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Efficacy of some novel insecticides and bio-products against shoot fly, *Atherigona Soccata* (Rondani) in maize

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Abstract
An investigation to study the efficacy of some novel insecticides and bio-products against shoot fly, *Atherigona soccata* (Rondani) in maize was carried out for two consecutive seasons *i.e.* 2013 and 2014, at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut. Efficacy of different insecticides and bio-products *viz.* Imidacloprid 70WS, Thiamethoxam 70WS, Carbofuran 3G, Phorate 10G, NSKE, Cow urine-NSKE, Imidacloprid 70WS-NSKE and Thiamethoxam 70WS-NSKE were evaluated against number of eggs of *A. soccata* revealed that the treatments, Imidacloprid 70WS-NSKE was found best to reduce the number of eggs laid by *A. soccata i.e.* 0.00 eggs/plant (11 DAE) and 0.45 eggs/plant (22 DAE) followed by Thiamethoxam 70WS-NSKE with 0.45 eggs/plant (11 DAE) and 0.72 eggs/plant (22 DAE). However, the maximum number of eggs survival of *A. soccata* was recorded with untreated control 1.85 eggs/plant (11 DAE) and 2.30 eggs/plant (22 DAE). Result revealed that all the treatments were found significantly effective in reducing the incidence of shoot fly and thus increasing the yield as compared to control. The higher grain yield (42.93 q/ha) and cost benefit ratio (1:16.10) were also obtained from Imidacloprid 70WS-NSKE.

Keywords: Efficacy, insecticides, bio-products, *Atherigona soccata,* maize

1. Introduction
Maize (*Zea mays* L.) is the third most important cereal in the world. Maize growers are shifting to specialty corn production due to higher returns and also opening opportunities for employment generation especially in peri-urban areas (Durga *et al.,* 2012) [6]. Maize can be classified according to the structure of the grain *viz.* sweet corn, flint corn, dent corn, soft or flour corn and popcorn. Maize grains contain nutritional value *viz.* starch 72%, protein 70%, fiber 8.5% and ash 1.7% (Khawar *et al.,* 2007) [9]. Maize is a valuable food grain, because it is among the highest in net energy content and lowest in protein and fiber content. Maize is a cereal plant that produces grains that can be cooked, roasted, fried, ground, pounded or crushed to prepare various food items. Ethanol obtained from maize can be used as a biomass fuel. Stigmas from female corn flowers, known as corn silk, can be used as herbal supplements. It can be used as forage, feed for livestock and making silage after fermentation of corn stocks. Maize is used extensively as the main source of calories in animal feeding and feed formulation (Oladejo and Adetunji, 2012) [13]. In India area, production and productivity of maize was 0.87 million hectares, 2.22 million tonnes and 2556 tonnes/hectare, respectively. In Uttar Pradesh it is grown in an area 0.74 million hectare, with production 1.24 million tonnes and productivity 1671 kg/ha (Anonymous, 2013-14) [2]. The crop attacked by more than 115 insect species, from sowing to crop harvest in India. Among pest complex of maize the most harmful insects *viz. Spodoptera exempta*, *Chilo partellus*, *Chilo orichalcociliellus*, *Sesamia cretica*, *Contarinia sorghicola*, *Atherigona soccata*, *Diuraphis noxia*, *Rhopalosiphum maidis*, *Microtermes najdensis*, *Microcerotermes diversus*, *Melanaphis sacchari*, *Locusta migratoria*, *Schistocerca gregaria* and *Epilachna similis* (Moharram *et al.,* 1996) [10]. It is common to see removing of maize crop due to heavy infestation of shoot fly. Shoot fly is one of the most important and destructive pest causing damage at seedling stage. Shoot fly causes maximum yield losses of 75.6% in grain and 68.6% in fodder (Pawar *et al.,* 1984) [16]. In view of change in climate and farming systems in the country, maize is suffering due to change in succession and incidence of shoot fly.

The economically and ecologically sound management practices will be required to combat the incidence of shoot fly in maize. Similar types of work done by few researchers Balikai and Bhagwat (2009) [3], Mudigoudra *et al.* (2009) [12], Siddique *et al.* (2011) [20] and Daware *et al.* (2011) [5]. Despite intensive work on management of shoot fly in Western Uttar Pradesh region during the '*spring*' season is lacking. Hence, an investigation to study the efficacy of some novel insecticides and bio-products against shoot fly, *Atherigona soccata* (Rondani) in maize was carried out, so that we can suggest to the farmer of this zone with least disturbance of agro-climatic conditions of Western Uttar Pradesh.

2. Material and Methods

An investigation to study the efficacy of some novel insecticides and bio-products against shoot fly, *Atherigona soccata* (Rondani) in maize was carried out for two consecutive seasons *i.e.* 2013 and 2014, at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut. The experiment was laid in randomized block design (RBD), having nine treatments *viz.* Imidacloprid 70WS@ 5 g/kg Seed, Thiamethoxam 70WS@ 2 g/kg Seed, Carbofuran 3G@ 12 kg/ha, Phorate 10G@ 10 kg/ha, NSKE@ 5%, Cow urine@ 5%-NSKE@ 5%, Imidacloprid 70WS@ 5 g/kg Seed -NSKE@ 5%, Thiamethoxam 70WS@ 2 g/kg Seed -NSKE@ 5% and untreated (control) which were replicated thrice. The maize seeds of variety 'NMH-123' was sown in plots size 6×4.8 mt^2 with row spacing 60 cm and plant to plant distance was 20 cm. Normal fertilizers doses and recommended agronomical practices were adopted. The treatments was imposed with knapsack sprayer using a spray fluid of 500 liter per ha. The two sprays and soil application were done at 7 and 21 DAE (Days after emergence), to compare the efficacy of treatments. To evaluate the efficacy of different treatments against number of eggs of *A. soccata*, in each plot, ten plants were randomly selected from six inner rows. Total number of eggs counted on ten plants converted into number of eggs per plant by average. The first observation was taken at 11 DAE and the second at 22 DAE. For recording grain yield, the six middle rows were harvested and total weight of grains was recorded into q/ha along with increase in yield. Cost benefit ratio, net return per rupees invested, was calculated by using the following formula.

$$\text{Cost: benefit ratio} = \frac{\text{Cost of increased yield (Rs/ha)}}{\text{Cost of treatment (Rs/ha)}}$$

The data recorded during the course of investigation were subjected to statistical analysis by using analysis of variance technique (ANOVA) for Randomized Block Design to compare means of different treatments as suggested by Panse and Sukhatme (1985) [15].

3. Results and Discussion

The results of the study are consistent over two years of experimentation and hence the pooled results over two years have been discussed. The statistically analyzed data on pooled number of eggs survival of *A. soccata* at 11 DAE are presented in Table-1. The pooled number of eggs survival of *A. soccata* ranged from 0.00 to 1.25 eggs/plant. The data revealed that the all the treatments were found significantly superior over the control to reduce the number of eggs survival of *A. soccata* at 11 DAE. Among all the treatments, Imidacloprid 70WS-NSKE was found highly effective with minimum number of eggs survival *i.e.* 0.00 eggs/plant followed by Thiamethoxam 70WS-NSKE with 0.45 eggs/plant. The next best treatment was Carbofuran 3G with 0.72 number of eggs/plant of *A. soccata*. The other superior treatments to reduce the number of eggs survival in order were Phorate 10G, Imidacloprid 70WS, Thiamethoxam 70WS, Cow urine-NSKE and NSKE with 0.92, 0.98, 1.10, 1.18 and 1.25 eggs/plant. The maximum number of survival eggs (1.85 eggs/plant) was recorded in control plot.

The pooled number of eggs survival of *A. soccata* at 22 DAE is also presented in Table-1. On the basis of pooled number of survival eggs of *A. soccata* it is clear that all the treatments were found significantly superior over control during the year, 2013 and 2014. Among all the treatments, Imidacloprid 70WS-NSKE was found best with minimum number of eggs survival of *A. soccata* with 0.45 eggs/plant. The treatment Thiamethoxam 70WS-NSKE was found second best to reducing the number of eggs survival of *A. soccata* with 0.72 eggs/plant. The next best treatment in order were Carbofuran 3G, Phorate 10G, Imidacloprid 70WS, Thiamethoxam 70WS, Cow urine-NSKE and NSKE with minimum number of eggs survival of *A. soccata* with 0.92, 1.00, 1.15, 1.27, 1.45 and 1.62 eggs/plant, respectively. The maximum number of eggs survival of *A. soccata* (2.30 eggs/plant) was recorded with control plot. The results of the present study are in conformity with the findings of Balikai *et al.* (2001) [4]. Similarly, the results of study conducted by Rao and Panwar (1992) [17], Gupta *et al.* (2004) [7], Shekharappa and Bhuti (2006) [19], Aghav *et al.* (2007) [1], Hari and Jindal (2008) [8], Balikai and Bhagwat (2009) [3], Mudigoudra *et al.* (2009) [12] and Mudigoudra and Shekharappa (2009) [11] also reported that Imidacloprid, Thiomethoxam, Carbofuran and NSKE significantly reduce the eggs survival of *A. soccata*.

The maximum yield 42.93 q/ha was obtained with application of Imidacloprid 70WS-NSKE (Table-2). The second best treatment regarding the yield was Thiamethoxam 70WS-NSKE with the grain yield of 36.18 q/ha and followed by Carbofuran 3G, Phorate 10G, Imidacloprid 70WS, Thiamethoxam 70WS, Cow urine-NSKE and NSKE with the grain yield of 31.16, 26.15, 22.91, 21.22, 21.14 and 20.24 q/ha, respectively. Cost benefit ratio of the treatments showed that Imidacloprid 70WS-NSKE ranked first indicating the maximum return Rs. 16.10 per rupee invested followed by Thiamethoxam 70WS-NSKE, Carbofuran 3G, Phorate 10G, Imidacloprid 70WS, Thiamethoxam 70WS and Cow urine-NSKE with 1:15.36, 1:14.37, 1:13.23, 1:10.90, 1:8.90 and 1:4.18 cost benefit ratio, respectively. The lowest cost benefit ratio (1: 3.67) was obtained in NSKE. The present finding supported by Balikai *et al.* (2001) [4], Hari and Jindal (2008) [8], Pal *et al.* (2009) [14] and Sable *et al.* (2010) [18] who similarly reported that the treatment Imidacloprid and NSKE highly effective with higher grain yield and higher cost benefit ratio.

Table 1: Effect of different treatments on number of eggs of *A. soccata* during the year, 2013 and 2014

Treatments	Dose	Number of eggs/plant					
		11 DAE			22 DAE		
		2013	2014	Pooled	2013	2014	Pooled
Imidacloprid 70WS	5 g/kg Seed	1.00* (1.41)	0.97 (1.40)	0.98 (1.40)	1.13 (1.46)	1.17 (1.47)	1.15 (1.46)
Thiamethoxam 70WS	2 g/kg Seed	1.10 (1.44)	1.10 (1.44)	1.10 (1.44)	1.27 (1.50)	1.27 (1.50)	1.27 (1.50)
Carbofuran 3G	12 kg/ha	0.70 (1.30)	0.73 (1.31)	0.72 (1.31)	0.90 (1.37)	0.93 (1.39)	0.92 (1.38)
Phorate 10G	10 kg/ha	0.90 (1.37)	0.93 (1.39)	0.92 (1.38)	1.00 (1.41)	1.00 (1.41)	1.00 (1.41)
NSKE	5%	1.23 (1.49)	1.27 (1.50)	1.25 (1.50)	1.60 (1.61)	1.63 (1.62)	1.62 (1.61)
Cow urine - NSKE	5%	1.17 (1.47)	1.20 (1.48)	1.18 (1.47)	1.43 (1.56)	1.47 (1.57)	1.45 (1.56)
Imidacloprid 70WS - NSKE	5 g/kg Seed - 5%	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.47 (1.21)	0.43 (1.19)	0.45 (1.20)
Thiamethoxam 70WS - NSKE	2 g/kg Seed - 5%	0.43 (1.19)	0.47 (1.21)	0.45 (1.20)	0.73 (1.31)	0.70 (1.30)	0.72 (1.31)
Control	-	1.83 (1.68)	1.87 (1.69)	1.85 (1.68)	2.23 (1.79)	2.37 (1.83)	2.30 (1.81)
SEM± CD at 5%		0.01 0.05	0.02 0.06	0.01 0.05	0.01 0.05	0.01 0.05	0.01 0.03

DAE= Days after emergence, *Average of three replications, Figures in parentheses are square root transformed values.

Table 2 Cost: benefit ratio of different treatments in maize on pooled yield

Treatment	Dose	Yield (q/ha)	Increase in yield over control (q/ha)	Value of increase yield (Rs./ha)	Cost of treatment/ha	Net profit (Rs./ha)	Cost: benefit ratio
Imidacloprid 70WS	5g/kg Seed	22.91	7.27	11813.75	992	10821.75	1: 10.90
Thiamethoxam 70WS	2g/kg Seed	21.22	5.58	9067.50	915	8152.50	1: 8.90
Carbofuran 3G	12kg/ha	31.16	15.52	25220.00	1640	23580.00	1: 14.37
Phorate 10G	10kg/ha	26.15	10.51	17078.75	1200	15878.75	1: 13.23
NSKE	5%	20.24	4.60	7475.00	1600	5875.00	1: 3.67
Cow urine-NSKE	5%	21.14	5.50	8937.50	1725	7212.50	1: 4.18
Imidacloprid 70WS- NSKE	5g/kg Seed-5%	42.93	27.29	44346.25	2592	41754.25	1: 16.10
Thiamethoxam 70WS-NSKE	5g/kg Seed-5%	36.18	20.54	33377.50	2040	31337.50	1: 15.36
Control	-	15.64					

Labour charges- @ Rs. 250/day/labour, Rental value of sprayer- @ Rs. 50/day, Market price of maize grain- @ Rs. 1625/qt.

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