International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; SP-8(4): 174-179

Received: 20-05-2020
Accepted: 22-06-2020

Meeral Suthar
Department of Entomology, BACA, AAU, Anand, Gujarat, India

MB Zala
Agricultural Research Station, AAU, Sansoli, Gujarat, India

HS Varma
Main Maize Research Station, AAU, Godhra, Gujarat, India

Minaxi Lunagariya
Department of Entomology, BACA, AAU, Anand, Gujarat, India

MB Patel
Main Maize Research Station, AAU, Godhra, Gujarat, India

BN Patel
Agricultural Research Station, AAU, Sansoli, Gujarat, India

PK Borad
Department of Entomology, BACA, AAU, Anand, Gujarat, India

Corresponding Author:
Meeral Suthar
Department of Entomology, BACA, AAU, Anand, Gujarat, India

Bioefficacy of granular insecticides against fall armyworm, *Spodoptera frugiperda* (JE Smith) in maize

Meeral Suthar, MB Zala, HS Varma, Minaxi Lunagariya, MB Patel, BN Patel and PK Borad

DOI: https://doi.org/10.22271/chemi.2020.v8.i4c.9889

Abstract
To study the efficacy of granular insecticides against fall armyworm in maize, an experiment was carried out at three different locations *i.e.*, Entomology Farm, BACA, AAU, Anand, Agriculture Research Station, AAU, Sansoli and Main Maize Research Station, AAU, Godhra during *Kharif*, 2019. Different eight granular insecticides were evaluated against fall armyworm in maize. Results revealed that whorl application of chlorantraniliprole 0.4% GR and fipronil 0.6 % GR @ 20 kg/ha, first at appearance of fall armyworm and second after 15 days were found effective as it recorded lower larval population, plant damage and cob damage and incurred higher straw and grain yield.

Keywords: maize, fall armyworm, *Spodoptera frugiperda*, granular insecticides

Introduction
Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 m t) in the global grain production. In India, maize is the third most important food crops after rice and wheat. According to advance estimate, it is cultivated in 17.49 lakh ha (Anonymous, 2019a) [2]. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries *etc*. In Gujarat it is cultivated in 4.3 lakh hectares with 7.9 lakh tones production and 1824 kg/ ha productivity (Anonymous, 2019b) [3]. Over seventeen species of insects have been found attacking maize. Amongst the Lepidoptera, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is the leading pest, causing considerable damage to the young crop (Alam, 1978) [4]. Economic damage in maize is mainly associated with defoliation of the whorl by fall armyworm larvae (Burkhardt, 1952) [5], although the insect also acts as a 'cutworm' by severing the main stem near the crown early in the growing season (Andrews, 1989) [6]. To manage this pest, farmers are using a range of management tactics, including host plant resistance, insecticide applications and biological control (Cisneros *et al.*, 2002) [7]. Keeping the economic importance of this pest in mind, this experiment was conducted to study the efficacy of granular insecticides against fall armyworm in maize.

Material and Methods
The experiment was laid out in Randomized Block Design with three replications at three different locations *i.e.* Entomology Farm, BACA, AAU, Anand, Agricultural Research Station, AAU, Sansoli and Main Maize Research Station, AAU, Godhra during *Kharif*, 2019. For the purpose, maize (Var. GAYMH-1) was sown in plot size of 4.8 x 6.0 m with 60 x 20 cm spacing by following standard agronomical practices except pest control. Different eight granular insecticides were evaluated for their efficacy against *S. frugiperda*. The first whorl application of granular insecticides was made at initiation of pest and subsequent after 15 days

of first application. For recording observations, ten plants were selected randomly from each net plot area. From these plants, total number of larvae as well as healthy and damaged plants were counted. The observations were recorded one day prior to first application and subsequently at 5, 10 and 15 days after each application. Number of healthy and damaged cobs were recorded from randomly selected 10 plants from each net plot at harvest. The data on larval population, damaged plants, damaged cobs and yield (grain and straw) were subjected to ANOVA.

Results and Discussion

Larval population (No. of larvae/10 plants)

The data on larval population of *S. frugiperda* was uniform in all the treatments before application of granular insecticides which indicated homogeneous distribution of pest in the experimental plots at three locations *i.e.,* Anand, Sansoli and Godhra. The results showed that all the granular applications effectively reduced the population of *S. frugiperda* till 15 days after first and second application, pooled over periods as well as pooled over periods and applications (Table 1 and 2). Results on pooled over first application indicated that the lowest larval population was recorded in plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (1.06 larvae/ 10 plants) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (1.38 larvae/ 10 plants). However, fipronil 0.6% GR, 120 g a.i./ha was found at par with thiocyclam hydrogen oxalate 4% GR, 800 g a.i./ha (1.78 larvae/ 10 plants) followed by fipronil 0.3% GR, 60 g a.i./ha ***(1.96*** larvae/ 10 plants***),*** carbofuran 3% CG, 600 g a.i./ha ***(2.26*** larvae/ 10 plants***),*** phorate 10% CG, 2000 g a.i./ha ***(2.36*** larvae/ 10 plants***),*** cartap hydrochloride 4% GR, 800 g a.i./ha ***(2.60*** larvae/ 10 plants***)*** and imidacloprid 0.3% GR, 60 g a.i./ha (3.15 larvae/ 10 plants***)***.

Significantly lower number of larva was found in plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (0.80 larvae/ 10 plants) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (1.04 larvae/ 10 plants), fipronil 0.3% GR, 60 g a.i./ha (1.35 larvae/ 10 plants), thiocyclam hydrogen oxalate 4% GR, 800 g a.i./ha (1.54 larvae/ 10 plants) and carbofuran 3% CG, 600 g a.i./ha (1.69 larvae/ 10 plants) as indicated from the data on pooled over periods of second application.

In case of pooled over periods and applications, the lowest population was found in plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (0.94 larvae/ 10 plants) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (1.19 larvae/ 10 plants). Overall, these two granular insecticides showed their superiority in reducing fall armyworm population.

Table 1: Evaluation of granular insecticides against fall armyworm, *S. frugiperda* infesting maize (Pooled over locations)

Tr. No.	Treatments	Dose (g a.i./ha)	No. of larva(e)/10 plants days after application								
			Before application	First				Second				Pooled over application
				5	10	15	Pooled	5	10	15	Pooled	
1	Fipronil 0.3 % GR	60	1.90 (3.11)	1.52^{b} (1.81)	1.57^{cd} (1.96)	1.63^{bcd} (2.16)	1.57^{cd} (1.96)	1.53^{b} (1.84)	1.42^{cd} (1.52)	1.45^{bc} (1.60)	1.36^{ab} (1.35)	1.47^{bc} (1.66)
2	Fipronil 0.6 % GR	120	1.97 (3.38)	1.34^{a} (1.30)	1.28^{ab} (1.14)	1.49^{ab} (1.72)	1.37^{ab} (1.38)	1.30^{a} (1.19)	1.11^{ab} (0.73)	1.16^{ab} (0.85)	1.24^{a} (1.04)	1.30^{a} (1.19)
3	Carbofuran 3 % CG	600	2.14 (4.08)	1.61^{bc} (2.09)	1.66^{cde} (2.26)	1.70^{cde} (2.39)	1.66^{cde} (2.26)	1.63^{b} (2.16)	1.50^{cde} (1.75)	1.57^{de} (1.96)	1.48^{abc} (1.69)	1.57^{cd} (1.96)
4	Chlorantraniliprole 0.4 % GR	80	2.05 (3.70)	1.20^{a} (0.94)	1.14^{a} (0.80)	1.42^{a} (1.52)	1.25^{a} (1.06)	1.24^{a} (1.04)	0.88^{a} (0.27)	0.93^{a} (0.36)	1.14^{a} (0.80)	1.20^{a} (0.94)
5	Imidacloprid 0.3 % GR	60	2.02 (3.58)	1.83^{d} (2.85)	1.89^{c} (3.07)	2.01^{f} (3.54)	1.91^{f} (3.15)	1.95^{d} (3.30)	1.79^{e} (2.70)	1.88^{d} (3.03)	1.74^{c} (2.53)	1.82^{e} (2.81)
6	Thiocyclam hydrogen oxalate 4 % GR	800	1.94 (3.26)	1.52^{b} (1.81)	1.42^{bc} (1.52)	1.60^{bc} (2.06)	1.51^{bc} (1.78)	1.56^{b} (1.93)	1.22^{bc} (0.99)	1.24^{d} (1.04)	1.43^{abc} (1.54)	1.47^{bc} (1.66)
7	Cartap hydrochloride 4 % GR	800	1.94 (3.26)	1.76^{cd} (2.60)	1.73^{de} (2.49)	1.80^{e} (2.74)	1.76^{ef} (2.60)	1.83^{cd} (2.85)	1.67^{de} (2.29)	1.73^{cd} (2.49)	1.68^{bc} (2.32)	1.72^{de} (2.46)
8	Phorate 10 % CG	2000	1.95 (3.46)	1.63^{bc} (2.16)	1.67^{cde} (2.29)	1.77^{de} (2.63)	1.69^{d} (2.36)	1.67^{bc} (2.29)	1.57^{de} (1.96)	1.60^{cd} (2.06)	1.62^{bc} (2.12)	1.66^{de} (2.26)
9	Control	---	1.99 (3.46)	2.13^{e} (4.04)	2.50^{f} (5.57)	2.65^{g} (6.52)	2.43^{g} (5.40)	2.90^{e} (7.91)	3.00^{f} (8.50)	3.21^{e} (9.80)	2.90^{d} (7.91)	2.66^{f} (6.58)
S. Em.± Treatment (T)			0.07	0.05	0.09	0.05	0.05	0.06	0.09	0.10	0.11	0.06
Location (L)			0.04	0.03	0.03	0.03	0.02	0.04	0.03	0.04	0.02	0.01
T x L			0.13	0.10	0.10	0.10	0.06	0.11	0.10	0.12	0.06	0.04
CD at 5% T			NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. %			11.28	11.03	10.41	10.36	10.70	11.81	11.59	13.21	12.66	11.74

Note: 1. Figures in parenthesis are retransformed values; those outside are are $\sqrt{x+0.5}$ transformed values
2. Treatment mean(s) with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. Significant parameters and its interaction: T, A, T X A, P X A, T X P X A, L, L X P, L X T, L X A X P, L X P X T, L X A X P X T

Table 2: Efficacy of granular insecticides against fall armyworm, *S. frugiperda* infesting maize (Pooled over locations)

Tr. No.	Treatment	Dose (g a.i./ha)	No. of larva(e)/10 plants			Pooled
			Anand	Sansoli	*Godhra*	
1	Fipronil 0.3 % GR	60	1.51^{cd} (2.06)	1.42^{bc} (1.52)	1.47^{b} (1.66)	1.47^{bc} (1.66)
2	Fipronil 0.6 % GR	120	1.31^{ab} (1.78)	1.25^{a} (1.06)	1.35^{ab} (1.32)	1.30^{a} (1.19)
3	Carbofuran 3 % CG	600	1.49^{c} (1.40)	1.40^{b} (1.46)	1.81^{d} (2.78)	1.57^{cd} (1.96)
4	Chlorantraniliprole 0.4 % GR	80	1.21^{a} (1.27)	1.13^{a} (0.78)	1.26^{a} (1.09)	1.20^{a} (0.94)

5	Imidacloprid 0.3 % GR	60	1.84^{f} (3.07)	1.80^{e} (2.74)	1.82^{d} (2.81)	1.82^{e} (2.81)
6	Thiocyclam hydrogen oxalate 4 % GR	800	1.35^{b} (2.56)	1.42^{bc} (1.52)	1.65^{c} (2.22)	1.47^{bc} (1.66)
7	Cartap hydrochloride 4 % GR	800	1.71^{e} (3.42)	1.66^{de} (2.26)	1.81^{d} (2.78)	1.72^{de} (2.46)
8	Phorate 10 % CG	2000	1.62^{de} (2.49)	1.56^{cd} (1.93)	1.80^{cd} (2.74)	1.66^{de} (2.26)
9	Control	---	2.76^{g} (4.38)	2.73^{f} (6.95)	2.50^{e} (5.75)	2.66^{f} (6.58)
S. Em.±	Treatment (T)		4.09	0.05	0.04	0.06
	Period (P)		2.36	0.03	0.02	0.04
	Application (A)		0.01	0.02	0.02	0.01
	T x P		7.09	0.08	0.08	0.10
	T x A		5.79	0.07	0.07	0.08
	P x A		3.34	0.04	0.04	0.03
	T x P x A		0.10	0.11	0.12	0.06
CD at 5%	T		Sig.	Sig.	Sig.	Sig.
C. V. %			10.53	12.42	12.16	11.74

Note: 1. Figures in parenthesis are retransformed values; those outside are arc sine transformed values
2. Treatment mean(s) with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. Significant parameters and its interaction: T, A, T X A, P X A, T X P X A, L, L X P, L X T, L X A X P, L X P X T, L X A X P X T

Plant damage (%)

The data on plant damage by *S. frugiperda* was uniform in all the treatments before application of granular insecticides which indicated homogeneous distribution of pest in the experimental plots at three locations *i.e.*, Anand, Sansoli and Godhra. The results showed that all the granular applications effectively reduced the population of *S. frugiperda* till 15 days after first and ***second application,*** pooled over periods as well as pooled over periods and applications (Table 3 and 4). Results on pooled over first application indicated that the lowest plant damage was recorded in plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (6.14 %) followed by fipronil 0.6% GR, 120 g a.i./ha (9.45 %), thiocyclam hydrogen oxalate 4% GR, 800 g a.i./ha (11.46 %).

The lowest damage was found in plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (***3.18*** %) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (***6.40*** %) and thiocyclam hydrogen oxalate 4% GR, 800 g a.i./ha (***7.19*** %) as revealed from the data on pooled over second application.

Results on pooled over periods and applications indicated that the lowest damage caused by *S. frugiperda* was recorded in plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (4.55 %) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (7.86 %). Overall, these two treatments were found highly effective in reducing the plant damage (%).

Table 3: Evaluation of granular insecticides against plant damage caused by fall armyworm, *S. frugiperda* infesting maize (Pooled over locations)

Tr. No.	Treatments	Dose (ga.i./ha)	Plant damage (%) days after application									
			Before application	First				Second				Pooled over applications
				5	10	15	Pooled	5	10	15	Pooled	
1	Fipronil 0.3 % GR	60	26.22 (19.52)	22.03^{b} (14.07)	23.84^{cd} (16.34)	27.56^{cd} (21.41)	24.48^{c} (17.17)	24.74^{b} (17.51)	22.03^{bc} (14.07)	24.74^{bc} (17.51)	23.84^{b} (16.34)	24.16^{c} (16.75)
2	Fipronil 0.6 % GR	120	26.96 (20.55)	15.29^{a} (6.95)	17.28^{ab} (8.82)	21.13^{d} (12.99)	17.90^{b} (9.45)	15.29^{a} (6.95)	10.23^{a} (3.15)	18.42^{ab} (9.98)	14.65^{a} (6.40)	16.28^{ab} (7.86)
3	Carbofuran 3 % CG	600	23.44 (15.82)	22.77^{b} (14.98)	24.58^{cde} (17.30)	26.39^{cd} (19.76)	24.58^{c} (17.30)	24.58^{b} (17.30)	22.77^{bc} (14.98)	25.32^{bc} (18.29)	24.22^{bc} (16.83)	24.40^{c} (17.07)
4	Chlorantraniliprole 0.4 % GR	80	26.96 (20.55)	12.34^{a} (4.57)	14.33^{a} (6.13)	16.38^{a} (7.95)	14.35^{a} (6.14)	10.29^{a} (3.19)	6.20^{a} (1.17)	14.33^{a} (6.13)	10.27^{a} (3.18)	12.31^{a} (4.55)
5	Imidacloprid 0.3 % GR	60	28.03 (22.08)	25.99^{b} (19.20)	29.43^{e} (24.14)	33.12^{e} (29.85)	29.51^{d} (24.26)	31.65^{c} (27.53)	27.96^{c} (21.98)	34.53^{d} (32.13)	31.38^{c} (27.11)	30.45^{d} (25.68)
6	Thiocyclam hydrogen oxalate 4 % GR	800	25.82 (18.97)	16.20^{a} (7.78)	20.23^{bc} (11.96)	22.94^{bc} (15.19)	19.79^{b} (11.46)	16.19^{a} (7.77)	14.33^{ab} (6.13)	16.13^{a} (7.72)	15.55^{a} (7.19)	17.67^{b} (9.21)
7	Cartap hydrochloride 4 % GR	800	25.15 (18.06)	25.32^{b} (18.29)	27.12^{de} (20.78)	30.98^{de} (26.50)	27.81^{d} (21.77)	29.43^{bc} (24.14)	26.55^{c} (19.98)	30.98^{cd} (26.50)	28.99^{bc} (23.49)	28.40^{cd} (22.62)
8	Phorate 10 % CG	2000	26.89 (20.46)	21.87^{b} (13.88)	23.68^{cd} (16.13)	28.03^{d} (22.08)	24.52^{c} (17.22)	25.65^{bc} (18.74)	25.32^{c} (18.29)	28.76^{cd} (23.15)	26.58^{bc} (20.02)	25.55^{c} (18.60)
9	Control	---	27.39^{a} (21.16)	34.36^{c} (31.85)	41.08^{a} (43.18)	45.74^{f} (51.29)	40.39^{e} (41.99)	54.71^{d} (66.62)	59.54^{d} (74.30)	65.54^{e} (82.86)	59.93^{d} (74.89)	50.16^{e} (58.96)
S. Em.± Treatment (T)			1.15	1.73	1.52	1.55	0.97	2.10	2.89	2.74	2.32	1.51
Location (L)			0.65	1.10	0.88	0.93	0.56	1.16	1.06	1.02	0.63	0.43
T x L			1.96	3.32	2.66	2.79	1.68	3.50	3.18	3.08	1.91	1.29
CD at 5% T			NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. %			12.92	26.41	18.74	17.27	20.36	23.47	23.12	18.58	21.93	21.54

Note: 1. Figures in parenthesis are retransformed values; those outside are arc sine transformed values
2. Treatment mean(s) with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. Significant parameters and its interaction: L, A, P, T, L X P, L X T, A X P, A X T, L X A X T

Table 4: Efficacy of granular insecticides against plant damage caused by fall armyworm, *S. frugiperda* infesting maize (Pooled over locations)

Tr. No.	Treatment	Dose (g a.i./ha)	Plant damage (%)			Pooled
			Anand	Sansoli	*Godhra*	
1	Fipronil 0.3 % GR	60	25.00^{bc} (17.86)	22.49^{bc} (14.63)	25.00^{cd} (17.86)	24.16^{c} (16.75)
2	Fipronil 0.6 % GR	120	16.89^{a} (8.44)	13.31^{a} (5.30)	18.63^{b} (10.21)	16.28^{ab} (7.86)
3	Carbofuran 3 % CG	600	23.39^{b} (15.76)	20.68^{b} (12.14)	29.13^{e} (23.70)	24.40^{c} (17.07)
4	Chlorantraniliprole 0.4 % GR	80	15.44^{a} (7.09)	9.21^{a} (2.56)	12.28^{a} (4.52)	12.31^{a} (4.55)
5	Imidacloprid 0.3 % GR	60	29.75^{d} (24.62)	27.87^{d} (21.85)	33.72^{f} (30.82)	30.45^{d} (25.68)
6	Thiocyclam hydrogen oxalate 4 % GR	800	17.34^{a} (8.88)	12.74^{a} (4.86)	22.94^{c} (15.19)	17.67^{b} (9.21)
7	Cartap hydrochloride 4 % GR	800	28.31^{cd} (22.49)	26.31^{cd} (19.65)	30.57^{ef} (25.87)	28.40^{cd} (22.62)
8	Phorate 10 % CG	2000	25..48^{bcd} (18.51)	22.94^{bc} (15.19)	28.23^{de} (22.37)	25.55^{c} (18.60)
9	Control	---	44.20^{e} (48.60)	47.35^{e} (54.10)	58.95^{g} (73.40)	50.16^{e} (58.96)
S. Em.±	Treatment (T)		1.34	1.42	1.09	1.51
	Period (P)		0.77	0.82	0.63	0.68
	Application (A)		0.63	0.67	0.51	0.35
	T x P		2.32	2.46	1.89	1.29
	T x A		1.90	2.00	1.55	1.49
	P x A		1.09	1.16	0.89	0.61
	T x P x A		3.29	3.48	2.68	1.83
CD at 5%	T		Sig.	Sig.	Sig.	Sig.
C. V. %			22.73	26.72	16.14	21.54

Note: 1. Figures in parenthesis are retransformed values; those outside are arc sine transformed values
2. Treatment mean(s) with the letter(s) in common are not significant by DNMRT at 5% level of significance
3. Significant parameters and its interaction: L, A, P, T, L X P, L X T, A X P, A X T, L X A X T

Cob damage (%)

Data on cob damage (Table 5) pooled over locations revealed that the lowest cob damage was recorded in chlorantraniliprole 0.4% GR, 80 g a.i./ha (6.24 %) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (8.01 %) and thiocyclam hydrogen oxalate 4% GR, 800 g a.i./ha (10.96 %).

Table 5: Evaluation of granular insecticides against cob damage caused by fall armyworm, *S. frugiperda* in maize (Pooled over locations)

Tr. No.	Treatments	Dose (g a.i./ha)	Cob damage (%)			
			Anand	Sansoli	Godhra	Pooled
1	Fipronil 0.3% GR	60	30.98^{b} (26.50)	23.84^{abc} (16.34)	33.20^{b} (29.98)	29.34^{b} (24.01)
2	Fipronil 0.6% GR	120	18.43^{a} (9.99)	18.43^{a} (9.99)	12.47^{a} (4.66)	16.44^{a} (8.01)
3	Carbofuran 3% CG	600	30.98^{b} (26.50)	21.14^{ab} (13.01)	30.98^{b} (26.50)	27.70^{b} (21.61)
4	Chlorantraniliprole 0.4% GR	80	12.48^{a} (4.67)	18.43^{a} (9.99)	12.47^{a} (4.66)	14.46^{a} (6.24)
5	Imidacloprid 0.3% GR	60	33.20^{bc} (29.98)	28.77^{c} (23.16)	39.22^{b} (39.98)	33.72^{b} (30.82)
6	Thiocyclam hydrogen oxalate 4% GR	800	18.43^{a} (9.99)	21.14^{ab} (13.01)	18.43^{a} (9.99)	19.33^{a} (10.96)
7	Cartap hydrochloride 4% GR	800	30.98^{b} (26.50)	26.55^{bc} (19.98)	37.21^{b} (36.56)	31.68^{b} (27.58)
8	Phorate 10% CG	2000	30.98^{b} (26.50)	23.84^{abc} (16.34)	35.20^{b} (33.23)	30.01^{b} (25.02)
9	Control	---	41.14^{c} (43.28)	41.14^{d} (43.28)	52.75^{c} (63.36)	45.01^{c} (50.02)
S. Em.±	Treatment (T)		2.40	2.01	3.21	2.50
	Location (L)		-	-	-	0.86
	T x L		-	-	-	2.59
CD at 5%			Sig.	Sig.	Sig.	Sig.
C. V. %			15.12	14.06	18.42	16.31

Notes: 1. Figures in parenthesis are retransformed values; those outside are arc sine transformed values
2. Treatment mean(s) with the letter(s) in common are not significant by DNMRT at 5% level of significance

Yield (kg/ha)

The highest grain yield (Table 6) was recorded from the plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (3069 kg/ha) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (3008 kg/ha).

The highest fodder yield was recorded from the plots treated with chlorantraniliprole 0.4% GR, 80 g a.i./ha (4277 kg/ha) and it was at par with fipronil 0.6% GR, 120 g a.i./ha (4187 kg/ha) and thiocyclam hydrogen oxalate 4% GR, 800 g a.i./ha (4026 kg/ha).

No much information on efficacy of granular insecticides against fall armyworm is available hence, information on this aspect in other crops is reviewed and discussed. Present findings are supported by Sarao and Kaur (2014) [8] who reported that chlorantraniliprole 0.4 % G at 30, 40 and 50 g a.i./ha was found effective against stem borer and leaf folder in basmati rice. Chlorantraniliprole 18.5 SC was found most effective against yellow stem borer in basmati rice (Rana and Singh, 2017) [12]. The insecticide chlorantraniliprole has been observed to be very effective for reduce rice stem borer infestation (Shui-jin *et al.*, 2009) [13]. Fipronil 5 % SC and chlorantraniliprole 0.4 % GR were more effective in managing *S. incertulas* in paddy (Dash and Mukherjee, 2003) [14]. Chlorantraniliprole 0.4 % GR best for reducing the infestation of yellow stem borer in paddy (Chormule *et al.*, 2014). Fipronil 0.6% GR was found effective against rice leaf folder (Sulagitti *et al.*, 2017) [16] which corroborated present finding.

Wakil *et al.* (2001) [9] reported the efficacy of carbofuran, a granular insecticide against stem borer on basmati rice. Singh *et al.* (2009) [17] proclaimed the efficacy of another granular insecticide, phorate against the stem borers. Similarly, Dhawan *et al.* (2010) [10] also reported that dead heart incidence was significantly low in 500 g a.i. ha dose of thiocyclam hydrogen oxalate 4 G. The Registration committee suggested application of carbofuran 3 % CG and phorate 10 % CG for management of *S. frugiperda* in maize (Anonymous, 2018) [1]. But here in this experiment these granular insecticides were not found superior in managing *S. frugiperda* in maize which may be due to difference in soil, climate, season, *etc*.

Table 6: Effect of granular insecticides on grain and fodder yield of maize (Pooled over locations)

Tr. No.	Treatments	g a.i./ha	Grain yield (kg/ha)				Fodder yield (kg/ha)			
			Anand	Sansoli	Godhra	Pooled	Anand	Sansoli	Godhra	Pooled
1	Fipronil 0.3% GR	60	2441^{b}	2602^{bc}	2431^{c}	2491^{cd}	3052^{b}	3653^{bcd}	2974^{bc}	3226^{c}
2	Fipronil 0.6% GR	120	3136^{a}	3023^{a}	2865^{a}	3008^{a}	4362^{a}	4243^{ab}	3972^{a}	4187^{a}
3	Carbofuran 3% CG	600	2464^{b}	2788^{ab}	2494^{bc}	2582^{bc}	3179^{b}	3905^{abc}	3178^{b}	3421^{b}
4	Chlorantraniliprole 0.4% GR	80	3227^{a}	3047^{a}	2936^{a}	3069^{a}	4484^{a}	4271^{a}	4077^{a}	4277^{a}
5	Imidacloprid 0.3% GR	60	2046^{bc}	2210^{c}	1925^{e}	2060^{f}	2672^{b}	3104^{d}	2542^{d}	2772^{e}
6	Thiocyclam hydrogen oxalate 4% GR	800	3092^{a}	2812^{ab}	2727^{ab}	2877^{b}	4287^{a}	3946^{abc}	3847^{a}	4026^{a}
7	Cartap hydrochloride 4% GR	800	2182^{b}	2315^{c}	2060de	2185^{e}	2782^{b}	3234^{d}	2707^{cd}	2907^{d}
8	Phorate 10% CG	2000	2390^{b}	2516^{bc}	2240^{cd}	2382^{d}	2954^{b}	3526^{cd}	2897^{bcd}	3126^{cd}
9	Control	---	1532^{c}	1620^{d}	1336f	1496^{g}	1813^{c}	2248^{e}	1804^{e}	1955^{f}
S. Em.±	Treatment (T)		180.23	122.21	82.43	73.28	173.77	179.31	121.64	98.90
	Location (L)		-	-	-	44.81	-	-	-	53.45
	T x L		-	-	-	134.42	-	-	-	160.35
CD at 5% T			Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. %			12.48	8.30	6.11	9.45	9.16	8.70	6.77	8.36

Note: 1. Treatment mean(s) with the letter(s) in common are not significant by DNMRT at 5% level of significance

References

1. Anonymous. Minutes of 391st meeting of registration committee held on 10.08.2018 at Krishi Bhavan, New Delhi, 2018.
2. Anonymous. http://agricoop.nic.in/sites/default/files/Cwwg-Data-as-on-08.11.2019.pdf. 2019a.
3. Anonymous. https://dag.gujarat.gov.in/images/directorofagriculture/pdf/3rd-Estimate-2019-20.pdf. 2019b.
4. Alam MM. Attempts at the biological control of major insect pests of maize in Barbados, *WI* (No. 2019-2017-4349), 1978.
5. Burkhardt CC. Feeding and pupating habits of the fall armyworm in corn. J. Econ. Entomol. 1952; 45(6):1035-1037.
6. Andrews KL. Manejo integrado de plagas insectiles en la agricultura, Zamorano Academic Press, Tegucigalpa, Honduras, 1989, 547-566.
7. Cisneros J, Goulson D, Derwent LC, Penagos DI, Hernández O, Williams T. Toxic effects of spinosad on predatory insects. Biol. Control. 2002; 23(2):156-163.
8. Sarao PS, Kaur H. Efficacy of Ferterra 0.4% GR (chlorantraniliprole) against stem borers and leaffolder insect-pests of basmati rice. J Environ. Biol. 2014; 35(5):815.
9. Wakil WM, Hasan R, Gulzar, A. Evaluation of different insecticides against rice stem borer and rice leaf folder. Pak. J Agri. Sc. 2001; 38:3-4.
10. Dhawan AK, Mahal MS, Sarao PS, Virk JS, Suri KS, Singh P, Singh R. Relative efficacy of new granular formulation against stem borers and leaf folder on basmati rice. J Insect Sci. 2010; 23:414-419.
11. Devananda KM, Khanpara AV, Vaja AM. Bio-efficacy of various insecticides against maize stem borer *Chilo partellus* (Swinhoe) Crambidae: Lepidoptera in Junagadh conditions. J Pharmacogn. Phytochem. 2018; 7(4):2011-2014.
12. Rana R, Singh, G. Efficacy and economics of newer insecticides against yellow stem borer, *Scirpophaga incertulas* Walker in basmati rice. J Plant Dev. Sci. 2017; 9(1):35-39.
13. Shui-jin H, Wen-jing Q, Hui L. Using chlorantraniliprole 18.5 SC to control rice stem borer, *Chilo suppressalis* (Walker). Acta Agriculturae Jiangxi, 2009, 21.
14. Dash AN, Mukherjee SK. Insecticidal control of major insect pest of rice. Pest Management and Economic Zoology. 2003; 11(2):147-151.

15. Chormule AJ, Kharbade SB, Patil SC, Tamboli ND. Evaluation of granular insecticides against rice yellow stem borer, *Scirpophaga incertulas* (Walker). Trends in Biosci. 2014; 7(12):1306-1309.
16. Sulagitti A, Raghuraman M, Reddy M. Management of Rice Leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Pyralidae: Lepidoptera) with Phenyl Pyrazole and Neonicotinoids. Trends in Biosci. 2017; 10(23):4900-4904
17. Singh B, Sarao P, Mahal MS. Comparative bioefficacy of certain granular insecticides against major lepidopterous pests of basmati rice in Punjab. J insect Sci. 2009; 22(4):431-34.