Research Article

Comparative Biocidal Potentials of Some Synthetic Insecticides against Maize Stem Borer, *Chilopartellus* (Swinhoe) under Field Conditions

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Abstract | Crops are prone to being attacked by various insect pests resulting in huge crop yield losses. Maize (*Zea mays* L.) the utmost yielding cereal crop worldwideis attacked by several insects, *Chilopartellus*(S) is the devastating one. The current study was conducted to probe the toxic effects of Chlorpyriphos 40 EC@500ml/acre, Padan 3% G (Cartaphydorchloride) @ 9 kg/acre, Carbofuran 3% G@8kg/acre, Monomehypo 5% G@7kg/acreand Fipronil 0.3% G@8kg/acre against *Chilopartellus*(S.). Recommended dose rates of all the insecticides were applied. Results of mean percentcropinfestation showed that the highest infestation (40.51 %) was observed in the control plot while the lowermost (5.23 %) was recorded in Chlorpyriphos 40% EC treated plot, being the most effective among all. In the case of mean reduction data over control, the highest reduction in plant infestation (96.08%) and no of dead hearts (93.65%) was noticed inthecase of Chlorpyriphos 40% EC while the lowermost infestation reduction i.e. 55.12% was noted in case of Fipronil 0.3% G treated plots. Results of mean infestation values of *C. partellus* depicted that maximum mean infestation was 72.11% and 59.11%was noted in control during the peak population months, August and September. Results of population dynamics with abiotic conditions revealed that highest population i.e. 17.10% recorded at 42.1 °C at 67.1 % relative humidity. Overall results concluded that the population of the *C. partellus* can be effectively controlled by the integration of Chlorpyriphos 40% EC into the Integrated Pest Management program.

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Introduction

Maize (*Zea mays* L.) the highest yielding cereal crop worldwide, is of prime significance for countries in Pakistan, where the rapidly snowballing population has now outstripped the existing food deliveries. After rice and wheat, maize ranks as the 3rd most significant cereal. Maize accounts for 4.8% of

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the entire cultivated area and 3.5% of the value added to agricultural production. It is being sown on an assessed area of 0.9 million hectares witha yearly yield of 1.3 million tons (Khan *et al*., 2021). It can be grown in nearly every proper agro-ecological area throughout the world at varying degrees of achievement. Due to its highest yielding potential among all the cereals, maize is referred to as the "Queen of cereals" (Sharma and Gauta, 2010; Ali *et al*., 2014). Like other cereal crops, maize is also liable to a broad range of biotic andabiotic factors, the occurrence of insect pests being one of them (Shakoor *et al*., 2017; Ali *et al*., 2021). Among the numerous insect pests, maize stem borer, ChilopartellusSwinhoe (Lepidoptera: Pyralidae) is an important pest,resulting in 90-95 % of the entire injury in the Kharif season (Jalali and Singh, 2002). It is among the main biotic constraints on the fruitful production of sorghum and maize throughout the world,predominantly in Africa and Asia (Arabjafari and Jalali, 2007). *C. partellus* caused 10-50 percent of damage in the Peshawar valley (Farid *et al*., 2007). Infestation of the insect pest is recognized by window panes and pinholes. The crop fails entirely owing to the austere attack of this insect pest at the early growing stages and finally at the post-harvest stage (Sarwar, 2012; Vishvendra *et al*., 2017).

For the effective control of *C. partellus*, the use of operative chemicals with a diverse mode of action at the appropriate stageof the crop stage is important (Samantha *et al*., 2007; Khan *et al*., 2015) but the main problem is resistance development against insecticides (Khawar *et al*., 2020) and some time pest skip from the intact with insecticide due to weeds in the field (Munir *et al*., 2020). Intelligent use of combined diversified insecticides reinforces theinsecticide resistance management approach (Sparks *et al*., 2001; Akob and Ewete, 2007; Qiao *et al*., 2007). Therefore practical demonstration of such promising toolsforinsect pest management in farmers' fields and economic evaluation of dissimilar insecticidal treatment is essential (Cugala *et al*., 2006; Bhandari *et al*., 2016) A wide range of insecticide chemistries and preparations have been used to control this insect pest (Saeed *et al*., 2006). Liquid and granular type of insecticides have been found effective against *C. partellus* (Khan *et al*., 2020). Granular formulations of carbofuran and chlorpyriphos were described as operative against the pest by Bhat and Baba (2007). Ahmad *et al*. (2002) assessed found few bio-insecticides very effective against, *C. partellus* (Lepidoptera: Pyralidae). Use of endosulfan and carbofuran as seed protectants with has been described as useful for the control of the pest (Mashwani *et al*., 2015). The objective of the study was to evaluate the effectiveness and resistance of innovative chemicals in the market against the pest on a consistent basis and used integrated pest management of Chilopartellus(s).

Keeping in view, the present research trials were planned to probe the toxic impacts of some formulations of insecticides for the control of *C. partellus*.

Materials and Methods

The relative efficacy of the below-mentioned insecticides as the granular and foliar application was ascertained under field conditions in RCBD design at Water Management Research Farm, Renala Khurd, Okara, Pakistan.

Table 1: *Treatments descriptions.*

Treatments	Treatment description	Dose rate
1	Chlorpyriphos 40EC	500ml acre^{-1}
2	Padan®3G –Cartap	9 kg acre^{-1}
3	Carbofuran 3 G	8 kg acre^{-1}
4	Monomehypo®- 5G	7 kg acre^{-1}
5	Fipronil 0.3% G	8 kg acre^{-1}
6	Control	--

There were six treatments in total (Table 1) and each treatment was replicated three times. The maize variety DKL-30T60 was cultivated as an examination crop. The plant-to-plant and row to row distance were maintained at 60×25 cm in a plot dimension of 4×3 m2. The recommended doses of the insecticides were applied by knapsack sprayer (in case of SC formulation) and physically with hands. All the crop-growing practices were trailed to sustain good crop growth and no insecticides other than those comprised in the experiment were applied.Irrigation was done using a cut-throat flume to avoid water losses. The first application was done 15 days afterward, sowing as a foliar spray in all treatments. whereas the second application was done 30 days after sowing. In these applications, T_4 is used as spray while, treatments T_1, T_2, T_3, and T_5 were used in granular form as whorl applications. Insect-affected plants and dead hearts were monitored by visually counting ten randomly selected plants from each plot (i.e. from the four

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central rows of each experimental plot) on a weekly basis from July until the middle of September when they had nearly disappeared from the crop field (Zulfiqar *et al*., 2010). The results thus attained were combined together to get an average plant infestation instigated by *C. partellus*. Based on these notes, the average plant attack and dead heart were computed.

Treatment impact on insect pest attack was further found using the formula (Kamala *et al*., 2012).

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

The average percent reduction in plant infestation/ dead heart reduction over control was computed as under.

$$\text{Plant infestation reduction (\%)} = \frac{P_1 - P_{2....}P_6}{P_1} \times 100$$

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

Afterward harvesting of the crop, seed produce was noted from each plot and transformed in to quintal ha^{-1}. The supplementary yield over the control plot was too computed for appraisal of yield performance of diverse treatments by means of the following formula:

$$Y_1 - Y_{2....}Y_6$$

Where;
Y_1= seeds producedin control, Y_2....Y_6= seeds produced in treated plots.

The cost-benefit (C:B) ratio was computed by keeping in mind the prevalent market price of spraying cost, insecticides and maize benefit-costs ratio was computed as follows.

$$\text{B: C ratio} = \frac{\text{Benefit over control}}{\text{Cost of treatments}} \times 100$$

Results and Discussion

The present research work was executed to probe the toxic effects of some granular insecticides and a liquid formulation against Chilopartellus. The results of the mean plant infestation (%) in maize caused by *C. partellus* (Table 2) revealed notable differences between the altered treatments under investigation. The average plant infestation (%) caused by C. partellus ranged from 5.23 to 40.51%. The highest infestation (40.51 %) was observed in the control plot, trailed by (18.10 %) Fipronil, 0.3% Gplotstrailed by Carbofuran 3G (15.34 %) while the lowest (5.23 %) was recorded in Chlorpyriphos 40EC treated plot, being the most effective among all. In the case of mean reduction data over control, the identical trend of relative effectiveness was recorded i.e. the highest reduction in plant infestation (96.08%) and dead hearts (93.65%) noticed in the case of Chlorpyriphos 40EC. Overall, the results revealed that all insecticidal treatments maintained their superiority over the control experimental plot in decreasing *C. partellu* infestations, though this varied significantly among themselves. Numerous researchersevaluated the effectiveness of many insecticides used as granular and foliar applications against *C. partellus* on maize diverse maize-growing parts of the world (Ahmad *et al*., 2002; Jalali and Singh, 2002; Anuradha *et al*., 2010; Kulkarni *et al*., 2015; Kumar and Kumar, 2017). Among the many insecticides studied in this study, the data obtained with Monomehypo 5G is roughly comparable to that obtained by Kulkarni *et al*. (2015) and Kumar and Alam (2017). Results of current research work depicted that 7.23% mean plant infestation was noted in plot treated with Monomehypo®-5G assupported by Kumar and Alam (2017) i.e. 10.60% mean infestation in the treated plot. A slight difference in value may be due to different levels of application. The results of my research work are different from the results ofa few research workers as well. Khan *et al*. (2020) described that granular insecticide carbofuran 3G was noticed as the most effective amongst all tested insecticides while in my research work, Chlorpyriphos 40EC was superior ineffectiveness against *C. partellus*. Singh *et al*. (2014) found that cypermethrin was highly effective against *C. partellus*.

The highest mean reduction of plant infestation and dead hearts (96.08%) was observed in experimental plots treated with Chlorpyriphos 40EC, followed by 92.67% (Monomehypo®-5G), 86.10% (Padan®3G-Cartap), and 80.52% (Carbofuran 3 G), while the lowest most reduction, i.e., 55.12%, was observed in plots treated with Fipronil 0.3% G (Table 2). Results (Figure 1) demonstrated *C. partellus* infestation was highest (86.14%) in untreatheted plot (control)

Table 2: *Impact of different insecticides on mean infestation resulted by Chilopartellus in the whole period of maize crop.*

Treatments	Mean(%) infestation	Mean (%) dead heart	Mean reduction over control	
			Plant infestation	Dead heart
Fipronil 0.3% G	18.10 (27.56)	11.78 (17.45)	55.12^{e}	41.78^{e}
Carbofuran 3 G	15.34 (24.06)	8.12 (10.57)	80.52^{d}	73.94^{d}
Padan®3G –Cartap	10.45 (18.89)	6.29 (13.35)	86.10^{c}	78.56^{c}
Monomehypo®–5G	8.67 (12.40)	3.10 (11.24)	92.67^{b}	89.47^{b}
Chlorpyriphos 40EC	5.23 (10.90)	1.12 (4.79)	96.08^{a}	93.15^{a}
Control	40.51 (50.17)	17.42 (23.59)	-	-
S.E.m (±)	(2.89)	(2.32)		
C.D. (P=0.05)	(2.26)	(1.16)		

**CD= critical difference; S.E.m= standard error of mean; values in parenthesis are of angular alteration; Treatments means were significant (P<0.05) at significance level=5%.*

Table 3: *Cost-benefit analysis of insecticides used as crop protectant.*

Treatments	Yield (q/ha)	Supplementary yield (Rs/ha)	Price of supplementary yield (Rs/ha)	Cost of treatment (Rs/ha)	Benefit	B:C
Fipronil 0.3% G	23.0	8.92	11265.1	1805	9572.4	5.30:1
Carbofuran 3 G	27.98	12.87	17645.6	1710	15526.4	9.07:1
Padan®3G –Cartap	30.2	15.7	21564	2420	19706	8.14:1
Monomehypo®–5G	37	22.1	30264.2	3165	27421.6	8.66:1
Chlorpyriphos 40EC	46	31.2	42876.3	2906	36416.2	12.53:1
Control	15.20	-	-	-	-	-

at the end of August compared to treated plots. Among the treatments, the relatively highest percent infestation (41.69%) was recorded in fiprfipronil-treatedts trailed by Carbofuran (36.78%), Padan®3G –Cartap (28.64%), Monomehypo®–5G (17.09%) while Chlorpyriphos 40EC proved the most effective (4.8%) at the end of last week of August.

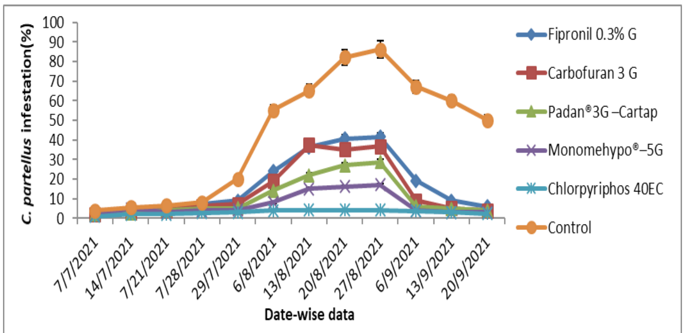

Figure 1: *Weekly data of Chilopartellus infestation afterward application of different insecticides.*

Data (Figure 2) displayed mean infestation values of *C. partellus* during the study months. The highest mean infestation (72.11%) was noted in control during the peak population month (i.e. August), trailed by September (59.11%) while the relatively low (8.52%) was recorded in the month of July. In treated plots, highest mean monthly infestation during the three months was noted infipronil treated plots, whereas the relatively lowermost was observed in Chlorpyirfos 0.6% G treated plots in the three months. Similarly, Hemerik *et al.* (2004) conducted research on aphid incidence on crops and noted an increased population trend with decrease in temperature as was observed in my study. While Tefera *et al.* (2011) described the development of post harvest insect pest attacks on maize crop temperature and humidity increases. The findings of Haq *et al.* (2018) also coincide with our current research suggesting that Chlorpyrifos have strong biocidal potential against maize stem borer

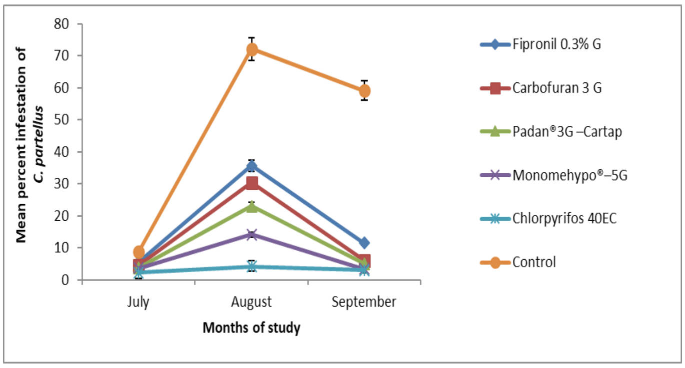

Figure 2: *Monthly data of Chilopartellus infestation afterward application of different insecticides.*

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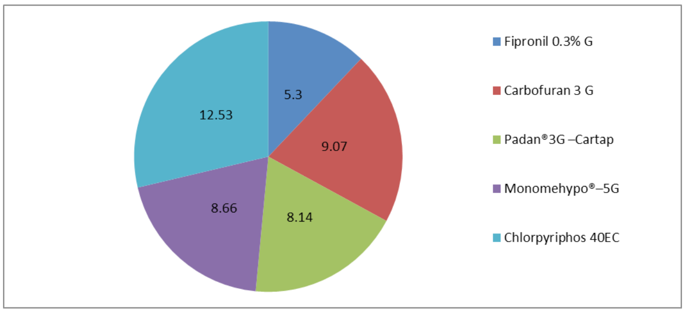

Figure 3: *Economics of different insecticides practiced for the control of Chilopartellus.*

Table 4: *Mean seasonal occurrence of Chilopartellusinfestation during the study period.*

Date	Insect population (%)	Meteorological data	
		Mean temperature (°C)	Main relative humidity (%)
15-7-2020	7.12	37.4	62.1
30-7-2020	9.35	38.0	64.3
15-8-2020	15.56	41.6	65.5
30-8-2020	17.10	42.1	67.1
15-9-2020	9.87	36.3	52.7

The highest population, 17.10%, was observed at 42.1 °C and 67.1% relative humidity (R:H), while the lowest population, 7.12%, was observed at 37.4°C and 62.1% r.h. The highest infestation, 20%, was noted at a temperature of 33.2°C and relative humidity of 50% (Table 4). Zulfiqar *et al.* (2010) conducted research on assessing the population dynamics and noted an upsurge in the *C. partellus* population as the temperature decreased, similar as to what was observed in my research work. Resultswere confirmed by Barbiani (2003), who examined the population dynamics on different maize varieties and noted increased population incidence as the temperature decreased at the end of September. Similarly, Shelton and Badenes (2006) also gave similar results on the development of natural aenemiesies and insepestsest of the maize crop. However, the values of insect pest infestations were different, which may be due to differences in insect species compared to my study.

Conclusions and Recommendations

Among the tested insecticides against *C. partellus* in the study, Chlorpyriphoshas been found most effective of all the tested insecticides in term of density reduction and decline in percent infestation of crop. Furthermore it can be concluded that Chlorpyriphos 40EC and Monomehypo®–5G can abridge the *C. partellus* population density in An eco-friendly way as well as the probability of resistance development in an insect.

Novelty Statement

The experimental results predicted that the population of the *C. partellus* can be effectively controlled by the integration of Chlorpyriphos 40%EC into the Integrated Pest Management program.

Author's Contribution

QA: design and supervises the trial.
MA, MU and AA: Execute the trial.
MFA, MUQ, and HR: Wrote the research article.
IH and AA: Statistical analyzed the data.
MY: Provided helpful material for experiment.

Conflict of interest

The authors have declared no conflict of interests.

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