.44%), Cartap hydrochloride 4%G (12.02%), Monomihypo (13.98%) and Thimet 5%G (15.08%). In case of dead-heart production, maximum dead heart (20.41%) were observed in control plot while lowermost (1.26%) in Chlorantraniliprole 0.4% G treated plot. Highest reduction in plant infestation (88.69%) over control was noticed in case of Chlorantraniliprole 0.4% G followed by Carbofuran 3 G (76.13%), Fipronil 0.3% G (67.38%), Cartap hydrochloride 4%G (53.50%), Monomihypo (46.18%) and Thimet 5%G (41.72%). In case of months of the study, maximum infestation (%) was noted during the month of August compared to July and September. Crop water productivity was highest (2.58 kg/m^3) in the case of Chlorantraniliprole 0.4% G treated plots, while a comparatively low (1.29 $kg\ m^{-3}$) was noted in the case of Thimat 5% treated plots under drip irrigation system but was superior to control plot (1.29 $kg\ m^{-3}$) under flood irrigation system Overall results disclosed that all the insecticidal treatments sustained their supremacy over check plot in reducing infestation of *C. partellus* and Chlorantraniliprole 0.4% G was the best among the tested insecticides against *C. partellus*.
Keywords: Dead-heart, infestation, plant infestation, flood irrigation system, lethal impacts

INTRODUCTION

Maize (*Zea mays* L.) is one of the high-yielding crops in the world. This crop is of key importance for Pakistan and other developing countries, where quickly increasing population has currently out-stripped the prevailing commodities supplies (Iqbal *et al*., 2021). Maize ranks as 3rd significant cereal afterward wheat and rice (Farhadi *et al*., 2021). Maize covers 4.8% of the total cropped area and contributes 3.5% to the value addition of the crops yield (Tariq and Iqbal, 2010). The estimated area under maize cultivation was 0.9 million hectares with yearly yield of 1.3 million tons in Pakistan (PARC, 2021). It can be grown nearly in each type of climatic conditions worldwide at diverse degree of success. Owing to maximum crop produce, maize is denoted as "Queen of cereals" (Sharma *et al*., 2010; Ali *et al*., 2014). Similar to the rest of the cereal crops, maize is too susceptible to a wide variety of abiotic and biotic aspects, the incidence of insect pests being one of them (Shakoor *et al*., 2010). Among these insects, maize stem borer, yield losses owing to *C. partellus* infestation can be up to 33% (Ali and Beshir, 2019). It is a key biotic problem in achieving sustainable maize production worldwide, mainly in Asia and Africa (Arabjafari and Jalali, 2007). As far as *C. partellus* mode of damage is concerned, larval nourishing in the growing areas of maize plants causes "dead hearts", which is important in the initial 2-3 weeks afterward emergence of seedlings (Chouraddi *et al*., 2017). The attack of *C. partellus* is being identified by window panes and pin holes arranged in straight line on attacked leaves which is typical symptom of its attack (Achhami *et al*., 2015). Maize stem borer remains biologically active continuously for the whole year when host plants are present and temperature is encouraging for their population buildup (Siddalingappa *et al*., 2010). Failure of crop occurs by severe pest infestation of

Sharif, S., M. Ali, M. Ashfaq and H. Rehman. 2023. Comparative efficacy of some granular insecticides against maize stem borer, *Chilo partellus* (Swinhoe) under high efficiency irrigation system. Pakistan Journal of Agricultural Sciences. 60: 637-642.
[Received 10Apr 2023; Accepted 17 Sep 2023; Published 11 Dec 2023]

maize stem borer at initial growing phases (Sarwar *et al*., 2012; Vishvendra *et al*., 2017) and eventually at post-harvest period causing yield losses up to 45% (Neupane *et al*., 2016). Management of *C. partellus* is mainly done through application of synthetic insecticides. A diversity of insecticide formulations and chemical composition has been observed an operative for the control of maize stem borer (Kumar *et al*., 2017a; Mahato *et al*., 2023). In Pakistan, many researchers have examined the toxic potential of synthetic insecticides against *C. partellus*. Padan and Furadon have been found very effective against *C. partellus* (Khan *et al*., 2019). Shahid *et al*. (2018) found Fipronil very effective against *C. partellus*. These opposing explanations and the introduction of innovative chemicals in the market demand the evaluation of these compounds for effectiveness against the pest on consistent basis. However, the recurrent use of such types of synthetic insecticides resulted in the loss of insecticides effectiveness against the *C. partellus* and there is need to move towards new insecticides. For efficient *C. partellus* control, the application of insecticides with novel modes of action at a suitable stage of the crop is worthwhile as the pest is a borer (Khan *et al*., 2015). This intellectual and joint use of diverse insecticides strengthens the insecticide resistance management tactic (Gonella and Alma, 2023). Hence applied demonstration of such potential approaches for insect pest management at farmer's field and monetary appraisal of diverse insecticides is indispensable (Bhandari *et al*., 2016). In past, research work, granular insecticides were applied through flood irrigation which usually results in wastage of pesticides. The proposed research trial was conducted to assess the lethal impacts of certain new formulations of insecticides for *C. partellus* control through drip irrigation (Chemigation) and crop water production.

MATERIALS AND METHODS

All the insecticides were purchase from Syngenta Pesticides Company, Punjab, Pakistan. Toxicity bioassays were executed in RCBD design at Water Management Research Farm (WMRF), Renala Khurd, Okara, Latitude: 30° 48' 17.51" N Longitude: 73° 35' 59.99" E, during Kharif season 2021-2022. There were overall six treatments and every treatment was repeated in thrice.

***Crop husbandry*:** The maize variety Pearl-2011was grown as trial crop. Water was applied through drip irrigation system according to crop water requirement. All other crop-raising practices were carried out to ensure healthy crop and no insecticides other than those comprised in the experiment were practiced. The granular insecticides were applied in the leaf whorls afterward 15 days of germination when the crop was more than 4 leaf stage (Khan *et al*., 2020). The area of single experimental unit was 578 m^2. The six treatments were randomly allocated to plots in each replication and were applied through drip (chemigation) and one was kept free of chemical as check.

Table 1. Physico-chemical properties of the soil.

Characteristics	Unit	Value		Status
		0-15 cm	15-30 cm	
Texture	-	Loam		
pH	-	8.00	8.00	Alkaline
EC	dS m^{-1}	1.73	1.71	Non-saline
Total N	%	0.06	0.04	Low
Available P	mg kg^{-1}	7.30	3.80	Low
Exchangeable K	mg kg^{-1}	183.00	155.00	Medium
Organic matter	%	1.15	1.07	Low
Bulk density	g m^{-3}	1.32	1.41	Low

Soil analysis report was acquired from Soil and Water Testing Laboratory, District Okara.

Table 2. Treatments descriptions.

Sr.	Name of Granules	Brand name	Dose/Acre
1	Thimet 5%G	Forait	5kg
2	Cartap hydrochloride 4% G	Padan	9kg
3	Chlorantraniliprole 0.4% G	Fertera (FMC)	4kg
4	Carbofuran 3 G	Furadan	8kg
5	Fipronil 0.3% G	Rigent	4kg
6	Monomehypo5%G	Dilute	7kg

From July until the middle of September, surveillance of insect-attacked plants and dead hearts was conducted by visually counting 10 randomly selected plants from each experimental plot (specifically, from the two middle plant rows of the plot), when they had approximately vanished from the maize crop. Scores applied in maize stem borer infestation were based on 1-9 numeral (with 1 being the highest resistance, no visible attack while 9 under highly infestation). Outcomes hence obtained were pooled into mean insect pest attack of *C. partellus*. Later on, percent insect pest attack/plant and dead heart was calculated.

Treatment effect on insect pest infestation was calculated by formula as given below;

$$\text{Mean plant infestation (\%)} = \frac{\text{Average of infested plants/plot}}{\text{Total number of plants/plot}} \times 100$$

Mean (%) decrease in plant infestation/dead heart was calculated through following formula;

$$\text{Reduction infestation (\%)} = \frac{P_1 - P_{2\ldots}P_5}{P_1} \times 100$$

Where, P_1 = dead heart/ plant infestation in control plot; P_2....P_6= dead heart/ plant infestation/in treated plot

***Crop Water Productivity (CWP)*:** For comparison of CWP, treated plots were irrigated through drip irrigation system while flood irrigation was applied. At harvesting time, crop water productivity was determined by dividing grain yield by total applied irrigation water and is expressed as according (Awan *et al*., 2007) as follows:

$$\text{Water Productivity (kg/m}^3\text{)} = \frac{\text{Grain Yield (Kg/ha)}}{\text{Amount of water applied (m}^3\text{/ha)}} \times 100$$

Population dynamics data: Data of mean insect population was recorded on fortnightly basis and was correlated metrological data, recorded through weather station mounted at WMRF, Renala Khurd, Okara.

Statistical analysis: Results of the research trial were analyzed as a randomized complete block design (RCBD) without sacrilegious the suppositions for the statistical model. The collected data of each parameter were pooled to mean data and analyzed through STATISTIX 8.1. Treatments means were separated through LSD Test at ($P \leq 0.05$), as defined by (Steel and Torrie, 1980).

RESULTS

Data about mean plant infestation (%) in maize owing to *C. partellus* (Table 3) showed statistically significant changes ($p<0.05$) among the different treatments. The plant infestation (%) owing to *C. partellus* in treated plots varied from 2.93-15.08%. The maximum infestation (25.87 %) was noted in untreated experimental plot, followed by (15.08 %) Thimet 5%G plots, trailed by Monomihypo (13.98%), Cartap hydrochloride (12.02 %), Fipronil (8.44%), Carbofuran (6.17%) while the lowermost (2.93 %) was recorded in Chlorantraniliprole applied plot, being the most operative among the selected treatments. Maximum dead hearts (20.41%) were observed in the control plot while the lowermost (1.26%) in Chlorantraniliprole 0.4% G treated plot. Other treatments showed intermediate results.

Table 3. Comparison of lethal effects of granular insecticides against *Chilo partellus*.

Treatments	Mean (%) infestation	Mean (%) dead heart	Infestation reduction (%) over control
Thimet 5%G	15.08 (27.30)	9.12 (15.20)	41.72
Monomihypo 5% w/w	13.98 (23.56)	8.74(13.62)	46.18
Cartap hydrochloride 4%G	12.02 (21.30)	6.02 (10.67)	53.50
Fipronil 0.3% G	8.44 (17.21)	3.86 (9.65)	67.38
Carbofuran 3 G	6.17 (12.36)	2.56 (8.26)	76.13
Chlorantraniliprole 0.4% G	2.93 (9.27)	1.26 (4.78)	88.69
Control	25.87 (41.34)	20.41 (21.56)	-
S.D.m (±)	(4.51)	(2.40)	-
C.D. (P=0.05)	(2.79)	(2.12)	-

*CD= Critical difference, S.D.m= Standard deviation of mean, values in parenthesis are of angular alteration

Results revealed that maximum *C. partellus* infestation (54.18 %) was observed control plot in the last week of August. Among the treated plots, comparatively higher insect attack (40.12%) was observed in experimental plots treated with Thimat %5G trailed by Monomihypo (39.10%), Cartap hydrochloride 4%G (38.21%), Fipronil 0.3% G (23.10%), Carbofuran 3 G (19.16%) while lowest infestation (5.12%) was recorded in case of chlorantraniliprole 0.4% G (29.10%) being the most effective one (Figure 1).

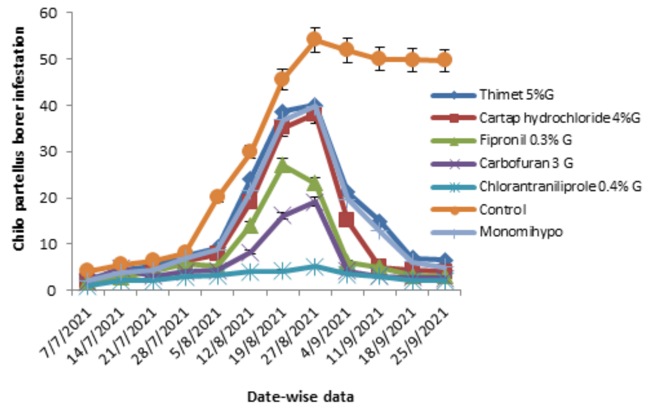

Figure 1. *Chilo partellus* infestation (%) data of Pos-treatment.

Data in Figure 2 showed mean values of *C. partellus* infestation during the studied months. Maximum *C. partellus* infestation (37.47%) was recorded in untreated plots in the month of August, followed by September (34.11%) whereas comparatively less infestation (6.04%) was observed during July. Maximum mean insect attack in the 3 months was observed in control while comparatively lowest was noted in plots treated with Chlorantraniliprole 0.4% G.

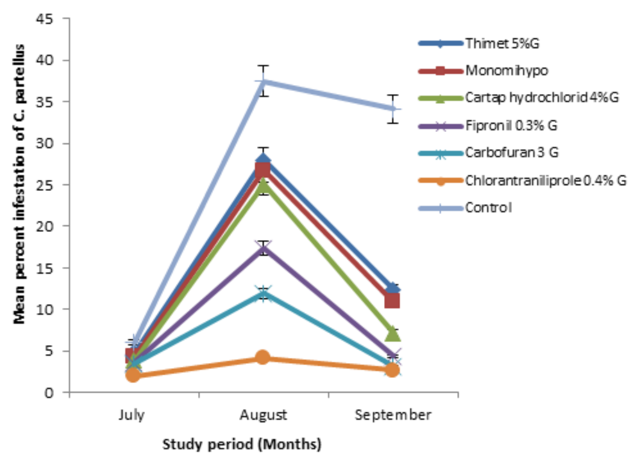

Figure 2. Monthly post-treatment data of *Chilo partellus* infestation.

Data showed that the highest water productivity (2.58 kg/m^3) was calculated in the case of Chlorantraniliprole 0.4% G treated plots, while a comparatively low (1.80 kg/ m^3) was noted in the case of Thimat 5% treated plots under drip irrigation system but was superior to control plot (1.29 kg/ m^3) under flood irrigation system (Fig. 3).

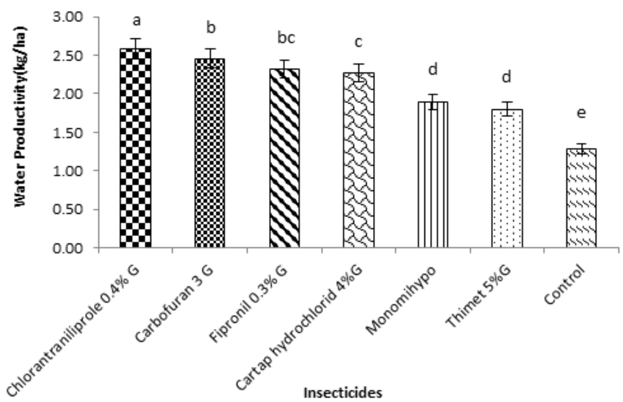

Figure 3. Comparison of crop water productivity values of the different experimental plots.

There was variation in population dynamics and insect pest attacks at different values of temperature and relative humidity. Maximum insect attack (15.10%) was noted at a temperature of 42.30 ºC and a relative humidity 67.10%. The lowermost insect attack i.e., 5.12% was noted at a temperature of 38.4 ºC and relative humidity of 62.1% (Table 3).

Table 4. Mean seasonal occurrence data of *C. partellus* population dynamics

Date	Mean insect population (%)	Climatological data	
		Mean temperature (ºC)	Relative humidity (%)
14-7-2020	5.12	38.4	62.1
30-7-2020	8.21	39.0	64.3
15-8-2020	14.30	41.6	65.5
30-8-2020	15.10	42.3	67.1
15-9-2020	9.41	36.4	52.7
30-8-2020	7.45	35.1	50.3

DISCUSSION

Numerous research workers evaluated the efficacy of numerous foliar as well as granular insecticides against *C. partellus* on maize in various maize growing regions, worldwide (Anuradha *et al*., 2013; Kulkarni *et al*., 2015). The data attained with Carbofuran 3 G among the many insecticides in the current research work is approximately close to Kulkarni *et al*. (2015) and Kumar and Jindal (2015). Outcomes of my study showed that 7.23% value of mean insect attack was observed in un-treated plot by Carbofuran 3 G at rate of 8 kg/acre are supported by Kumar and Alam (2017b) i.e., 10.60% mean insect attack in case of Chlorantraniliprole (20 SC). Minor change in findings may be owing to changed level of applications. However, findings of my study are dissimilar to results of some researchers too. Like Radha defined that Chlorantraniliprole 0.4% G was superior in effectiveness against *C. partellus* as compared to other tested insecticides. Singh *et al*. (2014) noted that cypermethrin was the highly operative against *C. partellus*. Insect pest attack in crops reduced the crop yield resultantly the crop water productivity also affected. Results crop water productivity in current research were supported by Ngelenzi *et al*. (2019) whom also noted increased crop water productivity in less attacked crop plots compared with plot under more insect pest attack. Abiotic factors like relative humidity, temperature etc. affects the population dynamics patterns of insect pests. Evaluating the population fluctuation showed increase in *C. partellus* population as the temperature and humidity got increased but up to certain limit, alike was revealed in results of my study. My results were corroborated by Barbiani, (2003) studied the population incidence on various maize genotypes and recorded augmented population occurrence during the mid and last of August. However, our results were contrary to findings of Hemerik *et al*. (2004) who executed investigation on aphid occurrence on crop and recorded augmented population in April rather than in August. This difference in values of insect pest attack owed to change in insect species in the both research trials. Khan *et al*. (2019) assessed the comparative efficacy of some insecticides excluding Chlorantraniliprole 0.4% G and found Furadon to be the most effective, which was the most effective one in our research work. Results of our research work were in line with those of Sidar *et al*. (2017) attained a decrease in plant damage and dead hearts caused by *C. partellus* by the application of Carbofuran (3.00) and some other granular insecticides. Results of our research work were contradictory with Neupane *et al*. (2016) whom found spinosad the most effective. The difference was be due to different geographical and ecological conditions. Decrease in insect infestation as was recorded in our research trial was recorded by Javed *et al*. (2018) whom tested the entomocidal impacts of some synthetic insecticides against Lepidopterous Borers and found emamectin benzoate the most promising. However, there was difference in mean infestation values which might de due to change of insect species and insecticides. Kaçar *et al*. (2023) noted that application of granular insecticides reduced the *Sesamia nonagrioides* and *Ostrinia nubilalis* infestations which supported our results. However, the values were not close to our research work which might be due to difference in insect species and climatological conditions.

Effect of temperature is very important in the life-cycle of an insect including *C. partellus*. The life-span is mainly dependent on climatic situations, particularly relative humidity and temperature (Mutamiswa *et al*., 2019). Panchal and Kachole (2013) described life history limitations of *C. partellus* and noted variation in the insect population at different temperature and relative humidity ranges as was recorded in our research work. The insect can survive both extended high and low temperatures due to its thermal tolerance and interactions between temperature and relative humidity (Mutamiswa *et al*. 2020).

***Conclusion*:** From the results of current research work, it can be concluded Chlorantraniliprole 0.4% G was the most effective insecticide while Thimat %5G was the effective. In the case of dead heart results, again Chlorantraniliprole 0.4% G over the most effective in reducing dead heart, was the next most effective one over the control plots. Thimat %5G was noted as the least effective among all the insecticides yet better than control. Abiotic conditions like temperature and humidity boosted the *C. partellus* infestation, especially during the last week of August. Application of these new insecticides, especially Chlorantraniliprole 0.4% G, can abridge *C. partellus* population density, leading to increased crop water productivity.

***Conflict of Interest*:** The Authors declare that there is no conflict of interest

***Authors' Contribution Statements*:** M.A designed the research work, S.S and H.R. conducted the experiment and wrote the manuscript. M.A done proof reading of the manuscript.

REFERENCES

Achhami, B.B., B.K.S. Bahadur and G.S. Bhandari. 2015. Assessment of maize stem borer damage on hybrid maize varieties in Chitwan, Nepal. Journal of Maize Research and Development 1:53-63.

Ali, N., G. Singh, S.P. Singh, S.S. Dhaka, M. Ram and K.B. Tawar. 2014. Efficacy of different management practices against *Chilo partellus* (Swinhoe) in Kharif maize in Western Uttar Pradesh. International Journal of Advanced Research 11:952-956.

Akhter, A. and A. Beshir. 2019. Economic impact of maize stem borer (*Chilo partellus*) attack on livelihood of maize farmers in Pakistan. Asian Journal of Agriculture and Biology 7:311-319.

Arabjafari, K.H. and S.K. Jalali. 2007. Identification and analysis of host plant resistance in leading maize genotypes against spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). Pakistan Journal of Biological Sciences 10:1885-1895.

Awan, T.H., T.H. Awan, R. Ali and Z. Manzoor. 2007. Screening of rice varieties suitable for direct seeding in Punjab. Journal of Animal and Plant Sciences 1-2:24-26.

Barbiani, G. 2003. High temperature and drought reduce many maize pests in Friuli. Notiziar Ersa 16:8-15.

Bhandari, G., B.B. Achhami, S. Neupane and S.D. Sharma. 2016. Differential resistance reaction of maize genotypes to maize stem borer (*Chilo partellus* Swinhoe) at Chitwan, Nepal. Journal of Maize Research and Development 23:133-143.

Chouraddi, M. and C.P. Mallapur. 2017. Assessment of crop loss and economic injury level of maize stem borer, *Chilo partellus* (Swinhoe). Journal of Entomology and Zoology Studies 4:1530-1535.

Farhadi, A., Y. Fakhri, R. Kachuei, Y. Vasseghian, E. Huseyn and A. Mousavi Khanegha. 2021. Prevalence and concentration of fumonisins in cereal-based foods: a global systematic review and meta-analysis study. Environmental Science and Pollution Research 17: 20998-21008.

Gonella, E. and A. Alma. 2023. The Role of Symbiont-Targeted Strategies in the Management of Pentatomidae and Tephritidae Pests under an Integrated Vision. Agronomy 13:868.

Hemerik, L., C. Busstra and P. Mols. 2004. Predicating the temperature dependent natural population expansion of the western corn root worm. Entomologia Experimentalis et Applicata 111:59-69.

Iqbal, A., M.A. Iqbal, M.F. Awad, M. Nasir, A. Sabagh and M.H. Siddiqui. 2021. Spatial arrangements and seeding rates influence biomass productivity, nutritional value and economic viability of maize (*Zea mays* L.). Pakistan Journal of Botany 3:967-973.

Javed, M., M.Z. Majeed, M. Sufyan, S. Ali and M. Afzal. 2018. Field efficacy of selected synthetic and botanical insecticides against lepidopterous borers, *Earias vittella* and *Helicoverpa armigera* (Lepidoptera: Noctuidae), on Okra (*Abelmoschus esculentus* (L.) Moench). Pakistan Journal of Zoology 50:2019-2028.

Kaçar, G., A. Butrón, D. Kontogiannatos, P. Han, M.F.G. Peñaflor, G.P. Farinós,... and K. Haddi. 2023. Recent trends in management strategies for two major maize borers: *Ostrinia nubilalis* and *Sesamia nonagrioides*. Journal of Pest Science 96:879-901.

Khan, I.U., M. Nawaz, F. Said and K. Sohail. 2015. Integrated pest management of maize stem borer, *Chilo partellus* (Swinhoe) in maize crop and its impact on yield. Journal of Entomology and Zoology Studies 5:470-472.

Khan, Z., Q. Ain, A. Raqib, M.S. Khan and L. Xing. 2020. Effectiveness of Granular and Liquid Insecticides against *Chilo partellus* on Maize in Pakistan. Polish Journal of Environmental Studies. 1:641-651.

Kumar, A. and A. Kumar. 2017a. Field efficacy of seven insecticides against *Chilo partellus* (Swinhoe) on maize (*Zea mays* L.) in Allahabad. Journal of Entomology and Zoology Studies 5:46-48.

Kumar, R. and T. Alam. 2017b. Bio-efficacy of some newer insecticides against maize stem borer, *Chilo partellus* (Swinhoe). Journal of Pharmacognosy and Phytochemistry 3:15-20.

Mahato, S., R.H. Naik, M. Bheemanna, M.S. Pallavi, S. Hurali, S.N. Rao,...and M. Paramsivam. 2023. Determination of chlorantraniliprole 18.5% SC in the paddy ecosystem and its risk assessment. Scientific Reports. 13:5464.

Mutamiswa, R., H. Machekano, F. Chidawanyika and C. Nyamukondiwa. 2019. Life-stage related responses to combined effects of acclimation temperature and humidity on the thermal tolerance of *Chilo partellus* (Swinhoe)(Lepidoptera: Crambidae). Journal of Thermal Biology 79:85-94.

Mutamiswa, R., H. Machekano, C. Nyamukondiwa and F. Chidawanyika. 2020. Host plant-related responses on the thermal fitness of *Chilo partellus* (Swinhoe)(Lepidoptera: Crambidae). Arthropod-Plant Interactions 14:463-471.

Neupane, S., G. Bhandari, S.D. Sharma, S. Yadav and S. Subedi. 2016. Management of stem borer (*Chilo partellus* Swinhoe) in maize using conventional pesticides in Chitwan, Nepal. Journal of Maize Research and Development 2:13-19.

Ngelenzi, M.J. O.J. Otieno and S. Mwanarusi. 2019. Improving Water Use Efficiency and Insect Pest Exclusion on French Bean (Phaseolus vulgaris L.) Using Different Coloured Agronet Covers. Journal of Agricultural Science 3:159-171.

Panchal, B.M. and M.S. Kachol. 2013. Life cycle of *Chilo partellus* (Swinhoe)(Lepidoptera: Pyralidae) on an artificial diets. International Journal of Plant, Animal and Environmental Sciences 3:19-22.

PARC, 2021. http://www.pakissan.com/english/allabout/crop/maize.shtml.

Shahid, M.I., M. Ishfaq, M. Ayub and F. Hafeez. 2018. Effectiveness of pesticides against maize stem borer in Sahiwal (Punjab, Pakistan). Journal of Entomology and Zoology Studies 6:348-351.

Sarwar, M. 2012. Management of rice stem borers (Lepidoptera: Pyralidae) through host plant resistance in early, medium and late plantings of rice (*Oryza sativa* L.). Journal of Cereals and Oilseeds 3:10-14

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

Shakoor, U., M. Rashid, A. Saboor, N. Khurshid, Z. Husnain and A. Rehman. 2017. Maize production response to climate change in Pakistan: A time series assessment. Sarhad Journal of Agriculture 2:320-330.

Shelton, A.M. and F.R. Badenes. 2006. Concepts and applications of trap cropping in pest management. Annual Review of Entomology 51:285-308.

Siddalingappa, C., V. Thippeswamy, Hosamani and S. Yalavar. 2010. Biology of maize stem borer, *Chilo partellus* (Swinhoe) (Crambidae: Lepidoptera) International Journal of Plant Production 3:91-93.

Sidar, Y.K., S. Deole, R.K. Gajbhiye and A. Nirmal. 2017. To evaluate the bioefficacy of granular insecticide molecules against pink stem borer. Journal of Entomology and Zoology studies 5:1114-1120.

Singh, A., A. Kumar, A. Dwivedi and P.K. Mishra. 2014. Management of stem borer, *Chilo partellus* (Swinhoe) on maize crop. Progressive Research 2:284-286.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw Hill Book. Co. Inc., New York. 336-6.

Tariq, M. and H. Iqbal. 2010. Maize in Pakistan–an overview. Agriculture and Natural Resources 5:757-763.

Tefera, T., S. Mugo, R. Tende and P. Likhayo. 2011. Methods of Screening Maize for Resistance to Stem Borers and Post-harvest Insect Pests. CIMMYT. Nairobi, Kenya. pp.1-30.

Vishvendra, D.V., S. Kumar, R. Kumar and V. Vaibhav. 2017. Screening of Maize Cultivars against Maize Stem Borer *Chilo partellus* (Swinhoe), under Natural Field Condition. International Journal of Current Microbiology and Applied Sciences 10:1463-1470.