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Bio-efficacy of different insecticides against ear head worm and ear head bug on kharif sorghum

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Abstract
A field experiment was conducted with the title Management of major pests of *kharif* sorghum. In *Kharif* season 2016 at Sorghum Research Station, VNMKV Parbhani (MS) India. The experiment was laid out in Randomized Block Design with Eight treatments and three replications. The seed of sorghum hybrid SPH-1641 was sown on 01st June 2016 by dibbling. The gross plot size was 5.4m X 4m and spacing was 45 X 15 cm. For the management of ear head worm the mean population of ear head worm after spray was calculated and result revealed that the treatment T4- Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10 lit. of water at milk stage recorded the lowest ear head worm population (1.11 ear head worm/5 cob) and Mean population of ear head bug after spray was calculated and result showed that T3 (Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage) proved to be most effective and recorded the lowest ear head bug population (2.00 ear head bug /5 cob).

Keywords: Sorghum, *Helicoverpa armigera*, *Peregrinus maidis*, insecticides, SH-1641

1. Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] is an important cereal crop in India popularly known as 'Jawar', or 'Great millet'. It is most likely originated in East Central Africa and it was acquainted with India from East Africa in the year 1500 BC. The benefit of this cereal crop is that it can be cultivated in both Kharifand Rabiseason. Sorghum is important feed and food crop in the world and utilized as fodder to feed millions of animals providing milk and meat for human being. Sorghum is nutritious its fodder contains in excess of 50 percent digestible nutrients with 8 percent protein, 2.5 percent fat and 45 percent nitrogen free concentrate. Maharashtra is foremost sorghum growing states in the country with an area, production, productivity of jowar was 2.23 million, 1.61 million tonnes and 720 kg ha-1, respectively (Anonymous 2019) [2]. Several reasons have been attributed for the low grain and fodder yield of sorghum. Among them insect pests ravage is one of the principal factors. Insect pests continue to compete with humans for the sorghum crop and knowledge of both old and new pests has accumulated at a faster rate in recent years as the crop has received increasing attention. About 150 insect species have been recorded on sorghum including in both field as well as store condition. Out of which 31 species are economically important. In Maharashtra about 18 important insect pests have been recorded on sorghum crop. Though a large number of pests have been reported on sorghum crop in Maharashtra very few have economic status. The major being sorghum shoot fly, *Atherigona soccata* Rondani, stem borer, *Chilo partellus* Swinhoe, sorghum shoot bug, *Perigrinus maidis* Ashmead, earhed bug, *Calocoris angustatus* Lethir, army worm, *Mythimna separate* Walker, midge fly, *Contarinia sorghicola* Coquillette, sorghum aphid, *Melanaphis sacchari* Zehntner, earhead hairy caterpillar, *Euproctis subnotata* Walkerand Ear head worm *Helicoverpa armigera* Hubner (Reddy and Davies, 1979) [10]. The Shoot bug, *Peregrinus maidis* (Ashmead) is the serious pest of sorghum in south India. The adult hopper is yellowish brown, with translucent wings and measures 3.2-3.8 mm in length. The full-grown nymphs are light brown with prominent eyes and wing pads. The adults and nymphs feed gregariously within the leaf whorls, the leaf sheaths and also on the leaves. As a result of their cell sap, the leaves become yellow and growth of the plants is retarded (Atwal and Dhaliwal 2013) [3]. Under natural infestation of shoot bug it resulted into losses of 11.16 and 21.11 in grain and fodder yield respectively. The economic injury level of shoot bug is 3.13 per plant (Raju Anaji, 2005) [9]. The Earhead bug, *Calocoris angustatus* (Lethiery) is the one of the most destructive pests of sorghum in southern India.

Both the nymphs and the adults feed in the green earheads. The adult is a small, slender, greenish yellow bug, measuring 5-8 mm in length and over 1 mm in width. As a result of feeding by the bugs, the grains remain chaffy or shriveled. When a large army of tiny nymphs feeds, the whole ear may become blackened at first and May eventually dry up, producing no grains (Atwal and Dhaliwal 2013) [3].

2. Materials and Methods

Earhead worm (*H. armigera*) and Earhead bug (*Calocoris angustatus*): The total number of larvae and bugs were recorded from randomly selected 10 plants in each plot. The pretreatment observation were recorded one day before one insecticidal spray at milking stage and post treatment observation were recorded at 1st, 5th, 7th, days after each spray (at milking stage days). The grain yield kg/plot was recorded and expressed as quintals ha^{-1}. Percent reduction in the number of larvae was worked out. Data on grain yield was analyzed using analysis of variance and finally gross and net returns were worked out for each chemical.

3. Results and Discussion

3.1.1 Ear head worm (*H. armigera*) population one day before insecticidal spray

The data on population of ear head worm, one day before insecticidal spray at milking stage presented in table-1, revealed that the population of ear head worm/5 cob ranged between 9.67 to 12.33, which was statistically non-significant indicating uniform distribution of these pest populations.

3.1.2 Ear head worm (*H. armigera*) population one day after insecticidal spray

The ear head worm population at 1st day after insecticidal spray (at milking stage of crop) varied from 0.67 to 12.67 ear head worms per 5 cob. The significantly less incidence of ear head worm were observed in all the insecticidal treatments [except T_8- Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)]. However, the lowest ear head worm population (0.67 ear head worm/5 cob) was recorded in T_4 (Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage. which was closely followed by T_3 (Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage), T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) and T_6 (Spraying of Oxydemeton-methyl 25 EC @ 20 ml/10 lit. of water at 14 DAE followed by Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.) with 1.00, 1.00 and 1.33 ear head worms per 5 cob respectively. All the above four insecticidal treatments were at par with each other and significantly superior over rest of the insecticidal treatments in respect of reducing ear head worm infestation.

3.1.3 Ear head worm (*H. armigera*) population fifth day after insecticidal spray

The ear head worm population at 5th day after insecticidal spray (at milking stage of crop) varied from 1.00 to 14.00 ear head worms per 5 cob. The significantly less incidence of ear head worm were observed in all the insecticidal treatments [except T_8- Farmer practice (one spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)]. However, the lowest ear head worm population (1.00 ear head worm/5 cob) was recorded in T_4 (Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage. which was closely followed by T_3 (Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage) and T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) with 1.33 and 1.67 ear head worms per 5 cob respectively. All the above three insecticidal treatments were at par with each other and significantly superior over rest of the insecticidal treatments in respect of reducing ear head worm infestation.

3.1.4 Ear head worm (*H. armigera*) population seventh day after insecticidal spray

The ear head worm population at 5th day after insecticidal spray (at milking stage of crop) varied from 1.67 to 14.67 ear head worms per 5 cob. Significantly less incidence of ear head worm were observed in all the insecticidal treatments (except T_8- Farmer practice one spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE). However, the lowest ear head worm population (1.67 ear head worm/5 cob) was recorded in T_4 (Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage. which was closely followed by T_3 (Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage) and T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) with 2.33 and 2.67 ear head worms per 5 cob respectively. All the above three insecticidal treatments were at par with each other and significantly superior over rest of the insecticidal treatments in respect of reducing ear head worm infestation.

3.1.5 Mean ear head worm (*H. armigera*) population after insecticidal spray

Mean population of ear head worm after spray was calculated and result revealed that the treatment T_4- Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage recorded the lowest ear head worm population (1.11 ear head worm/5 cob). The next best treatments were T_3- Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage (1.55 ear head worm/5 cob), T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) (1.78 ear head worm/5 cob), Whereas the treatments T_6 (Spraying of Oxydemeton-methyl 25 EC @ 20 ml/10 lit. of water at 14 DAE followed by Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.), T_1 (Seed treatment with Imidacloprid 48% FS @ 14 ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage), T_7 (spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @ 25 ml/10 lit. of water at milk stage) and T_5 (Spray of Imidacloprip 17.8 SL @ 3ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage) were the next in order with 2.33, 3.22, 3.44 and 3.54 ear head worm population /5 cob respectively. The highest population of ear head worm (13.7 ear head worm/5 cob) recorded in T_8-

Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE). Kuttalam *et al*., (2011) [5] reported that Emamectin benzoate 5 EC @ 13 and 15 g a.i/ha was found to be effective in suppressing the larval population of the pests compared to other insecticides.

Present results are in conformity with findings of Deshmukh *et al*. (2010) [4] revealed that Flubendiamide 0.007 percent, Indoxacarb 0.0075 percent, Spinosad 0.009 percent and Emamectin benzoate 0.0015 percent were found the most effective in reducing the *H. armigera* population and pod damage of chickpea. Govindan *et al*. (2011) [5] reported that Emamectin benzoate 5 SG @ 11g a.i/ha was effectively reduced the larval population of *H. armigera* 7 days after application. Singh and Kumar (2012) found that Emamectin benzoate 0.0015 percent Flubendiamide 0.007 percent and Rynaxypyr 0.009 percent were most effective in reducing the *H. armigera* population and pod damage of chick pea. Nagare R. D. (2016) [7] revealed that the treatment T_7 – Emamectin benzoate 5 SG @ 3.5g/10 lit. of water recorded the lowest ear head worm population (0.82 ear head worm/panicle).

Table 1: Bio-efficacy of different insecticides against ear head worm (*H. armigera*) of sorghum at milking stage

Tr. No.	Treatment	Ear head worm population/ 5 cob					Ear head bug population/ 5 cob
		1 DBS	1 DAS	5 DAS	7 DAS	Mean	Mean
T_1	Seed treatment with Imidacloprid 48% FS @ 14 ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	10.33 (3.28)	2.33 (1.67)	2.67 (1.77)	4.67 (2.27)	3.22 (1.90)	5.11 (2.34)
T_2	Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.	10.67 (3.32)	1.00 (1.22)	1.67 (1.46)	2.67 (1.77)	1.78 (1.48)	2.89 (1.81)
T_3	Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10lit. of water at milk stage.	9.67 (3.17)	1.00 (1.22)	1.33 (1.34)	2.33 (1.67)	1.55 (1.41)	2.00 (1.54)
T_4	Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage.	10.33 (3.28)	0.67 (1.05)	1.00 (1.22)	1.67 (1.46)	1.11 (1.24)	3.55 (1.99)
T_5	Spray of Imidacloprip 17.8 SL @ 3ml /10 lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	11.33 (3.43)	2.00 (1.58)	3.3 (1.95)	5.33 (2.41)	3.54 (1.98)	5.44 (2.41)
T_6	Spraying of Oxydemeton-methyl 25 EC @ 20 ml/10 lit. of water at 14 DAE followed by Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.	12.00 (3.52)	1.33 (1.34)	2.00 (1.58)	3.67 (2.03)	2.33 (1.65)	3.22 (1.91)
T_7	spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @ 25 ml/10lit. of water at milk stage	12.33 (3.57)	1.67 (1.46)	3.33 (1.95)	5.33 (2.41)	3.44 (1.94)	6.00 (2.52)
T_8	Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)	12.00 (3.53)	12.67 (3.61)	14.00 (3.79)	14.67 (3.89)	13.7 (3.76)	13.3 (3.63)
	S.E. ±	0.17	0.11	0.10	0.08	0.06	0.09
	C.D. at 5%	0.53	0.36	0.30	0.25	0.19	0.28

* Figures in parentheses denote $\sqrt{x+0.5}$ transformed values.
DBS- Day before spray and DAS- Days after spray

3.2 Bio-efficacy of different insecticides against ear head bug (*Calocoris angustatus*) of sorghum at milking stage

The results pertaining to the effect of different insecticides on the population of ear head bug on sorghum after spray are presented in table-1.

3.2.1 Mean ear head bug (*Calocoris angustatus*) population after insecticidal spray

Mean population of ear head bug after spray was calculated and result showed that T_3 (Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage) proved to be most effective and recorded the lowest ear head bug population (2.00 ear head bug /5 cob). The next best treatments were T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) and T_6 (Spraying of Oxydemeton-methyl 25 EC @ 20 ml/10 lit. of water at 14 DAE followed by Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) with 2.89 and 3.22 ear head bug per 5 cob respectively. All these three treatments significantly superior over rest of treatments. Other than this the treatments T_4 (Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage) (3.55 ear head bug/5 cob), T_1 (Seed treatment with Imidacloprid 48% FS @ 14 ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage) (5.11 ear head bug/5 cob), T_5 (Spray of Imidacloprip 17.8 SL @ 3ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage) (5.44 ear head bug/5 cob), T_7 (spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @ 25 ml/10 lit. of water at milk stage) (6.00 ear head bug/5 cob) were the next in order in case of effectiveness against ear head bug. The highest population of ear head bug (13.3 ear head bug/5 cob) recorded in T_8- Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE).

Present results are in conformity with findings of Paul (1976) found that Carbaryl, Malathion, Quinalphos and BSC as a dust at 20 kg/ha at complete anthesis and milky stage give the significant control of *C. angustatus.* Jotwani *et al*., (1978) studied to determine the relative efficacy of different insecticides for the control of ear head bug effectively controlled by Quinalphos 0.05%. Anonymous (1984) [1] tested several insecticide for ear head bug control during 1982-83 rainy season and post rainy season at ICRISAT centre were Quinalphos 0.05% effectively control of bug population.

3.3 Effect of different insecticides on grain yield of sorghum

The data on the effect of various treatments on grain yield, fodder yields and ICBR ratio of sorghum furnished in the table-2, showed that all the insecticidal treatments recorded

significantly higher grain yield of sorghum over farmer practice, [except T_8- (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)]. Among the treatments maximum grain yield (32.20 qt/ha) was obtained in T_4 (Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage) which was at par with T_3 (Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage) and T_6 (Spraying of Oxydemeton-methyl 25 EC @ 20 ml/10 lit. of water at 14 DAE followed by Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) in which (31.69 qt/ha) and (31.48 qt/ha) grain yield was recorded respectively. The treatments T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) (25.21 qt/ha), T_1 (Seed treatment with Imidacloprid 48% FS @ 14 ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage) (23.77 qt/ha), T_5 (Spray of Imidacloprip 17.8 SL @ 3ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage) (23.25 qt/ha), T_7 (spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @ 25 ml/10 lit. of water at milk stage) (23.25 qt/ha) were the next in order of grain yield. T_8- Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE). recorded lowest yield i.e. (15.28 qt/ha).

Table 2: Effect of different insecticides on grain yield of sorghum (q/ha)

Tr. No.	Treatment	Grain yield (q/ha)	Fodder yield (q/ha)	ICBR
T_1	Seed treatment with Imidacloprid 48% FS @14 ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	23.77	148.72	1:18.12
T_2	Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.	25.21	146.67	1:16.15
T_3	Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10lit. of water at milk stage.	31.69	142.55	1:4.77
T_4	Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10lit. of water at milk stage.	32.20	144.61	1:5.47
T_5	Spray of Imidacloprip 17.8 SL @ 3ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	23.25	119.63	1:8.05
T_6	Spraying of Oxydemeton-methyl 25 EC @ 20 ml/10 lit. of water at 14 DAE followed by Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.	31.48	127.28	1:10.38
T_7	spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @25 ml/10 lit. of water at milk stage	23.25	111.40	1:3.89
T_8	Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)	15.28	107.19	--
	S.E. ±	1.16	12.24	--
	C.D. at 5%	3.54	27.08	-
				-

4. Summery and Conclusion

Mean population of ear head worm after spray was calculated and result revealed that the treatment T_4- Soil application of Carbofuran G 3% @ 20 kg/ha at the time of sowing + Emamectin benzoate 5 SG @ 3.5 g/10 lit. of water at milk stage recorded the lowest ear head worm population (1.11 ear head worm/5 cob). The next best treatments were T_3- Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10lit. of water at milk stage (1.55 ear head worm/5 cob), T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) (1.78 ear head worm/5 cob), Mean population of ear head bug after spray was calculated and result showed that T_3 (Soil application of Phorate 10% D @ 25 kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10lit. of water at milk stage) proved to be most effective and recorded the lowest ear head bug population (2.00 ear head bug /5 cob). The next best treatments were T_2 (Seed treatment with Thiamethoxam 350 FS @ 7 ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) and T_6 (Spraying of Oxydemeton-methyl 25 EC @ 20 ml/10 lit. of water at 14 DAE followed by Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) with 2.89 and 3.22 ear head bug per 5 cob respectively. All these three treatments significantly superior over rest of treatments.

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