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EFFICACY OF CONVENTIONAL INSECTICIDES AGAINST MAIZE STEM BORER (*CHILO PARTELLUS)* AND SHOOT FLY (*ATHERIGONA SOCCATA)*

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MK collected, and interpreted the data, MFK designed & reviewed, AS analyzed the data, GY reviewed the manuscript.

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Chilo partellus, *Atherigona soccata*, Imidacloprid, Thiamethoxam, Endosulfan, Permethrin, Carbofuran, Phorate.

ABSTRACT

Maize stem borer, *Chilo partellus* Swinhoe and shoot fly, *Atherigona soccata* Rondani are considered as major pests of maize (*Zea mays*, L.). Carbofuran (Carbamate), Endosulfan (Organochlorine), Phorate (Organophosphate), Permethrin (Pyrethroid) and two neonicotinoid insecticides; Imidacloprid and Thiamethoxam were selected to compare their efficacy against *Chilo partellus* and *Atherigona soccata* on maize crop under natural infestation during spring, winter and autumn seasons. All insecticides reduced *Atherigona soccata and Chilo partellus* infestation significantly ($p<0.05$). Imidacloprid and thiamethoxam were found statistically at par against *Atherigona soccata* and better than endosulfan. Permethrin and carbofuran were found statistically at par in first week and better than phorate while in second week permethrin and carbofuran were statistically at par but phorate was found better than them.

1. INTRODUCTION

Maize (*Zea mays*, L.) is Pakistan's third important cereal crop after wheat and rice (Memon et al., 2012). The production area of maize is 1653 thousand hectares in Pakistan which produced 10.635 million tonnes output in the year 2021-22. Maize subsidizes 3.2 percent value added in agriculture and 0.7 percent to GDP (GoP., 2022). Among the low yield factors of maize, insect pests are important ones (Gerpacio & Pingali, 2007). *Chilo partellus* Swinhoe, *Sesamia inferens* Walker, *Busseola fusca* Fuller and *Atherigona soccata* Rondani are considered as major pests (Songa et al., 2001; Addo-Bediako & Thanguane, 2012). Severe infestation of maize shoot fly and maize borer may cause complete failure of crop (Singh & Sharma, 1984). Granular formulations of carbofuran, benfuracarb and furathiocarb as soil applications were found to be effective in the of *Chilo partellus*, *Busseola fusca* and *Cicadulina mbila* at maize planting in South Africa (Rensburg et al., 1991).

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Sridhar et al. (2016) reported that imidacloprid and thiamethoxam can be used as seed dressing with imidacloprid found to be more effective in controlling *Atherigona soccata* and both of them did not show any adverse effect on seed germination during laboratory experiments. In the present study the efficacy of different insecticides was assessed against *Atherigona soccata* and *Chilo partellus* on maize crop under natural infestation during spring, winter and autumn seasons and prediction of the most effective pesticide through statistical bio-efficacy comparison was made.

2. MATERIALS AND METHODS

Experimental Field

The experiment was laid out in randomized block design (RBD). The plots were 4 meters long and 3 meters wide. The distance between plants was 22 cm with a distance of 60 cm between parallel rows. The adjacent experimental plots were kept apart from each other by 3 meters.

Application of Insecticides

Carbofuran (Carbamate), Endosulfan (Organochlorine), Phorate (Organophosphate), Permethrin (Pyrethroid) and two neonicotinoid insecticides; Imidacloprid and Thiamethoxam were selected to compare the efficacy against *Chilo partellus* and *Atherigona soccata* on maize crop under natural infestation during spring, winter and autumn seasons. Each treatment was replicated three times to authenticate the experiments. Untreated control plots were managed to observe the negative control values. The application of imidacloprid @ 5g ai/kg seeds and thiamethoxam @ 3.5g ai/kg seeds was done as seed dresser. For seed dressing maize seeds were treated with the test insecticide one day previous to sowing and then dried in shade. Insecticides (endosulfan @ 210g ai and permethrin @ 75g ai) in the form of emulsifiable concentrate were diluted in the water to make desired doses. Separate sprayers were used to spray each insecticide. Carbofuran @ 240g ai and phorate @ 250g ai were applied in granular form. Records of pre-treatment infestations were taken 24 hours before the application of insecticides. Five plants were selected in a random manner from each plot for the population dynamics of the pests.

Data/Statistical Analysis

Percent mortality was obtained through Henderson-Tilton's (1955) formula, i.e.

Where, n = Insect population, T = treated, Co = control

$$\text{Corrected \%} = \left(1 - \frac{\text{n in Co before treatment} \times \text{n in T after treatment}}{\text{n in Co after treatment} \times \text{n in T before treatment}}\right) \times 100$$

To compare the efficacy of insecticides two-way ANOVA followed by Duncan's multiple range test were also conducted via SPSS version 19 using the actual numbers of larval mortality.

3. RESULTS AND DISCUSSION

The results revealed that the populations of *Chilo partellus* and *Atherigona soccata* were significantly lower than control in pesticide treated plots. Imidacloprid gave its maximum mortality percentage i.e., 88.89% after 1st week of application during spring season (Table 1). Likewise, thiamethoxam provided more than 91% killing of shootfly and endosulfan provided upto 92.29% control of shootfly in a treatment. All three test insecticides caused significant ($p<0.05$) drop in *Atherigona soccata* infestation, while imidacloprid and thiamethoxam were not significantly different from each other at the 5% level of significance. The highest control was observed in spring season while it was significantly at par in autumn and winter. The present findings are in conformity with Sonalkar et al. (2018) who reported that imidacloprid seed treatment followed by quinalphos spray 15 days after emergence was found significantly the most effective in reducing shoot fly infestation. Kumar and Tiwana (2018) observed that seed dressing with thiamethoxam resulted in decrease in numbers of deadhearts caused by *Atherigona soccata* on sorghum, closely followed by fipronil and imidacloprid. Ali and Khan (2022) found endosulfan and deltamethrin the most effective against brinjal fruit borer, *Leucinodes orbonalis*. Sandhu (2016) suggested that seed treatment with thiamethoxam 30 FS @ 5 ml/kg seed and imidacloprid 600 FS @ 7 ml/kg seed were effective in reducing shoot fly incidence.

All three test insecticides reduced *Chilo partellus* infestation significantly ($p<0.05$) in both weeks; permethrin and carbofuran were found statistically at par in 1st week and better than phorate while in 2nd week permethrin and carbofuran were statistically at par but phorate was found better than them. In 1st week the highest control was observed in spring season followed by autumn season and the lowest control was observed in winter whereas in 2nd week the control was not significantly different in autumn and winter but the highest control was observed in spring season. Permethrin gave more than 88% control of stem borer, *Chilo partellus* in a treatment (Table 2). Carbofuran provided upto 87.10 % control of stem borer. The results are in accord with Nazir (2009) who reported that Furadan (carbofuran) 3G applied at 20 kg/ha and Cascade 10 DC at 500 ml/ha were found to be the most effective among all other treatments displaying the lowest plant infestation against *Chilo partellus* on maize during spring. Iqbal et al. (2017) tested four granular (carbofuran, fipronil, cartap, monomihypo), two foliar (emmamectin, deltamethrin) and two seed dressers insecticides (imidacloprid, thiamethoxam) against *Chilo partellus* on maize under field conditions and observed that all insecticide considerably reduced stem borer infestation and showed positive effect on maize yield. Imidacloprid and fipronil resulted in least infestation of the stem borer.

Moreover, carbofuran was found to be the most effectual against *Chilo partellus* followed by fipronil (Saleem et al., 2014). Ahmad et al. (2012) suggested furadan was more effective than organophosphate and other granular insecticides. Phorate; an organophosphate insecticide causes up to 91.74 % mortalities (Table 2). These findings are in line with Kumar et al. (2017) who compared the efficacy of some novel insecticides and bio-products against *Atherigona soccata* in maize and reported that imidacloprid 70WS-NSKE was found to be the most effective in reducing the number of eggs of *Atherigona soccata* followed by Thiamethoxam 70WS-NSKE. The next best treatment in order were Carbofuran 3G, Phorate 10G, Imidacloprid 70WS, Thiamethoxam 70WS, Cow urine-NSKE and NSKE. Likewise, different concentrations of cypermethrin were analyzed for their efficacy against stem borer *Chilo partellus* on maize crop. All concentrations resulted in significant control of the stem borer (Akhtar et al., 2018). Paul (2007) recommended use of 10% phorate or carbofuran 3% granules at the time of sowing @ 2.5 kg a.i./ha for the control of *Atherigona soccata*. Also, endosulfan @ 0.07% or cypermethrin @ 0.005% or cartap hydrochloride 0.5 kg a.i./ha or triazophos @ 0.5 kg a.i./ha spray twice a week after sowing or during second week were suggested. For *Chilo partellus* spray of carbaryl 0.1% or endosulfan 0.07% thrice at an interval of 15 days from a month after sowing; and two whorl applications of 4 % endosulfan or 10% carbaryl or 4% cartap hydrochloride granules, first @ 5 kg/ha at 25 – 30 days after crop emergence and second @ 10 kg/ha 10 - 15 days later were suggested; and if infestation is severe, three applications at 5.0, 7.5 and 10.0 kg/ha were recommended.

4. CONCLUSION

Results show that all test insecticides provided significant control against *Chilo partellus* and *Atherigona soccata*. Neonicotinoid insecticides were found better than endosulfan in controlling *Atherigona soccata*. Permethrin and carbofuran were found statistically at par in first week and better than phorate while in second week permethrin and carbofuran were statistically at par but phorate was found better than them.

5. CONFLICT OF INTEREST

All authors have declared that there is no conflict of interests regarding the publication of this article.

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Table 1. Efficacy of different insecticides against shootfly, *Atherigona soccata*

Insecticide	Field	Season	Treatment	Pre-treatment infestations (%)	Post-treatment Infestations (%)		% Mortality	
					1 week	2 week	1 week	2 week
Imidacloprid	A	Spring	1	-	7	11	80.00	67.65
			2	-	8	10	77.14	70.59
			3	-	5	7	85.71	79.41
			Control	30	35	34	--	--
		Autumn	1	-	3	6	82.35	73.91
			2	-	5	7	70.59	69.57
			3	-	4	8	76.47	65.22
			Control	15	17	23	--	--
		Winter	1	-	4	7	77.78	72.00
			2	-	3	5	83.33	80.00
			3	-	6	9	66.67	64.00
			Control	14	18	25	--	--
	B	Spring	1	-	4	6	87.10	83.78
			2	-	5	7	83.87	81.08
			3	-	9	10	70.97	72.97
			Control	27	31	37	--	--
		Autumn	1	-	4	7	75.00	69.57
			2	-	5	8	68.75	65.22
			3	-	4	6	75.00	73.91
			Control	15	16	23	--	--
		Winter	1		3	6	80.00	71.43
			2		5	7	66.67	66.67
			3		6	7	60.00	66.67
			Control	13	15	21	--	--
	C	Spring	1	-	5	5	86.11	84.38
			2	-	6	8	83.33	75.00
			3	-	4	5	88.89	84.38
			Control	28	36	32	--	--
		Autumn	1	-	4	5	75.00	80.00
			2	-	5	7	68.75	72.00
			3	-	6	9	62.50	64.00
			Control	13	16	25	--	--
		Winter	1	-	5	7	66.67	70.83
			2	-	7	9	53.33	62.50
			3	-	6	8	60.00	66.67
			Control	12	15	24	--	--

Thiamethoxam	D	Spring	1	-	6	5	82.86	87.80
			2	-	5	5	85.71	87.80
			3	-	6	7	82.86	82.93
			Control	28	35	41	--	--
		Autumn	1	-	9	9	70.00	72.73
			2	-	5	7	83.33	78.79
			3	-	8	10	73.33	69.70
			Control	23	30	33	--	--
		Winter	1	-	8	11	63.64	60.71
			2	-	9	10	59.09	64.29
			3	-	7	9	68.18	67.86
			Control	16	22	28	--	--
	E	Spring	1	-	10	12	71.43	64.71
			2	-	9	10	74.29	70.59
			3	-	8	9	77.14	73.53
			Control	31	35	34	--	--
		Autumn	1	-	6	9	70.00	66.67
			2	-	5	8	75.00	70.37
			3	-	3	5	85.00	81.48
			Control	18	20	27	--	--
		Winter	1	-	4	8	75.00	63.64
			2	-	3	6	81.25	72.73
			3	-	2	5	87.50	77.27
			Control	14	16	22	--	--
	F	Spring	1	-	3	5	91.89	88.64
			2	-	4	7	89.19	84.09
			3	-	7	10	81.08	77.27
			Control	32	37	44	--	--
		Autumn	1	-	4	7	76.47	69.57
			2	-	5	8	70.59	65.22
			3	-	9	11	47.06	52.17
			Control	15	17	23	--	--
		Winter	1	-	3	6	81.25	71.43
			2	-	5	7	68.75	66.67
			3	-	6	8	62.50	61.90
			Control	15	16	21	--	--
		Spring	1	24	3	6	88.54	79.38
			2	26	6	9	78.85	71.44
			3	30	8	12	75.56	67.00
			Control	33	36	40	--	--

Endosulfan	G	Autumn	1	9	3	5	71.43	68.25
			2	12	5	7	64.29	66.67
			3	13	7	10	53.85	56.04
			Control	12	14	21	--	--
		Winter	1	11	4	6	68.48	66.23
			2	10	4	7	65.33	56.67
			3	12	6	9	56.67	53.57
			Control	13	15	21	--	--
	H	Spring	1	22	2	6	92.29	80.42
			2	24	5	8	82.32	76.07
			3	27	9	11	71.72	70.75
			Control	28	33	39	--	--
		Autumn	1	8	1	4	89.06	68.18
			2	9	3	5	70.83	64.65
			3	11	6	9	52.27	47.93
			Control	14	16	22	--	--
		Winter	1	7	2	5	73.47	53.57
			2	9	2	4	79.37	71.11
			3	10	5	8	53.57	48.00
			Control	13	14	20	--	--
	I	Spring	1	15	4	7	77.60	69.38
			2	18	6	9	72.00	67.19
			3	20	9	13	62.20	57.34
			Control	21	25	32	--	--
		Autumn	1	14	6	8	64.29	57.14
			2	17	8	10	60.78	55.88
			3	16	7	10	63.54	53.12
			Control	15	18	20	--	--
		Winter	1	8	4	6	53.57	48.68
			2	10	6	9	44.29	38.42
			3	11	6	7	49.35	56.46
			Control	13	14	19	--	--

Table 2. Efficacy of different insecticides against maize Stem Borer, *Chilo partellus*

Insecticide	Field	Season	Treatment	Pre-treatment infestations (%)	Post-treatment Infestations (%)		% Mortality	
					1 week	2 week	1 week	2 week
Permethrin	J	Spring	1	28	7	6	77.50	81.34
			2	26	6	6	79.23	79.90
			3	25	5	7	82.00	75.61
			Control	27	30	31	--	--
		Autumn	1	14	3	3	82.86	81.95
			2	14	4	4	77.14	75.94
			3	13	5	7	69.23	54.66
			Control	16	20	19	--	--
		Winter	1	11	4	6	73.21	65.29
			2	10	4	5	70.53	68.18
			3	9	2	4	83.63	71.72
			Control	14	19	22	--	--
	K	Spring	1	27	5	5	82.68	84.20
			2	25	4	4	85.03	86.35
			3	23	4	7	83.73	74.04
			Control	29	31	34	--	--
		Autumn	1	14	3	3	80.83	82.65
			2	15	6	8	64.21	56.83
			3	14	5	9	68.05	47.96
			Control	17	19	21	--	--
		Winter	1	10	3	7	73.53	47.50
			2	12	5	8	63.24	50.00
			3	9	3	7	70.59	41.67
			Control	15	17	20	--	--
	L	Spring	1	25	3	4	88.44	85.14
			2	23	4	4	83.25	83.85
			3	24	5	7	79.94	72.92
			Control	26	27	28	--	--
		Autumn	1	24	5	3	79.17	88.33
			2	25	7	4	72.00	85.07
			3	27	6	8	77.78	72.35
			Control	28	28	30	--	--
		Winter	1	12	5	7	62.96	57.58
			2	11	6	10	51.52	33.88
			3	11	4	8	67.68	47.11
			Control	16	18	22	--	--
Carbofuran	M	Spring	1	23	4	4	83.25	84.41
			2	14	4	7	72.49	55.17
			3	25	4	4	84.59	85.66
			Control	26	27	29	--	--
		Autumn	1	25	7	11	73.81	62.47
			2	15	4	10	75.05	43.14
			3	27	7	12	75.75	62.09
			Control	29	31	34	--	--
		Winter	1	12	5	5	62.50	71.15
			2	10	4	5	64.00	65.38
			3	11	4	4	67.27	74.83
			Control	18	20	26	--	--
		Spring	1	22	6	9	74.61	61.91
			2	23	6	12	75.71	51.42
			3	25	5	6	81.38	77.66
			Control	27	29	29	--	--

	N	Autumn	1	19	5	5	78.38	79.13
			2	17	6	7	71.01	67.34
			3	20	7	6	71.25	76.21
			Control	23	28	29	--	--
		Winter	1	15	4	7	79.73	68.33
			2	18	5	9	78.89	66.07
			3	19	4	6	84.00	78.57
			Control	19	25	28	--	--
	O	Spring	1	21	3	7	87.10	72.55
			2	22	4	6	83.58	77.54
			3	24	4	9	84.95	69.12
			Control	28	31	34	--	--
		Autumn	1	16	5	4	71.73	78.41
			2	14	5	4	67.69	75.32
			3	18	6	7	69.84	66.41
			Control	19	21	22	--	--
		Winter	1	13	6	4	63.56	79.93
			2	9	3	2	73.68	85.51
			3	11	4	4	71.29	76.28
			Control	15	19	23	--	--
Phorate	P	Spring	1	57	12	5	79.79	91.74
			2	52	11	8	79.69	85.52
			3	53	11	9	80.08	84.02
			Control	48	50	51	--	--
		Autumn	1	31	8	6	78.80	85.64
			2	22	6	6	77.60	79.77
			3	25	9	8	70.43	76.26
			Control	23	28	31	--	--
		Winter	1	16	7	6	63.16	73.91
			2	14	5	5	69.92	75.16
			3	12	6	4	57.89	76.81
			Control	16	19	23	--	--
	Q	Spring	1	29	8	9	76.35	74.84
			2	32	7	4	81.25	89.86
			3	28	3	3	90.82	91.31
			Control	30	35	37	--	--
		Autumn	1	19	7	7	67.25	69.51
			2	18	5	7	75.31	67.82
			3	16	5	6	72.22	68.97
			Control	24	27	29	--	--
		Winter	1	12	5	4	62.50	72.73
			2	15	6	5	64.00	72.73
			3	17	8	7	57.65	66.31
			Control	18	20	22	--	--
	R	Spring	1	27	7	5	79.57	88.26
			2	31	8	6	79.67	87.73
			3	27	6	7	82.49	83.56
			Control	26	33	41	--	--
		Autumn	1	18	7	7	69.75	71.84
			2	16	8	8	61.11	63.79
			3	13	7	3	58.12	83.29
			Control	21	27	29	--	--
		Winter	1	11	6	6	59.81	68.18
			2	17	10	7	56.66	75.98
			3	13	6	4	65.99	82.05
			Control	14	19	24	--	--