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Shinde GS
Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Bhede BV
Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Rathod VU
Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
Shinde GS
Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Evaluation of different whorl applications for management of fall armyworm, *Spodoptera frugiperda* (J. E. smith) on maize

Shinde GS, Bhede BV and Rathod VU

Abstract
The field experiment was carried out to evaluate the different whorl applications for management of fall armyworm, *Spodoptera frugiperda* (J. E. smith) on maize. An experiment with nine whorl applications *viz.*, Carbofuran 3G @ 33 Kg / ha, Ash @ 35 kg/ha, Sand + Lime (9:1) @ 62 kg/ha, Entomopathogenic nematode @ 5 Kg / ha, Poison bait (Wheat bran 10 Kg + Jaggary 2 Kg + 3 lit. Water + Thiodicarb 100 g) @ 44 kg/ha, *Beauveria bassiana* @ 2.5 kg/ha, *Metarhizium anisopliae* @ 2.5 kg/ha, *Nomuraea rileyi* @ 2.5 kg/ha was laid out in randomized block design with three replications along with an untreated control for comparison. Among the different management option evaluated *Nomuraea rileyi* was superior in managing the population of fall armyworm and safer to natural enemies i.e. lady beetle, predatory bug and earwig. It was followed by *Metarhizium anisopliae*, *Beauveria bassiana*, poiaon bait and sand + lime. The least efficient treatment with highest population among all whorl application was ash. Highly toxic whorl application to natural enemies was carbofuran and poison bait.

Keywords: *Spodoptera frugiperda*, maize, management, whorl application

Introduction
Maize (*Zea mays* L.) also known as corn belongs to family Gramineae. It is an important cereal crop grown throughout the world Araus *et al*. (2002) [2]. It has highest genetic yield potential than any other cereals crop and there is no cereal on the earth which has so immense potential and hence, it is referred to as "Queen of Cereals" or "Miracle Crop" Rautaray *et al*. (2013) [11].

Arthropod pests are among the key factors contributing to low yield of maize and they are central to many serious problems facing maize production today. Despite use of pesticides, there are still great crop losses at present due to arthropod pests, particularly in developing countries Ferdu *et al*. (2001). More than 141 species of insects have been recorded on maize in the field. Out of these pests, the maize stalk borer (*Busseola fusca*), spotted stalk borer (*Chilo partellus*), and various termite species (*Macrotermes* and *Microtermes spp*.) are recognized to be the key pests. Apart from this the recently introduced pest fall armyworm *Spodoptera frugiperda* is of serious concern due to its notorious and polyphagous behavior. The main reason for its fast spread might be its strong capacity to fly and disperse long distance annually during the summer months Mallapur *et al, (*2018) [9].

Fall armyworm which is indigenous in the America is a polyphagous pest causing economic damage of various crops such as maize, sorghum, beans and cotton Roger *et al*. (2017) [12]. Fall armyworm was first reported in West Africa in late 2016, and early 2017, the pest invaded Eastern and Southern Africa. Recent report confirmed the occurrence of FAW in 28 countries in Africa Abrahams *et al*. (2017; Roger *et al*., 2017) [12]. In India, it was first noticed in mid-May 2018 in Shivamogga, Karnataka. Now it has been reported from multiple locations in different states Sharanabasappa *et al*, (2018; Chormule *et. al*., (2018) [3].

Management of fall armyworm requires various strategies. Whorl application with granules, dust formulations with biopesticides and foliar sprays of novel insecticides proven to be effective in management of maize stem borers. This technique may be useful to manage fall armyworm on maize which is an alternative to synthetic insecticide spray and safe to natural enemies. Hence, the present investigations were carried out to evaluate different whorl applications for management of fall armyworm on maize.

Materials and Method

The field experiment was carried out at Department of Agriculture Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, and Parbhani during *Kharif* 2019. An experiment with nine whorl applications *viz.,* Carbofuran 3G @ 33 Kg / ha, Ash @ 35 kg/ha, Sand + Lime (9:1) @ 62 kg/ha, Entomopathogenic nematode @ 5 Kg / ha, Poison bait (Wheat bran 10 Kg + Jaggary 2 Kg + 3 lit. Water + Thiodicarb 100 g) @ 44 kg/ha, *Beauveria bassiana* @ 2.5 kg/ha, *Metarhizium anisopliae* @ 2.5 kg/ha, *Nomuraea rileyi* @ 2.5 kg/ha was laid out in randomized block design with three replications along with an untreated control for comparison. Variety Komal was sown with spacing of 45x15 cm row to row and plant to plant and the plot size was 4.2x5.4m. The whorl applications were done after 15 days and 45 days after germination. The observations on larval population and damaged plants were recorded 1 day before, 3, 7 and 14 days after application. The observations were recorded on randomly selected 10 plants in each plot. The observations on natural enemies were recorded at 1 day before, 7 and 14 days after application. At harvest the yield of cob per plot was recorded and converted into q/ha for comparison. The data obtained from the different treatments were computed to determine the mean values. The mean values after suitable transformation were subjected to statistical analysis to test significance as per Gomez and Gomez (1984) [6] for interpretation of the results using OPSTAT software. The economics of application of various treatments were calculated and incremental cost benefit ratio was worked out.

Results and Discussion

The results regarding average larvae of fall armyworm after first whorl application of treatments revealed that all the whorl applications were found to be significantly superior over untreated control in reducing larvae (Table 1). The plots of whorl application with poison bait recorded lowest larvae to the extent of 0.60 larvae / plant. It was followed by carbofuran 3G, sand + sime, *Nomuraea rileyi*, (0.70 larvae / plant) *Metarhizium anisopliae* (0.86 larvae/plant) and ash (0.90 larvae / plant). The highest larvae among the whorl application was found in EPN (0.90 larvae / plant). The untreated control recorded 1.30 larvae / plant.The results regarding average damaged plants revealed that all the whorl application were found significantly superior over untreated control in reducing damaged plants. The plots treated with whorl application of poison bait and *Nomuraea rileyi* recorded significantly lowest damaged plants to the extent of 25 per cent which was at par with whorl application with carbofuran 3G, sand + lime, *Metarhizium anisopliae*, *Beauveria bassiana* and EPN having 28.33, 31.66, 31.66, 35 and 35 per cent respectively. The highest damaged plants was found in whorl application of ash (37.66 per cent) among insecticidal treatment. The untreated control recorded 50 per cent damaged plants. The results regarding average larvae of fall armyworm after second whorl application of treatments revealed that all the whorl applications were found to be significantly superior over untreated control in reducing larvae.

The plots of whorl application with *Nomuraea rileyi* recorded lowest larvae to the extent of 0.76 larvae / plant (Table 2). The next effective treatments were *Metarhizium anisopliae* (1.10 larvae / plant), *Beauveria bassiana* (1.16 larvae / plant), and poison bait (1.20 larvae / plant). These were followed by EPN, carbofuran and sand + lime with 1.30, 1.33 and 1.46 larvae / plant, respectively. The maximum larvae among the whorl application were found in ash (1.73 larvae / plant). The untreated control recorded highest larval population (2.46 larvae / plant) among all treatments. The results regarding average damaged plants revealed that all the whorl applications were found effective over untreated control. The most effective whorl application was application of *Nomuraea rileyi* which recorded lowest damaged plants to the extent of 28.33 per cent. The next effective treatments were whorl application of *Metarhizium anisopliae* (35 per cent), poison bait (40 per cent), carbofuran (45 per cent) and *Beauveria bassiana* (45 per cent). These were followed by sand + lime and EPN having 50.00 and 55.33 per cent damaged plants, respectively. The least effective treatment was whorl application of ash (68.33 per cent) among the whorl application. The untreated control recorded highest damaged plants (79.33 per cent) among all treatment.

The mean population of predatory bugs after the first whorl application indicated that the whorl application of EPN, *Beauveria bassiana*, *Nomuraea rileyi*, *Metarhizium anisopliae*, ash and sand + lime were safer to predatory bugs (Table 3). The whorl application of carbofuran and poison bait were harmful to these bugs. The average population of lady beetle was maximum in whorl application of EPN (1.35 /plant) indicating that it had no harmful effects on lady beetles. The next safer treatments were *Nomuraea rileyi* (1.20 /plant), *Metarhizium anisopliae*, *Beauveria bassiana*, sand + lime (1.15 /plant), ash (1.10 /plant) and poison bait (0.80 / plant). The most harmful treatment was carbofuran which recorded minimum population (0.55 /plant). The untreated plot recorded highest population of lady beetles (1.50 / plant) than any other treatments. The mean data indicated that the whorl application of any material did not harmful to earwig except carbofuran.

The mean population of predatory bugs after second whorl application showed that among the insecticidal treatments, the maximum population was noticed in whorl application of *Nomuraea relyi* (0.65 bugs / plant) (Table 4). The remaining treatments were also safer to these bugs except carbofuran and poison bait. The mean population of lady beetles revealed that the maximum population (0.85 / plant) was recorded in whorl application of ash. The next safer treatment was *Nomuraea rileyi* (0.80 / plant) and followed by EPN (0.75 / plant), sand + lime (0.60 / plant), *Metarhizium anisopliae* (0.50 / plant), *Beauveria bassiana* (0.40 / plant) and poison bait (0.20 / plant). The most detrimental treatment was carbofuran (0.10 / plant). The untreated plots recorded highest population of lady beetles (1.50 / plant) than treated plots. The mean population of earwigs showed that whorl application of ash, EPN, sand + lime, *Nomuraea rileyi*, *Metarhizium anisopliae* and *Beaveria bassiana* were safer to earwig. Whereas carbofuran was harmful to the population of earwig than other treatments.

All the whorl applications were observed to be significantly superior in recording higher grain yield of maize over untreated control (Table 5). The grain yield of different treatments varied from 24.20 to 15.10 q/ha. The significantly highest grain yield of maize (24.20 q/ha) was recorded in the plots which had whorl application of *Nomurea rileyi*. It was followed by whorl application with *Metarhizium anisopliae* (23.00 q/ha), Poison bait (22.50 q/ha), *Beauveria bassiana* (21.50 q/ha), Carbofuran (19.70 q/ha), EPN (18.60 q/ha), Sand + Lime (18.70 q/ha) and Ash (16.70 q/ha). The lowest grain yield was recorded from the plots treated with Ash

among insecticidal treatments. The untreated plots recorded lowest grain yield (15.10 q/ha) among all treatments. The highest benefit cost ratio was recorded in treatment of *Nomuraea rileyi* (1:7.2). Followed by *Metarhizium anisopliae* (1:5.9), *Beauveria bassiana* (1:2.9), poison bait (1:1.67), sand + lime (1:1.4), carbofuran (1:0.30) EPN (1:0.23) and lowest benefit cost ratio obtained in whorl application of ash (1:0.005) (Table 6).

The present findings are in agreement with those of earlier researchers like Mallapur *et al.*, (2018) [9] reported that *N. rileyi* application can be one of the potential tool to combat the invasive notorious pest, *S. frugiperda.* Harika *et al.*, (2020) [7] who observed the microbial bioinsecticide significantaly effective in managing the fall armyworm larvae. *M. relyi* showed highest per cent mortality over untreated control with lowest foliar damage. Ramanujan *et al.*, (2020) [10] recomonded *M. anisopliae* and *B. bassiana* as potential isolates for management of FAW in maize crop, as the plots treated with this biocontrol agent showed minimum infestation levels of FAW and considerable increases in the yield than the untreated control. Ganguli *et al.*, (1997) [5] reported that application of carbofuran 3G (at 7.5 Kg / ha in whorl leaf) in 15 days old crop proved to be most effective in protecting against borer. Lunagariya et *al*., (2020) [8] determine the efficacy of different poison baits against fall armyworm, *Spodoptera frugiperda* (J. E. Smith) infesting maize. Among the various poison baits evaluated, rice bran 25 kg + jaggery 5 kg + thiodicarb 75 WP 250 g/ha, maize flour 25 kg + jaggery 5 kg + thiodicarb 75 WP 250 g/ha, rice bran 25 kg + jaggery 5 kg + emamectin benzoate 5 SG 125 g/ha, maize flour 25 kg + jaggery 5 kg + emamectin benzoate 5 SG 125 g/ha were found superior in managing the population of FAW which reduce plants and cob damage and ultimately effect on grain and fodder yield of maize.

Table 1: Effect of first whorl application of different materials on larval population and damage of fall armyworm on maize

Tr. No.	Treatment	No. of larvae / plant					Damaged plants (%)				
		Precount	3 DAA	7 DAA	14 DAA	Mean	Precount	3 DAA	7 DAA	14 DAA	Mean
T1	Carbofuran	*0.80 (1.33)	0.40 (1.18)	0.40 (1.18)	1.30 (1.50)	0.70	**25.00 (29.91)	20.00 (26.44)	20.00 (26.51)	45.00 (42.10)	28.33
T2	Ash	0.90 (1.37)	0.50 (1.22)	0.60 (1.26)	1.60 (1.61)	0.90	30.00 (32.98)	23.00 (29.91)	30.00 (33.18)	60.00 (50.83)	37.66
T3	Sand + Lime	1.00 (1.40)	0.50 (1.22)	0.30 (1.13)	1.30 (1.51)	0.70	35.00 (36.11)	25.00 (29.97)	20.00 (26.53)	50.00 (44.98)	31.66
T4	EPN	0.80 (1.33)	0.70 (1.30)	0.60 (1.26)	1.60 (1.60)	0.960	30.00 (33.14)	30.00 (33.19)	25.00 (29.97)	50.00 (44.98)	35.00
T5	Poison bait	0.80 (1.34)	0.40 (1.18)	0.30 (1.14)	1.10 (1.44)	0.60	25.00 (29.91)	20.00 26.55	15.00 (22.74)	40.00 (39.13)	25.00
T6	*Beauveria bassiana*	0.90 (1.37)	0.80 (1.34)	0.60 (1.26)	1.40 (1.54)	0.93	35.00 (36.22)	30.00 (33.19)	25.00 (29.98)	50.00 (44.98)	35.00
T7	*Metarhizium anisopliae*	0.80 (1.34)	0.70 (1.30)	0.50 (1.22)	1.40 (1.54)	0.86	30.00 (33.14)	25.00 (29.97)	25.00 (29.97)	45.00 (42.10)	31.66
T8	*Nomuraea rileyi*	1.00 (1.41)	0.80 (1.34)	0.40 (1.18)	0.9 (1.40)	0.70	35.00 (36.22).	25.00 (29.98)	15.00 (22.74)	35.00 (36.25)	25.00
T9	Control	0.80 (1.34)	0.90 (1.37)	1.20 (1.48)	1.80 (1.67)	1.30	25.00 (29.91)	35.00 (36.25)	45.00 (42.11)	70.00 (56.77)	50.00
	SE +	0.06	0.03	0.04	0.05		2.470	1.150	0.916	2.47	
	CD at 5%	N/S	0.11	0.137	0.15		N/S	3.480	2.77	7.49	
	CV (%)	8.11	5.09	6.35	5.82		12.95	6.520	5.41	9.60	

*Figures in parenthesis are square root transformed value

** Figures in parenthesis are angular transformed value

Table 2: Effect of second whorl application of different materials on larval population and damage of fall armyworm on maize

Tr. No.	Treatment	No. of larvae / plant					Damaged plants (%)				
		Precount	3 DAA	7 DAA	14 DAA	Mean	Precount	3 DAA	7 DAA	14 DAA	Mean
T1	Carbofuran	1.90* (1.70)	1.40 (1.60)	1.00 (1.41)	1.6 (1.60)	1.33	55.00** (47.94)	45.00 (42.02)	35.00 (36.22)	55.00 (47.86)	45.00
T2	Ash	2.00 (1.71)	1.70 (1.76)	1.40 (1.54)	2.10 (1.76)	1.73	70.00 (57.76)	65.00 (54.03)	60.00 (50.83)	80.00 (68.05)	68.33
T3	Sand + Lime	1.80 (1.67)	1.60 (1.64)	1.10 (1.44)	1.7 (1.64)	1.46	60.00 (50.83)	50.00 (44.98)	45.00 (42.02)	55.00 (47.89)	50.00
T4	EPN	1.70 (1.63)	1.50 (1.54)	1.00 (1.41)	1.40 (1.54)	1.30	65.00 (54.03)	51.00 (45.97)	50.00 (44.58)	65.00 (53.71)	55.33
T5	Poison bait	1.50 (1.57)	1.10 (1.61)	0.9 (1.37)	1.60 (1.61)	1.20	55.00 (47.94)	40.00 (39.13)	30.00 (32.98)	50.00 (44.98)	40.00
T6	*Beauveria bassiana*	1.70 (1.63)	1.00 (1.58)	1 (1.40)	1.50 (1.58)	1.16	50.00 (44.98)	45.00 (42.11)	40.00 (39.13)	50.00 (44.98)	45.00
T7	*Metarhizium anisopliae*	1.50 (1.57)	1.20 (1.48)	0.9 (1.37)	1.20 (1.48)	1.10	45.00 (42.02)	35.00 (36.25)	25.00 (29.96)	45.00 (42.10)	35.00
T8	*Nomuraea rileyi*	1.30 (1.51)	0.90 (1.33)	0.6 (1.26)	0.80 (1.33)	0.76	40.00 (39.13)	30.00 (33.18)	20.00 (26.48)	35.00 (35.93)	28.33
T9	Control	2.10 (1.75)	2.20 (1.92)	2.5 (1.86)	2.70 (1.92)	2.46	75.00 (60.75)	70.00 (56.78)	80.00 (63.52)	85.00 (67.37)	79.33
	SE +	0.10	0.057	0.064	0.057		1.43	3.43	3.21	4.64	

	CD at 5%	N/S	0.171	0.193	0.171		4.32	10.38	9.70	14.07	
	CV (%)	10.49	6.08	7.60	6.080		5.07	13.58	13.7	15.98	

*Figures in parenthesis are square root transformed value
**Figures in parenthesis are angular transformed value

Table 3: Effect of first whorl application of different materials on natural enemies of fall armyworm on maize

Tr. No.	Treatment	No. of predatory bugs / plant				No. of lady beetles (Grub + Adult) / plant				No. of earwig / plant			
		Precount	7 DAA	14 DAA	Mean	Precount	7 DAA	14 DAA	Mean	Precount	7 DAA	14 DAA	Mean
T_1	Carbofuran	0.00	0.00 (1.00)	0.10 (1.04)	0.10	0.90 (1.37)	0.40 (1.18)	0.70 (1.30)	0.55	0.00	0.00	0.00. (1.00)	0.00
T_2	Ash	0.00	0.10 (1.048)	0.40 (1.18)	0.25	1.00 (1.44)	1.00 (1.41)	1.20 (1.48)	1.10	0.00	0.00	0.10 (1.04)	0.10
T_3	Sand + Lime	0.00	0.40 (1.18)	0.50 (1.22)	0.45	1.00 (1.41)	1.10 (1.44)	1.20 (1.48)	1.15	0.00	0.00	0.10 (1.04)	0.10
T_4	EPN	0.00	0.30 (1.14)	0.60 (1.26)	0.45	0.80 (1.26)	1.20 (1.48)	1.50 (1.58)	1.35	0.00	0.00	0.20 (1.09)	0.10
T_5	Poison bait	0.00	0.00 (1.00)	0.10 (1.04)	0.10	0.80 (1.30)	0.50 (1.22)	1.10 (1.44)	0.80	0.00	0.00	0.10 (1.04)	0.10
T_6	*Beauveria bassiana*	0.00	0.40 (1.18)	0.50 (1.22)	0.45	0.90 (1.37)	1.00 (1.41)	1.30 (1.51)	1.15	0.00	0.00	0.20 (1.09)	0.10
T_7	*Metarhizium anisopliae*	0.00	0.30 (1.14)	0.50 (1.22)	0.40	0.80 (1.34)	1.10 (1.44)	1.20 (1.48)	1.15	0.00	0.00	0.20 (1.09)	0.10
T_8	*Nomuraea rileyi*	0.00	0.30 (1.14)	0.50 (1.22)	0.40	1.00 (1.40)	1.10 (1.44)	1.30 (1.51)	1.20	0.00	0.00	0.30 (1.15)	0.15
T_9	Control	0.00	0.50 (1.21)	0.60 (1.26)	0.55	0.80 (1.30)	1.20 (1.48)	1.80 (1.67)	1.50	0.00	0.00	0.30 (1.13)	0.15
	SE +		0.04	0.03		0.05	0.04	0.05				0.03	
	CD at 5%		0.12	0.11		N/S	0.13	0.15					
	CV (%)		6.51	5.72		7.14	5.42	5.86				6.00	

*Figures in parenthesis are square root transformed values.

Table 4: Effect of second whorl application of different materials on natural enemies of fall armyworm

Tr. No.	Treatment	No. of predatory bugs / plant				No. of lady beetles (Grub + Adult) / plant				No. of earwig / plant			
		Precount	7 DAA	14 DAA	Mean	Precount	7 DAA	14 DAA	Mean	Precount	7 DAA	14 DAA	Mean
T_1	Carbofuran	0.40 (1.14)	0.20 (1.04)	0.10 (1.04)	0.15	0.30 (1.00)	0.10 (1.04)	0.10 (1.04)	0.10	0.00 (1.00)	0.00 (1.00)	0.10 (1.04)	0.10
T_2	Ash	0.80 (1.40)	0.60 (1.37)	0.50 (1.34)	0.55	1.00 (1.09)	0.90 (1.37)	0.80 (1.34)	0.85	0.20 (1.09)	0.10 (1.04)	0.20 (1.09)	0.15
T_3	Sand + Lime	0.80 (1.39)	0.60 (1.30)	0.60 (1.22)	0.60	1.00 (1.09)	0.70 (1.30)	0.50 (1.22)	0.60	0.20 (1.09)	0.20 (1.09)	0.10 (1.04)	0.15
T_4	EPN	0.90 (1.33)	0.50 (1.34)	0.60 (1.30)	0.55	0.80 (1.09)	0.80 (1.34)	0.70 (1.30)	0.75	0.20 (1.09)	0.20 (1.09)	0.10 (1.04)	0.15
T_5	Poison bait	0.40 (1.18)	0.20 (1.09)	0.20 (1.09)	0.20	0.40 (1.00)	0.20 (1.09)	0.20 (1.09)	0.20	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00
T_6	*Beauveria bassiana*	0.70 (1.30)	0.50 (1.18)	0.40 (1.18)	0.45	0.70 (1.04)	0.40 (1.18)	0.40 (1.18)	0.40	0.10 (1.04)	0.10 (1.04)	0.10 (1.04)	0.10
T_7	*Metarhizium anisopliae*	0.70 (1.29)	0.40 (1.22)	0.60 (1.22)	0.50	0.70 (1.09)	0.50 (1.22)	0.50 (1.22)	0.50	0.20 (1.09)	0.00 (1.00)	0.10 (1.04)	0.10
T_8	*Nomuraea rileyi*	0.80 (1.32)	0.60 (1.33)	0.70 (1.33)	0.65	0.80 (1.04)	0.80 (1.33)	0.80 (1.33)	0.80	0.10 (1.04)	0.10 (1.04)	0.00 (1.00)	0.10
T_9	Control	1.00 (1.40)	0.80 (1.40)	1.00 (1.37)	0.90	1.00 (1.13)	1.00 (1.40)	0.90 (1.37)	0.95	0.30 (1.13)	0.30 (1.14)	0.20 (1.09)	0.25
	SE +	0.10	0.060	0.05		0.03	0.06	0.05		0.03	0.02	0.01	
	CD at 5%	N/S	0.18	0.16		N/S	0.18	0.16		N/S	0.08	0.05	
	CV (%)	13.73	8.30	7.44		6.03	8.30	7.44		6.03	4.64	3.15	

*Figures in parenthesis are square root transformed values.

Table 5: Effect of whorl application of different materials on grain yield of maize

Tr. No.	Treatment	Dose /ha	Yield (q/ha)
T1	Carbofuran	33 kg	22.50
T2	Ash	35 kg	16.70
T3	Sand + Lime	62 kg	18.70
T4	EPN	5.0 kg	20.50
T5	Poison bait	44 kg	23.00
T6	*Beauveria bassiana*	2.5 kg	19.50
T7	*Metarhizium anisopliae*	2.5 kg	22.80
T8	*Nomuraea rileyi*	2.5 kg	24.20

T9	Control		15.10
	SE +		1.66
	CD at 5%		2.35
	CV (%)		14.02

Table 6: Economics of different whorl applications for management of fall armyworm on maize of maize

Tr. No.	Treatments	Yield (q/ha)	Increase in yield over Control (q/ha)	Cost of treatment(Rs/ha)		Total cost (Rs/ha)	Value of additional yield over untreated control (Rs/ha)	Net profit (Rs/ha)	ICBR	Rank
				Cost of material used for two whorl applications (Rs/ha.)	Labour charges					
T_1	Carbofuran	22.50	7.40	5200	2800	9600	13024	3424	1:0.35	VI
T_2	Ash	16.70	1.60	000	2800	2800	2816	16	1:0.005	VIII
T_3	Sand + Lime	18.70	3.60	154	2800	2954	6336	3382	1:1.4	V
T_4	EPN	20.50	5.40	7500	1200	8700	9504	2004	1:0.23	VII
T_5	Poison bait	23.00	7.90	1920	2800	5200	13904	8704	1:1.67	IV
T_6	*Beauveria bassiana*	19.50	4.40	750	1200	1950	7744	5794	1:2.9	III
T_7	*Metarhizium anisopliae*	22.80	7.70	750	1200	1950	13552	11602	1:5.9	II
T_8	*Nomuraea rileyi*	24.20	9.10	750	1200	1950	16016	14066	1:7.2	I
T_9	Control	15.10	-							

Rates:

i) Carbofuran Rs 100 / Kg. ii) Lime Rs 7 /Kg. iii) EPN Rs 500/Kg.
iv) Jaggary Rs 40/Kg. v) Thiodicarb Rs 800 /250g vi) *Beauveria bassiana* Rs 150/1lit.
vii) *Metarhizium anisopliae* RS 150/1lit. viii) *Nomuraea rileyi* Rs150 /1lit. ix) Labour charge (male) Rs 300/day/labour
x) Labour charge (female) Rs 200/day/labour xi) Sprayer charge Rs 200/day. xii) Marketable price maize Rs 1760 /qt.

Conclusion

The present investigations revealed that the whorls applications of entomopathoges were most effective against fall armyworm as well as safer to natural enemies and cost effective. Among the whorl application, *Nomuraea rileyi* was most effective for management of fall armyworm, it was followed by poison bait, *Metarhizium anisopliae*, carbofuran, *beauveria bassiana*, sand + lime and EPN. All whorl applications were safer to natural enemies except carbofuran and poison bait.

Conclusion

Whorl application of entomopathogens are most effective against fall armyworm as well as safer to natural enemies and cost effective. Whorl application of *Nomuraea rileyi* was most effective for management of fall armyworm and followed by poison bair, *Metarhizium anisopliae*, carbofuran, *Beauveria bassiana*, sand + lime and EPN. Except poison bait and carbofuran, remaining all whorl applications were safer to natural enemies of fall armyworm on maize.

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