www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(9): 1144-1148

www.thepharmajournal.com
Received: 25-07-2022
Accepted: 27-08-2022

UR Dobariya
Department of Entomology, B. A. College of Agriculture, AAU, Anand, Gujarat, India

DB Sisodiya
Department of Entomology, B. A. College of Agriculture, AAU, Anand, Gujarat, India

Corresponding Author:
UR Dobariya
Department of Entomology, B. A. College of Agriculture, AAU, Anand, Gujarat, India

Evaluation of insecticides as seed treatment against fall armyworm, *Spodoptera frugiperda* (J. E. Smith) infesting fodder maize, *Zea mays* L.

UR Dobariya and DB Sisodiya

Abstract
An experiment was conducted to evaluate different insecticides as seed treatment against fall armyworm, *Spodoptera frugiperda* infesting fodder maize. Among the tested insecticides, cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed was significantly superior to rest of the treatments in reducing the FAW (1.32 larvae/20 plant). Seed treatment with cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed was recorded significantly lower plant damage (29.97%). Maximum plant damage (%) was registered in plot having seed treatment with fipronil 5 SC @ 6ml/kg of seed (61.72%), fipronil 5 SC @ 8ml/kg of seed (61.64%), thiamethoxam 30 FS @ 6 ml/kg of seed (59.99%) and imidacloprid 600 FS @ 6 ml/kg of seed (58.30%). The highest green fodder yield (633 q/ha) was obtained from the plot having seed treatment of cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed.

Keywords: Fodder maize, seed treatment, *Spodoptera frugiperda*, cyantraniliprole 19.8 + thiamethoxam 19.8 FS and green fodder yield

Introduction
As the world's population continues to grow, the scientific community must explore all options to help growers meet the world's ever-increasing demand for food and other resources. One of the primary goal is to increase milk production, as milk is an excellent source of nutrition. India is ranked first in milk production contributing 23% of global milk production. Milk production in the country has grown at a compound annual growth rate of about 6.2% to reach 209.96 million metric tonnes in 2020-21 from 146.31 million tonnes in 2014-15 (Anonymous, 2022) [3]. Milk production is heavily reliant on the availability of high-quality fodder. As land available for fodder production has decreased, there is a tremendous pressure from livestock on availability total feed and fodder. Maize (*Zea mays* L.) popularly known as corn is one of the key cereals as well as fodder crop grown in India. As a fodder crop, maize has second rank next to sorghum in India in area and production. Fodder maize is grown in over 0.9 million ha area in different parts of the country *viz*., Haryana, Punjab, Gujarat and some parts of Rajasthan because of the higher livestock productivity. In Gujarat, total land area is 188.10 lakh ha, out of which 99.66 lakh ha (52.98%) is net sown area, while 25.52 lakh ha area is barren and uncultivable. Around 8.64 lakh ha area is under fodder crops cultivation in Gujarat (Anonymous, 2019) [1]. Maize is attacked by nearly 130 species of insect pests in India causing considerable yield losses (Atwal and Dhaliwal, 2002) [4]. Adding to the list of new invasive pest, fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) belongs to order Lepidoptera and family Noctuidae is native to the tropical region of the western hemisphere from the United States to Argentina. In India, it was first reported in Hassan district of Karnataka on maize (Sharanabasappa *et al*., 2018) [7] which later spread to Tamil Nadu (Srikanth *et al*., 2018) [9], Andhra Pradesh (Venkateswarlu *et al*., 2018) [11] and Chhattisgarh (Deole and Paul, 2018) [5]. In Gujarat, it was also reported from Anklav village, of Anand district of Gujarat (Sisodiya *et al*., 2018) [8]. It is a cosmopolitan pest of the maize crop (Wiseman *et al*., 1966) [12] feeding on all growth stages of maize but most frequently in the whorl of young plants up to 45 days. The maize grown for fodder purpose is generally harvested at 60 days after sowing. Therefore, it is not possible to spray the crop in young plants to avoid the problem of pesticide residues. Thus, owing to the importance of this pest and period of occurrence in fodder maize a study was conducted on basis to evaluate insecticides as seed treatment against this invasive pest infesting fodder maize.

Materials and Method

In order to evaluate insecticides as seed treatment against *S. frugiperda* infesting maize, a field experiment was conducted at Entomology farm, Department of Entomology, BACA, AAU, Anand (Gujarat) during *kharif*, 2021. The experiment was laid down in Randomized Block Design with eleven treatments and three replications. Fodder maize variety African tall was sown, with a spacing of 30 cm between two rows and 10 cm within the row in gross and net area of 3.6 x 6.0 m and 3.0 x 5.8 m, respectively. Fodder maize was sown by adopting all recommended agronomical practices except pest control practices to see the impact of seed treatment. As per the treatments, the treated seeds were kept separate for each treatment and dried under shade for 12 hours and next day morning used for the sowing. The initial plant population per 1 m row length was recorded randomly from three spots at 10 days after sowing. For recording observations on number of larva(e) and damaged and healthy plant(s), 20 plants were selected randomly from net plot and were recorded at 7, 14, 21, 28, 35 and 42 days after sowing. The yield of green fodder (q/ha) was recorded from net plot area of each treated as well as untreated plot. From the data on green fodder yield, per cent increase in yield over control and avoidable loss were calculated for each treatment using following formula (Paul, 1976) [6].

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} x\ 100$$

$$\text{Avoidable loss (\%)} = \frac{\text{Highest yield in treated plot} - \text{Yield in treated plot}}{\text{Highest yield in treated plot}}$$

Results and discussion

Initial plant population/1m row

The data on the initial plant population/1 m row length is given in Table 1. The differences among treatments for the initial plant population were non-significant, indicating that there was no any detrimental effect of the treatments on germination of the crop.

Table 1: Effect of insecticides applied as seed treatment on initial plant population

Tr. No.	Treatments	Dose(ml)/kg of seed	Initial plant population/ 1m row length
T_1	Thiamethoxam 30 FS	6.0	9.22
T_2	Thiamethoxam 30 FS	8.0	9.66
T_3	Thiamethoxam 30 FS	10.0	9.55
T_4	Imidacloprid 600 FS	6.0	9.77
T_5	Imidacloprid 600 FS	8.0	9.00
T_6	Imidacloprid 600 FS	10.0	9.66
T_7	Fipronil 5 SC	6.0	9.22
T_8	Fipronil 5 SC	8.0	9.44
T_9	Fipronil 5 SC	10.0	9.33
T_{10}	Cyantraniliprole 19.8 + thiamethoxam 19.8 FS	6.0	9.77
T_{11}	Untreated control	-	9.66
SEm ±	Treatments (T)	-	1.35
CD at 5%		-	NS
CV (%)		-	17.52

Larval population (No. of larva (e)/ 20 plants)

The data on larval population recorded after fourteen days after sowing presented in Table 2. There was no incidence of fall armyworm in the plot having seed treatment with cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed. The next best treatment was seed treated with imidacloprid 600 FS @ 10 ml/kg of seed (6.05 larvae/20 plant) and it was at par with thiamethoxam 30 FS @ 10 ml/kg of seed (6.21 larvae/20 plant), imidacloprid 600 FS @ 8 ml/kg of seed (6.31 larvae/20 plant), thiamethoxam 30 FS @ 8 ml/kg of seed (6.31 larvae/20 plant) and fipronil 5 SC @ 10ml/kg of seed (6.52 larvae/20 plant). Maximum larval population observed in seed treated with fipronil 5 SC @ 6ml/kg of seed (10 larvae/20 plant), fipronil 5 SC @ 8ml/kg of seed (9.80 larvae/20 plant), thiamethoxam 30 FS @ 6 ml/kg of seed (9.55 larvae/20 plant) and imidacloprid 600 FS @ 6 ml/kg of seed (9.36 larvae/20 plant). More or less similar trend of treatments was observed during 21, 28, 35 and 42 days after sowing in recording the larval population of *S. frugiperda* in fodder maize and superiority of cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed was continued.

Plant Damage (%)

The data on the per cent damaged plant recorded after fourteen days of the sowing are presented in Table 4. There was no any damaged plant observed in the plot having seed treatment with cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed and it was significantly superior over other treatments. The next treatment in terms of plant damage was seed treated with imidacloprid 600 FS @ 10 ml/kg of seed (4.99%) and it was at par with thiamethoxam 30 FS @ 10 ml/kg of seed (6.48%), imidacloprid 600 FS @ 8 ml/kg of seed (8.15%), thiamethoxam 30 FS @ 8 ml/kg of seed (9.59%) and fipronil 5 SC @ 10ml/kg of seed (9.59%). Among evaluated insecticides, significantly higher plant damage (%) observed in seed treated with fipronil 5 SC @ 6ml/kg of seed (23.27%), fipronil 5 SC @ 8ml/kg of seed (19.98%), thiamethoxam 30 FS @ 6 ml/kg of seed (19.83%) and imidacloprid 600 FS @ 6 ml/kg of seed (18.25%). Similar trend of treatments was observed during 21, 28, 35 and 42 days after sowing in recording the per cent damaged plant of *S. frugiperda* in fodder maize.

There was no any inimical effect of thiamethoxam 30 FS (6, 8, 10 ml/kg of seed), imidacloprid 600 FS (6, 8, 10 ml/kg of seed), cyantraniliprole 19.8 + thiamethoxam 19.8 FS (6 ml/kg of seed) on germination of the crop (Anonymous, 2021c) [2]. These reviews are completely supportive to the present investigation. Lowest larval population was also observed in seed treatment with cyantraniliprole 19.8 + thiamethoxam FS

19.8 at 6 ml/kg seed and incidence of FAW was not observed up to 14 days after germination as well as lowest plant damage at 7 (0.00%), 14 (0.56%), 21 (16.61%) and 28 (24.70%) days after germination (Anonymous, 2021c) [2]. Cyantraniliprole 19.8 + thiamethoxam FS 19.8 provided best protection from the FAW by receding lowest damage rating. The diamide insecticides as stand-alone compounds or as combination products provided better control than thiamethoxam and fipronil (Suganthi *et al*., 2022) [10]. These past investigations are completely supportive to the present research work.

Table 2: Evaluation of insecticides as seed treatment against fall armyworm, *S. frugiperda* infesting fodder maize

Tr. No.	Treatments	Dose(ml)/kg of seed	No. of larva(e)/ 20 plant at indicated days after sowing (DAS)				
			14	21	28	35	42
T_1	Thiamethoxam 30 FS	6.0	3.17^{d} (9.55)	3.58^{c} (12.32)	4.05^{cd} (15.90)	4.28^{cd} (17.82)	4.42^{cdef} (19.04)
T_2	Thiamethoxam 30 FS	8.0	2.61^{b} (6.31)	2.97^{b} (8.32)	3.46^{b} (11.47)	3.64^{bc} (12.75)	3.74^{bcde} (13.49)
T_3	Thiamethoxam 30 FS	10.0	2.59^{b} (6.21)	2.93^{b} (8.08)	3.38^{b} (10.92)	3.57^{b} (12.24)	3.72^{bcde} (13.34)
T_4	Imidacloprid 600 FS	6.0	3.14^{cd} (9.36)	3.55^{c} (12.10)	4.03^{cd} (15.74)	4.28^{cd} (17.82)	4.40^{bcdef} (18.86)
T_5	Imidacloprid 600 FS	8.0	2.61^{b} (6.31)	2.93^{b} (8.08)	3.42^{b} (11.2)	3.62^{bc} (12.60)	3.74^{bcde} (13.49)
T_6	Imidacloprid 600 FS	10.0	2.56^{b} (6.05)	2.89^{b} (7.85)	3.34^{b} (10.66)	3.55^{b} (12.10)	3.71^{b} (13.26)
T_7	Fipronil 5 SC	6.0	3.24^{d} (10.00)	3.61^{c} (12.53)	4.09^{d} (16.23)	4.33^{de} (18.25)	4.42^{cdef} (19.04)
T_8	Fipronil 5 SC	8.0	3.21^{d} (9.80)	3.59^{c} (12.39)	4.06^{d} (15.98)	4.32^{de} (18.16)	4.43^{ef} (19.12)
T_9	Fipronil 5 SC	10.0	2.65^{bc} (6.52)	3.01^{b} (8.56)	3.48^{bc} (11.61)	3.63^{bc} (12.68)	3.76^{bcde} (13.64)
T_{10}	Cyantraniliprole 19.8 + thiamethoxam 19.8	6.0	0.70^{a} (0.00)	0.70^{a} (0.01)	1.50^{a} (1.75)	1.97^{a} (3.38)	2.52^{a} (5.85)
T_{11}	Untreated control	-	3.85^{e} (14.32)	4.19^{d} (17.06)	4.73^{e} (21.87)	4.98e (24.3)	5.06^{f} (25.10)
SEm ±	Treatments (T)	-	0.15	0.15	0.17	0.20	0.22
	Period (P)	-	-	-	-	-	-
	T x P	-	-	-	-	-	-
F Test (T)		-	Sig.	Sig.	Sig.	Sig.	Sig.
CV (%)		-	9.40	8.46	8.07	9.16	9.54

Note: (1) Figures outside the parentheses are $\sqrt{X + 0.5}$ transformed values and those inside the parentheses are retransformed values
(2) Treatment means followed by the same letter within a column are not significantly different by DNMRT at 5% level of significance
(3) Significant parameters and interaction: P, T x P
(4) The incidence of fall armyworm was not observed at 7 days of sowing

Table 3: Evaluation of insecticides as seed treatment against fall armyworm, *S. frugiperda* infesting fodder maize

Tr. No.	Treatments	Dose(ml)/kg of seed	Plant damage (%)/ 20 plant at indicated days after sowing (DAS)				
			14	21	28	35	42
T_1	Thiamethoxam 30 FS	6.0	26.44^{c} (19.83)	28.43^{c} (22.67)	36.25^{c} (34.96)	41.14^{de} (43.28)	50.76^{d} (59.99)
T_2	Thiamethoxam 30 FS	8.0	18.04^{b} (9.59)	18.42^{b} (9.98)	27.58^{b} (21.44)	34.13^{bc} (31.48)	42.09^{bc} (44.93)
T_3	Thiamethoxam 30 FS	10.0	14.75^{b} (6.48)	16.20^{b} (7.78)	25.29^{b} (18.25)	33.14^{b} (29.89)	40.18^{ab} (41.63)
T_4	Imidacloprid 600 FS	6.0	25.29^{c} (18.25)	27.69^{c} (21.59)	35.23^{c} (33.28)	40.18^{cde} (41.63)	49.78^{cd} (58.30)
T_5	Imidacloprid 600 FS	8.0	16.59^{b} (8.15)	16.20^{b} (7.78)	26.55^{b} (19.98)	34.21^{bc} (31.61)	41.14^{ab} (43.28)
T_6	Imidacloprid 600 FS	10.0	12.91^{b} (4.99)	14.75^{b} (6.48)	24.03^{b} (16.58)	31.05^{b} (26.60)	39.19^{ab} (39.93)
T_7	Fipronil 5 SC	6.0	28.84^{c} (23.27)	31.05^{c} (26.60)	38.22^{cd} (38.28)	43.07^{ef} (46.63)	51.78^{d} (61.72)
T_8	Fipronil 5 SC	8.0	26.55^{c} (19.98)	29.98^{c} (24.97)	37.24^{c} (36.62)	42.11^{e} (44.96)	51.73^{d} (61.64)
T_9	Fipronil 5 SC	10.0	18.04^{b} (9.59)	19.87^{b} (11.55)	27.69^{b} (21.59)	35.20^{bcd} (33.23)	42.09^{bc} (44.93)
T_{10}	Cyantraniliprole 19.8 + Thiamethoxam 19.8 FS	6.0	0.00 (0.00)	0.00s (0.00)	18.42^{a} (9.98)	24.03^{a} (16.58)	33.19^{a} (29.97)
T_{11}	Untreated control	-	37.21^{d} (36.57)	40.12^{d} (41.52)	44.04^{d} (48.32)	48.91^{f} (56.8)	54.09^{d} (65.6)
SEm ±	Treatments (T)	-	1.93	2.01	1.73	1.88	2.50
	Period (P)	-	-	-	-	-	-
	T x P	-	-	-	-	-	-
F Test (T)		-	Sig.	Sig.	Sig.	Sig.	Sig.
CV (%)		-	16.25	15.59	9.68	8.77	9.60

Note: (1) Figures in parentheses are retransformed values and those outside are arcsine transformed values
(2) Treatment means followed by the same letter within a column are not significantly different by DNMRT at 5% level of significance
(3) Significant parameters and interaction: P, T x P
(4) The incidence of fall armyworm was not observed at 7 days of sowing

Yield of green fodder maize

The data on fodder yield (q/ha) of maize were presented in Table 4. The highest fodder yield of maize was recorded from the cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed (633 q/ha) followed by imidacloprid 600 FS @ 10 ml/kg of seed (553 q/ha), thiamethoxam 30 FS @ 10 ml/kg of seed (549 q/ha) and they all were remained at par with each other. The imidacloprid 600 FS @ 8 ml/kg of seed (543 q/ha) was at par with thiamethoxam 30 FS @ 8 ml/kg of seed (539 q/ha), thiamethoxam 30 FS @ 6 ml/kg of seed (520 q/ha), fipronil 5 SC @ 8ml/kg of seed (514 q/ha) and fipronil 5 SC @ 6ml/kg of seed (511 imidacloprid 600 FS @ 6 ml/kg of seed (14.73%) and thiamethoxam 30 FS @ 6 ml/kg of seed (14.29%) provided with average increase in the yield. Whereas, among the tested insecticides, minimum (12.31%) increase in yield was found from plot treated with fipronil 5 SC @ 6 ml/kg of seed followed by fipronil 5 SC @ 8 ml/kg of seed (12.97%).

Increase in yield over control

Increase in yield over control in fodder maize was worked out for different seed treatments and indicated that maximum (39.12%) increase in yield over control was found from seed treated with cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed, followed by imidacloprid 600 FS @ 10 ml/kg of seed (21.54%), thiamethoxam 30 FS @ 10 ml/kg of seed (20.66%) and fipronil 5 SC @ 10 ml/kg of seed (20.22%). Plots treated with imidacloprid 600 FS @ 8 ml/kg of seed (19.34%), thiamethoxam 30 FS @ 8 ml/kg of seed (18.46%), imidacloprid 600 FS @ 6 ml/kg of seed (14.73%) and thiamethoxam 30 FS @ 6 ml/kg of seed (14.29%) provided with average increase in the yield. Whereas, among the tested insecticides, minimum (12.31%) increase in yield was found from plot treated with fipronil 5 SC @ 6 ml/kg of seed followed by fipronil 5 SC @ 8 ml/kg of seed (12.97%).

Avoidable losses

Avoidable losses in yield of green fodder maize concerned, it varied from 14.84 to 22.63 per cent in different treatments (Table 4.16). The avoidable loss was the lowest (14.84%) in the treatment of imidacloprid 600 FS @ 10 ml/kg of seed followed by thiamethoxam 30 FS @ 10 ml/kg of seed (15.58%), fipronil 5 SC @ 10 ml/kg of seed (15.96%), imidacloprid 600 FS @ 8 ml/kg of seed (16.70%) and thiamethoxam 30 FS @ 8 ml/kg of seed (17.44%). The avoidable losses of imidacloprid 600 FS @ 6 ml/kg of seed (20.59%), thiamethoxam 30 FS @ 6 ml/kg of seed (20.96%), fipronil 5 SC @ 8 ml/kg of seed (22.08%) was intermediate. The highest (22.63%) avoidable loss was calculated in the treatment of fipronil 5 SC @ 6 ml/kg of seed.

Table 4: Impact of insecticides applied as seed treatment on yield of green fodder maize

Tr. No.	Treatments	Dose(ml)/kg of seed	Green fodder yield (q/ ha)	Increase in yield over control (%)	Avoidable loss (%)
T_1	Thiamethoxam 30 FS	6.0	520^{bc}	14.29	20.96
T_2	Thiamethoxam 30 FS	8.0	539^{b}	18.46	17.44
T_3	Thiamethoxam 30 FS	10.0	549^{ab}	20.66	15.58
T_4	Imidacloprid 600 FS	6.0	522^{bc}	14.73	20.59
T_5	Imidacloprid 600 FS	8.0	543^{b}	19.34	16.70
T_6	Imidacloprid 600 FS	10.0	553^{ab}	21.54	14.84
T_7	Fipronil 5 SC	6.0	511^{bc}	12.31	22.63
T_8	Fipronil 5 SC	8.0	514^{bc}	12.97	22.08
T_9	Fipronil 5 SC	10.0	547^{b}	20.22	15.96
T_{10}	Cyantraniliprole 19.8 + Thiamethoxam 19.8 FS	6.0	633^{a}	39.12	-
T_{11}	Untreated control	-	455^{c}	-	33.02
SEm ±	Treatments (T)		24.83	-	-
F Test (T)			Sig.	-	-
CV (%)			8.00	-	-

Note: Treatment means followed by the same letter within a column are not significantly different by DNMRT at 5% level of significance

Conclusion

It can be deduced from the present investigation, that seed treatment with cyantraniliprole 19.8 + thiamethoxam 19.8 FS @ 6 ml/kg of seed were found more effective in managing the population and damage of FAW in fodder maize up to 21 days which also reflected on green fodder yield as well.

References

1. Anonymous. ICAR- AICRP on forage crops and utilization, Jhansi, India, pp. 1-21, retrieved on 3rd June, 2021, retrieved from, 2019. https://www.researchgate.net/publication/336230799_Revisiting_National_Forage_Demand_and_Availability_Scenario/link/5d98859d92851c2f70ec27b9/download
2. Anonymous. Annual Research Report. Main Maize Research Station, Godhra, AAU, Anand, 2021c, 12-17.
3. Anonymous. Economic survey 2021-22. retrieved on 18th June, 2022, retrieved from, 2022. https://www.indiabudget.gov.in/economicsurvey/ebook_es2022/files/basic
4. Atwal AS, Dhaliwal GS. Agricultural Pests of South Asia and Their Management. Kalyani Publishers, Ludhiana, 2002, 189-192.
5. Deole S, Paul N. First report of fall army worm, *Spodoptera frugiperda* (J. E. Smith), their nature of damage and biology on maize crop at Raipur, Chhattisgarh. Journal of Entomology and Zoology Studies. 2018;6(6):219-221.
6. Paul MD. Studies on the chemical control of mustard pests. Indian Journal of Plant Protection. 1976;4(1):9-14.
7. Sharanabasappa CM, Kalleshwaraswamy CM, Asokan R, Mahadeva Swamy HM, Marutid MS, Pavithra HB *et al*. First report of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), an alien invasive pest on maize in India. Pest Management in Horticultural. Ecosystems. 2018;24:23-29.
8. Sisodiya DB, Raghunandan BL, Bhatt NA, Verma HS, Shewale CP, Timbadiya BG *et al*. The fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera:

Noctuidae) first report of new invasive pest in maize fields of Gujarat, India. Journal of Entomology and Zoology Studies. 2018;6(5):2089-2091.
9. Srikanth J, Geetha N, Singaravelu B, Ramasubramanian T, Mahesh P, Saravanan L *et al*. First report of occurrence of fall armyworm *Spodoptera frugiperda* in sugarcane from Tamil Nadu, India. Journal of Sugarcane Research. 2018;8(2):195-202.
10. Suganthi A, Krishnamoorthy SV, Sathiah N, Rabindra RJ, Muthukrishnan N, Jeyarani S *et al*. Bioefficacy, persistent toxicity, and persistence of translocated residues of seed treatment insecticides in maize against fall armyworm, *Spodoptera frugiperda* (J. E. Smith). Crop Protection. 2022;154:105892.
11. Venkateswarlu U, Johnson M, Narasimhulu R, Muralikrishna T. Occurrence of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera, Noctuidae), a new pest on bajra & sorghum in the fields of agricultural research station, Ananthapuramu, Andhra Pradesh, India. Journal of Entomology and Zoology Studies. 2018;6(6):811-813.
12. Wiseman BR, Painter RH, Wassom CE. Detecting corn seedling differences in the greenhouse by visual classification of damage by the fall armyworm. Journal of Economic Entomology. 1966;59(5):1211-1214.