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Bioefficacy of different insecticides against shoot fly (*A. soccata*) and stem borer (*C. partellus*) 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 Sorghum shoot fly and stem borer the effective treatments found 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) found most effective against shoot fly followed by T_1 (Seed treatment with Imidacloprid 48% FS @14ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage). T_2 (Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) recorded lowest stem borer dead hearts followed by T_1 (Seed treatment with Imidacloprid 48% FS @ 14 ml/kg of seed + spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage) and 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). 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).

Keywords: Shoot fly, *Atherigona soccata*, *Chilo partellus*, insecticides, SPH-1641

Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] is an important cereal crop in India popularly known as 'Jawar', or 'Great millet'. It is probably originated in East Central Africa and it was introduced to India from East Africa in the year 1500 BC. The advantage of this cereal crop is that it can be cultivated in both *Kharif* and *Rabi* season. Sorghum is important feed and food crop in the world and used as fodder to feed millions of animals providing milk and meat for human being. Sorghum is very nutritious its fodder contains more than 50 percent digestible nutrients with 8 percent protein, 2.5 percent fat and 45 percent nitrogen free extract. The major sorghum producing countries of the world are India, USA, South Africa, China, Nigeria, Sudan and Argentina, it contribute 60.13 million tones production from 40 million ha area (Anonymous, 2015-16). In the world, USA is the largest producer of sorghum occupying 20.03 percent of area with 16.41 percent production. (Anonymous., 2016).
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, Gram caterpillar, *Helicoverpa armigera* Hubner, earhead hairy caterpillar, *Euproctis subnotata* Walker (Reddy and Davies,1979) [17]. The insect attacks the young crop when it is in the six leaf stage. As the maggots feed on the main shoot, the growing point is destroyed and by the time they pupate, the plant is almost dead. The young plants show typical dead-heart symptoms (Atwal and Dhaliwal 2013) [4]. The total loss in yield is sometimes as high as 60 percent. Shootfly cause damage to extent of 90 percent (Chandurwar and Borikar, 1992) [5]. The spotted stem borer, *Chilo partellus* (Swinhoe) is the most important pest of maize and sorghum all over the country and in many parts of Asia and Africa (Jalali and Singh, 2002) [7]. The grown up caterpillars are about 20-25 mm long and dirty grayish white, with black head and four brownish longitudinal stripes on the back. The adults are yellowish-grey moths, about 25 mm across the wings when spread.

The freshly hatched larvae begin to feed on the tender leaves, making pin holes and leaf windowing. After feeding for few hours on leaves, they enter through the mid whorl into the shoot. (Anonymous, 2006) [2]. In case of younger plants, the growing point and the base of the central whorl are infested resulting in the drying up of the central whorl and forming the dead heart (Atwal and Dhaliwal 2013) [4]. The yield losses of 55 to 83 percent due to stem borer infestation have been recorded in Northern India in sorghum by (Jotwani *et al.* 1971) [8]. In sorghum, loss due to *Chilo partellus* was observed even up to 88 percent (Seshu Reddy,1988).The losses in grain yield due to stem borer, *Chilo partellus* (Swinhoe) varies from 24.3 to 36.3 percent in different agro-climatic regions of India (Panwar, 1998) [15].

Materials and Methods

Observations were recorded for shoot fly, stem borer in each plot and replication on following basis. Shoot fly (*Atherigona soccata*, egg count Numbers of eggs on randomly selected 10 plants per plots were counted on 7th, 14th and 21st day after emergence. dead heart count: The total number of plants in each plot and plants showing dead hearts in main shoots were recorded at 7th, 14th and 21st day after emergence. Further percent dead hearts were worked out. stem borer (*chilo partellus*) dead heart count The observations to assess the damage caused by stem borer larvae were recorded as dead hearts on 45th and 60th day after emergence. The percent dead hearts by stem borer were worked out.

Results and Discussion

Plant count on 7th day after emergence

The data on total number of plants per plot recorded on 7th days after emergence are presented in table-3. The data presented in table-1 revealed that the plant population ranged between 84.72 to 93.47 percent and was non-significant.

Average number of eggs per 10 plants laid by shoot fly (*A. soccata*) on 7th, 14thand 21st days after emergence.

The data are presented in table-2 with regards to the average number of eggs laid by shootfly per 10 plants recorded on 7th, 14th, 21st and 28th days after emergence are presented in table-4.

On 7th days after emergence

Average number of eggs laid by shoot fly per 10 plants on 7th days after emergence ranged between 3.00 to 4.33. The results were non significant however lowest shoot fly eggs per 10 plants recorded in 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.] (3.00) and 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.] (3.00).Were highest shoot fly eggs per 10 plants recorded in 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.] (4.33).

On 14th days after emergence

The Average number of eggs laid by shoot fly per 10 plants on 14th days after emergence ranged between 10.67 to 14.33. The results are were non significant however lowest shoot fly eggs per 10 plants recorded in T_5 [Spray of Imidacloprip 17.8 SL @ 3 ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.] (10.67). Were highest shoot fly eggs per 10 plants recorded in T_2 [Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.] (14.33).

On 21st days after emergence

Average number of eggs laid by shoot fly per 10 plants on 21st days after emergence ranged between 19.00 to 30.33. Significantly minimum number of shoot fly eggs were recorded in the treatment 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] (19.00) which was at par with 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] (22.00), 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] (24.00), T_8 [Farmer practice One spray of chlorpyrifos 20 EC @ 25ml/10 lit. of water at 14 DAE] (24.33), T_5 [Spray of Imidacloprip 17.8 SL @ 3ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage] (24.67). Significantly highest number of shoot fly eggs were recorded in the treatment T_2 [Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.] (30.33) which was at par with T_1 [Seed treatment with Imidacloprid 48% FS @14ml/kg of seed + spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage] (29.67).

Table 1: Percent emergence

Tr. No.	Treatment	Percent emergence
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.	93.06 (75.67)
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.	92.78 (74.51)
T_3	Soil application of Phorate 10% D @ 25kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10 lit. of water at milk stage.	93.47 (75.21)
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.	89.44 (71.42)
T_5	Spray of Imidacloprip 17.8 SL @ 3 ml /10 lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	92.08 (74.41)
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.	90.42 (72.07)
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	91.11 (72.70)

T_8	Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)	84.72 (67.42)
	S.E. +	2.08
	C.D. at 5%	NS

Table 2: Average number of eggs laid by shootfly (*A. soccata*) per 10 plants on 7th, 14th, 21st, 28th days after emergence.

Tr. No.	Treatment	Average number of egg laid per 10 plants		
		7th DAE	14th DAE	21st DAE
T_1	Seed treatment with Imidacloprid 48% FS @14ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	3.67 (2.03)	13.33 (3.69)	29.67 (5.48)
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.	4.33 (2.19)	14.33 (3.83)	30.33 (5.54)
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.	3.67 (2.02)	12.00 (3.50)	24.00 (4.94)
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.	3.67 (2.03)	12.67 (3.60)	25.00 (5.03)
T_5	Spray of Imidacloprip 17.8 SL @ 3 ml /10 lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	3.67 (2.02)	10.67 (3.31)	24.67 (5.01)
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.	3.00 (1.85)	11.00 (3.36)	19.00 (4.40)
T_7	spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @25ml/10lit. of water at milk stage	3.00 (1.87)	11.00 (3.38)	22.00 (4.72)
T_8	Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)	3.33 (1.94)	12.00 (3.52)	24.33 (4.97)
	S.E. +	0.12	0.23	0.23
	C.D. at 5%	0.36	0.71	0.70

* Figures in parentheses denote $\sqrt{x+0.5}$ transformed values.
DAE-Days after emergence

More egg laying on the sorghum plants emerged from seed treatment may be due to attraction of flies to healthy stand and dark green colour of seedling. the finding more or less similar to workers like Naitam and Sukhani (1985) [13] reported that oviposition was generally more in insecticidal seed treatments as compared to control indicating more attraction of shoot fly towards healthy seedlings in seed treated plots. Kudale (2002) [12] reported that eggs laying was more on seedlings raised from carbofuran seed treatment followed by imidacloprid and thiamethoxam seed treatment indicating ovipositional preference to healthy seedlings. Pande (2001) [14] observed maximum eggs of shootfly on sorghum emerged from treated seed with thiamethoxam @ 5g/kg followed by imidacloprid seed treatment @ 10 g/kg seed. Aghav and Sable (2003) [1] observed highest percent plants with eggs in the plots treated with thiamethoxam seed treatment while maximum egg laying was observed in the plots of imidacloprid followed by thiamethoxam.

Percent dead hearts due to shoot fly (*A. soccata*) on 7th, 14th and 21st days after emergence

The observations regarding percent dead hearts caused due to shootfly recorded on 7th, 14th, 21st and 28th days after emergence are presented in table.

On 7th days after emergence

On 7th days after emergence the percent dead hearts recorded ranged between 0.58 to 2.21. Significantly minimum percent of dead hearts were recorded in the treatment T_2 [Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage] (0.58) followed by 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] (0.72), 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.] (0.74) and 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] (0.74). These treatments were found superior over the rest of the treatments and were at par with each other. The next best treatment was 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] (1.74). Significantly highest percent of dead hearts were recorded in the treatment T_8 Farmer practice [One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE] (2.21) followed by 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] (2.03) and T_7 [Spray of chlorpyrifos 20 EC @ 25ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @25ml/10lit. of water at milk stage] (2.01) and were at par with each other.

On 14th days after emergence

On 14th days after emergence the percent dead hearts recorded ranged between 7.72 to 19.64. Significantly minimum percent of dead hearts were recorded in 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.] (7.72) followed by 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] (8.69), 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] (8.72) and 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] (9.06). These treatments were found superior over the rest of the treatments and were at par with each other. The next best treatment was 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] (11.41). Significantly highest percent of dead hearts were recorded in the treatment T_8 Farmer practice [One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE] (19.64) followed by T_7 [Spray of chlorpyrifos 20 EC @ 25ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @ 25 ml/10 lit. of water at milk stage] (16.56) and T_5 [Spray of Imidacloprip 17.8 SL @ 3ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage] (12.61) and were at par with each other.

Table 3: Percent dead heart due to shootfly (*A. soccata*) on 7th, 14th, 21st, 28th days after emergence.

Tr. No.	Treatment	Average percent dead heart per plot			
		7th DAE	14th DAE	21st DAE	28th DAE
T_1	Seed treatment with Imidacloprid 48% FS @14ml/kg of seed + spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	0.72 (4.82)	8.69 (1.71)	16.29 (2.37)	21.26 (2.73)
T_2	Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage.	0.58 (4.31)	8.72 (1.71)	15.20 (2.26)	20.83 (2.71)
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.	0.74 (4.88)	9.06 (1.74)	23.37 (2.88)	26.75 (3.11)
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.	0.74 (4.87)	7.72 (1.61)	19.23 (2.59)	22.97 (2.85)
T_5	Spray of Imidacloprip 17.8 SL @ 3 ml /10lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage.	1.74 (7.51)	12.61 (2.07)	25.43 (3.02)	29.72 (3.30)
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.	2.03 (8.10)	11.41 (1.97)	24.86 (2.98)	28.51 (3.22)
T_7	spray of chlorpyrifos 20 EC @ 25ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @25ml/10lit. of water at milk stage	2.01 (8.14)	16.56 (2.40)	26.59 (3.10)	31.11 (3.38)
T_8	Farmer practice (One spray of chlorpyrifos 20 EC @ 25ml/10 lit. of water at 14 DAE)	2.21 (8.52)	19.64 (2.62)	27.49 (3.16)	33.62 (3.54)
	S.E. +	0.43	0.70	1.47	1.19
	C.D. at 5%	1.31	2.14	4.47	3.63

* Figures in parentheses denote angular transformed values.
DAE-Days after emergence

Table 4: Percent dead heart due to stem borer (*Chilo partellus*) on 45th and 60th days after emergence.

Tr. No.	Treatment	Average percent dead heart per plot	
		45th DAE	60th DAE
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.	5.50 (13.56)	8.92 (17.30)
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.	3.71 (11.07)	8.43 (16.85)
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.	6.83 (15.11)	11.55 (19.82)
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.	4.00 (11.50)	8.74 (17.15)
T_5	Spray of Imidacloprip 17.8 SL @ 3ml /10 lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage.	8.69 (17.10)	12.23 (20.46)
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.	5.52 (16.94)	9.72 (18.14)
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	8.11 (16.54)	12.02 (20.28)
T_8	Farmer practice (One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE)	12.87 (20.98)	19.10 (25.82)
	S.E. +	0.65	1.04
	C.D. at 5%	1.99	3.15

* Figures in parentheses denote angular transformed values.
DAE-Days after emergence

On 21st days after emergence

The percent dead hearts recorded on 21st days after emergence ranged between 15.20 to 27.49. The treatment T_2 [Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage] (15.20) recorded significantly lower number of dead hearts which was at par with 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] (16.29) and 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.] (19.23). The next best treatment was 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] (23.37). Significantly highest percent of dead hearts were recorded in the treatment T_8 Farmer practice [One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE] (27.49) followed by T_7 [Spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE followed by Spray of Phosolone 35% EC @25ml/10lit. of water at milk stage] (26.59), T_5 [Spray of Imidacloprip 17.8 SL @ 3 ml /10 lit. of water at 14 DAE followed by spray of

Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage] (25.43) 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] (24.86) and were at par with each other. Karibasavaraja *et al.* (2005) observed least incidence of sorghum shootfly in seed dress with thiamethoxam 70 WS @ 56 and 4 g a.i./ kg seeds.

Results of present studies are in accordance with findings of Wadghule (2005) [20] found that thiamethoxam 70 WS @ 2.1g a.i./ kg seed was the most effective treatment and records the lowest dead hearts percentage caused due to shoot fly. Kandalkar and Wanjari (2006) [9] conducted a field experiment at Akola, Maharashtra in 2002-04 and found that the seed treatment with thiamethoxam 70 WS recorded the minimum percentage of shoot fly dead hearts which was followed by treatment with imidacloprid 70 WS, imidacloprid 600 FS and carbosulfan 25, Kumar and Prabhraj (2007) [11] studied bioeficacy of chemicals for seed treatment against sorghum shoot fly and shoot bug. Seed treatment with thiamethoxam 70 WS @ 2 g/kg seed recorded lower infestation of dead heart (7.9%). Daware *et al.* (2011) 6[] Field experiments were conducted for three consecutive years 2005–2007 in *kharif* season to find out the effective and economical seed dresser for the management of sorghum shoot fly *Atherigona soccata* (Rondani) at Sorghum Research Station, Marathwada Agricultural University, Parbhani. The treatment with thiamethoxam @ 3. 1 g a. i./kg seed recorded significantly lowest shoot fly deadhearts (22. 66%) and gave maximum yield (3071. 59 kg/ha).

Percent dead hearts due to stem borer (*C. partellus*) on 45th and 60th days after emergence.

The data with regards to the dead hearts caused by stem borer recorded on 45th and 60th days after emergence are presented in table.

On 45th days after emergence

The percent dead hearts ranged between 3.71 to 12.87 on 45th days after emergence. Significantly lowest percent of dead hearts were recorded in the treatment 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] (3.71) which was at par with 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.] (4.00). The next best treatment was 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] (5.50), 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] (5.52), 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] (6.83), 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] (8.11) 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] (8.69). Significantly highest percent of dead hearts were recorded in the treatment T_8 Farmer practice [One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE] (12.87).

On 60th days after emergence

On 60th days after emergence percent dead hearts ranged between 8.43 to 19.10. The treatment 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] (8.43) recorded the minimum percent of dead hearts followed by 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.] (8.74), 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] (8.92), 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] (9.72) and T_3 [Soil application of Phorate 10% D @ 25kg/ha at the time of sowing + spray of Novaluron 10 EC @ 10 ml/10lit. of water at milk stage] (11.55). These treatments were found superior over the rest of the treatments and were at par with each other. Significantly highest percent of dead hearts were recorded in the treatment T_8 Farmer practice [One spray of chlorpyrifos 20 EC @ 25 ml/10 lit. of water at 14 DAE] (19.10) followed by T_5 [Spray of Imidacloprip 17.8 SL @ 3 ml /10 lit. of water at 14 DAE followed by spray of Cypermethrin 25 EC @ 5 ml/10 lit. of water at milk stage] (12.23) 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] (12.03).

The data presented in table indicated that the stem borer dead hearts at 45th and 60th day after emergence was found minimum in the treatmemt T_2 (Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) wshile 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) and T_1 (Seed treatment with Imidacloprid 48% FS @14ml/kg of seed + spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage) also found equally good. The results of investigation indicate that the Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage was effective for the management of stem borer.

The results are in support and conformity with present investigation. Subhedar *et al.* (1992) [19] reported that whorl application of carbofuran @ 8 kg/ha was the most effective treatment for the control of *Chilo partellus* on sorghum in a field assessment conducted in India. Katole *et al.* (2003) 10[] seed treatment with newly launched systemic insecticides imidacloprid and thiamethoxam followed by foliar spray after 30 days with imidacloprid 17.8 SL @0.01 percent or thiamethoxam 25 WG @ 0.01 were found highly effective for management of sorghum shoot fly and stem borer as two application management approach. Prem Kishor *et al.* (2004) [16] conducted field experiment to study bioefficacy and persistence of thiamethoxam (cruiser) in sorghum at New Delhi, India i.e. *kharif* 2003-04 with two formulation i.e. 350 FS (6.0 ml + 20 ml water and 9.0 ml + 20 ml water/kg seed) of thiamethoxam showed that both the formulations in low and high doses were effective against *A. soccata* and *C. partellus.*

Summer and Conclusion

The data pertaining to the dead heart of shoot fly and indicated that there were less percentage of dead hearts at 7th, 14th and 21st DAE in the plots of treatment 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). T_1(Seed treatment with Imidacloprid 48% FS @14ml/kg of seed + spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage) in which seeds were treated with thiamethoxam and Imidacloprid as compared to T_8, T_7, T_6, T_5, T_4 and T_3 in which seeds were sown without any seed treatment. The results clearly indicate that the seed treatment with thiamethoxam and Imidacloprid is effective for management of shoot fly. The data pertaining to the dead heart of stem borer and indicated that the stem borer dead hearts at 45th and 60th day after emergence was found minimum in the treatmemt T_2 (Seed treatment with Thiamethoxam 350 FS @7ml/kg of seed + Spray of Quinolphos 25 EC @ 20 ml/ 10 lit. of water at milk stage) while 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) and T_1 (Seed treatment with Imidacloprid 48% FS @14ml/kg of seed + spray of Cypermethrin 25 EC @ 5ml/10 lit. of water at milk stage) also found equally good. The results of investigation indicate that the 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 was effective for the management of stem borer.

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