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Evaluation of insecticides for the control of stem borer and wireworm infesting un-irrigated fodder sorghum

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Abstract
A field experiment was conducted during *rabi*, 2016-17 and 2017-18 to evaluate the efficacy of granular insecticides against stem borer and wireworm infesting un-irrigated fodder sorghum. An experiment was conducted at Agricultural Research Station, Anand Agricultural University, Arnej, Ta. Dholka, Dist. Ahmedabad. For the purpose different seven granular insecticides available in the market were applied in the soil along with seed and basal application of the fertilizer, while in case of seed treatment insecticide were applied to seeds and treated seeds were sown after proper drying. Among the tested insecticides seed treatment with thiamethoxam 30 FS @ 8 ml/kg seeds was found very good treatment in protecting the crop against stem borer and wire worm by recording maximum initial plant population and plant population at harvest, minimum reduction in plant population, minimum dead heart (%) and maximum dry fodder yield (kg/ha). It was followed by seed treatment with imidacloprid 600 FS and granular application of fipronil 0.3% G in soil in their efficacy.

Keywords: Efficacy, Stem borer, wireworm, fodder, sorghum

Introduction
Sorghum is the most important food and fodder crop of dry land agriculture. Sorghum grains are important as food and as livestock feed. The stem and foliage are used as a green fodder, hay, silage and pasture. The stems are also used as fuel and building material. Worldwide, sorghum is grown in an area of 42.50 million hectares to produce 59.91 million tonnes, with the productivity of around 1.60 tonnes per hectare [3]. In Gujarat, sorghum is grown as grain crop in South Gujarat, dual purpose in North Gujarat, Kachchh, and Saurashtra and partly as fodder in dairy developed area including *Bhal* region of Ahmedabad district which occupies on an average about 75,500 hectares. The productivity in *Kharif* and *Rabi* is 989 kg/ha and 744 kg/ha, respectively [2]. Sorghum is susceptible to insect pests from emergence to late grain fill. Early sorghum pests include shoot fly, stem borer, armyworm and soil insects. These pests are normally present in a grain as well as fodder sorghum crop in low numbers where their damage can be tolerated. Despite the ability of sorghum to grow successfully its production is constrained by about 150 insect pests [7]. However, seasonal conditions can sometimes stimulate the buildup of a large population of one or more of these and they can cause significant damage. Recently in *Bhal* area heavy incidence of stem borer and wire worm (that feed on the on seedling plant roots, reducing plant stands and vigor) [1] were noticed on the farmer's fields in *rabi* season. The information for the control of these pests in the region was not available. In light of these facts, an experiment was proposed.

Materials and Methods
To evaluate the efficacy of granular insecticides, an experiment was conducted in Randomized Block Design with three replications at Agricultural Research Station, AAU, Arnej, Ta. Dholka, Dist. Ahmedabad rabi, 2016-17 and 2017-18 *i.e*, for two years. For the purpose different five granular insecticides (Carbofuran 3% G 1 kg a.i./ha, Cartap hydrochloride 4% G 1 kg a.i./ha, Chlorontraniliprole 0.4% G 0.133 kg a.i./ha, Fipronil 0.3% G 0.10 kg a.i./ha and Phorate 10 G 1.00 kg a.i./ha) available in the market were applied in the soil along with seed and basal application of the fertilizer, while in case of seed treatment, two insecticide (Thiamethoxam 30 FS 0.144 kg a.i./ha and Imidacloprid 600 FS 0.288 kg a.i./ha) were applied to seeds and treated seeds of the Var. *Solapuri* of fodder sorghum were sown after proper drying. The data on initial plant population after germination were recporded at 30 days after sowing and at harvest as well as number of withered and healthy shoot(s) per 1 meter row

length were counted at 30, 45 and 60 DAS from 3 randomly selected spots. Thus, data on reduction of plant population (%) and withered shoot(s)/dead heart (%) were worked out. Dry fodder yield was also recorded from each net plot area. Data, thus obtained were subjected to ANOVA after following standard statistical procedure to draw the valid conclusion.

Results and Discussion

Initial plant population (Table 1)

The maximum plant population was recorded in the plot treated with thiamethoxam 30 FS (0.144 kg a.i./ha) (23.89 plants/1 m row length) during 2016-17. It was remained at par with imidacloprid 600 FS (0.288 kg a.i/ha) (23.11 plant/ 1 m row length) and fipronil 0.3 % G (0.1 kg a.i./ha) (23.00 plant/1m raw length), whereas significantly lower plant population was recorded in the plot treated with phorate 10% G (1.0 kg a.i./ha) (19.78 plants/1m row length). Difference among the treatment for initial plant population was significant during 2017-18. Imidacloprid 600 FS (26.00 plants/1 m row length) recorded significantly higher plant population and remain at par with Fipronil 0.3G (25.44 plants/1 m row length) and thiamethoxam 30 FS (24.33 plants/1 m row length). Initial plant population recorded at 30 days after sowing showed non-significant difference among the treatment in the pooled (2016-17 and 20147-18). However, higher plant population were recorded from the plot treated with imidacloprid 600 FS (24.56 plants/1 m row length), thiamethoxam 30 FS (24.11 plants/1 m row length) and Fipronil 0.3G (24.22 plants/1 m row length).

Plant population at harvest (Table 1)

Significantly higher plant population (22.89 plant/ 1m row length) was recorded from the plot treat with thiamethoxam 30 FS followed by imidacloprid 600 FS and fipronil 0.3 % G (21.33 plant/ 1 m row length) during 2016-17. During 2017-18, imidacloprid 600 FS (25.33 plants/1 m row length) recorded significantly higher plant population and remain at par with fipronil 0.3G (24.66 plants/1 m row length) and thiamethoxam 30 FS (23.34 plants/1 m row length). The pooled data (2016-17 and 2017-18) revealed that the plant population recorded at harvest revealed significantly higher plant population in the plot treated with imidacloprid 600 FS (23.33 plants/1 m row length), thiamethoxam 30 FS (23.11 plants/1 m row length), fipronil 0.3G (23.00 plants/1 m row length) and chlorontraniliprole 0.4% G (21.44 plants/1 m row length).

Reduction in plant population (%) (Table 1)

During the year 2016-17, significantly lower reduction in plant population was recorded in the plot treated with thiamethoxam 30 FS (4.19%) and it was followed by carbofuran 3% G (6.60%), imidacloprid 600 FS (7.70 %) and Fipronil 0.3% G (7.31), were as significantly higher plant population reduction (19.06 %) was observed in the plot treated with phorate 10 % G. Significantly lower reduction in plant population was recorded in the plot treated with imidacloprid 600 FS (2.56 %) and it was followed by Fipronil 0.3% G (3.05 %) and thiamethoxam 30 FS (4.15 %) and they were found statistically at par during 2017-18. The pooled data (2016-17 and 2017-18) on reduction in plant population was found Significantly lower in the plot treated with thiamethoxam 30 FS (4.17%), imidacloprid 600 FS (5.13%) and fipronil 0.3% G (5.18%) compared to phorate 10 G and cartap hydrochloride 0.4G and they were statistically at par.

Table 1: Effect of different insecticides on plant population as affected by stem borer and wire worm in un-irrigated sorghum

Sr. No.	Treatments	Plant population/m row length								
		Initial			Harvest			Reduction (%)		
		2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
1	2	3	4	5	6	7	8	9	10	11
1	Carbofuran 3% G (1kg a.i./ha)	21.89^{abc}	22.00^{bc}	21.95^{ab}	20.44^{ab}	20.55^{bcd}	20.50^{ab}	6.61^{b}	6.57^{bc}	6.59^{bc}
2	Cartap hydrochloride 4% G (1kg a.i./ha)	20.11^{bc}	20.44^{c}	20.28^{b}	16.67^{c}	18.78^{de}	17.72^{bc}	17.18^{a}	8.36^{ab}	12.77^{ab}
3	Chlorontraniliprole 0.4% G (0.1kg a.i./ha)	21.67^{abc}	24.33^{ab}	23.00^{ab}	20.00^{ab}	22.89^{abc}	21.44^{a}	7.70^{b}	5.97^{bc}	6.84^{bc}
4	Fipronil 0.3% G (0.1kg a.i./ha)	23.00^{a}	25.44^{a}	24.22^{a}	21.33^{a}	24.66^{a}	23.00^{a}	7.31^{b}	3.05^{c}	5.18^{c}
5	Phorate 10 G (1.87kg a.i./ha)	19.78^{c}	21.89^{bc}	20.83^{b}	16.00^{c}	19.89^{cd}	17.95^{bc}	19.06^{a}	9.07^{ab}	14.07^{a}
6	Thiamethoxam 30 FS (0.144 kg a.i./ha)	23.89^{a}	24.33^{ab}	24.11^{a}	22.89^{a}	23.34^{ab}	23.11^{a}	4.19^{b}	4.15^{c}	4.17^{c}
7	Imidacloprid 600 FS (0.288 kg a.i./ha)	23.11^{a}	26.00^{a}	24.56^{a}	21.33^{a}	25.33^{a}	23.33^{a}	7.70^{b}	2.56^{c}	5.13^{c}
8	Control	22.22^{ab}	19.22^{c}	20.72^{b}	17.67^{bc}	16.89^{e}	17.28^{c}	20.55^{a}	12.18^{a}	16.36^{a}
S. Em. (T)		0.73	0.93	0.99	22.46	0.94	0.92	20.54	1.22	1.99
Y		--	--	0.30	--	--	0.32	--	--	0.43
T X Y		--	--	0.84	--	--	0.91	--	--	1.20
C.D. at 0.05 % (T)		2.22	2.82	NS	2.69	2.85	3.09	3.59	3.70	6.66
Y		--	--	S	--	--	S	--	--	S
T X Y		--	--	2.42	--	--	NS	--	--	3.47
C.V. (%)		5.76	7.02	6.45	7.85	7.56	7.70	18.13	32.59	23.41

Note:

1. Insecticide(s) placed at Sr. No. 1 to 5 were applied as soil application at the time of sowing, while insecticide(s) placed at Sr. No. 6 and 7 were applied as seed treatment.
2. Treatment mean(s) with letter(s) in common are nor differed significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance.
3. Wireworm population was not found during above observations from nearby area.

Dead Heart (%) (Table 2)

Dead heart (%) recorded at 30 days after sowing (DAS) showed significantly lower dead heart (%) in the plot treated with thiamethoxam 30 FS (6.44%) during 2016-17. The imidacloprid 600 FS was stood 2nd by recording 8.67 % dead heart (%) followed by fipronil 0.3 % G (8.71 %) and both the treatments were remain at par. Same trend was observed after 45 and 60 DAS for the dead heart (%) as observed during 30 DAS. While during 2017-18, significantly lower dead heart (%) was recorded at 30 DAS from the plot treated with

fipronil 0.3 % G (5.28%) and it was remained at par with imidacloprid 600 FS (5.64 %) and thiamethoxam 30 FS (7.17%). After 45 DAS, significantly lower dead heart (%) was recorded from the plot treated with imidacloprid 600 FS (07.25%) and fipronil 0.3 % G (07.30%) and they were at par. Thiamethoxam 30 FS (10.73%) stood 2nd in order. Same trend was observed at 60 DAS for the dead heart (%) as observed during 45 DAS. The pooled data (2016-17 and 2017-18) on dead heart (%) recorded at 30 DAS showed significantly lower dead heart (%) in the plot treated with thiamethoxam 30 FS (6.80%), fipronil 0.3 % G (6.90%) and imidacloprid 600 FS (7.08%) and were remained at par. More or less similar trend was observed after 45 and 60 DAS for the dead heart (%) as observed at 30 DAS.

Anuradha [4] observed that seed treatment with thiamethoxam 30 FS @ 8 ml/kg recorded minimum dead heart (%) and plant infestation during *kharif* as well as Rabi season. Sorghum with seed treatment of thiamethoxam 70 WS @ 3 g/kg followed by one spray of NSKE 5% at 35 days after emergence (DAE) of the crop, were effective in reducing the incidence of shoot fly, stem borer and shoot bug and also gave higher grain and fodder yield as reported by Daware and Ambilwade [6]. Kumbhar and Singh [8] reported that among the entire insecticidal treatments efficacy against pink stem borer in rice, imidacloprid 17.8 SL (1.37%) and thiamethoxam 25 SL (1.69%) was found to be most effective in reducing dead heart incidence over the standard check monocrotophos 36 SL (1.95%). Balikai [5] reported that the seed treatment with thiamethoxam 70 WS @ 3 g/kg seeds proved highly effective against shoot fly by recording 5.2 per cent dead hearts. The next best treatment in respect of shoot fly suppression was seed treatment with thiamethoxam 70 WS @ 2 g/kg seeds which in turn was on par with imidacloprid 70 WS @ 5 g/kg seeds. Similarly, the seed treatment of fipronil 500 FS @ 6 ml/kg seed and fipronil 500 FS @ 7.5 ml/kg seed gave good control of shoofly fly throughout the season in sorghum as concluded by Suliman [9].

Table 2: Effect of different insecticides on dead heart (%) as affected by stem borer in un-irrigated sorghum

Sr. No.	Treatments	Dead heart (%) days after sowing								
		30			45			60		
		2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
1	2	3	4	5	6	7	8	9	10	11
1	Carbofuran 3% G (1kg a.i./ha)	22.21^{b} (14.29)	19.41^{ab} (11.04)	20.81^{b} (12.62)	25.75^{bc} (18.87)	19.95^{bc} (11.64)	22.85^{bc} (15.08)	28.20^{bc} (22.33)	22.94^{b} (15.19)	25.57^{bc} (18.63)
2	Cartap hydrochloride 4% G (1kg a.i./ha)	23.58^{b} (16.00)	20.58^{ab} (22.36)	22.08^{ab} (14.13)	28.66^{a} (23.00)	21.67^{b} (13.64)	25.17^{ab} (18.09)	31.35^{a} (27.07)	23.91^{b} (16.43)	27.63^{ab} (21.51)
3	Chlorontraniliprole 0.4% G (0.1kg a.i./ha)	22.20^{b} (14.28)	18.14^{b} (9.69)	20.17^{b} (11.89)	25.32^{c} (18.29)	20.03^{bc} (11.73)	22.67^{bc} (14.86)	27.95^{cd} (21.97)	22.35^{b} (14.46)	25.15^{bc} (18.06)
4	Fipronil 0.3% G (0.1kg a.i./ha)	17.17^{c} (08.71)	13.29^{c} (05.28)	15.23^{c} (06.90)	22.76^{d} (14.97)	15.67^{d} (07.30)	19.22^{cd} (10.84)	25.96^{de} (19.16)	18.49^{c} (10.06)	22.22^{c} (14.30)
5	Phorate 10 G (1.87kg a.i./ha)	22.96^{b} (15.22)	19.66^{ab} (11.32)	21.31^{b} (13.21)	27.54^{ab} (21.38)	20.62^{bc} (12.40)	24.08^{ab} (16.65)	30.24^{ab} (25.36)	24.36^{b} (17.01)	27.30^{ab} (21.04)
6	Thiamethoxam 30 FS (0.144 kg a.i./ha)	14.70^{d} (06.44)	15.53^{c} (07.17)	15.12^{c} (06.80)	19.33^{e} (10.96)	19.12^{c} (10.73)	19.23^{cd} (10.85)	22.21^{f} (14.29)	22.31^{b} (14.41)	22.26^{c} (14.35)
7	Imidacloprid 600 FS (0.288 kg a.i./ha)	17.12^{c} (08.67)	13.74^{c} (05.64)	15.43^{c} (07.08)	22.36^{d} (14.47)	15.62^{d} (07.25)	18.99^{d} (10.59)	25.36^{e} (18.34)	18.30^{c} (09.86)	21.83^{c} (13.83)
8	Control	26.55^{a} (19.58)	21.86^{a} (13.86)	24.21^{a} (16.82)	29.60^{a} (24.40)	25.26^{a} (18.21)	27.43^{a} (21.22)	31.85^{a} (27.85)	28.94^{a} (23.42)	30.39^{a} (25.59)
S. Em. (T)		0.45	0.75	0.84	0.62	0.70	1.16	0.45	0.85	1.30
Y		--	--	0.22	--	--	0.23	--	--	0.26
T X Y		--	--	0.62	--	--	0.66	--	--	0.74
C.D. at 0.05 % (T)		1.36	2.27	2.81	1.88	2.12	3.89	1.36	2.59	4.36
Y		--	--	S	--	--	S	--	--	S
T X Y		--	--	1.78	--	--	1.91	--	--	2.14
C.V. (%)		3.73	7.29	5.53	4.27	6.12	5.09	3.73	6.52	5.07

Note

1. Figures inside the parenthesis in column No. 6, 7 and 8 are retransformed values and those outside are arcsine transformed
2. Insecticide(s) placed at Sr. No. 1 to 5 were applied as soil application at the time of sowing, while insecticide(s) placed at Sr. No. 6 and 7 were applied as seed treatment.
3. Treatment mean(s) with letter(s) in common are nor differed significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance.
4. Wireworm population was not found during above observations from nearby area.

Dry fodder Yield (kg/ha) (Table 3)

Dry fodder yield (kg/ha) was significantly differed due to the control of stem borer and wireworm by application of different insecticidal treatments during 2016-17. Thiamethoxam 30 FS (0.144 kg a.i./ha) recorded significantly higher dry fodder yield (6417 kg/ha) than rest of the treatments except imidacloprid 600 FS (5194 kg/ha).Significantly lower dry fodder yield was recorded phorate 10 % G (3583 kg/ha) and it was at par with control (3194 kg/ha). More or less similar trend was observed during 2nd year *i.e.*, 2017-18 in recording dry fodder yield (kg/ha) and thiamethoxam 30 FS (0.144 kg a.i./ha) recorded significantly higher yield (7806 kg/ha). The pooled data (2016-17 and 2017-18) on dry fodder yield (kg/ha) the treatment thiamethoxam 30 FS recorded significantly higher dry fodder yield (7111 kg/ha) than rest of the treatments. Imidacloprid 600 FS stood 2nd in recording dry fodder yield (5847 kg/ha) which was remained at par with chlorontraniliprole 0.4% G (5667 kg/ha), fipronil 0.3 % G (5250 kg/ha) and carbofuran 3% G (5181 kg/ha). Significantly lower dry fodder yield was recorded by phorate 10 % G (4014 kg/ha) and it was at par with control (3889 kg/ha).

Table 3: Effect of different insecticides on yield as affected by stem borer and wireworm in un-irrigated sorghum

Sr. No.	Treatments	Dry fodder yield (Kg/ha)		
		2016-17	2017-18	Pooled
1	2	3	4	5
1	Carbofuran 3% G (1kg a.i./ha)	4111^{bc}	6250^{bc}	5181^{bc}
2	Cartap hydrochloride 4% G (1kg a.i./ha)	3694^{c}	5750^{cd}	4722^{cd}
3	Chlorontraniliprole 0.4% G (0.1kg a.i./ha)	4139^{bc}	7194^{ab}	5667^{bc}
4	Fipronil 0.3% G (0.1kg a.i./ha)	4500^{bc}	6000^{bc}	5250^{bc}
5	Phorate 10 G (1.87kg a.i./ha)	3583^{c}	4444^{d}	4014^{d}
6	Thiamethoxam 30 FS (0.144 kg a.i./ha)	6417^{a}	7806^{a}	7111^{a}
7	Imidacloprid 600 FS (0.288 kg a.i./ha)	5194^{ab}	6500^{abc}	5847^{b}
8	Control	3194^{c}	4583^{d}	3889^{d}
S. Em. (T)		409	414	302
Y		-	-	146
T X Y		-	-	412
C.D. at 0.05 % (T)		1241	1258	867
Y		-	-	S
T X Y		-	-	NS
C.V. (%)		16.27	11.84	13.69

Note

1. Insecticide(s) placed at Sr. No. 1 to 5 were applied as soil application at the time of sowing, while insecticide(s) placed at Sr. No. 6 and 7 were applied as seed treatment.
2. Treatment mean(s) with letter(s) in common are nor differed significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance.

Conclusion

Overall, seed treatment with thiamethoxam 30 FS was found very good treatment in protecting the crop against stem borer and wire worm which was followed by seed treatment with imidacloprid 600 FS and granular application of fipronil 0.3% G in soil under unirrigated conditions.

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