



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; SP-8(5): 106-110

© 2020 IJCS

Received: 23-07-2020

Accepted: 28-08-2020

Dileep Kumar NT

Post Graduate Student,
Department of Entomology,
College of Agriculture,
University of Agricultural
Sciences, GKVK, Bangalore,
Karnataka, India

Murali Mohan K

Associate Professor, Department
of Entomology, College of
Agriculture, University of
Agricultural Sciences, GKVK,
Bangalore, Karnataka, India

Prabhu C Ganiger

Senior Scientist
AICRP on small millets
University of Agricultural
Sciences, GKVK, Bangalore,
Karnataka, India

Mahesh HM

Ph.D., Scholar, Department of
Entomology, College of
Agriculture, University of
Agricultural Sciences,
GKVK, Bangalore, Karnataka,
India

Corresponding Author:**Murali Mohan K**

Associate Professor, Department
of Entomology, College of
Agriculture, University of
Agricultural Sciences, GKVK,
Bangalore, Karnataka, India

Safe and cost effective management of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) using green insecticide baits

Dileep Kumar NT, Murali Mohan K, Prabhu C Ganiger and Mahesh HM

DOI: <https://doi.org/10.22271/chemi.2020.v8.i5b.10454>

Abstract

The fall armyworm, *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae), is a new invasive species in India. This pest is occurring in serious proportions, causing significant damage to the maize crop in several states across the country. Insecticides are applied several times for managing the fall armyworm on maize, which significantly increases the cost of plant protection. In this study green chemistry molecules were directly applied to the leaf whorls in the form of poison baits, in the place of foliar sprays. Main objective of this study was to reduce the cost of plant protection by changing the method of chemical delivery and to make the produce safe for consumption by using green chemistry (slightly toxic) insecticides. Poison baits prepared using spinetoram 5 ml/kg, 2.5 ml/kg and novaluron 5 ml/kg recorded maximum larval mortality and minimized the leaf damage by fall armyworm. These insecticides contributed for 97.20, 93.15 and 92.46 per cent reduction in larval population over untreated control, respectively at 14 days after second application. Comparative efficacy of insecticide when applied as baits *vis-a-vis* foliar sprays suggested that the difference was non-significant in spinetoram, novaluron and chlorantraniliprole. There was substantial reduction in the cost of plant protection ranging from 22 to 44 per cent in bait application over foliar spray involving same insecticide. Overall, this study opens up new opportunity for reducing the cost of plant protection while managing fall armyworm on maize.

Keywords: Fall armyworm, *Spodoptera frugiperda*, Green chemistry insecticides, Poison baits

Introduction

The fall armyworm, *Spodoptera frugiperda* (Smith) (Noctuidae: Lepidoptera) is one of the very serious insect pests on variety of crops around the world. It is a polyphagous pest that causes significant losses to many agricultural crops and is reported to infest more than 353 plant species belonging to 76 families (Montezano *et al.*, 2018) ^[1] viz., maize, rice, sorghum, sugarcane, cabbage, beet, peanut, soybean, alfalfa, onion, tomato, potato and cotton (Pogue 2002; CABI 2016) ^[2, 3]. Among these crops, this species is known to cause heavy yield losses in cereal crops such as maize and sorghum. In corn, yield losses due to fall armyworm damage can reach up to 32% in the United States (Wiseman and Isenhour, 1993) ^[4] and 45-60% in Nicaragua (Hruska and Glandstone, 1988) ^[5]. In Brazil, *S. frugiperda* causes up to 34% reduction in maize grain yield that amounts to an annual loss of US\$ 400 million (Lima *et al.* 2010) ^[6].

The fall armyworm is native to the Americas and it is a key pest of maize (*Zea mays* L.) throughout the Americas (Sparks, 1979) ^[7]. This pest was noticed in Nigeria in West Africa during early 2016 and in East Africa in 2017 (Abrahams *et al.*, 2017) ^[8]. Subsequently, this dreaded pest was reported from India on maize crop (Ganiger *et al.*, 2018 Sharanabasappa *et al.* 2018) ^[9, 10]. In recent times fall armyworm immigration was reported from china (Xu *et al.* 2019) ^[11].

The developing larvae eat different parts of the host plant, depending on the stage of crop and the age of the larvae. Larvae always confine to the leaf whorl portion and feed hiding in whorls. Young larvae usually feed on leaves, creating a characteristic "windowing" effect and moist sawdust-like frass near the funnel. Early in the season, this feeding can kill the growing point, which prevents cob formation.

In older plants the larger larvae can bore into the developing maize cobs, reducing yield quantity and quality. This pest has a migratory behaviour with a high dispersal capacity that allows the pest to quickly spread along the range of its host plants.

Among the several options, management of fall armyworm largely revolve around application insecticides, particularly in the countries where fall armyworm has been reported during recent times. As this pest species occurs on young plants and persists through the entire crop period completing several generations, it warrants application of chemicals multiple times. Hence, it results in substantial increase in cost incurred on insecticides. Further, large scale use of extremely & highly hazardous insecticides on fall armyworm pose serious risk on animals (when used as fodder) and human beings. In this investigation, we attempted to reduce the quantity of insecticides used per unit area by modifying method delivery of chemicals using green chemistry insecticides. Instead of spraying we tried to deliver the chemicals in the form of poison bait directly into the whorl portion where fall armyworm larvae live and feed. Here, we primarily focussed on reducing the cost of plant protection and keeping crop safe for consumption.

Materials and Methods

In this study three different experiments were conducted a) Preliminary laboratory assessment of efficacy of green chemistry insecticides on fall armyworm when used as poison baits b) assessment of efficacy of poison baits on fall armyworm in the field c) comparison of efficacy of chemicals used as poison baits *vis-a-vis* sprays

Initially, efficacy of green chemistry molecules on fall armyworm was assessed through bioassays and bait feeding studies in the laboratory. Here, insecticides were mixed with the bait material and laboratory reared larvae were allowed to feed on the bait. Later, chemicals that were found effective in the laboratory were chosen for field studies. The quantity of bait required per plant was also estimated through preliminary field experiments.

The field experiments with regard to assessing the efficacy of green chemistry molecules as poison baits and foliar sprays

was conducted during *Rabi* 2018 on maize crop (sweet corn). Four green chemistry insecticides *viz.*, spinetoram 11.7 SC, chlorantraniliprole 18.5 SC, novaluron 10 EC, azadirachtin 1% that were found promising in the laboratory assessment were assessed along with emamectin benzoate 5 SG (most commonly used insecticide on fall armyworm in India) and thiodicarb 75 WP as standard check. Spinetoram, chlorantraniliprole and novaluron were assessed at two different doses with highest concentration @ 10 X of the dose used for sprays and lowest concentration was half of this. As azadirachtin and emamectin benzoate were not found effective at lower concentrations in the laboratory experiments, these chemicals were assessed only at highest concentration (Table 1). The experiment was conducted in randomized block design (RBD) and every treatment was replicated thrice.

The bait was prepared by mixing rice bran in 10% jaggery and the mixture was allowed to ferment overnight. Next day, prior to the application, the insecticides were mixed with bait material and applied in the whorls of fall armyworm infested maize plants @ 1 gram per plant. In the control plots, bait material without insecticide was applied to the plant whorls. The treatments were imposed twice: first application was on 20 days old maize crop followed by second application after 15 days of first application. Simultaneously, these insecticides were also assessed as foliar sprays at recommended doses. The observation on number of larvae per plant was recorded prior to the application of the bait. After the application of baits, larval mortality was recorded at seven days and fourteen days after each application. In addition to larval mortality, the leaf damage was also recorded based on visual scoring as described by Davis and Williams (1992)^[12]. The observations were recorded on ten randomly selected plants in each replication. Grain yield per plot was recorded at harvest. Reduction in pest population and leaf area damage over untreated control was calculated by using formula suggested by Henderson and Tilton (1955). The data on larval population was subjected to square root transformation and data on per cent leaf damage was subjected to arcsine transformation. Later, transformed values were analysed using ANOVA.

Table 1: Treatment details

Treatment number	Treatment detail
T1	Poison bait with spinetoram 11.7 SC @ 5 ml per kg of bait
T2	Poison bait with spinetoram 11.7 SC @ 2.5 ml per kg of bait
T3	Poison bait with chlorantraniliprole 18.5 SC @ 3 ml per kg of bait
T4	Poison bait with chlorantraniliprole 18.5 SC @ 1.5 ml per kg of bait
T5	Poison bait with novaluron 10 EC @ 5 ml per kg of bait
T6	Poison bait with novaluron 10 EC @ 2.5 ml per kg of bait
T7	Poison bait with azadirachtin 10000 ppm @ 10 ml per kg of bait
T8	Poison bait with thiodicarb 75 WP @ 10 g per kg of bait
T9	Poison bait with emamectin benzoate 5 SG @ 4 grams per kg of bait
T10	Untreated control

Result and Discussion

Pre-treatment pest population ranged from 1.30 to 1.50 larvae per plant across the plots and were statistically non-significant, indicating uniformity of pest population in the experimental plot.

After the application of baits, there was substantial reduction in larval populations in all the treatments compared to untreated control. Lowest larval population was recorded in spinetoram, chlorantraniliprole and novaluron treated plots

followed by emamectin benzoate, thiodicarb and azadirachtin treated plants.

Fourteen days after first application the mean larval population per plant in treated plants ranged from 0.22 to 0.50 as compared to 1.73 in untreated control. The spinetoram 11.7 SC @ 5 ml/kg, 2.5 ml/kg, novaluron 10 EC @ 5 ml/kg and standard check thiodicarb 75 WP 10 g/kg recorded 86.35, 83.73, 80.68 and 82.06 per cent reduction in larval population over untreated control, respectively after first time application

of poison bait. This clearly indicates that poison baits are effective in reducing the larval populations of the fall armyworm.

It was noticed that the mean larval population reduced further significantly after the second application of poison bait. In the treated plots mean larval population per plant ranged from 0.03 to 0.30 as compared to 1.05 in untreated control. Insecticides viz., spinetoram 11.7 SC @ 5 ml/kg, 2.5 ml/kg and novaluron 10 EC @ 5 ml/kg provided 97.20%, 93.15% and 92.46% reduction in larval population over the untreated control, respectively. This was followed by chlorantraniliprole 18.5 SC @ 3 ml/kg, 1.5 ml/kg, novaluron 10 EC @ 2.5 ml/kg, azadirachtin 1% 10 ml/kg and emamectin benzoate 5 SG 4 g/ha which recorded 70.63 to 87.37 per cent reduction in larval population over untreated control.

In addition to larval mortality, leaf damage (%) caused by fall armyworm larvae was also recorded. Leaf damage varied from 55.67 to 60.33 per cent across the plots before the imposition of treatments and was uniform across the plots. Damage on leaves caused by the fall armyworm was significantly reduced fourteen days after first application in treated plants and it ranged from 2.83 to 25.33% as compared to 52.50% in control. The spinetoram 11.7 SC @ 5 ml/kg, 2.5 ml/kg, chlorantraniliprole 18.5 SC @ 3 ml/kg and novaluron 10 EC @ 5 ml/kg recorded 74.71, 71.58, 70.15 and 73.01% reduction in leaf damage over untreated control, respectively. The leaf damage by fall armyworm larvae reduced further (5.50 to 20.83%) after the second application of poison bait. The spinetoram 11.7 SC @ 5 ml/kg, 2.5 ml/kg, chlorantraniliprole 18.5 SC @ 3 ml/kg and novaluron 10 EC @ 5 ml/kg, 2.5 ml/kg recorded 89.09, 83.36, 81.79, 85.62 and 80.94 per cent reduction in leaf damage over untreated control and were found better than the other treatments.

The grain yield of maize crop in the experimental plots varied from 20.60 to 33.83 q/ha. The maximum yield (33.83 q/ha) was recorded in spinetoram 11.7 SC @ 5 ml/kg treated plot. The spinetoram 11.7 SC @ 2.5 ml/kg, chlorantraniliprole 18.5 SC @ 3 ml/kg, 1.5 ml/kg, novaluron 10 EC @ 5 ml/kg, 2.5 ml/kg, azadirachtin 1% 10 ml/kg, emamectin benzoate 5 SG 4 g/kg and a standard check thiodicarb 75 WP 10 g/kg recorded yield ranging from 24.77 to 32.67 q/ha and found superior than untreated control (20.60 q/ha).

We compared the efficacy of insecticides used as poison bait vis-a-vis foliar spray using same chemical in reducing damage caused by fall armyworm. The results suggested that bait application was as effective as foliar sprays involving same insecticide. The difference in effectiveness of chemical as bait

& spray application was non-significant in insecticides viz., spinetoram 11.7 SC, chlorantraniliprole 18.5 SC, novaluron 10 EC and thiodicarb 75 WP. However, in case of azadirachtin, bait application was more effective than foliar spray and contrasting result was noticed with emamectin benzoate where spray gave superior protection over bait application.

Cost of plant protection when insecticides were used as foliar spray and poison baits was calculated by factoring cost of insecticides and labour requirement in both the methods of application. Later, per cent increase or decrease in cost of bait application per acre over foliar sprays was calculated. It was found that the cost of plant protection as bait application was substantially lower than the foliar sprays with chemicals viz., spinetoram 11.7 SC, chlorantraniliprole 18.5 SC and thiodicarb 75 WP (42 to 44.78% reduction in cost over sprays). In case of emamectin benzoate bait application was found expensive than foliar spray. Main contributing factor for decrease in cost of plant protection in bait was reduction in quantity of insecticides required compared to foliar sprays. As new generation molecules are relatively more expensive, reduction in quantity of insecticides required directly translated into overall reduction in cost of protection.

For managing fall armyworm, insecticides are applied as foliar sprays. This species is relatively difficult to manage and necessitates multiple sprays which subsequently increases the cost of plant protection. As this pest is confined to whorl region of the plant, we explored the possibility of applying insecticides as baits in the whorl to reduce the cost. Hitherto, only thiodicarb was used in most of the insect baits on caterpillars and it is a highly toxic chemical. In this study we found that greener molecules with pre-harvest interval (PHI) of < 5 days were very effective as baits. Further, the cost of plant protection was significantly low when these insecticides were used as baits (up to 45% cost reduction). Though, poison baits are effective, it is relatively tedious to apply it in the plant whorls.

Designing & developing a bait applicator will have profound influence on popularization of insecticide application as baits in maize crop against fall armyworm. These findings provide new cost effective and safer options for management of the fall armyworm, *S. frugiperda*. As molecules assessed and found effective in this study belong to different chemical groups, rotating these chemicals as one of the components of integrated pest management schedules would go a long way in delaying the development of resistance against these chemicals.

Table 2: Efficacy of insecticides applied as poison baits on larval populations of *Spodoptera frugiperda* in maize

Treatments	Number of larvae per plant (average of 10 plants)							Percent reduction over control	
	Pre-treatment population	1 st application of bait			2 nd application of bait			After 1 st application of bait	After 2 nd application of bait
		7 DAT	14 DAT	Mean	7 DAT	14 DAT	Mean		
Spinetoram 11.7 SC @ 5 ml/kg of bait	1.50 (1.41)	0.27 (0.88)	0.17 (0.82)	0.22	0.07 (0.75)	0.00 (0.71)	0.03	86.35	97.2
Spinetoram 11.7 SC @ 2.5 ml/kg bait	1.43 (1.39)	0.30 (0.89)	0.20 (0.84)	0.25	0.10 (0.77)	0.03 (0.73)	0.07	83.73	93.15
Chlorantraniliprole 18.5 SC @ 3 ml/kg bait	1.33 (1.35)	0.30 (0.89)	0.33 (0.91)	0.32	0.20 (0.84)	0.03 (0.73)	0.12	77.61	87.37
Chlorantraniliprole 18.5 SC @ 1.5 ml/kg bait	1.37 (1.37)	0.33 (0.91)	0.40 (0.95)	0.37	0.30 (0.89)	0.10 (0.77)	0.20	74.87	79.56
Novaluron 10 EC @ 5 ml/kg bait	1.30 (1.34)	0.27 (0.88)	0.27 (0.88)	0.27	0.13 (0.80)	0.00 (0.71)	0.07	80.68	92.46
Novaluron 10 EC @ 2.5 ml/kg bait	1.37 (1.37)	0.27 (0.88)	0.33 (0.91)	0.30	0.17 (0.82)	0.10 (0.77)	0.13	79.63	86.72
Azadirachtin 1% @ 10 ml/kg bait	1.43 (1.39)	0.43 (0.97)	0.57 (1.03)	0.50	0.40 (0.95)	0.20 (0.84)	0.30	67.47	70.63
Emamectin benzoate 5 SG @ 4 g/kg bait	1.40 (1.38)	0.30 (0.89)	0.23 (0.86)	0.27	0.33 (0.80)	0.20 (0.77)	0.27	68.77	73
Thiodicarb 75 WP @ 10 g/kg bait	1.40 (1.38)	0.40 (0.95)	0.53 (1.02)	0.47	0.13 (0.91)	0.10 (0.84)	0.12	82.06	88
Untreated control	1.47 (1.40)	1.73 (1.49)	1.43 (1.39)	1.58	1.10 (1.26)	1.00 (1.22)	1.05	-	-
S.Em (±)	0.02	0.02	0.02	-	0.01	0.01	-	-	-
CD (p=0.05)	0.07	0.05	0.05	-	0.04	0.03	-	-	-
CV (%)	3.01	3.10	2.75	-	2.82	2.21	-	-	-

Table 3: Efficacy of insecticides applied as poison baits on leaf damage caused by *Spodoptera frugiperda* in maize

Treatments	Pre-treatment leaf damage	Per cent leaf damage on plants (average of 10 plants)						Percent reduction over control	
		I Spray			II Spray			1 st application	2 nd application
		7 DAT	14 DAT	Mean	7 DAT	14 DAT	Mean		
Spinetoram 11.7 SC @ 5 ml/kg of bait	57.33 (0.86)	13.00 (0.37)	12.67 (0.36)	12.83	6.67 (0.26)	4.33 (0.21)	5.50	74.71	89.09
Spinetoram 11.7 SC @ 2.5 ml/kg of bait	60.33 (0.89)	16.33 (0.42)	14.00 (0.38)	15.17	9.33 (0.31)	8.33 (0.29)	8.83	71.58	83.36
Chlorantraniliprole 18.5 SC @ 3 ml/kg of bait	59.33 (0.88)	17.33 (0.43)	14.00 (0.38)	15.67	10.33 (0.33)	8.67 (0.30)	9.50	70.15	81.79
Chlorantraniliprole 18.5 SC @ 1.5 ml/kg of bait	58.00 (0.87)	19.33 (0.46)	16.33 (0.42)	17.83	12.67 (0.36)	10.67 (0.33)	11.67	65.26	77.12
Novaluron 10 EC @ 5 ml/kg of bait	59.33 (0.88)	15.00 (0.40)	13.33 (0.37)	14.17	8.67 (0.30)	6.33 (0.25)	7.50	73.01	85.62
Novaluron 10 EC @ 2.5 ml/kg of bait	55.67 (0.84)	18.67 (0.45)	15.33 (0.40)	17.00	10.33 (0.33)	8.33 (0.29)	9.33	65.49	80.94
Azadirachtin 1% @ 10 ml/kg of bait	57.00 (0.86)	24.67 (0.52)	26.00 (0.54)	25.33	21.00 (0.48)	20.67 (0.47)	20.83	49.78	58.44
Emamectin benzoate 5 SG @ 4 g/kg of bait	56.33 (0.86)	23.33 (0.45)	23.67 (0.46)	23.50	18.00 (0.36)	15.67 (0.34)	16.83	62.43	76.67
Thiodicarb 75 WP @ 10 g/kg of bait	57.67 (0.85)	19.00 (0.50)	19.33 (0.51)	19.17	12.13 (0.44)	11.33 (0.41)	11.83	52.85	66.02
Untreated control	59.33 (0.88)	59.00 (0.88)	46.00 (0.75)	52.50	51.67 (0.88)	52.67 (0.81)	52.17	-	-
S.Em (±)	0.01	0.01	0.01	-	0.01	0.01	-	-	-
CD (p=0.05)	0.02	0.02	0.02	-	0.02	0.02	-	-	-
CV (%)	1.43	2.18	2.24	-	2.80	3.59	-	-	-

Table 4: Effect of application of insecticide baits on maize grain yield

Treatments	Yield (g/ha)
Spinetoram 11.7 SC @ 5 ml/kg of bait	33.83
Spinetoram 11.7 SC @ 2.5 ml/kg of bait	31.58
Chlorantraniliprole 18.5 SC @ 3 ml/kg of bait	31.33
Chlorantraniliprole 18.5 SC @ 1.5 ml/kg of bait	29.75
Novaluron 10 EC @ 5 ml/kg of bait of bait	32.67
Novaluron 10 EC @ 2.5 ml/kg of bait	31.33
Azadirachtin 1% @ 10 ml/kg of bait	24.77
Emamectin benzoate 5 SG @ 4 g/kg of bait	32.47
Thiodicarb 75 WP @ 10 g/kg of bait	26.67
Untreated control	20.60
S.Em (±)	0.03
CD (p=0.05)	0.09
CV (%)	0.93

Table 5: Comparison of efficacy of insecticides applied as foliar spray and poison baits

Insecticide	Insecticide dose		Per cent reduction in larval population over control		Paired 't' test
	Spray (ml or g per litre)	Bait (ml or g per kg)	Spray	Poison bait	
Spinetoram 11.7 SC	0.6	3	94.19	86.19	NS (P=0.33)
Chlorantraniliprole 18.5 EC	0.4	2	88.38	72.06	NS (P=0.08)
Novaluron 10 EC	1	3	87.52	79.04	NS (P=0.20)
Azadirachtin 1%	2	10	32.67	60.47	** (P=0.04)
Emamectin benzoate 5 SG	0.4	4	90.86	62.7	** (P=0.01)
Thiodicarb 75 WP	2	10	81.71	83.80	NS (P=0.20)

(** significant difference)

NS: Non significant

Table 6: Reduction in cost of plant protection when insecticides were used as baits over sprays for management of *S. frugiperda* on maize

Insecticides	Per cent reduction in cost (INR)
Spinetoram 11.7 SC	44.78
Chlorantraniliprole 18.5 SC	44.40
Novaluron 10 EC	24.00
Azadirachtin 1%	20.00
Emamectin benzoate 5 SG	-32.00
Thiodicarb 70 WP	42.66

References

- Montezano DG, Specht A, Sosa-Gomez DR, RoqueSpecht VF, Sousa-Silva JC, Paula-Moraes SV *et al.* Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas, African Entomology. 2018; 26(2):286-300
- Pogue MA. World revision of the genus *Spodoptera* guenee (Lepidoptera, Noctuidae). American Entomological Society. 2002; 43:1-202.
- CABI. 2016. *Spodoptera frugiperda* (fall army worm). Invasive Species Compendium. <http://www.cabi.org/isc/datasheet/29810> (Date of access: 01/12/2016). <http://www.cabi.org/isc/datasheet/29810>
- Wiseman BR, Isenhour DJ. Response of four commercial corn hybrids to infestations of fall armyworm and corn earworm (Lepidoptera: Noctuidae). Florida Entomologist. 1993; 76:283-292.
- Hruska AJ, Gladstone SM. Effect of period and level of infestation of the fall armyworm, *Spodoptera frugiperda*, on irrigated maize yield. Florida Entomologist. 1988; 71:249-54.
- Lima MS, Silva PSL, Oliveira OF, Silva KB, Freitas FCL. Corn yield response to weed and fall armyworm controls. Planta Daninha. 2010; 28(1):103-111.
- Sparks AN. A review of the biology of the fall armyworm. Fla Entomol, 1979; 62:82-87.
- Abrahams P, Beale T, Cock M, Corniani N, Day R, Godwin J *et al.* Fall armyworm status impacts and control options in Africa: preliminary evidence note.UK

- 2017: CABI; [accessed 2017 Sept 01]. https://www.cabi.org/uploads/ics/Dfid_Faw_Inception_Report_04may2017final.pdf
9. Ganiger PC, Yeshwanth HM, Mohan MK, Vinay N, Kumar ARV, Chandrashekara K *et al.* Occurrence of the new invasive pest, fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), in the maize fields of Karnataka, India. *Current Science*. 2018; 115:621-623.
 10. Sharanabasappa, Kalleshwaraswamy CM, Asokan R, Swamy MHM, Maruthi 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 Horticulture Ecosystem*. 2018; 24:23-29
 11. Xu SX, Xing HC, Ru JH, Lin WU, Jing SX, Yuan ZS *et al.* Case study on the first immigration of fall armyworm *Spodoptera frugiperda* invading into China. *Journal of Integrative Agriculture*. 2019; 18:2-10.
 12. Davis FM, Williams WP. Visual rating scales for screening whorl -stage corn for resistance to fall armyworm. Mississippi Agricultural & Forestry Experiment Station, Technical Bulletin 186, Mississippi State University, MS 39762, U.S.A, 1992.