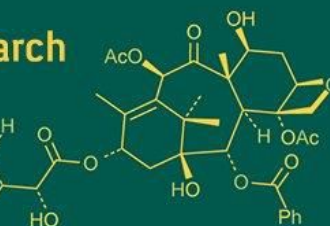


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Assessment of efficacy of thiamethoxam 30% FS as seed treatment for management of early crop-stage insect pest in corn

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Abstract

The present study was conducted to evaluate the bio-efficacy of thiamethoxam 30% w/w FS as seed treatments against early-stage pests of maize. The effect of seed treatment on germination and plant vigour was also studied. The experiment was conducted at Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, West Bengal, India during 2020-21 and 2021-2022. The experiment was laid out in Randomized Block Design (RBD) with seven treatments and each treatment was replicated four times. Results of the present experiments revealed that seed treatment with thiamethoxam 30% w/w FS @2.40 g a.i/kg of seed improved the germination and plant growth and it was found to be the most effective against shoot fly and aphid. No significant adverse effect on coccinellids predators were observed at the tested doses.

Keywords: Maize, thiamethoxam 30 FS, aphid, shoot fly, germination, coccinellids

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop grown in diverse geographical and climate conditions around the world. It is popularly called as the 'Queen of cereals' due to its numerous use (Tali *et al.*, 2018) [1] wider adaptability and highest genetic yield potential among cereal crops. In India this crop is grown in *kharif* (rainy), *rabi* (winter) and spring seasons. But it is mainly grown as *kharif* crop with 85% of the land under cultivation during the season. Although it was originated from central Mexico but at present it is one of the most widely distributed crops in the world. In India, it is cultivated throughout the country in diverse habitats. The leading states that grow the crop are Andhra Pradesh, Karnataka, Rajasthan, Maharashtra, Bihar, Uttar Pradesh, Madhya Pradesh, and Himachal Pradesh. Production of maize is increasing at a rate three times the annual rate of wheat and two times of annual rate of rice (Fischer *et al.*, 2014) [2]. Apart from providing high-quality animal feed and staple food for humans, maize is an essential raw material used in thousands of industrial products such as food sweeteners, alcoholic beverages, starch, oil, protein, film, textiles, gum, packaging, and paper. Maize grain contains protein (10%), oil (4%), carbohydrates (70%), fat (5 to 7%), fibers (5 to 7%) and minerals (2%) (Tali *et al.*, 2018) [3].

Maize crop is infested by a large number of insect pests due to its soft and succulent foliage. About 250 species of insect and mite pests have been reported to damage this crop. But only half a dozen is of economic importance which threatens to limit the production of this crop (Mathur, 1991) [4]. One of the most significant and damaging pests that harms seedlings is the shoot fly (*Atherigona orientalis* (Muscidae: Diptera)). Maximum yield losses from shoot fly are 75.6% for grain and 68.6% for fodder (Pawar *et al.*, 1984) [5]. Shoot fly prefers to lay eggs on the seedlings and the maggot bores the stem and cuts the growing point leading to the desiccation of central shoot to form dead hearts (Sandhu and Kaushal, 1976) [6]. The maize leaf aphid, *Rhopalosiphum maidis* Fitch, is the other pest of economic concern that causes a significant decrease in yield (Siddiqui and Marwaha, 1993) [7]. It is a polyphagous and multivoltine pest which sucks the plant sap causing stunted growth of plant. Both of these two pests are early-stage pests of maize crop. The control measures for management of shoot fly need to be adopted earlier because once the maggot enters into the stem, it becomes difficult to manage them. Insecticides are frequently applied to manage these pests but due to

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frequent application of same insecticides, there is a chance of development of insecticide resistance, pest resurgence and eradication of natural enemies. Seed treatment may be helpful to manage these pests in the early stage of the crop. Moreover, the amount of active ingredient utilized per unit area in seed treatment is lower than that of pesticide application, which is weather-independent. Insecticides having same mode of actions should not be applied repeatedly to manage insecticide resistance. It necessitates to evaluate insecticides having novel model of action for successful management of the pests. Hence, the present study was conducted to evaluate the efficacy of thiamethoxam 30 FS as a seed treatment for management of aphids and shoot fly in maize along with its effect on germination, plants vigour. The effect on natural enemies was also studied in the present experiment.

Materials and Methods

The present field experiments were conducted during 2020-21 and 2021-2022 at Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, West Bengal, India to evaluate the efficacy of thiamethoxam 30 FS as a seed treatment for management of aphids and shoot fly in maize. The experiment was laid out in Randomized Block Design (RBD) with seven treatments viz., thiamethoxam 30% w/w FS @ 0.60 g a.i/ha, 1.20 g a.i/ha, 1.80 g a.i/ha, 2.40 g a.i/ha, imidacloprid 48% FS @ 0.60 g a.i/ha, thiamethoxam 70 WS @ 2.45 g a.i/ha and untreated control. Each treatment was replicated four times. The seed was treated with the chemicals as homogeneous slurry dressing one day before planting. The treated seeds (variety-DKC 9081) were sown in 25 square meter plots. The distance between plants and within rows was 20 and 60 cm, respectively. The seed germination was recorded on whole plot basis. The incidence of deadhearts were recorded at 14, 21, 28 and 35 days after sowing (DAS) on whole plot basis as per Panwar (2005) [8]. In case of aphid, number of aphids were recorded at 21, 28, 35 and 42 DAS from randomly selected 10 plants per plot. The height of the plants was recorded at 30, 45, 60 and 75 DAS from randomly selected 5 plants per plot. The effect of the treatment on natural enemies such as coccinellids was assessed by recording the number of coccinellids population at 21, 28, 35 and 42 DAS from 10 randomly selected plants per plot. The data, thus obtained, were analyzed using two-way ANOVA after making necessary transformation wherever required. Different treatment means were separated by least significant difference test (LSD) at $p=0.05$ (Gomez and Gomez, 1984) [9].

Results and Discussion

The results of the present experiments revealed that plots treated with insecticides provided a significant reduction of shoot fly and aphid as compared to the untreated control. During the first year of study (2020-21), thiamethoxam 30% w/w FS @ 2.4 g a.i/kg of seed was found to be the best treatment in reducing the deadheart incidence followed by the treatment thiamethoxam 70 WS @ 2.45 g a.i/kg of seed (Table-1). Plots treated with thiamethoxam 30% w/w FS @ 2.4 g a.i/kg of seed showed 85.39%, 84.06% and 81.16% reduction of deadhearts incidence over control at 14, 21 and 28 days after sowing (DAS), respectively. During the second year of the study, almost a similar trend of efficacy was observed. Thiamethoxam 30% w/w FS @ 2.4 g a.i/kg

of seed was found to be the best treatment in terms of percent reduction of shoot fly over control (Table-2). This treatment provided 83.43%, 81.45% and 80.24% reduction of dead heart incidence over control at 14, 21 and 28 days after sowing (DAS), respectively. Deadheart incidence in maize causes loss of plant population and ultimately yield of the crop as maize is a non-tillering crop (Sharma and Singh, 1975) [10]. In the present study, thiamethoxam 30% w/w FS @ 2.4 g a.i/kg of seed was found to be the best treatment for management of shoot fly incidence in maize. The above results are also in agreement with the findings of Jindal *et al.* (2021) [11] who reported that thiamethoxam 30FS @ 10.0 ml/kg seed is appropriate to manage shoot fly. The result of present finding also corroborates with the work of Shanmugam *et al.*, 2023 [12]. They reported that seed treatment with thiamethoxam 30% w/w FS @ 2.4 g a.i/kg of seed was found to be effective against shoot fly, *Atherigona orientalis* with the lowest dead heart incidence. The effectiveness of neonicotinoids as seed treatment for management of early-stage pest of maize, sorghum and wheat is already documented by many other workers (Maienfisch *et al.*, 1999; Tharp *et al.*, 2000) [13, 14]. The effectiveness of another formulation of thiamethoxam (70WS) for the management of *A. naqvii* in maize was also reported by Jindal and Kumar (2017) [15]. Thiamethoxam is a second-generation neonicotinoid having systemic activity as well as crop and seed safety characteristics (Wilde *et al.*, 2004) [16]. The effectiveness of thiamethoxam 30% w/w FS may be due to the water-based flowable suspension (FS) formulation as this formulation is more environmentally friendly, have good retention on seed and the preferred one for seed treatments (Knowles, 2008) [17].

In case of aphid the result of the first-year study revealed that the most effective treatment was thiamethoxam 30% w/w FS @ 2.40 g a.i/Kg of seed which was at par with the immediate lower dose of the same chemical (1.80 g a.i/Kg of seed). Seeds treated with thiamethoxam 30% w/w FS @ 2.40 g a.i/Kg showed 86.64%, 83.80% and 82.07% reduction of aphid population per plant over control at 21, 28 and 35 days after sowing, respectively (Table-3). During the second year of the study, almost a similar trend of efficacy was observed. Thiamethoxam 30% w/w FS @ 2.4 g a.i/kg of seed was found to be the most effective treatment in terms of percent reduction of aphid population over control (Table-4). The present findings are in agreement with the findings of Shanmugam *et al.*, 2023 [12].

Coccinella sp and *Menochilus sp* were found to be the most abundant coccinellid predator in maize during the period of study. No significant adverse effect of thiamethoxam 30% w/w FS was observed on coccinellid population during both the year of study (Table-5 and 6). Similar results were also reported by Shanmugam *et al.* (2023) [12] who reported that thiamethoxam 30% w/w FS was relatively safer to natural enemies viz., coccinellids and spiders. Our findings are supported by the findings of Katole and Patil (2000) [18], who reported that seed dressings are biosafe against a variety of predators, including lady bird beetles.

Treatment of seed with thiamethoxam 30FS showed no significant adverse effect on germination (Table-7 and 8) during both the years of study. Rather, height of seedling was significantly improved in thiamethoxam 30FS treated plots as compared to untreated control. The improved germination and increase in growth of sorghum and maize with imidacloprid and thiamethoxam seed treatment was

also reported by Jindal *et al.*, 2021 ^[11], Katole *et al.*, 2003 ^[19]; Jindal and Hari, 2008 ^[20]. The improved growth of the crop may be due to the phytotonic effect of neonicotinoid on

seedling growth (Katole *et al.*, 2003; Jindal and Hari, 2008) ^[19, 20].

Table 1: Effect of thiamethoxam 30%w/w FS on incidence of deadhearts caused by shoot fly in corn (1st season)

Treatments	Dose (g a.i/kg of seed)	% Deadheart							
		14 DAS	% ROC	21 DAS	% ROC	28 DAS	% ROC	35 DAS	% ROC
Thiamethoxam 30% w/w FS	0.60	3.21 (10.32)	57.37	3.98 (11.51)	55.63	4.48 (12.22)	50.93	6.13 (14.33)	49.51
Thiamethoxam 30% w/w FS	1.20	2.34 (8.80)	68.92	2.97 (9.92)	66.89	3.45 (10.70)	62.21	4.81 (12.67)	60.38
Thiamethoxam 30% w/w FS	1.80	1.53 (7.11)	79.68	2.08 (8.29)	76.81	2.38 (8.87)	73.93	3.41 (10.64)	71.91
Thiamethoxam 30% w/w FS	2.40	1.10 (6.02)	85.39	1.43 (6.87)	84.06	1.72 (7.54)	81.16	2.49 (9.08)	79.49
Imidacloprid 48% FS	0.60	2.17 (8.47)	71.18	2.83 (9.68)	68.45	3.74 (11.15)	59.04	5.35 (13.37)	55.93
Thiamethoxam 70 WS	2.45	1.24 (6.39)	83.53	1.58 (7.22)	82.39	1.79 (7.69)	80.39	2.59 (9.26)	78.67
Untreated control	-	7.53 (15.93)	-	8.97 (17.43)	-	10.62 (19.02)	-	12.14 (20.39)	-
S. Em ($\pm$)	-	0.09	-	0.10	-	0.07	-	0.12	-
CD (p=0.05)	-	0.28	-	0.31	-	0.21	-	0.35	-

N.B: DAS- Days After Sowing, % ROC- Per cent Reduction over control. Figures in parentheses are square root transformed values.

Table 2: Effect of thiamethoxam 30%w/w FS on incidence of deadhearts caused by shoot fly in corn (2nd season).

Treatments	Dose (g a.i/kg of seed)	% Dead Heart							
		14 DAS	% ROC	21 DAS	% ROC	28 DAS	% ROC	35 DAS	% ROC
Thiamethoxam 30% w/w FS	0.60	2.98 (9.94)	58.15	3.74 (11.15)	56.91	4.65 (12.45)	52.89	5.78 (13.91)	50.09
Thiamethoxam 30% w/w FS	1.20	2.31 (8.74)	67.56	2.98 (9.94)	65.67	3.64 (11.00)	63.12	4.71 (12.53)	59.33
Thiamethoxam 30% w/w FS	1.80	1.62 (7.31)	77.25	2.19 (8.51)	74.77	2.73 (9.51)	72.34	3.14 (10.21)	72.88
Thiamethoxam 30% w/w FS	2.40	1.18 (6.24)	83.43	1.61 (7.29)	81.45	1.95 (8.03)	80.24	2.65 (9.37)	77.12
Imidacloprid 48% FS	0.60	2.17 (8.47)	69.52	2.83 (9.68)	67.40	3.74 (11.15)	62.11	5.35 (13.37)	53.80
Thiamethoxam 70 WS	2.45	1.24 (6.39)	82.58	1.68 (7.45)	80.65	2.11 (8.35)	78.62	2.67 (9.40)	76.94
Untreated control	-	7.12 (15.48)	-	8.68 (17.13)	-	9.87 (18.31)	-	11.58 (19.98)	-
S. Em ($\pm$)	-	0.06	-	0.04	-	0.10	-	0.10	-
CD (p=0.05)	-	0.19	-	0.12	-	0.31	-	0.29	-

N.B: DAS- Days After Sowing, % ROC- Per cent Reduction over control. Figures in parentheses are square root transformed values

Table 3: Effect of thiamethoxam 30% w/w FS on incidence of aphid in corn (1st season).

Treatments	Dose (g a.i/kg of seed)	No. of Aphids/Plant							
		21 DAS	% ROC	28 DAS	% ROC	35 DAS	% ROC	42 DAS	% ROC
Thiamethoxam 30% w/w FS	0.60	3.45 (1.99)	72.06	11.32 (3.44)	70.65	28.45 (5.38)	58.97	43.98 (6.67)	46.84
Thiamethoxam 30% w/w FS	1.20	2.98 (1.87)	75.87	10.32 (3.29)	73.24	21.56 (4.70)	68.91	40.76 (6.42)	50.73
Thiamethoxam 30% w/w FS	1.80	2.09 (1.61)	83.08	6.99 (2.74)	81.88	13.76 (3.78)	80.16	26.14 (5.16)	68.40
Thiamethoxam 30% w/w FS	2.40	1.65 (1.47)	86.64	6.25 (2.60)	83.80	12.43 (3.60)	82.07	24.87 (5.04)	69.94
Imidacloprid 48% FS	0.60	3.19 (1.92)	74.17	10.43 (3.31)	72.96	20.98 (4.63)	69.74	42.13 (6.53)	49.08
Thiamethoxam 70 WS	2.45	2.14 (1.62)	82.67	7.71 (2.87)	80.01	15.98 (4.06)	76.95	26.98 (5.24)	67.39
Untreated control	-	12.35 (3.58)	-	38.57 (6.25)	-	69.34 (8.36)	-	82.73 (9.12)	-
S. Em ($\pm$)	-	0.08	-	0.18	-	0.37	-	0.30	-
CD (p=0.05)	-	0.24	-	0.53	-	1.12	-	0.89	-

N.B: DAS- Days After Sowing, % ROC- Per cent Reduction over control. Figures in parentheses are square root transformed values

Table 4: Effect of thiamethoxam 30% w/w FS on incidence of aphid in corn (2nd season).

Treatments	Dose (g a.i/kg of seed)	No. of Aphids/Plant							
		21 DAS	% ROC	28 DAS	% ROC	35 DAS	% ROC	42 DAS	% ROC
Thiamethoxam 30% w/w FS	0.60	3.54 (2.01)	67.43	11.76 (3.50)	65.39	28.93 (5.42)	56.01	48.97 (7.03)	44.33
Thiamethoxam 30% w/w FS	1.20	2.87 (1.84)	73.60	10.18 (3.27)	70.04	21.45 (4.69)	67.38	41.54 (6.48)	52.77
Thiamethoxam 30% w/w FS	1.80	1.87 (1.54)	82.80	6.78 (2.70)	80.05	13.24 (3.71)	79.87	28.74 (5.41)	67.33
Thiamethoxam 30% w/w FS	2.40	1.54 (1.43)	85.83	5.98 (2.55)	82.40	11.97 (3.53)	81.80	25.98 (5.15)	70.46
Imidacloprid 48% FS	0.60	2.96 (1.86)	72.77	10.21 (3.27)	69.95	21.98 (4.74)	66.58	42.36 (6.55)	51.84
Thiamethoxam 70 WS	2.45	1.97 (1.57)	81.88	6.89 (2.72)	79.72	15.83 (4.04)	75.93	28.43 (5.38)	67.68
Untreated control	-	10.87 (3.37)	-	33.98 (5.87)	-	65.76 (8.14)	-	87.96 (9.41)	-
S. Em (±)	-	0.09	-	0.20	-	0.37	-	0.62	-
CD (p=0.05)	-	0.28	-	0.61	-	1.12	-	1.87	-

N.B: DAS- Days After Sowing, % ROC- Per cent Reduction over control. Figures in parentheses are square root transformed values

Table 5: Effect thiamethoxam 30% w/w FS on coccinellids population in corn (1st season).

Treatments	Dose (g a.i/kg of seed)	Coccinellids population/10 plants				
		21 DAS	28 DAS	35 DAS	42 DAS	Mean
Thiamethoxam 30% w/w FS	0.60	3.45 (1.99)	5.64 (2.48)	8.43 (2.99)	10.43 (3.31)	6.99
Thiamethoxam 30% w/w FS	1.20	2.95 (1.86)	4.89 (2.32)	9.54 (3.17)	10.21 (3.27)	6.90
Thiamethoxam 30% w/w FS	1.80	2.85 (1.83)	5.32 (2.41)	9.46 (3.16)	9.85 (3.22)	6.87
Thiamethoxam 30% w/w FS	2.40	2.67 (1.78)	4.88 (2.32)	8.98 (3.08)	9.49 (3.16)	6.51
Imidacloprid 48% FS	0.60	2.48 (1.73)	4.56 (2.25)	8.42 (2.99)	9.86 (3.22)	6.33
Thiamethoxam 70 WS	2.45	2.19 (1.64)	3.97 (2.11)	8.21 (2.95)	9.12 (3.10)	5.87
Untreated control	-	3.76 (2.06)	6.29 (2.61)	8.02 (2.92)	10.04 (3.25)	7.03
S. Em (±)	-	0.06	0.18	0.14	0.18	0.06
CD (p=0.05)	-	0.19	0.53	0.43	0.54	0.19

N.B: DAS- Days After Sowing, % ROC- Per cent Reduction over control. Figures in parentheses are square root transformed values.

Table 6: Effect of thiamethoxam 30% w/w FS on coccinellids population in corn (2nd season).

Treatments	Dose (g a.i/kg of seed)	Coccinellids population/10 plants.				
		21 DAS	28 DAS	35 DAS	42 DAS	Mean
Thiamethoxam 30% w/w FS	0.60	4.42 (2.22)	6.63 (2.67)	9.38 (3.14)	11.38 (3.45)	7.95
Thiamethoxam 30% w/w FS	1.20	3.98 (2.12)	5.87 (2.52)	10.56 (3.33)	11.16 (3.41)	7.89
Thiamethoxam 30% w/w FS	1.80	3.84 (2.08)	6.28 (2.60)	10.42 (3.30)	10.84 (3.37)	7.85
Thiamethoxam 30% w/w FS	2.40	3.68 (2.04)	5.86 (2.52)	9.94 (3.23)	10.43 (3.31)	7.48
Imidacloprid 48% FS	0.60	3.43 (1.98)	5.55 (2.46)	9.27 (3.13)	10.45 (3.31)	7.18
Thiamethoxam 70 WS	2.45	3.29 (1.95)	4.98 (2.34)	9.21 (3.12)	10.18 (3.27)	6.92
Untreated control	-	4.73 (2.29)	7.26 (2.79)	8.96 (3.08)	11.09 (3.40)	8.01
S. Em (±)	-	0.09	0.10	0.14	0.06	-
CD (p=0.05)	-	0.27	0.31	0.41	0.18	-

N.B: DAS- Days After Sowing, % ROC- Per cent Reduction over control. Figures in parentheses are square root transformed values

Table 7: Effect of thiamethoxam 30% w/w FS on germination and plant growth of corn (1st season).

Treatments	Dose (g a.i/kg of seed)	% Germination	Plant height (cm/plant)			
			30DAS	45 DAS	60 DAS	75 DAS
Thiamethoxam 30% w/w FS	0.60	92.15 (73.73)	80.63 (9.01)	113.87 (10.69)	166.76 (12.93)	197.97 (14.09)
Thiamethoxam 30% w/w FS	1.20	92.87 (74.51)	82.44 (9.11)	118.28 (10.90)	169.87 (13.05)	221.98 (14.92)
Thiamethoxam 30% w/w FS	1.80	93.13 (74.80)	83.42 (9.16)	120.31 (10.99)	170.65 (13.08)	222.43 (14.93)
Thiamethoxam 30% w/w FS	2.40	93.45 (75.17)	86.14 (9.31)	122.56 (11.09)	172.32 (13.15)	224.87 (15.01)
Imidacloprid 48% FS	0.60	93.84 (75.63)	84.15 (9.20)	118.87 (10.93)	165.32 (12.88)	213.59 (14.63)
Thiamethoxam 70 WS	2.45	93.12 (74.79)	85.13 (9.25)	121.14 (11.03)	171.18 (13.10)	222.75 (14.94)
Untreated control	-	92.12 (73.70)	76.48 (8.77)	108.96 (10.46)	162.64 (12.77)	188.95 (13.76)
S. Em (±)	-	0.08	0.37	0.46	0.32	0.42
CD (p=0.05)	-	0.25	1.12	1.38	0.96	1.27

N.B.: DAS-Days after sowing. Figures in the parentheses are angular (% germination) and square root (plant height) transformed values.

Table 8: Effect of thiamethoxam 30% w/w FS on germination and plant growth of corn (2nd season).

Treatments	Dose (g a.i./kg of seed)	% Germination	Plant height (cm/plant)			
			30DAS	45 DAS	60 DAS	75 DAS
Thiamethoxam 30% w/w FS	0.60	93.28 (74.98)	81.84 (9.07)	115.06 (10.75)	168.09 (12.98)	199.64 (14.15)
Thiamethoxam 30% w/w FS	1.20	93.94 (75.75)	83.69 (9.18)	119.48 (10.95)	171.17 (13.10)	223.65 (14.97)
Thiamethoxam 30% w/w FS	1.80	94.25 (76.13)	84.63 (9.23)	121.59 (11.05)	171.98 (13.13)	224.09 (14.99)
Thiamethoxam 30% w/w FS	2.40	94.57 (76.52)	87.39 (9.37)	123.73 (11.15)	173.65 (13.20)	226.55 (15.07)
Imidacloprid 48% FS	0.60	94.08 (75.92)	85.35 (9.27)	120.08 (10.98)	166.66 (12.93)	215.28 (14.69)
Thiamethoxam 70 WS	2.45	94.24 (76.11)	86.31 (9.32)	122.34 (11.08)	172.54 (13.15)	224.47 (15.00)
Untreated control	-	93.21 (74.90)	77.69 (8.84)	110.19 (10.52)	163.97 (12.82)	190.68 (13.83)
S. Em (±)	-	0.09	0.35	0.42	0.31	0.41
CD (p=0.05)	-	0.28	1.04	1.25	0.94	1.23

N.B.: DAS-Days after sowing. Figures in the parentheses are angular (%germination) and square root (plant height) transformed values.

Conclusion

It can be concluded from the present findings that thiamethoxam 30FS @ 2.40 g a.i./kg of seed was the most effective treatment for management of shoot fly infestation in maize and thiamethoxam 30FS @ 1.80 g a.i./kg of seed was the best treatment for successful management of aphid in maize. Seed treatment with thiamethoxam 30FS also improved the germination as well as plants vigour in maize. These insecticides as seed treatment showed no significant adverse effect on coccinellid predator in maize agro-ecosystem.

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