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BIO-EFFICACY OF DIFFERENT INSECTICIDES AGAINST SHOOT FLY ON SORGHUM

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ABSTRACT

The field experiment was conducted to evaluate the effect of seed treatment with different insecticides against sorghum shoot fly (*Atherigona soccata* Rondani) during *Kharif*, 2017 at the agronomy farm, Rajasthan College of Agriculture, Udaipur. The results reveal that all treatments were significantly superior over control. Among the treatments seed treatment with imidacloprid 70 WS was observed better with a minimum mean per cent oviposition (43.31) at 12 days after germination. The seed treatment with imidacloprid 70 WS was also observed to be significantly superior over all other treatments on the 14th, 21st and 28th days after germination with a mean dead heart of 11.74, 18.04 and 22.14 per cent, respectively.

Key words: *Atherigona soccata* Rondani, Dead heart, Insecticides, Sorghum and Seed treatment

INTRODUCTION

Sorghum [*Sorghum bicolour* (L.) Monch], commonly known as jowar is one of the important crops of dry land agriculture in semi arid tropics. It is an important food and fodder crop providing not only food for millions of people in developing countries, but also provides a bulk of fodder to farm animals and is a prime source of income in dry land area. Sorghum grain contains appreciably high concentration of carbohydrate (72.6%), protein (10.4%), fat (1.9%), crude fibre (1.6%) and mineral matter (1.6%) with high digestibility. In India, sorghum is grown in area of 5.82 million hectare area with an annual grain production of 5.39 million tonnes and productivity of 854.4 kg/ha (Agriculture Statistics, 2015). The major sorghum growing states in the country are Maharashtra, Karnataka, Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Uttar Pradesh and Gujarat. In Rajasthan, it is extensively cultivated in Ajmer, Tonk, Pali, Udaipur, Rajsamand, Chittorgrah, Bhilwara and Jaipur districts of Rajasthan on 5.79 lakh hectare area with an annual production of about 3.49 tonnes, yield of 603 kg per ha and productivity of 763 kg per ha (Anonymous, K*harif* 2016-17).

The major insect pests that infest sorghum are shoot fly (*Atherigona soccata* Rondani), grasshopper (*Hieroglyphus banian* Fabricius), grey weevil (*Myllocerus undecimpustulatus* Marshall), stem borer (*Chilo partellus* Swinhoe), aphid (*Aphis sacchari* Zehntner) and termite (*Odontotermes obesus* Rambur). Among these biotic stresses sorghum shoot fly, *Atherigona soccata* is a serious pest that reduces sorghum production in the semi-arid tropics. The shoot flies attacks sorghum between 7 to 28 days after the seedling emergence (Nwanze *et al*., 1990) causing dead hearts formation and at times lead to the complete failure of crop under severe infestation. Due to shoot fly infestation, grain loss of 80–90% and 68% of fodder yield has been recorded in India (Balikai and Bhagwat, 2009 & Kahate *et al*., 2014). The shoot fly (*Atherigona soccata*) in particular infest the sorghum crop in early phase of vegetation and can be effectively managed by adoption of proper seed treatment technology. Though several recommendation of seed treatment for the management of shoot fly have been made by various workers but many new insecticide molecules which are effective as seed treatment are yet to be utilized for its use as seed treatment in sorghum against shoot fly. Hence a systematic investigation to evaluate efficacy of various insecticides as seed treatment against shoot fly incidence infesting sorghum will enable to find promising and effective molecule for seed treatment in sorghum.

MATERIALS AND METHODS

The field experiment to evaluate the "efficacy of seed treatment on shoot fly incidence" was carried out at agronomy farm during *Kharif* 2017 at Agronomy Farm. The field experiment was conducted under natural

infestation condition. Variety CSV-15 was sown on 5th July in a randomized block design with three replications. Each replication consisted of nine plots of 1.5x4.0 square meter plot size with row to row and plant to plant spacing of 50 cm x15 cm. There were three rows of plants for each treatment in each plot. There were nine treatments applied as seed and soil treatments at different dosages at the time of sowing.

The seeds were treated with various formulations of insecticides and soil treatments at the time of sowing. The observations on the efficacy of treatments were recorded in each plot in terms of per cent dead heart formation, oviposition, plant height, plant vigour, and grain yield. The crop was inspected regularly for the infestation by other pests and was protected after one month of crop growth by adopting a standard protection measures.

Treatments Detail:

S. No.	Treatments	Dose/ kg of seed
T_1	Chlorpyriphos 20 EC	10 ml
T_2	Quinolphos 25 EC	10 ml
T_3	Imidacloprid 70 WS	3 ml
T_4	Fipronil 5 SC	5 ml
T_5	Acetamiprid 20% SP	5 ml
T_6	Chlorantraniliprole 18.5 SC	1 ml
T_7	Thiamethoxam 30 FS	10 ml
T_8	Soil application of Carbofuran 3G	20 kg/ha.
T_9	Control	-

Observation:

Regular field visit were made to observe the eggs and dead hearts caused by *A. soccata* on plants during morning hours. The plants in each treatment were observed for oviposition, leaf glossiness, plant vigour, plant stand at 12 days after germination and for dead heart formation at 14, 21 and 28 days after germination and for grain yield and plant height at the time of harvest.

(i) Plant vigour: The observation on plant vigour on 10 randomly selected tagged plants were recorded at 12 days after germination for each treatment in each replication by visual grading the plants on 1 to 5 scale rating. The plants with low vigour were scaled 1-2, with medium plant vigour as 3 and the scale of 4-5 indicate the very high plant vigour.

(ii) Oviposition: The oviposition by shoot fly was recorded on 10 randomly selected plants for each treatment in each replication. The oviposition by *A. Soccata* was recorded by counting the number of tagged plants with shoot fly eggs at 12 days after germination. The per cent plants with shoot fly oviposition were calculated for each treatment as mentioned below.

$$\text{\% plant with shoot fly oviposition} = \frac{\text{Number of plants with eggs}}{\text{Total number of plants observed}} \times 100$$

(iii) Dead hearts: The number of plants showing dead hearts formation due to shoot fly infestation were recorded at 14, 21 and 28 days after germination in each treatment in each replication and the data were expressed as a per cent of dead hearts.

$$\text{Dead heart (\%)} = \frac{\text{Number of plant with dead deart}}{\text{Total number of plants observed}} \times 100$$

(iv) Plant height: The 10 randomly selected plants of each treatment were tagged and height of plant from its base to central leaf area was recorded at harvest.

(v) Grain yield: After harvesting the grain yield of each variety in each replication was recorded after threshing and drying of grains and grain yield per hectare was calculated. The data on resistance attributing parameters were statistically analysed for variance and the varieties were finally categorised as resistance/less susceptible, moderate resistance/susceptible and highly susceptible.

RESULTS AND DISCUSSION

To find out an effective seed treatment technology for the protection of sorghum, the new insecticide molecules along with recommended chemicals have been tested for choosing the best treatment by evaluating their relative efficacy on oviposition, plant vigour, dead heart formation and grain yield. The results obtained are discussed as under:

The result of the present investigation presented in table 1 and depicted in fig 1 revealed that all the treatments were significantly superior over control in reducing shoot fly population infesting sorghum during *Kharif* 2017. The seed treatment of imidacloprid 70 WS@ 3ml/kg seed recorded least oviposition (43.31%), dead heart formation (11.74, 18.04 and 22.14 at 14, 21 and 28 days after germination) and higher plant vigour rating of 4.67, plant height (225.33 cm.) and a higher grain yield of 33.40 q/ha and proved most effective against shoot fly infestation in sorghum during *Kharif*-2017. The treatment consisting of soil application of carbofuran 3G@ 20kg/ha was found least effective against shoot fly with maximum oviposition (70.33), highest per cent mean dead heart formation (33.78, 38.04 and 40.09 at 14, 21 and 28 days after germination), least plant vigour rating of 2.67, lowest plant height (209.00 cm) and least grain yield of 25.11q/ha during the investigation.

Table 1. Relative efficacy of different treatments against sorghum shoot fly, *Atherigona soccata* Rondani during *Kharif* 2017.

S. No.	Treatments	Plant Vigour (1–5)	Egg (%) 12 DAG	Dead Heart (%) 14 DAG	Dead Heart (%) 21 DAG	Dead Heart (%) 28 DAG	Plant Height (cm.)	Yield (q/ha)
T1	Chlorpyriphos 20 EC	3.33	50.85 (60.14)	32.11 (28.25)	35.40 (33.39)	36.10 (34.71)	212.67	29.10
T2	Quinalphos 25 EC	4.00	45.00 (50.00)	28.78 (23.17)	30.24 (25.36)	32.67 (29.14)	214.33	30.11
T3	Imidacloprid70 WS	4.67	41.15 (43.31)	20.04 (11.74)	25.13 (18.04)	28.07 (22.14)	225.33	33.40
T4	Fipronil 5 SC	3.00	54.78 (66.74)	34.63 (32.30)	37.13 (36.43)	38.76 (39.20)	210.33	28.10
T5	Acetamiprid 20% SP	3.67	46.92 (53.35)	28.75 (23.13)	30.71 (26.09)	34.32 (31.79)	222.67	29.87
T6	Chlorantraniliprole 18.5 SC	3.00	52.78 (63.40)	34.98 (32.87)	37.32 (36.76)	38.63 (38.97)	210.00	27.91
T7	Thiamethoxam 30 FS	4.33	43.08 (46.65)	22.35 (14.46)	26.24 (19.55)	30.40 (25.61)	224.00	32.89
T8	Soil application of Carbofuran 3G	2.67	57.00 (70.33)	35.53 (33.78)	38.08 (38.04)	39.29 (40.09)	209.00	25.11
T9	Control	1.33	61.71 (77.55)	41.60 (44.08)	42.56 (45.74)	43.78 (47.87)	202.00	22.43
	S.Em±	0.12	2.04	0.70	1.01	1.06	2.61	0.09
	C.D. (5%)	0.35	6.12	2.10	3.03	3.18	7.82	0.28

Table 2: Economics of different chemical treatments against sorghum shoot fly, *Atherigona soccata* Rondani (*Kharif* 2017).

Treatments	Yield in (q/ha)	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Treatment Cost (Rs/ha)	Net return (Rs/ha)	Net return over control (Rs/ha)	% increase over control (Rs/ha)	Increase yield over control (q/ha)	C:B ratio
Chlorpyriphos 20 EC	29.10	37830	13944	317	23569	8354	29.74	6.67	1:1.65
Quinalphos 25 EC	30.11	39143	13944	281	24918	9703	34.24	7.68	1:1.75
Imidacloprid70 WS	33.40	43420	13944	295	29181	13966	48.91	10.97	1:2.05
Fipronil 5 SC	28.10	36530	13944	297	22289	7074	25.28	5.67	1:1.57
Acetamiprid 20% SP	29.87	38831	13944	294	24593	9378	33.17	7.44	1:1.73
Chlorantraniliprole 18.5 SC	27.91	36283	13944	272	22067	6852	24.43	5.48	1:1.55
Thiamethoxam 30 FS	32.89	42757	13944	470	28343	13128	46.63	10.46	1:1.97
Soil application of Carbofuran 3G	25.11	32643	13944	1900	16799	1584	11.95	2.68	1:1.06
Control	22.43	29159	13944	0	15215	-	-	-	-

Price of sorghum = Rs. 1300/q, Chlorpyriphos 20 EC = Rs. 317, Quinalphos 25 EC= Rs. 281, Fipronil 5 SC = Rs. 297, Cost of labour = Rs. 250/labour, Imidacloprid70 WS = Rs. 295, Acetamiprid 20% SP = RS. 294, Thiamethoxam 30 FS = Rs. 470, Chlorantraniliprole 18.5 SC = Rs. 272, Carbofuran 3G = Rs. 1900.

1. Plant vigour: The results presented table 1 reveal that the maximum plant vigour rating was recorded in seed treatment with imidacloprid 70 WS@ 3ml/kg seed (4.67) followed by thiamethoxam 30 FS@ 10ml/kg seed (4.33), quinalphos 25 EC@ 10ml/kg seed (4.00), acetamipirid 20% SP@ 5ml/kg seed (3.67), chlorpyriphos 20 EC@ 10ml/kg seed (3.33), fipronil 5 SC@ 5ml/kg seed (3.00) and chlorantraniliprole 18.5 SC@ 1ml/kg seed (3.00) at

12 days after germination during *Kharif* 2017. The minimum plant vigour rating of 2.67 was recorded in treatment consisting of soil application of carbofuran 3G@ 20kg/ha. The findings are in close conformity with findings of Jayanthi *et al*. (2002) and Sharma and Nwanze (1997) who found higher plant vigour was responsible for multiple resistances against *A. soccata*.

2. Oviposition: The results presented in table 1 and depicted in fig 1 reveal that the seed treatment of imidacloprid 70 WS@ 3ml/kg seed recorded least oviposition (43.31 mean plants with shoot fly eggs) and proved most effective in reducing shoot fly oviposition during *Kharif* 2017. It was closely followed by the seed treatment of thiamethoxam 30 FS@ 10ml/kg which recorded 46.65 percent oviposition and was found statistically at par to most effective treatment. The seed treatment with quinalphos 25 EC@ 10ml/kg seeds and acetamiprid 20%@ 5ml/kg seeds with 50.00% and 53.35% mean oviposition during *Kharif* 2017 were next in order of effectiveness followed by seed treatment with chlorpyriphos 20 EC@ 10ml/kg seed and chlorantraniliprole 18.5 SC@ 1ml/kg seed with 60.14 and 63.40 mean percent plants with shoot fly oviposition on sorghum plants during *Kharif* 2017. The maximum per cent oviposition by shoot fly was observed in treatment with soil application of carbofuran 3G@ 20kg/ha (70.33%) and considered as least effective treatment in terms of oviposition by shoot fly during *Kharif* 2017. The result of present investigation gets full support from the findings of Kudale (2002) and Aghav *et al*. (2007), who found that maximum oviposition by shoot fly was observed in treatment with soil application of carbofuran 3G.

3. Dead heart formation at 14, 21 and 28 days after germination: The observations on percent plant sowing dead heart formation at 14, 21 and 28 days after germination during *Kharif* 2017 presented in table 1 and depicted in fig 1 show that the number of plants showing dead heart formation were minimum in seed treatment of imidacloprid 70 WS@ 3ml/kg seed and proved most effective in reducing the dead heart formation by shoot fly with 11.74, 18.04 and 22.14 per cent mean plant sowing dead heart formation at 14, 21 and 28 days after germination respectively during *Kharif* 2017. The seed treatment with thiamethoxam 30 FS@ 10ml/kg seed was found next effective with 14.46, 19.55 and 25.61 per cent mean plant showing dead heart formation at 14, 21 and 28 days after germination respectively and was at par with the seed treatment of imidacloprid 70 WS@ 3ml/kg seed during *Kharif* 2017. It was followed by seed treatment of chlorantraniliprole 18.5 SC@ 1ml/kg seed with 32.87, 36.76 and 38.97, fipronil 5 SC@ 5ml/kg seed with 32.30, 36.43 and 39.20, Chlorpyriphos 20 EC@ 10ml/kg seed with 28.25, 33.39 and 34.71, acetamiprid 20% SP@ 5ml/kg seed with 23.13, 26.09 and 31.79 and quinalphos 25 EC@ 10ml/kg seed with 23.17, 25.36 and 29.14 per cent plant sowing dead heart formation at 14, 21 and 28 days after germination respectively. The number of plants showing dead heart formation were recorded maximum in treatment consisting of soil application of carbofuran 3G@ 20kg/ha with 33.78, 38.04 and 40.09 per cent plant showing dead heart formation at 14, 21 and 28 days after germination and proved to be least effective in reducing the number of plants with dead heart formation during *Kharif* 2017. The effectiveness of thiamethoxam was also well documented by Kumar and Prabhuraj (2007) and Karibasavaraja *et al.* (2005) who showed that seed dressing with thiamethoxam 70 WS was very effective in reducing the percentage of dead hearts caused by *A. soccata*. Similar results were observed by Sridar *et al.* (2016) and Sandhu (2016) who have established the effectiveness of imidacloprid in reducing shoot fly incidence with minimum dead heart formation in sorghum.

4**. Plant height:** The observation on mean plant height presented in table 1 reveals that the maximum plant height was observed in seed treatment with imidacloprid 70 WS@ 3ml/kg seed of 225.33 cm followed by seed treatment with thiamethoxam 30 FS@ 10ml/kg seed with mean plant height of 224.00 cm during *Kharif* 2017. The minimum plant height was observed in treatment with soil application of carbofuran 3G@ 20kg/ha of 209.00 cm. The result of present investigation gets full support from the findings of Sridhar *et al*. (2016) and Birangal *et al.* (2017) who found that maximum plant height was recorded in plots treated with imidacloprid.

5. Grain yield: The observation on mean grain yield presented in table 1 and depicted in fig 2 reveal that the highest grain yield of 33.40 q/ha was recorded in seed treatment of imidacloprid 70 WS@ 3ml/kg seed during *Kharif* 2017. It was followed by seed treatment with thiamethoxam 30 FS@ 10ml/kg seed with a mean grain yield of 32.89 q/ha during *Kharif* 2017. The grain yield was lowest in treatment of soil application of carbofuran 3G@ 20kg/ha with a mean grain yield of 25.11 q/ha during *Kharif* 2017. The seed treatment quinalphos 25 EC@ 10ml/kg seed, seed treatment of acetamipirid 20% SP@ 5ml/kg seed, seed treatment of chlorpyriphos 20 EC@ 10ml/kg seed, seed treatment of fipronil 5 SC@ 5ml/kg seed and seed treatment of chlorantraniliprole 18.5 SC@ 1ml/kg seed resulted in a higher mean grain yield of 30.11, 29.87, 29.10, 28.10 and 27.91 q/ha respectively and proved superior to soil application of carbofuran 3G@ 20kg/ha in reducing the shoot fly infestation. The seed treatment with imidacloprid 70 WS@ 3ml/kg seed recorded significantly higher grain yield over rest of the treatments with the highest cost

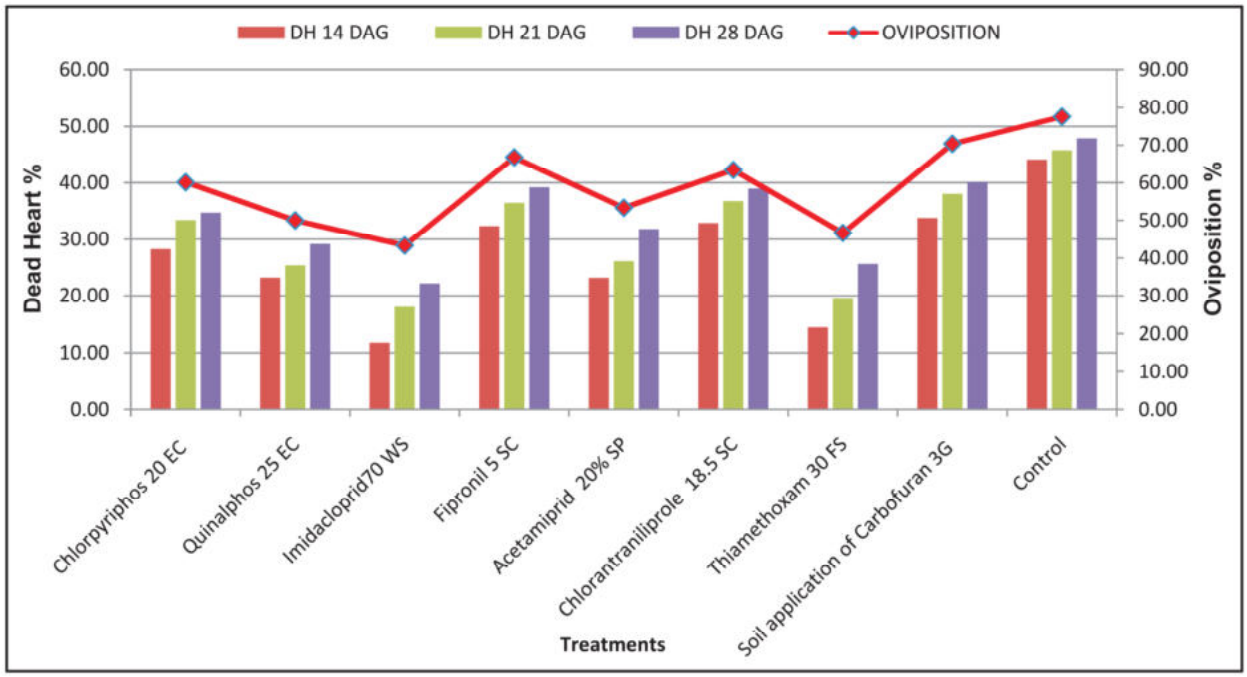

Fig.1: Efficacy of different treatments on oviposition and dead heart formations by shoot fly

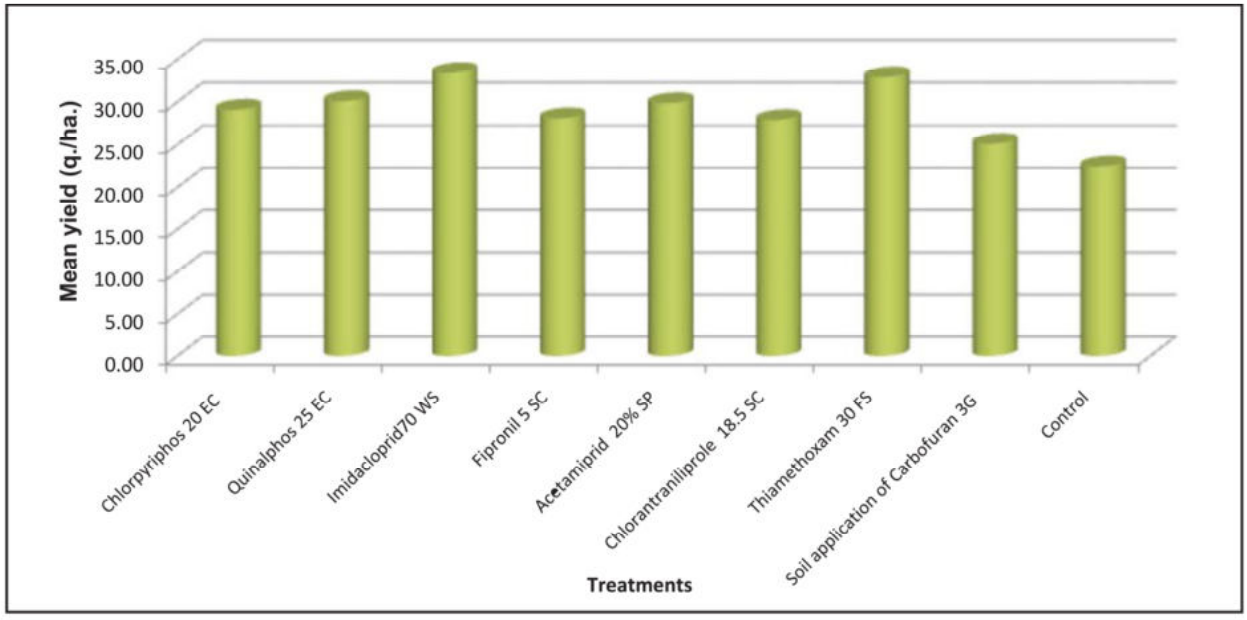

Fig.2: Effect of different treatments on mean grain yield of sorghum (q/ha.)

benefit ratio (Table 2) of 1: 2.05 followed by thiamethoxam 30 FS@ 10ml/kg seed (1: 1.97), quinalphos@ 10ml/kg seed (1:1.75), acetamiprid 20% SP@ 5ml/kg seed (1:1.73), chlorpyriphos@ 10ml/kg seed (1:1.65), fipronil 5 SC@ 5ml/kg seed (1:1.57) and chlorantraniliprole 18.5 SC@ 1ml/kg seed (1:1.55). Earlier findings of Daware *et al.* (2011), Aghav *et al.* (2007), Kumar and Prabhuraj (2007) and Kishore *et al.* (2004) show that the treatments thiamethoxam 70 WS and imidacloprid 70 WS were found most effective against shoot fly and recorded a higher grain yield. Birangal *et al.* (2017) also reveled that imidacloprid 48% FS@ 10 ml/kg seed followed by spray of quinalphos 25% EC@ 2 ml/l proved the most effective treatment with higher grain yield.

It is apparent from results of the present investigation that the seed treatment with imidacloprid 70 WS@ 3ml/kg seeds proved effective against *A. soccata* infesting sorghum exhibiting reduced

oviposition, dead heart formation and increased grain yield. The effectiveness of the insecticide was earlier reported by Karibasavaraja *et al*. (2005) and Kishore *et al*. (2004) against shoot fly, *A. soccata*. However, the seed treatment with thiamethoxam 30 FS@ 10ml/kg seed was also found effective earlier too Daware *et al.* (2011) and Kumar and Prabhuraj (2007) also reported similar results.

The effectiveness of newer molecules fipronil, Chlorantraniliprole and acetamiprid are not well documented but the result of the present investigation reveal that the seed treatment with newer molecules proved effective treatment against *A. soccata* in reducing dead heart formation and yielding higher grain yield. These treatments were found superior to the chemical quinalphos and soil application of carbofuran (Kishore *et al*., 2004 and Sridhar *et al*., 2016.)

It is apparent from the forgoing discussion that among various treatments the seed treatment with imidacloprid or thiamethoxam provided effective control of shoot fly infestation in sorghum. However the soil application of carbofuran was found least effective in reducing *A. soccata* population and seed treatment with fipronil, acetamiprid and Chlorantraniliprole were found superior over carbofuran. The present findings are in close conformity with finding of Sandu (2016) and Patil & Bagde (2017) who found that these chemicals were found superior in reducing shoot fly damage in sorghum.

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