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Efficacy of various insecticides against maize stem borer *Chilo partellus* (Swinhoe) and their cost-benefit analysis at Prayagraj

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Abstract
The present studies on the Efficacy of various insecticides against maize stem borer *Chilo partellus* (Swinhoe) and their cost-benefit analysis at Prayagraj were conducted during field experiment which is laid-out in randomized block design with three replications at research field of the department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, during the Kharif season of 2019-2020. Comparing with seven treatments along with control plot reveals that all the chemical treatments were significantly superior over control. Among all the treatments lowest percent infestation of maize stem borer and mean percent reduction was recorded in Carbofuran 3G (9.09%) (60.28%) and followed by Cypermethrin 25 EC (10.1%) (55.87%), followed by Imidacloprid 200SL (11.1%) (51.46%), and Bifenthrin 10 EC (11.78%) (48.53%), then followed by Novaluron 10 EC (12.45%) (45.60%) and the remaining treatment, Cartap hydrochloride 50% SP (14.14%) (38.22%) and Deltamethrin 2.8 EC (15.15%) (33.81%) are the remaining treatments which are least effective against control of maize stem borer. The yield obtained and B:C analysis shows that the yields among the treatment were significant. The highest yield was recorded in Carbofuran 3G (39 q/ha) with B:C ratio (1:2.20) Which is superior to all other treatments. Next is Cypermethrin 25 EC recorded (36.44 q/ha) with B:C ratio (1:2.01), then followed by Imidacloprid 200 SL (33.89q/ha) with B:C ratio (1:1.89), then followed by Bifenthrin 10 EC recorded yield (32.4 q/ha) with B:C ratio (1:1.63) and the yield recorded by other treatments are Novaluron 10 EC (30.12 q/ha) with B:C ratio (1:1.63), then followed by Cartap Hydrochloride 50% SP (27.83 q/ha) with B:C ratio (1:1.1.52), then followed by Deltamethrin 2.8 EC (24.42 q/ha) with B:C ratio (1:1.3) is the least yield plot among the chemical treatment plot.

Keywords: *Chilo partellus*, cost: benefit ratio, carbofuran 3G, insecticides, efficacy

Introduction
Maize (*Zea mays* L.) is the third most important grain crop of the world which is widely cultivated all over the world in different agro-climatic zones. Worldwide, it is popularly known as "Queen of cereals" due to its wider adaptability and highest genetic yield potential among cereal crops. It has a wider genetic base and the extraordinary level of genotypic diversity which makes it most versatile and adaptive under different agro-climatic conditions. Maize is a storehouse of various nutrients such as carbohydrates, proteins, minerals, vitamins, iron etc. and particularly supplying high energy of 365 Cal/100g. In India, Maize was cultivated on an area of 8.67 million hectares with production and productivity of 21.60 milliontonnes and 24.92 quintals per hectare, respectively during 2011-12 (Anonymous 2016) [5]. In Uttar pradesh, it was grown on 63 thousand hectares with a production of 11 thousand metric tonnes and productivity of 17.78 quintal per hectare during 2013-14 (Anonymous 2015) [4]. The generation of new agricultural technology has led to 12 times increase in maize production i.e. from 1.73 tonnes in 1950-51 to 21.60 milliontonnes at present in India. However, the average productivity of maize crop in the India i.e. 29.67 quintals per hectare and U.P i.e. 17.78 quintals per hectare, is very low as compared to that of world i.e. 51.85 quintals per hectare in 2011 (FAO 2016) [9].
Sarup *et al.* (1987) [18] listed 130 insect species attacking maize crops at their different growth stages. However, according to Mathur (1992) [15] there are more than 250 numbers of insect and mite pests infesting maize crops in India. Further, Siddiqui and Marwaha (1994) [9] reported that out of all the pests causing varying degrees of damage to maize crop from sowing to harvest, only a dozen are quite serious and require control measures. Amongst the pest complex of maize, *Chilo partellus* (Swinhoe), *Sesamia inferens* Walker and *Atherigona soccata*

Rondani and *A. naqvi* Steyskal are of major importance during different seasons in India (Kumar *et al.* 2005) [14]. Among the various insect pests, maize stem borer, *Chilo partellus* is the most dominant contributing 90-95 per cent of the total damage in *Kharif* season (Jalali and Singh, 2002). Maize is most vulnerable to *Chilo partellus* (Lepidoptera: Crambidae) which causes severe losses to it (Songa *et al*., 2001). A loss of 24-75 per cent has been reported by the attack of this pest alone (Kumar and Mihm, 1995, 1996; Kumar, 2002) [12, 13, 11]. Stem borer can cause severe damage at different stages in the development of cereal crops from seedling to maturity. When infestation is severe, there is a physiological disruption of plant growth; hence panicle emergence and grain formation are severely affected (Addo-Bediako and Thanguane, 2012) [2].

Materials and Methods

Field experiment has been laid-out in randomized block design with three replications at research field of the department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, during the *Kharif* season of 2019. There were eight treatments including an untreated control and each treatment was replicated thrice in the randomized block design. The Maize seed king 9999 of 294.4gm/147.2 m^2 is been used for gross cultivated area with spacing 60 cm plant to plant and 20 cm row to row distance. All agronomical package of practices recommended for the successful cultivation of crop was followed. After 25 days of germination, the pest damage (pinholes, dead heart) are observed from different plots in respective replications. Observations regarding the pest incidence were carried out throughout the entire cropping season at weekly intervals starting from august by recording leaf infestation, dead heart, stem pinholes and adult moth catch. The incidence of the borer on the shoot was recorded by observing the total number of pinholes, dead heart and leaf whorls are calculated from complete plants in each plot. Observations were recorded one day before spray 7th, 14th, days after spraying. The spray formulations were prepared from the commercially available material except for Carbofuran 3G and all the treatments were applied with a manually operated knap sack sprayer whereas Carbofuran 3G is applied manually with hands. All the crop raising practices were followed to maintain healthy crop growth and no insecticides other than those included in the trial were applied. The treatments were applied once. First application was done 30 days after sowing as foliar spray in all treatments. To ascertain the field efficacy of different insecticides, observations on the number of infested plants and dead heart from four middle rows in each plot were recorded after each spray. The data thus obtained were merged to obtain cumulative plant infestation/dead heart caused by maize stem borer.

Table 1: Insecticide application and their Dosage to control maize Stem borer infestation

S. No.	Treatments No.	Treatments	Dosage /ha	Dosage/ Block	Total Treatment area
1	T_1	Bifenthrin 10 EC	400 ml/ha	0.08 ml	0.24 ml
2	T_2	Cypermethrin 25 EC	100 ml/lit	0.01 ml	0.03 ml
3	T_3	Deltamethrin 2.8 EC	0.4 ml/lit	0.04 ml	0.12 ml
4	T_4	Novaluron 10 EC	0.1 ml/lit	0.02 ml	0.06 ml
5	T_5	Cartap Hydrochloride 50% SP	18.75 kg/ha	3.75 gm	11.25 gm
6	T_6	Imidacloprid 200 SL	700 gm/ha	0.14 gm	0.42 gm
7	T_7	Carbofuran 3G	7.5 kg/ha	1.5 gm	4.5 gm
8	T_0	Control	-		

Grain yield (kg/ha)

The maize cobs were picked from all plants per plot and grains were shelled. The average weight of picked cob grains was used to calculate the grain yield. Cost effectiveness of each treatment will be assessed based on net returns. Net return of each treatment will be worked out by deducting the total cost of the treatment from gross returns. Total cost of production included both cultivations as well as plant protection charges.

Results and Discussion

1. To evaluate the efficacy of various insecticides on percent (%) infestation of maize stem borer (*Chilo partellus*) during kharif season in 2019.

Percent plant infestation after 3 days

Among all the treatments lowest percent plant infestation of maize stem borer was recorded in Carbofuran 3G (11.1%), followed by Cypermethrin (13.13%), followed by Imidacloprid (14.14%) and Bifenthrin (14.14%) are at par with each other followed by Novaluron (15.1%), followed by cartap Hydrochloride (16.1%), and Deltamethrin (17.17%) is at least effective among all the treatments.

Percent infestation after 7 days

The lowest percent plant infestation of maize stem borer was recorded in Carbofuran 3G (9.09%), followed by Cypermethrin (10.1%), followed by Imidacloprid (11.1%), then followed by Bifenthrin (12.12%), followed by Novaluron (13.1%), followed by cartap Hydrochloride (14.14%), and Deltamethrin (14.14%) are par with each other and is at least effective among all the treatments.

Percent infestation after 14 days

The data on the percent plant infestation of maize stem borer on the fourteenth day after spray revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest percent plant infestation of maize stem borer was recorded in Carbofuran (7.07%) and Cypermethrin (7.07%) are at par with each other then followed by Imidachloprid (8.08%) and Bifenthrin (12.9%) are par with each other then followed by Novaluron (10.11%) then followed by Cartap Hydrochloride (12.12%) and Deltamethrin (14.14%).

2. Mean percentage reduction of plant infestation of maize stem borer [chilo partellus (Swinhoe)] in treated plots over control plot.

The highest mean percentage reduction of plant infestation of maize stem borer was recorded in Carbofuran (60.28%) and followed by Cypermethrin (55.87%), and then followed by Imidacloprid (51.46%), followed by Bifenthrin (48.53%), then followed by Novaluron (45.60%) and the remaining

treatments, Cartap Hydrochloride (38.22%) and Deltamethrin (33.81%) are the remaining treatments which show the least effective mean percentage reduction over control plot against maize stem borer infestation.

Table 2: Efficacy of various insecticides on percentage (%) infestation of maize stem borer (*Chilo partellus*) after first Spray with their mean percent reduction

Treatments		Mean plant infestation					Mean% reduction Over control
		Before	3 DAS	7 DAS	14 DAS	Mean	
T_0	Control	16.16	20.2	22.2	26.26	22.89	-
T_1	Bifenthrin 10 EC @400 ml /ha	18.18	14.14	13.13	8.08	11.78	48.53%
T_2	Cypermethrin 25 EC @ 100 ml /ha	16.16	13.13	10.1	7.07	10.1	55.87%
T_3	Deltamethrin 2.8 EC 0.4 ml /ha	19.19	17.17	14.14	14.14	15.15	33.81%
T_4	Novaluron 10 EC @ 0.1 ml /ha	17.17	15.15	12.12	10.1	12.45	45.60%
T_5	Cartap Hydrochloride 50% SP @ 18.75 kg /ha	19.19	16.16	14.14	12.12	14.14	38.22%
T_6	Imidacloprid 200 SL @ 700 gm /ha	17.17	14.14	11.1	8.08	11.11	51.46%
T_7	Carbofuran 3G @ 7.5 kg/ha	14.14	11.1	9.09	7.07	9.09	60.28%
	Overall Mean	19.31	15.15	13.25	11.61	13.33	47.68%
	F- test	NS	S	S	S	S	-
	S. Ed. (±)	1.24	1.50	1.45	1.15	1.21	-
	C. D. (P = 0.05)	3.7	4.57	4.42	3.49	3.68	-

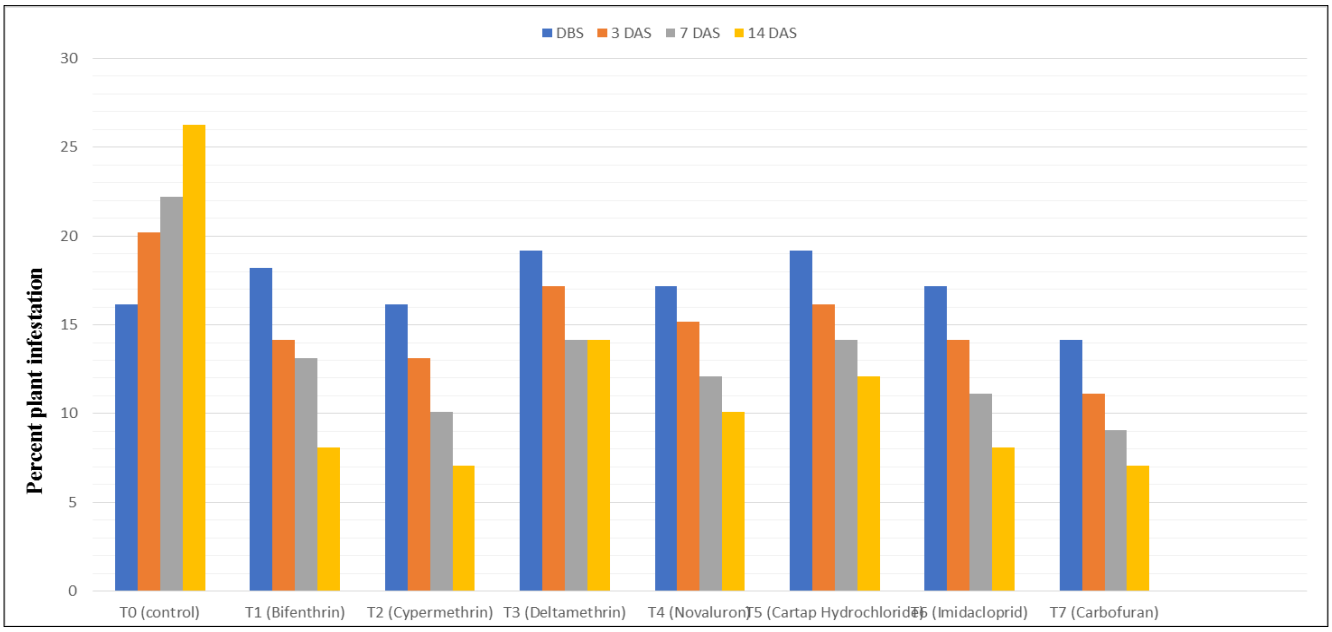

Fig 1: Efficacy of various insecticides on percentage (%) incidence of maize stem borer (*Chilo partellus)* after first spray

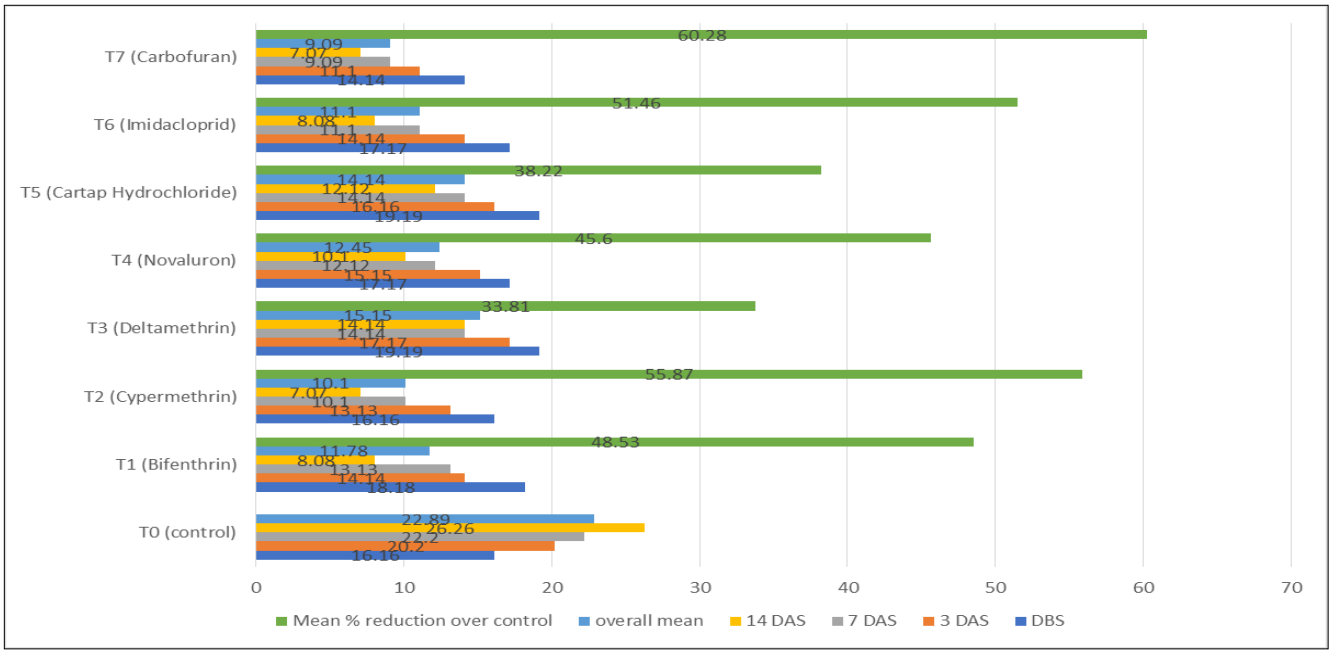

Fig 2: Graphical representation of Mean (%) reduction of maize stem borer infestation

Economic evaluation of various treatments

The following data obtained from B:C analysis shows that the yields among the treatment were significant. The highest yield was recorded in Carbofuran 3G @ 1.5 gm (39 q/ha) with B:C ratio (1:2.20) Which is superior than all other treatments. Next is Cypermethrin 25 EC @ 0.01 ml/lit recorded (36.44 q/ha) with B:C ratio (1:2.01), then followed by Imidacloprid 200 SL @ 0.14 gm/lit (33.89q/ha) with B:C ratio (1:1.89), then followed by Bifenthrin 10 EC @ 0.8 ml/lit recorded yield (32.4 q/ha) with B:C ratio (1:1.63) and the yield recorded by other treatments are Novaluron 10 EC @ 0.02 ml/lit (30.12 q/ha) with B:C ratio (1:1.63),then followed by Cartap Hydrochloride 50% SP @ 3.75 gm (27.83 q/ha) with B:C ratio (1:1.1.52), then followed by Deltamethrin 2.8 EC @ 0.04 ml/lit (24.42 q/ha) with B:C ratio (1:1.3) is the least yield plot among the chemical treatment plot. The lowest yield is recorded in the control plot with no control measures against maize stem borer is (18.69 q/ha).

Cost: benefit ratio

The highest yield was recorded in Carbofuran 3G @1.5 gm (39 q/ha) with B:C ratio (1:2.20) Which is superior to all other treatments. Zahid *et al*., (2014) [25]. Proved the results revealed that Carbofuron 3G was recorded as the most effective followed by Fipronil 4G Kumar and Kumar (2017) Out of seven different chemicals spray highest yield was recorded in T3 Carbofuron (42.72 q/ha) followed by T5 Cypermethrin (40.80 q/ha), T2 Fipronil (37.44 q/ha), T1Indoxacarb (34.79 q/ha),T4 Cartap (31.68 q/ha), T6 Profenophos (28.54 q/ha). Kumar and Alam (2017) The maximum and yield were recorded in chlorantraniliprole 20 SC @ 0.3 ml/l followed by carbofuran 3G @ 7 kg/ha treated plot. However, minimum yield (q/ha) was recorded in the untreated control. Among all the insecticidal treatments used for management of *Chilo partellus*, the highest benefit: cost ratio was evinced in insecticidal treatment flubendiamide 480 SC @ 0.2 ml/l in sequence with carbofuran 3G @ 7 kg/ha.

Table 3: Economics of Cultivation

No:	Treatments	Yield per plot	Yield of q/ha	Cost of yield / Rs/q	Total cost of yield (Rs.)	Common cost (Rs.)	Treatment cost (Rs.)	Total cost (Rs.)	Net returns in Rs	C : B Rtaio
T1	Bifenthrin 10 EC	1.94 kg	32.4 q	1700	55080	28880	1486	30366	24714	1:1.81
T2	Cypermethrin 25 EC	2.186 kg	36.44 q	1700	61948	28880	1920	30800	31148	1:2.01
T3	Deltamethrin 2.8 EC	1.46 kg	24.42 q	1700	41514	28880	2070	30950	10564	1:1.3
T4	Novaluron 10 EC	1.80 kg	30.12 q	1700	51204	28880	2380	31260	19944	1:1.63
T5	Cartap Hydrochloride 50% SP	1.66 kg	27.83 q	1700	47311	28880	2087	30967	16344	1:1.52
T6	Imidacloprid 200 SL	2.03 kg	33.89 q	1700	57613	28880	1536	30416	27197	1:1.89
T7	Carbofuran 3G	2.34 kg	39 q	1700	66306	28880	30105	1225	36201	1:2.20
T0	Control	1.12 kg	18.69 q	1700	31773	28880	00	28880	2893	1:1.1

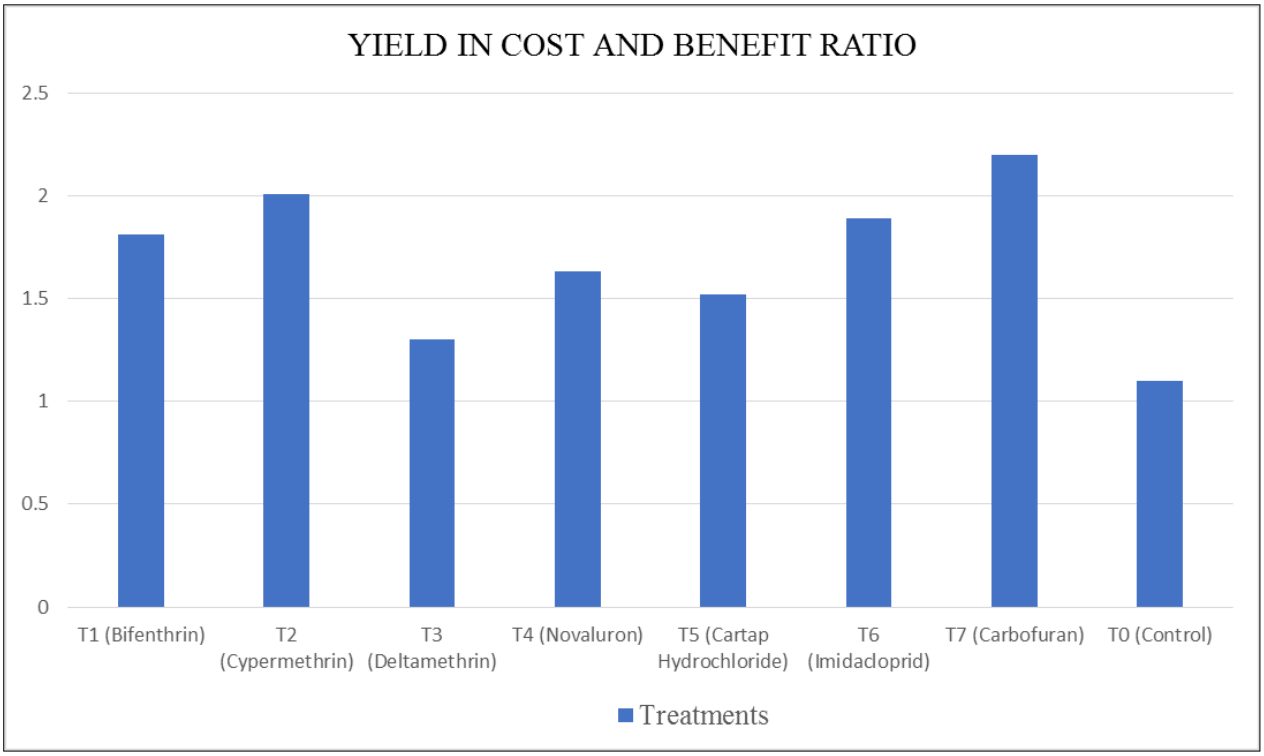

Fig 3: Economic Cost: Benefit ratio of maize from different plots

Summary and conclusion

From the critical analysis of the present finding it is concluded that among all the treatments Carbofuran 3G (T7) was most effective then, followed by Cypermethrin 25 EC (T2), followed by Imidacloprid 200 SL (T6), Bifenthrin 10 EC (T1), then followed by Novaluron 10EC (T4) and the remaining treatments, Cartap hydrochloride 50% SP (T5) and Deltamethrin 2.8 EC (T3) are the remaining treatments which are least effective against control of maize stem borer. The recommended dose of chemicals may be useful in proper integrated pest management strategy against maize stem borer.

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