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Effect of newer insecticides against maize aphid, *Rhopalosiphum maidis* (Fitch)

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Abstract
The field investigations were carried out to evaluate the efficacy of seven newer insecticide molecules *viz*., profenophos 50 EC@ 30 ml, indoxacarb 14.5 SC @ 8.5 ml, emamectin benzoate 5 SG@ 4 g, spinosad 45SC @ 4 ml, thiamethoxam 12.6 + lambdacyhalothrin 9.5@ 2.5 ml, chlorantraniliprole 18.5 SC 3 ml, and flubendiamide 49.35 SC @ 2.5 per 10 lit. of water respectively. The results revealed that all the insecticidal treatments were significantly effective against aphid over untreated control. Among that thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC was most effective treatment. The next effective insecticides were profenophos 50 EC, emamectin benzoate 5 SG, indoxacarb 14.5 SC, chlorantraniliprole 18.5 SC, flubendiamide 39.35 SC and spinosad 45 SC.

Keywords: Efficacy, aphid, maize, profenophos, indoxacarb, emamectin benzoate, spinosad, thiamethoxam + lambdacyhalothrin, chlorantraniliprole, flubendiamide

1. Introduction
Maize (Zea mays) is the third major cereal crop extensively grown in temperate, subtropical and tropical regions of the world. It is known for its wider adaptability and multipurpose uses [9]. Green maize plants are used as succulent fodder, roasted green cobs are liked by people. It is also good feed for piggery, poultry and other animal. The grain is very nourishing, with about 70 – 72 per cent assailable carbohydrates, 4 - 4.5 per cent fats and oils and 9.5 - 11 per cent proteins [5]. India ranks sixth in global maize production and fifteenth position in its productivity in world, contributing to 2.4 per cent of world production with almost 5 per cent share in world harvested area. In India, Rabi maize was sown in around 7.22 lakh hectares as of 30th November 2018 which was lower than 8.34 lakh hectares during corresponding period last year. In Bihar, maize was sown in around 2.47 lakh hectares which was almost equal to 3.16 lakh hectares during corresponding period last year. Crop conditions are favorable till the time. All India Rabi maize production is estimated by at 26.50 MMT for the year 2018. In Maharashtra the production was 3450.4 Tones, productivity 3143 kg ha-1and area 1097.7 hectare during 2018. In Maharashtra, maize is cultivated mainly in Aurangabad, Jalna, Buldhana, Jalgaon, Nanded, Solapur, Sangali and Satara districts [1]. The economically important pest is aphid *Rhopalosiphum maidis* (Fitch) causing considerable yield loss in maize [7]. Feeding of aphids disturbs water transport in plants, which is extremely dangerous in periods of draught, and decreases the level of chlorophyll in tissues, which in turn affects photosynthesis and nutrient uptake by plants [8, 11]. The indirect harmfulness of aphids is associated with the fact that by sucking tissue fluids they increase plant susceptibility to infection of pathogens [6]. Some aphid species can also be vectors for viruses infecting maize plants e.g. maize dwarf mosaic virus (MDMV) and also viruses infecting cereals e.g. barley yellow dwarf virus (BYDY). To overcome resistance problems, reduce doses of insecticides with selective mode of action and persistence against target pest. The present study evaluates the effect of the newer insecticides for the management of maize aphid.

2. Materials and Methods
The experiment was laid out in a Randomized Block Design with three replications. The whole area of experimental field was divided into three replications and each block was again divided into eight plots. The observations on total number of nymphs of aphid were recorded at one day before, 2, 7, and 14 days after application of insecticides for each spraying.

2.1 Treatment details

Sr. No.	Treatments	Dose (ml or gm)/ ha
1	Profenophos 50 EC	1500 ml
2	Indoxacarb 14.5 SC	425 ml
3	Emamectin benzoate 5SG	200 g
4	Spinosad 45SC	200 ml
5	Thiamethoxam 12.6 + Lambda cyhalothrin 9.5	125 ml
6	Chlorantraniliprole 18.5 SC	150 ml
7	Flubendiamide 49.35 SC	125 ml
8	Water spray	-

2.3 The details of experiments are given below

Experimental Design	Randomized Block Design
Season	*Rabi* 2018 □ 19
Plot size	6.0 x 3.6 m^2
Variety	Komal
Spacing between plants	60 x 30 cm^2

3. Results and Discussion

3.1 Effect of insecticides on aphid population of maize after First Spraying

The data recorded before application of insecticides was plant infestation by aphid was non-significant showing even distribution of plant infestation before spraying (Table 1). On 2 DAS after first application of insecticides revealed that all the insecticides were found significantly superior over water spray in reducing aphid population on maize thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (1.33 aphid/3leaf) recorded minimum aphid population and it was at par with profenophos 50 EC (3.00 aphid/3leaf). emamectin benzoate 5 SG (3.5 aphid/3leaf), indoxacarb 14.5 SC (4.2 aphid /3leaf), chorantraniliprole 18.5 SC (7.8 aphid/3leaf), flubendiamide 39.35 SC (8.1 aphid/3leaf) and spinosad 45 SC (8.5 aphid/3leaf) were the other treatments in their order of effectiveness. However water spray (22.5 aphid/3leaf) does not have any effect against aphid on maize.

On 7 DAS, also same trend of effectiveness was observed and all the insecticidal treatments were found effective in reducing aphid population significantly than water spray after first application of treatments. Thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (1.66 aphid/3leaf) recorded minimum aphid population was significantly superior over all the treatments however other treatments in their order of effectiveness were profenophos 50 EC (4.3 aphid/3leaf), emamectin benzoate 5 SG (5.5 aphid/3leaf), indoxacarb 14.5 SC (6.4 aphid /3leaf), chorantraniliprole 18.5 SC (10.4 aphid/3leaf), flubendiamide 39.35 SC (11.4 aphid/3leaf) and spinosad 45 SC (12.7 aphid/3leaf). Water spray (26.3 aphid/3leaf) was found least effective against aphid on maize at 7 DAS. All the insecticides were found significantly superior over water spray (33.7 aphid/3leaf) in reducing aphid population of maize after 14 days after first application of treatments thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC(1.66 aphid/3leaf) recorded minimum aphid population and was significantly superior over all the treatments. Profenophos 50 EC (17.00 aphid/3leaf) and chorantraniliprole 18.5 SC (17.8 aphid/3leaf) were the next best treatments and were at par with flubendiamide 39.35 SC (18.1 aphid /3leaf), emamectin benzoate 5 SG (18.7 aphid/3leaf), spinosad 45 SC (19.2 aphid/3leaf) and indoxacarb 14.5 SC (19.5 aphid /3leaf).

3.2 Effect of insecticides on aphid population of maize after Second Spraying

The observation provided in Table No. 2 showed that the pre-count of aphid infestation was not important, showing even distribution before spraying. The data on the effect of various insecticides on aphid plant infestation after the second spray are given below. On 2 DAS, after second application of the insecticides thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (1.4 aphid/3 leaf) was found to be substantially superior to water spray in reducing maize aphid population along with other treatments and was at par with profenophos 50 EC (2.1 aphid /3leaf) and emamectin benzoate 5 SG (2.1 aphid/3leaf). Other excellent treatments were indoxacarb 14.5 SC (4.1 aphid /3leaf), chlorantraniliprole 18.5 SC (7.1 aphid/3leaf), flubendiamide 39.35 SC (8.4 aphid/3leaf) and spinosad 45 SC (10.5 aphid/3leaf). Water spray was found to be less effective against maize aphid (36.2 aphid/3leaf). On 7 DAS, after second application of insecticides thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (2.00 aphid/3leaf) and all insecticides were found to be substantially superior to water spray in reducing maize aphid population and treatment of the thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC(2.0 aphid/3leaf) was at par with profenophos 50 EC (2.8 aphid/3leaf), emamectin benzoate 5 SG (3.4 aphid/3leaf). Indoxacarb 14.5 SC(6.4 aphid/3leaf), chlorantraniliprole 18.5 SC (8.4 aphid/3leaf), flubendiamide 39.35 SC(9.1 aphid/3leaf) and spinosad 45 SC(12.5 aphid/3leaf) have found to be effective for aphid management and water spray (40.5 aphid/3leaf) been found to be less effective for aphid control on maize at 7 DAS.

On 14 DAS, after second application of insecticides thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (4.3 aphid/3leaf) was found to be substantially superior to water spray in reducing maize aphid population and was at par with profenophos 50EC (4.8 aphid/3leaf). Indoxacarb 14.5 SC (8.1 aphid/3leaf), emamectin benzoate 5 SG (9.4 aphid/3leaf), flubendiamide 39.35 SC (10.1 aphid/3leaf), chlorantraniliprole 18.5 SC (10.2 aphid/3leaf) and spinosad 45 SC (20.5 aphid/3leaf) were the next best insecticidal treatments. In water spray (45.3 aphid/3leaf) increase of maize aphid found on 14 DAS after second application of treatments.

3.3 Effect of insecticides on aphid population of maize after third Spraying

The observation given in Table No 3. indicates that the pre-count of aphid infestation was even before spraying and the data on the effect of various insecticides on aphid plant infestation after the third spray are given below. After the third application of insecticides, all insecticides were found to be significantly superior to water spray in reducing maize aphid population and treatment of thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (0.2 aphid/3leaf) was at par with profenophos 50 EC (0.6 aphid/3leaf), emamectin benzoate 5 SG (1.0 aphid /3leaf) and indoxacarb 14.5 SC (1.5 aphid/3leaf) on 2 DAS. The next effective treatments were chlorantraniliprole 18.5 SC (2.8 aphid/3leaf), flubendiamide 39.35 SC (3.5 aphid/3leaf) and spinosad 45 SC (6.9 aphid/3leaf). Water spray (11.6 aphid /3leaf) recorded highest maize aphid on 2 DAS.

On 7 DAS, All insecticides were found to be substantially superior to water spray in reducing the maize aphid population after the third application of treatments. Thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (0.3 aphid/3leaf) reported a minimum aphid population and was statistically equal to treatments of profenophos 50 EC (0.8 aphid/3leaf), emamectin benzoate 5 SG (1.2 aphid/3leaf) and indoxacarb 14.5 SC (1.8 aphid/3leaf). Other treatments in which aphid infestation was substantially decreased were chlorantraniliprole 18.5 SC (2.7 aphid/3leaf), flubendiamide

39.35 SC (3.1 aphid/3leaf) and spinosad 45 SC (7.2 aphid / 3leaf). The highest infestation of pests was recorded by water spray, i.e. (12.2 aphid/3leaf) at 7 DAS. All insecticides were found to be significantly superior to water spray on 14 DAS in reducing the maize aphid population after the third application of insecticides thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (0.5 aphid/3leaf) recorded minimum aphid population and were at par with profenophos 50 EC (1.2 aphid/3leaf). Emamectin Benzoate 5 SG (2.3 aphid/3leaf), indoxacarb 14.5 SC (3.4 aphid/3leaf), chlorantraniliprole 18.5 SC (5.1 aphid/3leaf), flubendiamide 39.35 SC (5.4 aphid / 3leaf) and spinosad 45 SC (7.8 aphi /3leaf) were other effective treatments in their order of effectiveness. Water spray (12.5 aphid/3leaf) showed growth at 14 DAS in the aphid population.

3.4 Cumulative effect of newer insecticides against *R. maidis*

The data displayed in Table No. 4. pertaining to cumulative effect of newer insecticides against aphids at three days after spray revealed that thimethoxam 12.6 + lambda cyhalothrin 9.5 ZC (1.5 aphid/3leaf) proved effective in reducing the population of aphids. However, this treatment was found statistically equal with profenophos 50 EC (8.1 aphid/3leaf) and emamectin benzoate 5 SG (9.2 aphid/3leaf). Whereas, the treatments indoxacarb 14.5 SC (10 aphid/3leaf), chlorantraniliprole 18.5 SC (12 aphid/3leaf), flubendiamide 39.35 SC (12.5 aphid /3leaf) and spinosad 45 SC (13.4 aphid/3leaf) found at par with each other. However, water spray recorded maximum population (27.5 aphid/3leaf) suggesting constant increase. The data on cumulative effect of different treatments against aphids at seven days after spray (Table 10) showed that application of Thimethoxam 12.6 + Lambda cyhalothrin 9.5 ZC (2.5 aphid/3leaf) proved effective in recording the population of aphids. However, this treatment was found statistically equal with Profenophos 50 EC (3.2 aphid/3leaf) and Emamectin Benzoate 5 SG (4.9 aphid/3leaf). Whereas, the treatments Indoxacarb 14.5 SC (6.2 aphid /3leaf), Chlorantraniliprole 18.5 SC (8.5 aphid/3leaf), Flubendiamide 39.35 SC (9.2 aphid /3leaf) and spinosad 45 SC (14.5 aphid/3leaf) found at par with each other. However, water spray recorded maximum population (40.6 aphid/3leaf).

Among the different treatments cumulative aphid population recorded at fourteen days after spray (Table 10) was minimum in the plots treated with Thimethoxam 12.6 + Lambda cyhalothrin 9.5 ZC (0.3 aphid/3leaf) and was proved effective in reducing the population of aphids. However, this treatment was found statistically at par with Profenophos 50 EC (0.8 aphid/3leaf) and Emamectin Benzoate 5 SG (1.5 aphid/3leaf). Whereas, the treatments Indoxacarb 14.5 SC (2.2 aphid /3leaf), Chlorantraniliprole 18.5 SC (3.5 aphid/3leaf), Flubendiamide 39.35 SC (4 aphid /3leaf) and spinosad 45 SC (7.3 aphid/3leaf) found at par with each other in reducing aphid infestation. However, water spray recorded maximum population (12.1aphid/3leaf).

It is evident from the cumulative mean data presented in Table 4. that after sprays treatment with Thimethoxam 12.6 + Lambda cyhalothrin 9.5 ZC (1.43 aphid/3leaf) proved effective in recording the population of aphids. However, this treatment was found statistically equal with Profenophos 50 EC (4.03 aphid/3leaf) and Emamectin Benzoate 5 SG (5.2 aphid/3leaf). Whereas, the treatments Indoxacarb 14.5 SC (6.13 aphid /3leaf), Chlorantraniliprole 18.5 SC (8.0 aphid/3leaf), Flubendiamide 39.35 SC (8.56 aphid /3leaf) and spinosad 45 SC (11.73 aphid/3leaf) found at par with each other and were the next best treatments for reducing aphid infestation. However, water spray recorded maximum population (26.73 aphid/3leaf).

The present finding are more less parallel to the finding of other workers, all insecticides thiamethoxam 25 WG, imidacloprid 17.8 SL, dimethoate 30 EC and biopesticides namely NSKE 5 per cent, nimark and karanj leaf extract 5 per cent, were significantly superior against sorghum aphid. The highest incremental cost benefit ratio was obtained in dimethoate (1:11.2) followed by imidacloprid (1:7.3), thiamethoxam (1:6.6) and NSKE 5 per cent (1:5.6)[2]. Flubendamide 480 SC @ 20 g a.i./ha, clothianidin 50 WDG @ 15 g a.i./ha and acetamiprid 20 SP @ 20 g a.i./ha showed significantly lower numbers of aphids; 0.5,0.8 and 1.1 aphids / shoot compared to other treatments after 15 days of spraying. For treatments with flubendamide 480 SC @20 g a.i./ha and clothianidin 50 WDG@15 g a.i./ha, a maximum yield of 41.8 q / h was achieved[10]. On the basis of grain yield, flubendiamide 480 SC @ 250ml/ha. was again the best treatment 48.29 q/ha and it was at par with clothianidin 50 WDG @ 30 gm/ha (47.71q/ha.), acetamiprid 20 SP @ 100 gm/ha. (47.63 q/ha) and significantly better than untreated control (38.21 q/ha) [3]. The percentage reduction in population over untreated check was highest in treatment Flubendiamide (82.04) followed by the treatments Thiamethoxam, Clothianidin 50 WDG, Imidacloprid, Dimethoate and Chlorantraniliprole effectively reduced the population of aphids by 80.22, 77.48, 75.50, 71.54 and 71.93 per cent respectively [4].

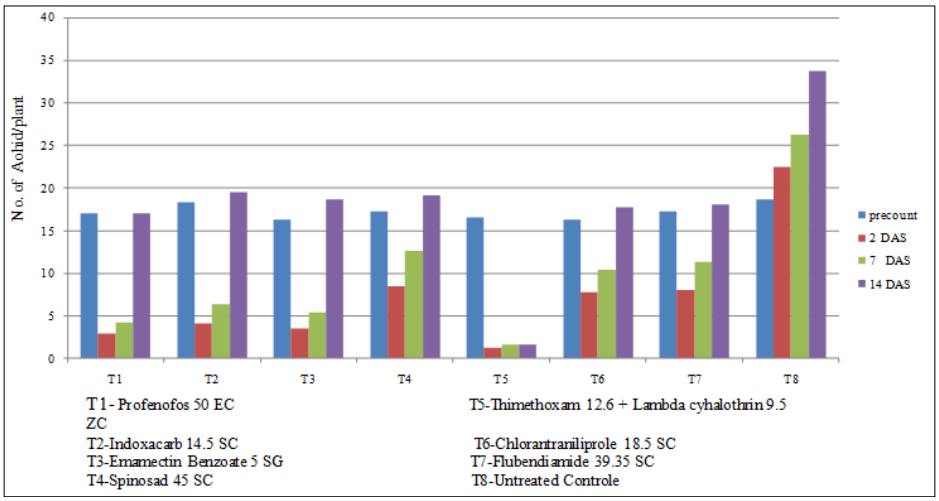

Fig 1: Effect of insecticides on Aphid population on maize during *Rabi*-2018 After first spray

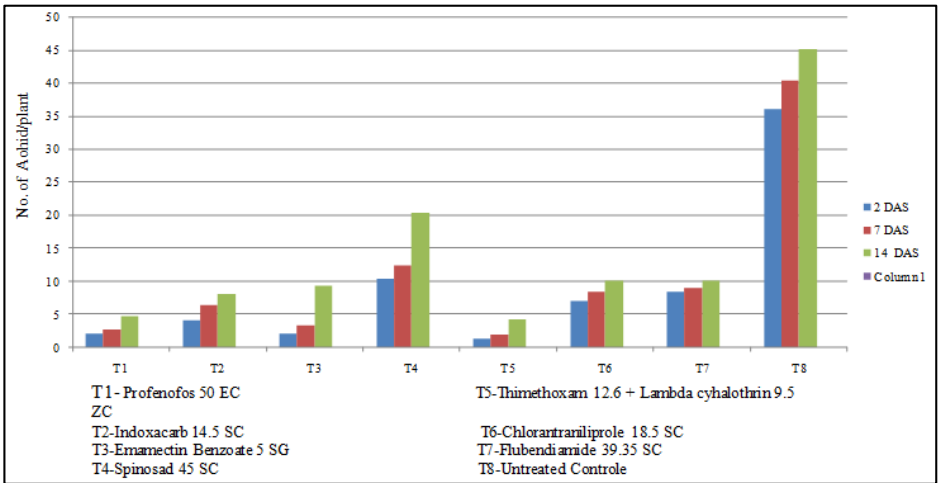

Fig 2: Effect of insecticides on Aphid population on maize during *Rabi*-2018 After second spray

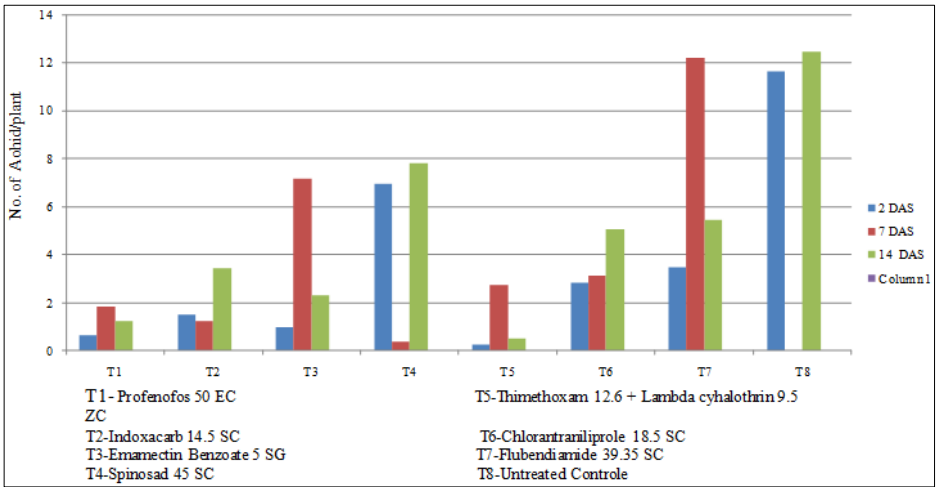

Fig 3: Effect of insecticides on Aphid population on maize during *Rabi*-2018 After third spray

Table 1: Effect of insecticides on aphid population of maize after First Spraying

Tr. No.	Treatment	No. of Aphid per 3leaf				
		Dose (ml or gm)/ha	Pre-count	2 DAS	7 DAS	14 DAS
T_1	Profenophos 50 EC	1500 ml	17.00 (4.21)	3.00 (1.98)	4.30 (2.29)	17 (4.20)
T_2	Indoxacarb 14.5 SC	425 ml	18.33 (4.38)	4.2 (2.27)	6.4 (2.71)	19.5 (4.51)
T_3	Emamectin benzoate 5 SG	200 g	16.33 (4.15)	3.5 (2.12)	5.5 (2.54)	18.7 (4.43)
T_4	Spinosad 45SC	200 ml	17.33 (4.26)	8.5 (3.06)	12.7 (3.68)	19.2 (4.48)
T_5	Thiamethoxam 12.6 +Lambda cyhalothrin 9.5	125 ml	16.55 (4.18)	1.33 (1.52)	1.66 (1.63)	1.66 (1.62)
T_6	Chlorantraniliprole 18.5 SC	150 ml	16.33 (4.15)	7.8 (2.96)	10.4 (3.36)	17.8 (4.33)
T_7	Flubendiamide 49.35 SC	125 ml	17.33 (4.26)	8.1 (3.01)	11.4 (3.50)	18.1 (4.36)
T_8	Water spray		18.66 (4.42)	22.5 (4.83)	26.3 (5.22)	33.7 (5.89)
	SE (m)		N/S	0.15	0.17	0.19
	CD at 5%			0.48	0.52	0.60
	CV (%)			9.96	9.41	8.07

Table 2: Effect of insecticides on aphid population of maize after second spraying

Tr. No.	Treatment	No. of aphid per 3leaf			
		Dose (ml or gm) /ha	2 DAS	7 DAS	14 DAS
T_1	Profenophos 50 EC	1500 ml	2.1 (1.74)	2.8 (1.94)	4.8 (2.40)
T_2	Indoxacarb 14.5 SC	425 ml	4.1 (2.24)	6.4 (2.71)	8.1 (3.00)
T_3	Emamectin benzoate 5 SG	200 g	2.1 (1.74)	3.4 (2.08)	9.4 (3.22)
T_4	Spinosad 45SC	200 ml	10.5 (3.38)	12.5 (3.64)	20.5 (4.61)
T_5	Thiamethoxam 12.6 + Lambda cyhalothrin 9.5	125 ml	1.4 (1.54)	2 (1.72)	4.3 (2.30)
T_6	Chlorantraniliprole 18.5 SC	150 ml	7.1 (2.83)	8.4 (3.06)	10.2 (3.42)
T_7	Flubendiamide 49.35 SC	125 ml	8.4 (3.05)	9.1 (3.17)	10.1 (3.33)
T_8	Water spray		36.2 (6.09)	40.5 (6.43)	45.3 (6.78)
	SE (m)		0.13	0.18	0.21
	CD at 5%		0.41	0.55	0.65
	CV (%)		8.26	10.15	10.27

Table 3: Effect of insecticides on aphid population on maize after third spraying

Tr. No.	Treatment	No. of aphid per 3leaf			
		Dose (ml or gm)/ha	2 DAS	7 DAS	14 DAS
T_1	Profenophos 50 EC	1500 ml	0.6 (1.27)	0.8 (1.33)	1.2 (1.48)
T_2	Indoxacarb 14.5 SC	425 ml	1.5 (1.57)	1.8 (1.64)	3.4 (2.09)
T_3	Emamectin benzoate 5 SG	200 g	1.0 (1.40)	1.2 (1.49)	2.3 (1.81)
T_4	Spinosad 45 SC	200 ml	6.9 (2.81)	7.2 (2.83)	7.8 (2.96)
T_5	Thiamethoxam 12.6 + Lambda cyhalothrin 9.5	125 ml	0.2 (1.12)	0.3 (1.16)	0.5 (1.22)
T_6	Chlorantraniliprole 18.5 SC	150 ml	2.8 (1.92)	2..7 (1.90)	5.1 (2.44)
T_7	Flubendiamide 49.35 SC	125 ml	3.5 (2.08)	3.1 (2.00)	5.4 (2.51)
T_8	Water spray		11.6 (3.54)	12.2 (3.62)	12.5 (3.66)
	SE(m)		0.18	0.19	0.11
	CD at 5%		0.57	0.62	0.33
	CV (%)		16.45	17.14	8.39

Table 4: Cumulative effect of newer insecticides against *R. maidis*

Tr. No.	Treatment	1st spray	2nd spray	3rd spray	Mean
T_1	Profenophos 50 EC	8.1 (2.84)	3.2 (2.03)	0.8 (1.36)	4.03 (2.13)
T_2	Indoxacarb 14.5 SC	10 (3.17)	6.2 (2.66)	2.2 (1.78)	6.13 (2.59)
T_3	Emamectin benzoate 5 SG	9.2 (3.03)	4.9 (2.36)	1.5 (1.57)	5.2 (2.40)
T_4	Spinosad 45SC	13.4 (3.75)	14.5 (3.90)	7.3 (2.88)	11.73 (3.53)
T_5	Thiamethoxam 12.6 +Lambda cyhalothrin 9.5	1.5 (1.59)	2.5 (1.86)	0.3 (1.53)	1.43 (1.53)
T_6	Chlorantraniliprole 18.5 SC	12 (3.56)	8.5 (3.08)	3.5 (2.11)	8 (2.93)
T_7	Flubendiamide 49.35 SC	12.5 (3.63)	9.2 (3.19)	4 (2.22)	8.56 (3.03)
T_8	Water spray	27.5 (5.32)	40.6 (6.44)	12.1 (3.61)	26.73 (5.13)
SE (m)		0.24	0.12	0.06	0.25
CD at 5%		0.749	0.384	0.198	0.779
CV (%)		12.58	6.79	5.35	15.12

4. Conclusion

Among the insecticides spraying, Thimethoxam 12.6 + Lambda cyhalothrin 9.5 ZC was most effective for management of Aphid. The next effective insecticides were Profenophos 50 EC, Emamectin Benzoate 5 SG, Indoxacarb 14.5 SC, chlorantraniliprole 18.5 SC, flubendiamide 39.35 SC, spinosad 45 SC.

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