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Field efficacy of different insecticides against ear head caterpillar (*Helicoverpa armigera* Hub.) infesting finger millet

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Abstract
A field experiment was conducted to determine the efficacy of Emamectin benzoate 5 SG, Chlorantraniliprole 18.5 SC, Spinosad 45 SC, Lambda cyhalothrin 5 EC, Beta cyfluthrin + Imidacloprid 19.81+8.49 W/W, Profenofos 50 EC, Chlorpyriphos 20 EC and NSE 5% against the surviving larval population of finger millet ear head caterpillar *Helicoverpa armigera* (Hub.) on finger millet in the experimental research area of farmers field in Beedshed village, Dist- Kolhapur during *Kharif* season of 2015. In newer insecticides lowest number of survival population of larvae was recorded in treatment Spinosad 45 SC @ 75 g a.i./ha 0.61 number of larvae per ear head followed by Chlorantraniliprole 18.5 SC @ 10 g a.i./ha 0.62, Emamectin benzoate 5 SG @ 9.5 g a.i./ha 0.64.

Keywords: Chlorantraniliprole, population, Spinosad

Introduction
Among the rainfed crop, millet is prominent group. India is the largest producer of many kinds of millets, which are often referred to coarse cereals. Millets grown in India are sorghum (Jowar), pearl millet (Bajara), finger millet (Ragi) and many kinds of other small millet *viz.*, kodo millet, foxtail millet, barnyard millet. Finger millet, *Eleusine coracana* G. is an important food grain crop of semi-arid tropics particularly of India and East Africa. In India popularly called as *Ragi* from its Sanskrit name *Rajika* and also *Nachani* and *Nagli* specially in Konkan region of Maharashtra. It is staple food of lower income class people of most of the villages in Konkan region. This crop is generally grown on the moderate hill slope where rice cultivation is not possible.

Finger millet is a rainfed crop. However, they especially valued for filling specific niches because they often succeed under stressful situation where other crops fail to produce an acceptable harvest. It has capacity to produce consistent yield, even without special care. It is considered as poor man's food.

Finger millet is high in dietary fibre and calcium and has also medicinal attributes and used by diverse communities for making special foods for diabetics, gluten free food for people suffering from celiac disease and weaning food for infants. Finger millet contain nutritionally important starch fraction, which are slowly digested and absorbed and favourable in diet pattern for metabolic disorders such as diabetes, hypertension and obesity. The grain contain 7 percent proteins, 1.29 percent fats, 72 to 79.5 percent carbohydrates, 2.2 percent mineral, 1.7 to 4.13 percent ash and 162 to 487 mg percent calcium [1]. Vitamin A, B and phosphorous are also present in smaller quantity. Iodine content in finger millet is reported to be the highest among food grain. Finger millet taste better than most other cereals. It has no major pest problem and so can be stored cheaply for a long time. Among the cereals it has relative broad amino acid spectrum. The straw has an immense utility as fodder for both draft and milch animal. It makes good fodder and contain up to 61 percent of total digestible nutrients. Silage is also made from finger millet forage at flowering stage. Finger millet husk, a byproduct from brewing as spent grain, has been reported to be a source of fibre as well as a good source of protein and is especially used in household poultry feeding

The crop ranks fourth in area and production among millets in the world. India alone contributes more than 50 percent of the world production. In India, finger millet is cultivated over wide range of agro-climatic conditions almost in all states. Finger millet contributed nearly 40 percent of small millets of India.

However the area under finger millet has around 1.30 million ha in 2013-14. The annual production is maintained around 2.23 million tonnes with a productivity of around 1,729 kg ha^{-1} [2]. However, the highest productivity is in Tamil Nadu followed by Karnataka. In Maharashtra, finger millet occupies an area of about 120 thousand ha with an annual grain production of 109 thousand tonnes with productivity 908 kg ha^{-1} in 2009-10 [3]. It is mainly cultivated in Thane, Raigad, Ratnagiri, Sindhudhurg, Dhule, Jalgaon, Nashik, Pune, Satara, Kolhapur districts of Maharashtra. The largest acreage of *ragi* is in Konkan region [4].

Finger millet is the most important millet grown in Maharashtra state along hill sides of Sahyadri and Satpuda ranges on lighter sloppy soils, which alone account for about 50 percent area and more than 2/3rd production of total small millets. It is grown on an area 1405 ha with an annual production of 13.97 q ha^{-1} with a productivity of 1031 kg ha^{-1} [2].

Finger millet is damaged by 57 insect species [5], of which shoot fly, *Atherigona miliaceae* Malloch, stem borer, *Sesamia inferem* Walk., flea beetle, *Chaetocnema sp*., red hairy caterpillar, *Amsacta albistriga* Walk., Bihar hairy caterpillar, *Diacrisia obliqua* Walk., Oriental armyworm, *Mythimna separata* Walk., ear head caterpillars, *Helicoverpa armigera* Hub., *Cryptoblabes* sp, *Eublemma silicula* Walk., and *Sitotroga cerealella* Oliv are the most important [5]. Due to the change in the climatic condition ear head caterpillar causing high damage and becoming major constraints in the finger millet production.

Materials and Methods

The observations of the ear head caterpillar population was recorded under field condition at the milk stage as per the method suggested by [6]. The data were recorded on number of healthy and damaged panicles by caterpillar (expressed as a percentage of the total number of panicles) from the two rows of each plot. Data on percentage healthy panicles with caterpillar damaged panicles were worked out and converted to square root values and subjected to analysis of variance.

Results and Discussion

The present investigations were carried out to evaluate the efficacy of newer insecticides against ear head caterpillar of finger millet

The data on number of larvae per ear head was recorded as and survival population of ear head caterpillar *H. armigera*, was recorded at 1st, 3rd and 7th days after first spray and presented in Table 1 and graphically represented in Fig 1.

The ear head caterpillar population was ranged from 1.00 to 1.40, when observations were recorded one day before the insecticide application. The significant differences did not existed among the treatments including the untreated control, thus indicated uniform infestation in the experimental plot.

The observations recorded on the 1st day after spraying, all the treatments were found significantly superior over untreated control in reducing the infestation of ear head caterpillar. The treatment with emamectin benzoate 5 SG @ 9.5 g a.i./ha found significantly superior all other insecticidal treatment and recorded 0.91 larvae/ear head. The treatment with spinosad 45 SC @ 75 g a.i./ha (0.94 larvae/ear head) and chlorantraniliprole 18.5 SC @ 10 g a.i./ha (0.95 larvae/ear head) found at par and were next in order of efficacy. The treatment with beta cyfluthrin + imidacloprid 19.81+8.49 W/W @ 36.75+15.75 g a.i./ha (1.20), lambda cyhalothrin 5 EC @ 50 g a.i/ha (1.23), chlorpyriphos 20 EC @ 1000 ml/ha (1.27), profenofos 50 EC @ 400 g a.i./ha (1.28), and NSE 5% @ 1500 ml/ha (1.40) were next in reducing caterpillar infestation and significant differences did not observed among them.

All the treatments were significantly superior over control when observations were recorded 3rd DAS. The treatment with chlorantraniliprole 18.5 SC @ 10 g a.i./ha found to be significantly superior all other insecticidal treatments and recorded 0.85 larvae/ear head, however it was at par with spinosad 45 SC @ 75 g a.i/ha and emamectin benzoate 5 SG @ 9.5 g a.i/ha. where 0.87 and 0.88 larvae/ear head were observed, respectively. The treatment with beta cyfluthrin + imidacloprid 19.81+8.49 W/W @ 36.75+15.75 g a.i./ha (1.08 larvae/ear head), lambda cyhalothrin 5 EC @ 50 g a.i./ha (1.13 larvae/ear head), profenofos 50 EC @ 400 g a.i/ha (1.17 larvae/ear head), chlorpyriphos 20 EC @ 1000 ml/ha (1.27 larvae/ear head), NSE 5% @ 1500 ml/ha (1.33 larvae/ear head) found to be next in order of efficacy.

On the 7th DAS all treatments found to be significantly superior as compared to untreated control. Among the treatments, the treatment with spinosad 45 SC @ 75 g a.i/ha found to be significantly superior as compared to all insecticidal treatments, however it was at par with chlorantraniliprole 18.5 SC @ 10 g a.i/ha, emamectin benzoate 5 SG @ 9.5 g a.i/ha and lambda-cyhalothrin 5 EC @ 50 a.i./ha where survival larval population was 0.75, 0.77, 0.86 and 0.93 larvae/ear head was observed, respectively. The treatment with, Beta cyfluthrin + Imidacloprid 19.81+8.49 W/W @ 36.75+15.75 a.i./ha, Profenofos 50 EC @ 400 a.i/ha, Chlorpyriphos 20 EC @ 1000 ml/ha and NSE 5% @ 1500 ml/ha where 1.07, 1.05, 1.13 and 1.20, larvae/ear head was recorded, respectively and found to be effective and next in order of efficacy. Significant difference does not existed among rest of the treatment.

Thus overall results of efficacy indicated that spinosad 45 SC @ 75 g a.i/ha, emamectin benzoate 5 SG @ 9.5 g a.i/ha, chlorantraniliprole 18.5 SC @ 10 g a.i/ha, were effective in reducing the survival population of ear head caterpillar, *H. armigera* (Hub).

Table 1: Efficacy of insecticides against finger millet ear head caterpillar under field condition after First spray.

Sr. No.	Treatments	Dose gm or ml/ha	Number of larvae per Ear head				Mean
			Pre count	1 DAS	3 DAS	7 DAS	
1	Emamectin benzoate 5 SG	1250	1.00 (1.22)*	0.91 (1.19)	0.88 (1.17)	0.86 (1.17)	0.88 (1.18)
2	Chlorantraniliprole 18.5 SC	250	1.27 (1.33)	0.95 (1.20)	0.85 (1.16)	0.77 (1.13)	0.86 (1.16)
3	Spinosad 45 SC	187.5	1.13 (1.27)	0.94 (1.20)	0.87 (1.17)	0.75 (1.12)	0.85 (1.16)
4	Lambda cyhalothrin 5 EC	150	1.07 (1.25)	1.23 (1.32)	1.13 (1.28)	0.93 (1.20)	1.10 (1.26)
5	Beta cyfluthrin + Imidacloprid 19.81+8.49 W/W	625	1.40	1.20	1.08	1.07	1.12

			(1.38)	(1.30)	(1.26)	(1.25)	(1.27)
6	Profenofos 50 EC	625	1.33 (1.35)	1.28 (1.33)	1.17 (1.29)	1.05 (1.24)	1.17 (1.29)
7	Chlorpyriphos 20 EC	500	1.27 (1.33)	1.27 (1.33)	1.27 (1.33)	1.13 (1.28)	1.22 (1.31)
8	NSE 5%	1500	1.07 (1.25)	1.40 (1.38)	1.33 (1.35)	1.20 (1.30)	1.31 (1.35)
9	Untreated Control	NA	1.20 (1.30)	1.40 (1.38)	1.53 (1.42)	1.80 (1.52)	1.58 (1.44)
	SE ±		NS	0.03	0.03	0.03	
	CD (5%)		NS	0.10	0.08	0.09	

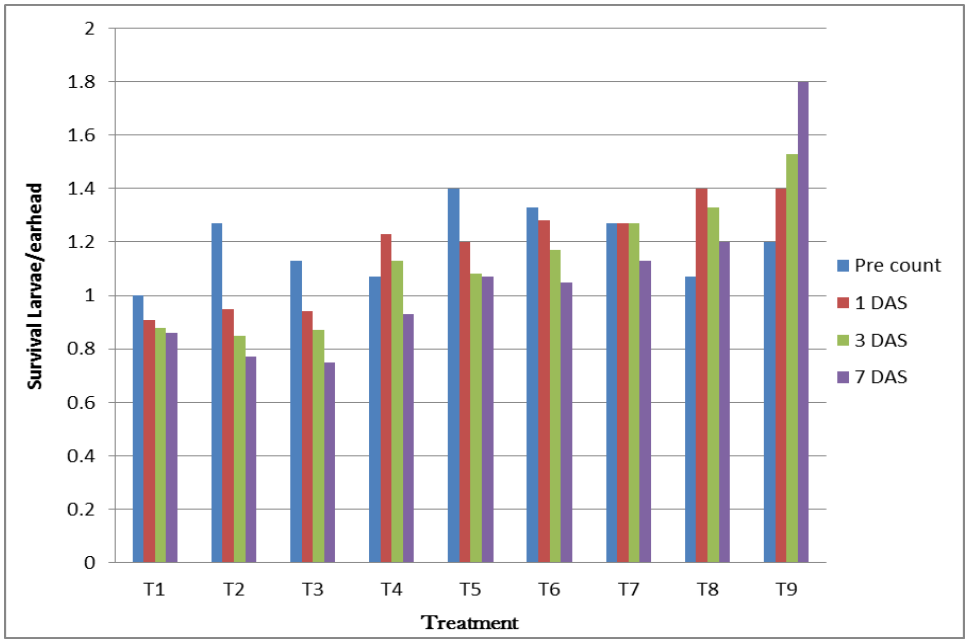

Fig 1: Efficacy of insecticides against finger millet ear head caterpillar after first spray.

Tr.no	Treartment name
T1.	Emamectin benzoate
T2.	Chlorantraniliprole
T3.	Spinosad
T4.	Lambda cyhalothrin
T5.	Beta cyfluthrin + Imidacloprid
T6.	Profenofos
T7.	Chlorpyriphos
T8.	NSE
T9.	Untreated Check

The data on the survival population after second spraying is presented in Table 2 and graphically represented in Fig. 2.

The data recorded at first days after second spray showed that all the treatments were significantly superior to control. The treatment with chlorantraniliprole 18.5 SC @ 10 g a.i/ha was found most superior over all insecticidal treatments and recorded 0.57 number of larvae per ear head, however it was at par with spinosad 45 SC @ 75 g a.i/ha (0.60 larvae/ear head), lambda cyhalothrin 5 EC @ 50 g a.i./ha (0.65 larvae/ear head) and profenofos 50 EC @ 400 g a.i/ha (0.67 larvae/ear head). Second best treatment was emamectin benzoate 5 SG @ 9.5 g a.i./ha (0.81 larvae/ear head) and was at par with chlorpyriphos 20 EC @ 1000 ml/ha (0.97 larvae/ear head) and significantly superior to beta cyfluthrin + imidacloprid 19.81+8.49 W/W @ 36.75+15.75 g a.i./ha (1.00 larvae/ear head), NSE 5% @ 1500 ml/ha (1.20 larvae/ear head) in reducing the survival population of ear head caterpillar.

The infestation of ear head caterpillar was found slightly decreased when observations were recorded 3rd day after second spray in all experimental plot. The treatment with emamectin benzoate 5 SG @ 9.5 g a.i./ha was found to be most effective treatment which was followed by chlorantraniliprole 18.5 SC @ 10 g a.i./ha, spinosad 45 SC @ 75 g a.i./ha, profenofos 50 EC @ 400 g a.i./ha, lambda cyhalothrin 5 EC @ 50 g a.i./ha. The treatment with beta cyfluthrin + imidacloprid 19.81+8.49 W/W @ 36.75+15.75 g a.i./ha, chlorpyriphos 20 EC @ 1000 ml/ha and NSE 5% @ 1500 ml/ha. were next in order of efficacy.

On the 7th day, all treatments found to be significantly superior as compared to untreated control. Among the treatments, the treatment with spinosad 45 SC @ 75 g a.i/ha found to be significantly superior as compared to all insecticidal treatments, however it was at par with emamectin benzoate 5 SG @ 9.5 g a.i./ha where 0.05 and 0.09 larvae/ear head was recorded, respectively. The treatment with, chlorantraniliprole 18.5 SC @ 10 g a.i./ha, lambda-cyhalothrin 5 EC @ 50 g a.i./ha, profenofos 50 EC @ 400 g a.i./ha, beta cyfluthrin + imidacloprid 19.81+8.49 W/W @ 36.75+15.75 g a.i./ha, chlorpyriphos 20 EC @ 1000 ml/ha and NSE 5% @ 1500 ml/ha where 0.20, 0.26, 0.27, 0.60, 1.00 and 1.26 larvae/ear head was recorded, respectively and found to be effective and next in order of efficacy. Significant difference does not existed among rest of the treatment.

The treatment with spinosad 45 SC @ 75 g a.i./ha, chlorantraniliprole 18.5 SC @ 10 g a.i./ha, emamectin benzoate 5 SG @ 9.5 g a.i./ha were found to be most effective treatments in reducing survival population of the ear head caterpillar, *H. armigera* (Hub).

Table 2: Efficacy of insecticides against finger millet ear head caterpillar after second spray.

Sr. No.	Treatments	Dose gm or ml/ha	Number of larvae per Ear head			Mean
			1 DAS	3 DAS	7 DAS	
1	Emamectin benzoate 5 SG	1250	0.81 (1.14)*	0.33 (0.91)	0.09 (0.77)	0.41 (0.94)
2	Chlorantraniliprole 18.5 SC	250	0.57 (1.03)	0.40 (0.95)	0.20 (0.84)	0.39 (0.94)
3	Spinosad 45 SC	187.5	0.60 (1.05)	0.47 (0.98)	0.05 (0.74)	0.37 (0.93)
4	Lambda cyhalothrin 5 EC	150	0.65 (1.07)	0.53 (1.01)	0.26 (0.87)	0.48 (0.99)
5	Beta cyfluthrin + Imidacloprid 19.81+8.49 W/W	625	1.00 (1.22)	0.73 (1.11)	0.60 (1.05)	0.78 (1.13)
6	Profenofos 50 EC	625	0.67 (1.08)	0.47 (0.98)	0.27 (0.88)	0.47 (0.98)
7	Chlorpyriphos 20 EC	500	0.97 (1.21)	1.00 (1.22)	1.00 (1.22)	0.99 (1.22)
8	NSE 5%	1500	1.20 (1.30)	1.20 (1.30)	1.26 (1.33)	1.22 (1.31)
9	Untreated Control	NA	2.00 (1.58)	2.13 (1.62)	2.40 (1.70)	2.18 (1.64)
	SE ±		0.02	0.02	0.01	
	CD (5%)		0.08	0.07	0.04	

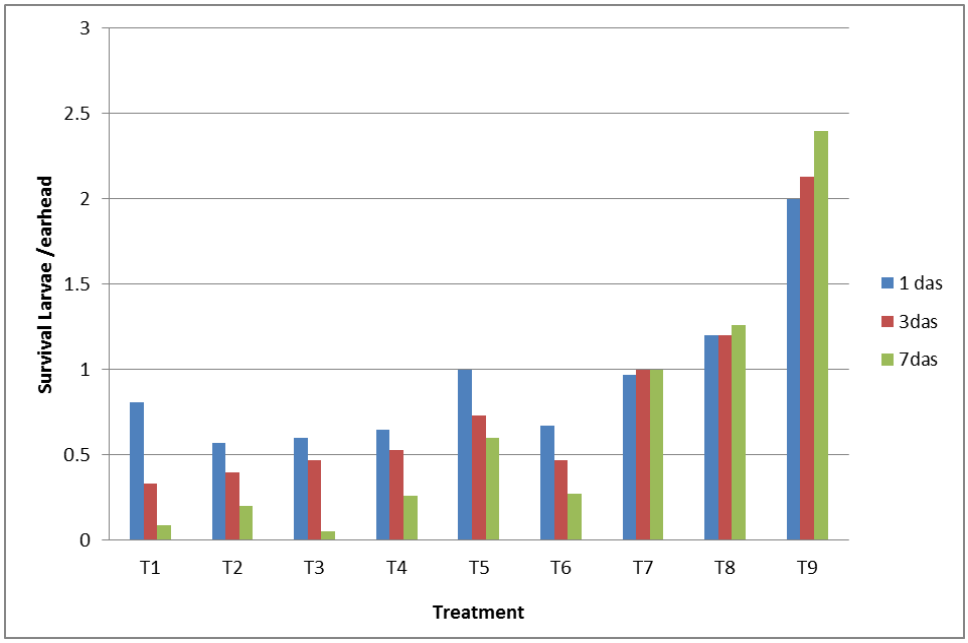

Fig 2: Efficacy of insecticides against finger millet ear head caterpillar after second spray.

Tr.no	Treartment name
T1.	Emamectin benzoate
T2.	Chlorantraniliprole
T3.	Spinosad
T4.	Lambda cyhalothrin
T5.	Beta cyfluthrin + Imidacloprid
T6.	Profenofos
T7.	Chlorpyriphos
T8.	NSE
T9.	Untreated Check

All the treatments were significantly effective in reducing the percent of ear head caterpillar (Table 2). In treated plots, caterpillar population ranged from 0.37 to 1.22 as against 2.18 percent in control, after second spray. Spinosad 45 SC @ 75 g a.i./ha was found most effective followed by Chlorantraniliprole 18.5 SC @ 10 g a.i./ha > Emamectin benzoate 5 SG @ 9.5 g a.i./ha > Profenofos 50 EC @ 400 g a.i./ha > Lambda cyhalothrin 5 EC @ 50 g a.i./ha > Beta cyfluthrin + Imidacloprid 19.81+8.49 W/W @ 36.75 + 15.75 g a.i./ha > Chlorpyriphos 20 EC @ 1000 ml/ha > NSE 5% @ 1500 ml/ha in the decreasing order. The highest larval population of 2.18 percent ear head caterpillar was recorded with untreated control. It was evident that chemical insecticides suppressed the population of ear head caterpillar.

The results obtained in the present study corroborate with the findings of Patil and Jamadagani (2008) [7] who reported that emamectin benzoate performed well in reducing *H. armigera* population in black gram. Deshmukh *et al.* (2010) [8] also reported that the spinosad 45 SC @ 0.009 percent was most effective against *H. armigera* infesting chickpea found at par with emamectin benzoate 5 SG @ 0.0015, whereas Barad *et al.* (2013) [9] reported that emamectin benzoate 5 SG was found to be most effective treatment against *H. armigera* and is safe to the natural enemies in red gram ecosystem. The effectiveness of emamectin benzoate against *H. armigera* infesting tomato was also reported by Sahito Ha *et al.* (2013)

[10]. Whereas Gadhiya *et al.* (2014) [11] reported that Chlorantraniliprole 18.5 SC @ 0.006 percent was found to be effective against *H. armigera* infesting groundnut. The superiority of Lambda cyhalothrin 5 EC @ 1ml/l in reducing the *H. armigera* population in chickpea was also mentioned by Yogeeswarudu *et al.* (2014) [12]. In comparative studies of chlorantraniliprole 18.5 SC and emamectin benzoate 5 SG against leaf folder of rice, Chanu and Sontakke (2015) [13]. concluded that both insecticides found effective than the recommended granular insecticide.

Conclusion

The studies carried out on efficacy of newer insecticides against finger millet ear head caterpillar revealed that two sprays of the treatment with Spinosad 45 SC @ 75 g a.i/ha followed by Chlorantraniliprole 18.5 SC @ 10 g a.i/ha and Emamectin benzoate 5 SG @ 9.5 g a.i/ha was found to be most effective against finger millet ear head caterpillar

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