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RESEARCH PAPER

Relationship of sowing dates with the seasonal incidence of fall armyworm *Spodoptera frugiperda* (J. E. Smith) in maize

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Abstract: Fall armyworm *Spodoptera frugiperda* (J.E. Smith) is an economically important insect pest of maize and spreads very widely in different agroecological zones. A field experiment was conducted to investigate the fall armyworm incidence on maize hybrid DHM 121 under different dates of sowing during *kharif* 2021 and *rabi* 2021-22. The results revealed that the peak per cent plant infestation by fall armyworm was observed in 42, 63 and 91 days old maize crop at 49th, 52nd, and 4th SMW (100.0%) in crop sown during 23rd October, 2021. Similarly, the peak larval incidence was observed in 84 day old crop at 5th SMW (0.65) in crop sown on 10th November, 2021 whereas the maximum oviposition was observed in 77 day old crop at 44th SMW (0.18) in crop sown on 17th August, 2021.The information obtained from the present study would help formulate fall armyworm forecasting models and potential management strategies in maize.

Keywords: Different sowing dates · Fall armyworm · Larval incidence · Maize · Oviposition · Plant infestation

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Introduction

Maize (*Zea mays* L.) is the most important global cereal crop grown in varied environmental conditions. In India, it is grown in an area of 9.2 million ha with a production of 31.51 million MT (DES 2021) which represents nearly 4 per cent of the global maize area and 2 per cent of global production. Maize is widely used as poultry feed (47%), fodder (13%), food (13%), starch industry (14%), processed food (7%), export, and other purposes (6%). Even though the production of maize has been increasing over the last 10 years, productivity remains low. The growth of maize has been hindered due to several biotic and abiotic stress challenges. Among biotic stresses, insect pests are one of the major reasons for the low productivity of maize. Globally, insect pests cause about an 18-26 per cent reduction in crop production which occurs in fields before harvest (Mantzoukas *et al.,* 2020). The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), native to tropical and subtropical regions of America (Sisay *et al.,* 2019), is an invasive insect pest of maize that causes significant yield losses. It is highly polyphagous and a long-distance migratory pest. The fall armyworm became a global pest due to its higher migratory nature, reproductive ability, and favourable climatic conditions. It causes extensive damage to maize by feeding on most parts of the maize plant including leaf whorl, tassel, and cob leaving shot holes, skeletonized leaves, and heavily windowed whorls with frass. The larvae of the fall armyworm can feed on more than 350 plant species, including maize, sugarcane, and rice (Montezano *et al.,* 2018). Losses due to fall armyworm on maize ranged from 8.3 to 20.6 million

tonnes annually (Day *et al.,* 2017). Knowledge of the population dynamics of fall armyworm provides basic information for developing effective management strategies which is essential for enhancing food security. The insect population varies in response to changes in ecological conditions such as competition, natural enemies, resources, and weather conditions (Prakash *et al.,* 2014). Considering the above facts, the present research work aims to study the seasonal incidence of fall armyworm under different dates of sowing in *kharif* and *rabi* maize.

Materials and methods

Experimentation

The field experiment was carried out to study the seasonal incidence of fall armyworm on maize at six different planting dates during August-December 2021 (late *kharif* to *rabi* season) at Winter Nursery Centre, ICAR-IIMR, Hyderabad. The maize single cross hybrid DHM 121 was sown on 2nd August, 17th August, 23rd October, 10th November, 24th November, and 4th December of 2021. A plot size of 7.5 m × 3 m was maintained with a spacing of 75 cm × 20 cm in three replications. All the recommended agronomical practices were followed in raising the crop. The observations on the number of plants damaged, number of larvae and egg masses were taken at weekly intervals on whole plot basis. Per cent plant infestation was calculated by using the formula.

$$\text{Per cent plant infestation} = \frac{\text{Number of infested plants}}{\text{Total number of plants}} \times 100$$

Results and discussion

Table 1 depicts the percent plant infestation by fall armyworm concerning standard meteorological weeks at different sowing dates in maize. The initial infestation of fall armyworm (4.62%) started in the 32nd Standard Meteorological Week (SMW) in the crop sown on 2nd August 2021 (First planting date-31SMW). The infestation was reduced to 1.53 per cent in the 33rd SMW; again, increased moderately up to the 42nd SMW, and a peak infestation of 87.00 per cent was observed in the 84 days old crop during 43rd SMW. During the second planting date (17th August 2021-33 SMW), the infestation of fall armyworm was first noticed from the 34th SMW (5.85%) while a sudden increase in infestation level (64.73%) was observed in 35 days old crop during the 37th SMW and persisted till the crop reached to 108 days old during 46th SMW. The maximum infestation (98.73%) was noticed in 70 days old crop during the 43rd SMW. The initial mean percent infestation of fall armyworm was observed during the 44th SMW (28.09%) in the crop sown on 23rd October 2021 (3rd planting date-34 SMW). It was further increased and continued till the 4th SMW. A higher percent plant infestation was observed during this planting date i.e. 23rd October compared to the crop sown between 2nd August 2021 and 17th August 2021. At the 49th, 52nd and 4th SMW, a maximum infestation of 100% was observed which coincided with plant age of 42, 63 and 91 days. During the fourth planting date (10th November 2021- 45th SMW), the initial infestation of fall armyworm started shortly after germination (25.87%) in 47th SMW and continued throughout the crop growth period. The 5th, 6th, and 7th SMW had the highest incidence of 98.48% which was observed in 84-98 day old crop.

A moderate infestation of 13.18 per cent was observed during the 49th SMW in the crop sown on 24 November 2021(Fifth planting date- 47 SMW) and the infestation was persistent throughout the crop growth period. The highest plant infestation of 96.38 per cent occurred in 84to 98 day old crop during the 7th, 8th, and 9th SMWs, respectively. During the sixth planting date (4th December 2021-49 SMW), the incidence of fall armyworm marginally decreased as compared to the previously sown three crops. The incidence begins soon after germination at the 50th SMW, with 15.60% infestation. During the 51st SMW, there was a sharp increase in the incidence up to 47.60% while the peak infestation (79.91%) was observed in 40 day old crop during 5th SMW. However, fall armyworm incidence was observed throughout the crop growth period.

The initial fall armyworm larval incidence (0.02) was observed in the 32nd Standard Meteorological Week (SMW) (Table 2) while oviposition was observed during the 34th SMW in the crop sown on 2nd August 2021 (First planting date: 31 SMW) (Table 3). The incidence was gradually increased to 0.34 in the 43rd SMW and decreased (0.14) in the 44th SMW. However, maximum oviposition (0.10) was observed in 42 day old crop during the 37th SMW. During the second planting date (17th August 2021-33 SMW), the larval incidence and oviposition were first noticed from the 34th SMW (0.09, 0.01) and gradually

Table 1. Per cent plant infestation of fall armyworm on maize at different dates of planting during 2021-22

Std. Weeks	Mean per cent of infested plants						
(SMW)	1st Planting (2 Aug 2021, 31 SMW)	2nd planting (17 Aug 2021, 33 SMW)	3rd planting (23 Oct 2021, 43 SMW)	4th planting (10 Nov 2021, 45 SMW)	5th planting (24 Nov 2021, 47 SMW)	6th planting (4 Dec 2021, 49 SMW)	Pooled mean
32	4.62	-	-	-	-	-	4.62
33	1.53	-	-	-	-	-	1.53
34	13.82	5.85	-	-	-	-	9.84
35	9.10	20.00	-	-	-	-	14.55
36	4.62	7.08	-	-	-	-	5.85
37	24.53	64.73	-	-	-	-	44.63
38	19.90	58.03	-	-	-	-	38.97
39	14.47	41.87	-	-	-	-	28.17
40	24.45	74.83	-	-	-	-	49.64
41	19.90	67.27	-	-	-	-	43.59
42	52.77	96.20	-	-	-	-	74.49
43	87.00	98.73	-	-	-	-	92.87
44	86.33	94.93	28.09	-	-	-	69.78
45	-	94.55	73.85	-	-	-	84.20
46	-	87.83	90.28	-	-	-	89.06
47	-	-	82.95	25.87	-	-	54.41
48	-	-	97.96	72.14	-	-	85.05
49		-	100.00	92.77	13.18	-	68.65
50		-	95.23	91.11	75.88	15.60	69.46
51		-	91.10	88.81	77.07	47.60	76.15
52		-	100.00	93.96	90.36	71.95	89.07
1		-	95.23	89.92	88.00	67.18	85.08
2		-	96.62	92.30	83.20	52.49	81.15
3		-	98.67	92.38	90.36	71.14	88.14
4		-	100.00	97.29	91.57	72.06	90.23
5		-	-	98.48	92.76	79.91	90.38
6		-	-	98.48	92.76	73.16	88.13
7		-	-	98.48	96.38	79.59	91.48
8		-	-	-	96.38	73.91	85.15
9		-	-	-	96.38	73.91	85.15
10		-	-	-	-	73.91	73.91
Range	1.53-87.00	5.85-98.73	28.09-100.00	25.87-98.48	13.18-96.38	15.60-79.91	1.53-92.87
Mean±SD	27.93±29.14	62.46±34.01	88.46±19.69	87.08±19.64	83.41±22.16	65.57±17.74	63.01±30.26

increased thereafter. The peak larval incidence (0.44) was observed in 70 day old crop during the 43rd SMW and persisted till the 46th SMW whereas the maximum oviposition (0.18) was observed during the 44th SMW and decreased thereafter. The initial mean larval incidence and oviposition were observed during the 44th SMW (0.07, 0.01) in the crop sown on 23rd October 2021 (Third planting date-43 SMW). The larval incidence was further increased to 0.59 during the 49th SMW while a maximum number of egg masses were observed in 49 day old crop during the 50th SMW (0.12) and decreased thereafter. During the fourth planting date (10th November 2021-45 SMW), the initial larval incidence and oviposition started (0.06, 0.02) in 47th SMW and the peak larval incidence (0.65) was observed in 84 day old crop during 5th SMW. However, maximum oviposition (0.14) was observed in 35 day old crop during 49th SMW. A moderate larval incidence (0.36) was observed during the 4th SMW while

Table 2. Fall armyworm larval incidence on maize at different dates of planting during 2021-22

Std. Weeks	Mean number of larvae/plant						
(SMW)	1st Planting (2 Aug 2021, 31 SMW)	2nd planting (17 Aug 2021, 33 SMW)	3rd planting (23 Oct 2021, 43 SMW)	4th planting (10 Nov 2021, 45 SMW)	5th planting (24 Nov 2021, 47 SMW)	6th planting (4 Dec 2021, 49 SMW)	Pooled mean
32	0.02	-	-	-	-	-	0.02
33	0.01	-	-	-	-	-	0.01
34	0.02	0.09	-	-	-	-	0.06
35	0.10	0.06	-	-	-	-	0.08
36	0.05	0.04	-	-	-	-	0.05
37	0.12	0.32	-	-	-	-	0.22
38	0.11	0.27	-	-	-	-	0.19
39	0.06	0.18	-	-	-	-	0.12
40	0.09	0.30	-	-	-	-	0.20
41	0.07	0.22	-	-	-	-	0.15
42	0.27	0.33	-	-	-	-	0.30
43	0.34	0.44	-	-	-	-	0.39
44	0.14	0.28	0.07	-	-	-	0.16
45	-	0.08	0.16	-	-	-	0.12
46	-	0.01	0.19	-	-	-	0.10
47	-		0.05	0.06	-	-	0.06
48	-		0.32	0.21	-	-	0.27
49	-	-	0.59	0.29	0.16	-	0.35
50	-	-	0.50	0.15	0.08	0.04	0.19
51	-	-	0.13	0.11	0.07	0.04	0.09
52	-	-	0.27	0.23	0.13	0.14	0.19
1	-	-	0.10	0.11	0.06	0.09	0.09
2	-	-	0.03	0.12	0.02	0.06	0.06
3	-	-	0.03	0.48	0.05	0.07	0.16
4	-	-	0.01	0.58	0.36	0.23	0.30
5	-	-	-	0.65	0.28	0.19	0.37
6	-	-	-	0.21	0.27	0.18	0.22
7	-	-	-	0.07	0.26	0.19	0.17
8	-	-	-	-	0.16	0.08	0.12
9	-	-	-	-	0.01	0.05	0.03
10	-	-	-	-	-	0.05	0.05
Range	0.01-0.34	0.01-0.44	0.01-0.59	0.06-.0.65	0.01-0.36	0.04-0.23	0.01-0.39
Mean±SD	0.11±0.10	0.20±0.13	0.19±0.19	0.25±0.20	0.15±0.11	0.11±0.07	0.15±0.11

moderate oviposition (0.08) was observed during the 6th SMW in the crop sown on 24th November 2021(Fifth planting date-47 SMW) and the incidence and oviposition were observed throughout the crop growth period. During the sixth planting date (4th December 2021-49 SMW), the incidence and oviposition begin at the 50th SMW and continued thereafter. During the 4th SMW, the peak incidence and oviposition (0.23, 0.09) was observed in 49 day old crop. The fall armyworm larval incidence and oviposition were observed throughout the crop growth period (Tables 2 and 3).

It was found that the fall armyworm mean infestation level in crop sown on 2nd August 2021 (27.93%) was much lower. The infestation on the crop sown on 17th August 2021 (62.46%) and 4^{rth} December 2021 (65.57%) sown crops were moderately higher, although there was a significant increase in infestation on the 10th November 2021 (87.08%), 23rd October 2021 (88.46%), and 24th

Table 3. Fall armyworm oviposition on maize at different dates of planting during 2021-22

Std. Weeks	Mean number of egg masses/ plant						
(SMW)	1st Planting (2 Aug 2021, 31 SMW)	2nd planting (17 Aug 2021, 33 SMW)	3rd planting (23 Oct 2021, 43 SMW)	4th planting (10 Nov 2021, 45 SMW)	5th planting (24 Nov 2021, 47 SMW)	6th planting (4 Dec 2021, 49 SMW)	Pooled mean
32	0.00	-	-	-	-	-	0.00
33	0.00	-	-	-	-	-	0.00
34	0.03	0.01	-	-	-	-	0.02
35	0.02	0.00	-	-	-	-	0.01
36	0.00	0.00	-	-	-	-	0.00
37	0.10	0.02	-	-	-	-	0.06
38	0.02	0.00	-	-	-	-	0.01
39	0.01	0.00	-	-	-	-	0.01
40	0.04	0.08	-	-	-	-	0.06
41	0.02	0.03	-	-	-	-	0.03
42	0.02	0.13	-	-	-	-	0.08
43	0.07	0.08	-	-	-	-	0.08
44	0.09	0.18	0.01	-	-	-	0.09
45	-	0.14	0.09	-	-	-	0.12
46	-	0.05	0.11	-	-	-	0.08
47	-	-	0.02	0.02	-	-	0.02
48	-	-	0.10	0.09	-	-	0.10
49	-	-	0.10	0.14	0.01	-	0.08
50	-	-	0.12	0.13	0.02	0.01	0.07
51	-	-	0.08	0.05	0.07	0.03	0.06
52	-	-	0.08	0.06	0.06	0.01	0.05
1	-	-	0.06	0.07	0.04	0.07	0.06
2	-	-	0.06	0.04	0.01	0.02	0.03
3	-	-	0.06	0.03	0.05	0.08	0.06
4	-	-	0.03	0.02	0.04	0.09	0.05
5	-	-	-	0.01	0.06	0.05	0.04
6	-	-	-	0.03	0.08	0.04	0.05
7	-	-	-	0.02	0.07	0.05	0.05
8	-	-	-	-	0.02	0.03	0.03
9	-	-	-	-	0.01	0.03	0.02
10	-	-	-	-	-	0.03	0.03
Range	0.00-0.10	0.00-0.18	0.01-0.12	0.01-0.14	0.01-0.08	0.01-0.09	0.00-0.12
Mean±SD	0.03±0.03	0.06±0.06	0.07±0.03	0.05±0.04	0.04±0.03	0.04±0.02	0.05±0.03

November 2021 (83.41%) planting dates, respectively. One of the possible reasons might be favourable weather conditions for the fall armyworm incidence during the third, fourth, and fifth planting dates. Initial fall armyworm infestation facilitated the build-up of the population of this pest for the succeeding planting dates.

Several researchers investigated the seasonal activity of fall armyworm in maize. Wyckhuys *et al.* (2006) recorded that the fall armyworm infestation was lowest during the early whorl and post-whorl stage with peak infestation during the whorl stage. Dhar *et al*. (2019) examined the seasonal prevalence of fall armyworm in the year 2018-19 in West Bengal. Summer maize suffered the most damage, with an infestation level ranging from 8.53 ± 0.68 per cent to 27.56 ± 0.65 per cent, compared to 4.49 ± 0.81 per cent to 12.85 ± 0.58 per cent in *rabi* maize. Canico *et al*. (2020) reported that fall armyworm infestation, damage, and population density increased

during the dry season. These findings imply that sowing maize early in the cropping season might effectively decrease fall armyworm infestation and damage as compared to the dry season, which supports current findings. Similar kinds of results were reported by Darshan (2020) where the late-sown maize crop suffered significantly greater damage as compared to the early-sown maize crop. Lavan Kumar (2020) studied the seasonal incidence of fall armyworm in sweet corn during *kharif* 2019 under three planting dates: early (15th June), mid (1st July), and late (16th July). As observed in all three plantings, FAW appeared 12 to 17 days after sowing, reached its peak between 25 and 45 days after sowing, and persisted until harvest. Warkad *et al*. (2021) worked on seasonal fluctuations of fall armyworm in maize during *rabi* 2019-20. The least damaged plants were observed at the start of the season (December) and increased throughout the season, peaking at crop maturity (50th SMW).

Kumar *et al*. (2020) reported a maximum incidence of fall armyworm during the first fortnight of November with 59, 61, 72, and 70 per cent damage while the minimum was seen in the second fortnight of November with 31, 21, 34, and 31 per cent at Perambalur, Veppanthattai, Alathur and Veppur blocks of Perambalur district, Tamil Nadu. Patel *et al*. (2020) reported that percent damaged plants by fall armyworm coincided with the larval population and commenced from 1stweek of August (31st SMW) and continued till 1st week of October (40th SMW) which ranged from 10 to 81.66 per cent. During the 3rd week of September 2019 (37th SMW), it showed its peak by recording 81.66 per cent damaged plants. Niassy *et al*. (2021) reported that the number of fall armyworm adults and larvae was significantly affected by crop phenology, with infestation being higher at vegetative and reproductive stages, but lower at mature stages of the crop. This might be due to unfavourable environmental conditions for pest infestation, particularly high minimum temperatures and heavy rainfall, which were inversely correlated with the occurrence of fall armyworm.

Conclusion

The maximum percent plant infestation was observed in 42, 63 and 91 days old maize crop sown in 34 SMW whereas peak larval incidence was noticed in 84 day old crop sown in 45 SMW. However, the maximum oviposition was observed in 77 day old crop sown in 33 SMW. Studies on seasonal pest infestation would be useful in devising the pest monitoring system and sustainable fall armyworm management modules.

Conflicts of interest

The authors declare that there are no conflicts of interest that exist.

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