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Economic evaluation of biorational and conventional insecticides for the control of maize stem borer *Chilo partellus* (Swinhoe) in *Zea mays*

Ravinder Kumar* and Jawala Jindal

Maize section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana (Punjab), INDIA

*Corresponding author. Email: drravinderchandel@pau.edu

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Abstract: Maize borer, *Chilo partellus* (Swinhoe) is the chief limiting factor for higher corn production. Field trials to assess the efficacy of different insecticides against *C. partellus* were carried in district Ropar, Punjab. It was observed that significantly lesser leaf injury incidence was recorded in biorational treatment T_1: chlorantriniliprole 18.5 SC (3.43 & 4.23) in comparison to broad spectrum conventional insecticide treatment T_3: Deltamethrin 2.8 EC (4.63& 5.36) and T_4 :Farmer's practice 4.43 and 6.93. Whereas in plots with parasitoid application (T_2), the leaf injury incidence was recorded to be 6.56 & 7.86 during 2012 and 2013, respectively. Though T_2 was statistically superior to control, however it was not at par with insecticide treatments. Furthermore similar trend was observed for deadhearts reduction in different treatments. It was recorded to be 3.16 and 3.90, 3.33 and 3.96, 3.53 and 3.96 in insecticide treatment plots T_1, T_3 and T_4 respectively. The economic returns on the basis of marketable grain yield in insecticide treated plots was more in T_1 followed by T_3 and T_4 (51.99, 49.58 and 48.51) in comparison to control (40.44) and biological control plots (46.75). Therefore experimental data revealed overall superiority of biorational pesticide in comparison to conventional insecticides for reduction in pest damage and economic returns. Hence the option of biorational for the control of maize stem borer not only justify safety to environment but also offers effective control of borer population in maize ecosystem due to its distinct chemical class and unique mode of action.

Keywords: Biorational, *Chilo partellus,* Chlorantriniliprole, Maize borer, Trichogramma

INTRODUCTION

The maize crop yield in India lags behind leading corn producing countries of the world in terms of productivity. Insects hitherto unknown to attack the maize crop now inflicts significant losses. At present total losses inflicted by different insect pests and diseases at different growth stages of the crop has been estimated in the order of 13.2 % under varied climatic conditions in India (Kumar *et al*, 2014) The maize stem borer, *Chilo partellus* (Swinhoe) is a key pest and reported to cause 7.0–35.7 per cent loss in grain yield in different agro-climatic regions of India (Anonymous, 2013). For its sound management strategy, effective chemicals and their timing of application (early whorl stage) is significant as this pest is internal feeder and control at later stage offers narrow scope for chemical control, In recent years as a part of pest management strategy, various methods of pest control have been developed to check the economic losses with more emphasis on new chemistry molecules, biological control and agronomic manipulations *etc*. The traditional insecticides like deltamethrin, fenvalerate, cypermehtrin, monocrotophos and carabryl *etc*. are in use over decades and to strengthen insecticide resistance management strategy, effective and environmentally safe insecticides with novel mode of actions should be focused. Chlorantraniliprole 18.5 SC is a new chemistry belonging to anthranilamide group having unique mode of action in muscle disruption and has been found effective against many lepidopteron insect pests (Hannig *et al*., 2009) and safer to beneficial organisms (Marchesini *et al*., 2008). Further the egg parasitoid *Trichogramma chilonis* Ishii has been found to be effective and economical at early whorl stage of the crop growth (Jalai and Singh 2003). This technology is also recommended in Punjab state by Punjab Agricultural University as a component of IPM strategy. Therefore, to demonstrate these promising tools of pest management at farmer's field and economic comparison of different insecticide treatments (biorational vs conventional) the present study was undertaken in the form of on-farm trials with the intent to demonstrate and validate the control efficacy of new insecticide treatment at farmer's field and also to provide a choice of effective as well as safer insecticide for the management of *C. partellus* for sustainable maize production.

MATERIALS AND METHODS

The present study about evaluation of different insecticides and their comparative economics, consisted four insecticide treatments including two biorational insecticides (T_1 and T_2) and two conventional chemical insecticides

(T_3 and T_4). The various treatments thus encompasses T_1 : Chlorantriniliprole 18.5 SC (@ 75 ml per hectare); T_2 : biological control with Tricho cards (@ 100,000 *Trichogramma chilonis* parasitised eggs of *Corycra cephalonica* per hectare on 14 days old crop); T_3 : Deltamethrin 2.8 EC @ 200 ml sprayed on 14 days old crop as a standard check and T_4: Farmer's practice (Lara @ 250 ml, a mixture insecticide formulation with Chlorpyriphas 50% + Cypermethrin 5%) sprayed on crop at the appearance of dead hearts and T_5 : untreated control. These studies were conducted in *kharif* seasons during 2012 and 2013 in the form of 5 (five) On-farm trails at farmer's field in five different blocks of district Ropar in Punjab. Thus in each location, an area of one acre was divided into five sub-plots (800 m^2 each) representing five treatments each having three replicates within the sub-plot. The various treatments were applied to each sub plot at 14 days after germination except in plots with farmer's practice treatment (T_4). The observation were recorded at 7 and 14 days after spray as well as 0 day (before spray), At harvest the yield was recorded in each treatment plots and converted to hectare basis. The data on borer damage in the form of per cent incidence of leaf injury and dead hearts incidence was estimated by randomly examining 100 plants in each treatment plot at 3 sub sampling. The mean data of all the locations was pooled and statistical analysis was conducted with two way analysis of variance where means were separated by Least square difference LSD values. (Gomez & Gomez, 1984) The comparative increase in grain yield and cost benefits ratio (increment grain yield and B:C ratio) was calculated by subtracting market value of grain yield under different treatments - market value of grain yield in control taking into account the prevailing market price of produce, inputs and labour charges.

RESULTS AND DISCUSSION

Leaf injury incidence: The incidence of leaf injury due to natural infestation of *C. partellus* was recorded 14 days after spray in different treatment plots during the year 2012 and 13 as presented in Table1. The leaf injury in different treatments *viz* Biorational, T_1: (3.43 & 4.23) was significantly better ($p = 0.05$) in comparison to conventional insecticide T_3: (4.63 & 5.36) and T_4 : 4.43 and 6.93. However in T_2 : the leaf injury incidence was 6.56 and 7.86 in 2012 and 2013 respectively and significantly superior ($p = 0.05$) to T_5 : control, but it was not at par with insecticide treated plots.

Dead hearts incidence: The incidence of dead hearts as presented in Table 2, recorded 14 days after spray during 2012 and 2013 was 3.16 and 3.90, 3.33 and 3.96, 3.53 and 3.96 in T_1, T_2 and T_3 respectively. The Bio-rational and chemical treatments performed equally promising for reduction in dead hearts but were statistically superior to control plots. The plots receiving parasitoid release (T_2) recorded 5.14 and 4.90 dead hearts incidence as compared with control 14.16 and 18.53. The overall means of all data parameters during both years as presented in Figure 1 and 2 recorded dead hearts incidence in the range of 3.72- 4.84 in different treatments over control (8.85) during the 2012 and 3.76-5.09 as compared with 14.74 in control during the year 2013.

Grain yield: The crop yield in the form of grain output in each treatment on plot basis and converted to hactare basis (q/ha) and presented in Table 3 revealed the similar pattern with higher yield in plots T_1 (52.23 and 51.76 q/ha) followed by T_3 and T_4 (50.50 and 48.66; 49.70 and 47.33 q/ha) respectively during two years of study period. In plots with biological control treatment also yield was (47.40 and 46.10 q/ha) significantly better ($p=0.05$) than control (40.73 and 40.16 q/ha) thus all the treatments indicated their superiority in better yield realization as compared with control.

Economic analysis : The untreated plots had statistically lower grain yield as compared with different treatments due to *C. partellus* infestation. Hence enhanced grain yield in range of 6.30-11.3 (Pooled mean of two years as shown in Table 3) was achieved by use of different protective measures in different treatments over the control. The mentioned biorational (T_1 and T_2) as well as conventional insecticides (T_3 and T_4) resulted in net profit of Rs. 7149-12223 per hectare during two years of study period . Thus chlorantraniliprole @ 75 ml/ha promises to be a strong new addition in maize pest management programme based on its properties of improved plant mobility and increased spectrum of insect control on Lepidopteran pests (Anuradha, 2013). In furtherance to superiority of biorational treatment T_1, the initial higher cost is compensated with better efficacy against pest over a longer period and realization of higher grain yield as compared with all other treatments under consideration (Figs.1 and 2) during the year 2012 and 2013.

Earlier workers also reported effectiveness of chlorantraniliprole in managing the lepidopteran borer in rice, sugarcane and brinjal (Wu-Jun *et al*., 2009; Singh *et al*., 2009; Suri, 2011 and Rajaval *et al*., 2011). Moreover, it was found safer to the beneficial insects in the maize and other agro ecosystems with additional benefit of environmentally sound approach as propounded by Marchesini *et al*. (2008). The biological control plots receiving single release of *Trichogramma chilonis* also recorded significant reduction in damage as compared with control but the per cent damage due to pest and monetary returns were not comparable with other biorational and chemical insecticides treatments. Farid *et al* (2007) reported that four releases of *T. chilonis* during the season led to as high as 68 % decrease in damage over control indicating the success of sequential release and it is in confirmation with the findings of Aggarwal and Jindal (2013), advocating inundative releases of *T. chilonis* in *Kharif* season maize under Punjab conditions to achieve better control. The farmer's practice of using insecticide at

Table 1. Effect of different treatments on reduction of leaf injury incidence of *C. partellus* in maize during *Kharif* 2012 and 2013.

Treatments	Dose (ml/ ha)	Per cent leaf injury incidence (2012)			Per cent leaf injury incidence (2013)		
		Before Spray	7 days after spray	14 days after spray	Before Spray	7 days after spray	14 days after spray
T_1	75	10.76 (19.14)	4.67 (12.59)	3.43 (10.66)	13.0 (21.12)	5.03 (12.80)	4.23 (11.21)
T_2	100,000 parasitized eggs	10.93 (19.29)	7.36 (15.73)	6.56 (14.83)	12.03 (20.28)	8.23 (16.66)	7.86 (16.13)
T_3	200	10.03 (18.45)	6.03 (14.21)	4.63 (12.41)	14.0 (21.96)	5.60 (13.66)	5.36 (13.38)
T_4	250	11.33 (19.66)	6.13 (14.33)	4.43 (12.14)	13.53 (21.57)	6.0 (14.17)	6.93 (15.20)
T_5	-	10.76 (19.14)	18.33 (25.34)	21.86 (27.86)	13.93 (21.90)	19.83 (26.43)	23.56 (29.02)
CD (p=0.05)		NS	0.53	1.20	NS	0.70	1.46

Figures in parentheses are arc sine transformed values; level of significance p=0.05, T_1 : Coragen 18.5 SC (Chlorantriniliptole) @ 75 ml/ha; T_2: Tricho cards @ 100,000 parasitized eggs of *Corcyra cephalonica*, T_3: Decis 2.8 EC (Deltamethrin) @ 200 ml/ ha as standard check, T_4: Farmers Practice (Choloropyriphos 50% + Cypermethrin 5%) @ 250 ml/ha; T_5: Control

Table 2. Effect of different treatments on reduction of Dead hearts incidence of *C. partellus* in maize during *Kharif* 2012 and 2013.

Treatments	Dose (ml/ha)	Per cent dead heart incidence (2012)			Per cent dead heart incidence (2013)		
		Before Spray	7 days after spray	14 days after spray	Before Spray	7 days after spray	14 days after spray
T_1	75	4.26 (11.89)	3.76 (11.16)	3.16 (10.23)	5.56 (13.74)	3.63 (11.90)	3.90 (11.36)
T_2	100,000 parasi-tized eggs	3.83 (11.26)	5.56 (13.18)	5.14 (13.11)	5.56 (13.62)	5.10 (13.40)	4.90 (12.75)
T_3	200	5.03 (12.91)	4.20 (11.78)	3.33 (10.49)	5.50 (13.55)	4.23 (11.83)	3.96 (11.47)
T_4	250	4.46 (12.19)	4.60 (12.35)	3.53 (10.79)	5.60 (13.68)	4.73 (12.52)	3.96 (11.48)
T_5	-	4.50 (12.23)	7.90 (16.29)	14.16 (22.34)	13.90 (26.10)	10.96 (19.31)	18.53 (25.48)
CD (p=0.05)		NS	1.99	1.35	NS	1.15	0.90

Figures in parentheses are arc sine transformed values; Level of significance p=0.05

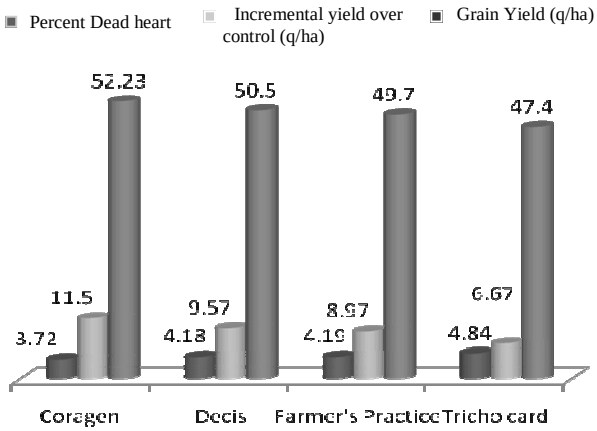

Fig. 1. *Effect of different treatments on dead hearts reduction and incremental grain yield of maize during 2012.*

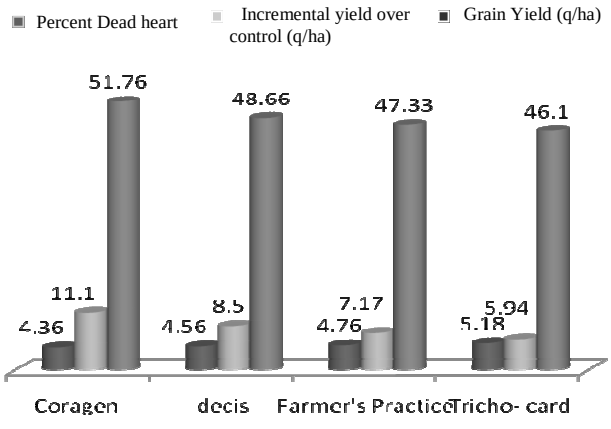

Fig. 2. *Effect of different treatments on dead hearts reduction and incremental grain yield of maize during 2013.*

Table 3. Grain yield and Economic return on hectare basis during 2012-13.

Treatments	Grain yield (q/ha)			Increased Yield over control (q/ha)		Pooled mean (q/ha)	Income from increased yield		Av. Cost during 12-13	Net profit (Rs./ha)		Pooled Mean (Rs./ha)
	2012	2013	Pooled Mean	2012	2013		2012	2013		2012	2013	
T_1	52.23	51.76	51.99	11.50	11.10	11.31	13225	13320	1050	12175	12270	12223
T_2	47.40	46.10	49.58	6.67	5.94	6.30	7670	7128	250	7420	6878	7149
T_3	50.50	48.66	48.51	9.57	8.50	9.03	11005	10200	350	10655	9850	10252
T_4	49.70	47.33	46.75	8.97	7.17	8.07	10315	8604	500	9815	8104	8960
T_5	40.73	40.16	40.44	-	-		-	-	-	-	-	
CD (p=0.05)	1.45	1.18	1.10	-	-		-	-	-	-	-	

Figures in parentheses are √ n+1 transformed values, Price of dry grain yield (Rs./q)- 1150 (during 2012) , 1200 (during 2013), Coragen : 1600 per 150 ml, Decis: 490 per litre, Lara: 500 per litre, Spray charges 250/- per hectare, Increased yield over control (Yield in respective treatment – yield in control treatment)

25-30 days old crop offers less benefit due to advanced damaging condition of pest inside whorls thus affecting the efficacy of insecticides and reduction in grain yield.

Conclusion

The overall superiority of Chlorantrinilprole 18.5 SC in comparison to other conventional insecticide treatments has marked effect on reduction of pest damage in the form of leaf injury level and dead heart incidence. Thus, resulting in higher grain yield and economic returns. Moreover being biorational, it seems environmentally sound approach and offers additional choice of insecticide for farmers to manage the *C. partellus* infestation in maize production system. The treatment involving release of biocontrol agent though helped to reduce the pest load on crop but level of reduction in pest damage and realization of grain yield could not be compared with chlorantriniliprole 18.5 SC treatment. The standard check consisting of old generation synthetic pyrethroid formulation (deltamethrin 2.8 EC) proved in comparison with promising treatment in terms of damage reduction. However there is need to replace old generation chemicals with safer and new chemistry molecules with a distinct class and unique mode of action for sustainable maize production programme.

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