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RESEARCH ARTICLE Agricultural Science Digest

Crop Weather Pest Relationship and Forewarning Model for *Spodoptera frugiperda* on Maize and Sorghum

T. Prathima[1], K.V.S. Sudheer[1], K. Devaki[1], C.V. Madhuri[1], G. Subramanyam[1], Lakshmiprasanna Aggile[1]

10.18805/ag.D-5741

ABSTRACT

Background: Fall Armyworm, *Spodoptera frugiperda* is a crop pest with over 80 host species that causes severe damage to maize and sorghum crops. *S. frugiperda* is native to tropical and subtropical region of America that has spread rapidly throughout the world.

Methods: Based on the severity of *S. frugiperda* in India a field experiment was conducted to study the pest influence in maize and Sorghum crops for two years *i.e.*, 2020 and 2021 during the kharif season at Regional Agricultural Research Station, Tirupati. Using correlation and regression techniques, the data was pooled and statistically analysed with weather parameters.

Result: Correlation studies revealed a significant positive relationship between pest damage and minimum temperature showed negative relation with morning and evening relative humidity, while wind velocity and evaporation are positively influenced *S. frugiperda* damage. Maximum temperature, wind velocity and evaporation together played a role in the occurrence of *S. frugiperda*. Regression equations were developed using SPSS for predicting the damage caused by *S. frugiperda*.

Key words: Fall armyworm, Maize, Sorghum, *Spodoptera frugiperda*.

INTRODUCTION

Maize (*Zea mays*) and Sorghum (*Sorghum bicolor*) are the most important cereal crops, because of their importance as a staple food and the animal feed. The crop productivity has been declining in recent years due to various biotic and environmental constraints. Pests and disease are two of the most significant constraints, as they reduce crop production and yield (Adhikari *et al*., 2020). *Spodoptera frugiperda* (J.E. Smith) has become the most common and destructive insect pest since 2018 that causes severe damage to maize in A.P. and other southern states. It is native to the tropical and subtropical regions of America (Sparks, 1979). The pest spread quickly at, almost all of Sub-Saharan African countries had been infested by 2017. In India, it was first reported from Shivamogga, Karnataka (Sharanabasappa *et al*., 2018) and it quickly spread into all the states except Himachal Pradesh and Jammu and Kashmir (Suby *et al*. 2020). The moth will migrate over 500 kilometres until oviposition (Day *et al*., 2017 and Prasanna *et al*., 2018). Adults have strong flying ability (100 km per night) and high reproduction rate which resulted in a rapid population spread, resulting in serious consequences (FAO, 2018).

S. frugiperda poses a threat to a large number of cultivated plant species. Its primary hosts were identified as maize and sorghum, while other monoculture crops like soybean and cotton, suffer from severe infestation. Maize (*Zea mays* L.), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), cotton (*Gossypium hirsutum* L.), potato (*Solanum tuberosum* L.), vegetables and other cultivated and wild plant species are all severely affected (Adhikari *et al.* 2020). It causes loss of photosynthetic area, delayed or reduced reproduction, grain degradation, structural damage and lodging of the maize plant (Chimweta *et al*., 2019). The maize strain of *S. frugiperda* is the most common and causes considerable damage to maize. Insect survival, development, geographic range, population size, population dynamics and species distribution, Insect physiology and development were affected directly or indirectly by the rising temperature (Raj Kumar *et al*., 2018). Information on the relationship between the incidence of pests and weather factors is required for developing weather-based pest forecasting.

Weather-based forewarning models are widely used in integrated pest management systems as a tool that does not harm predators and reducing environmental pollution through need-based insecticide application (Narayana swamy *et al*., 2017). Due to lack of knowledge about fall armyworm feeding habits, farmers are attempting to control the pest with indiscriminate use of chemical pesticides, detergents and ash. In India, Farmers are using two to three rounds of insecticides for the management of fall armyworm in maize

[1]Acharya N.G. Ranga Agricultural University, Regional Agricultural Research Station, Tirupati-517 502, Andhra Pradesh, India.

Corresponding Author: T. Prathima, Acharya N.G. Ranga Agricultural University, Regional Agricultural Research Station, Tirupati-517 502, Andhra Pradesh, India. Email: t.prathima@angrau.ac.in

How to cite this article: Prathima, T., Sudheer, K.V.S., Devaki, K., Madhuri, C.V., Subramanyam, G. and Aggile, L. (2023). Crop Weather Pest Relationship and Forewarning Model for *Spodoptera frugiperda* on Maize and Sorghum. Agricultural Science Digest. DOI: 10.18805/ag.D-5741.

Submitted: 07-02-2023 **Accepted:** 11-07-2023 **Online:** 09-08-2023

ecosystem (Deshmukh *et al*., 2021b). For effective insect pest management, an operationally feasible forewarning model for insect pest prediction is required. Taking this into consideration, an attempt was made to predict the occurrence of *S. frugiperda* population.

MATERIALS AND METHODS

Location

Field experiment on maize and sorghum were conducted under rainfed conditions during kharif season for two years, 2020 and 2021 at Regional Agricultural Research Station, Tirupati. It is situated between 13.62°N and 79.41°E with a 980 m mean sea level. The average annual rainfall of Tirupati for the year 2020 and 2021 was 1482.8 mm was 1695.8 mm.

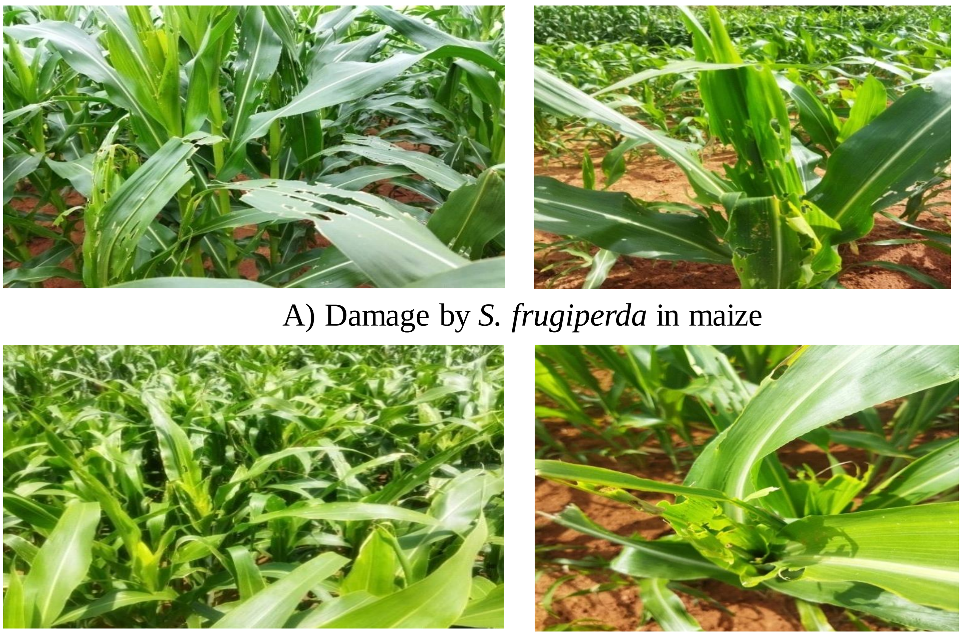
Experimental details

The research was designed in split plot method followed by three dates of sowings *i.e*., D1= 1st fortnight (FN) of July, D2=1st FN of Augustand D3=1st FN of September 10 mm four varieties, *i.e*., V1 (NTJ-2), V2=Dhanvi, V3=NTJ-5 and V=Kaveri with three replications.The seeds were sown with recommended spacing for maize (60 cm × 20 cm) and sorghum (45 cm × 15 cm) and all the agronomic practices like gap filling, weeding, fertilizer application, irrigations in the absence of rainfall were followed. To achieve natural pest incidence on the crop, pesticides were not applied throughout the growing season. From 20 DAS, the pest population was recorded by counting all the infested plants (Number of plants per plot) from each plot at 20-day intervals up to the crop maturity. The pest incidence, *i.e*., no. of damaged leaves and plants in each plot were recorded (Fig 1). The daily weather variables like maximum temperature, minimum temperature, rainfall, morning relative humidity, evening relative humidity, wind velocity and sunshine hours were observed for the crop period in RARS weather station, Tirupati, to correlate the relationship between weather and pest occurrence. The multiple regression equations were developed for predicting the *S. frugiperda.* Statistical analysis was performed using IBM SPSSv16.

RESULTS AND DISCUSSION

Population dynamics of *S. frugiperda*

The results pertaining to the per cent damage in maize and sorghum at 20,40 and 60 DAS for the year 2020 were presented in the Fig 2 revealed that the damage was maximum in maize crop compared to sorghum crop. Higher damage was noticed in July sown maize and sorghum crops at 40 DAS. The amount of rainfall received and maximum morning and evening relative humidity prevailed during 1st 20 days favoured for the peak incidence of pest due to excessive vegetative growth of the crop. During 2021, *S. frugiperda* incidence was first noticed at 30 DAS**.** The per cent damage of maize and sorghum was taken from 30-36 standard meteorological weeks for July sown crop, 37-42 standard weeks for August sown crop and 45-46th standard weeks for September sown crop. During 2021, pest incidence was higher in maize crop compared to sorghum. However, pest incidence progressively decreased with delayed sowing. The least per cent damage was observed



A) Damage by *S. frugiperda* in maize

B) Damage by *S. frugiperda* in sorgum

Fig 1: Damage of maize and sorghum plants by *Spodoptera frugiperda.*

in September 1st FN sown crops (21.6 and 27% in maize and 9.8 and 11.5% in Sorghum) as depicted in Fig 3.

Relationship of *Spodoptera frugiperda* with weather parameters

Coefficient of determination improved for both seven-day (Table 1) and three-day lead periods (Table 2) and validated for predicting the *S. frugiperda* incidence. Regression studies indicated the positive significant influence of minimum temperatures in maize (3-daylead period) and negative significant influence of BSSH in sorghum (7-day lead period) on pest incidence.

The results of the correlation analysis showed a positive link between the incidence and accumulation of *S. frugiperda* with the weather variables maximum temperature, minimum temperature, wind velocity, daylight hours and evaporation. While, over a seven-day lead period, a negative association between the relative humidity and the prevalence of pests was seen (Table 3). The relative humidity had a detrimental effect on the occurrence of pests over the three-day lead period (Table 4). According to Table 5's correlation coefficients between the pest population and weather variables for the sorghum crop, the minimum temperature, wind speed and relative humidity in the evening all have a significant positive

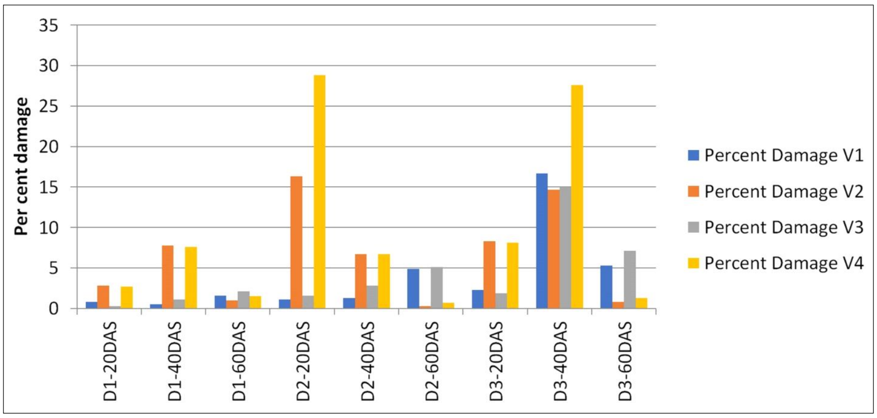


Fig 2: Per cent damage of maize and sorghum caused by fall army worm in different dates of sowing during 2020.

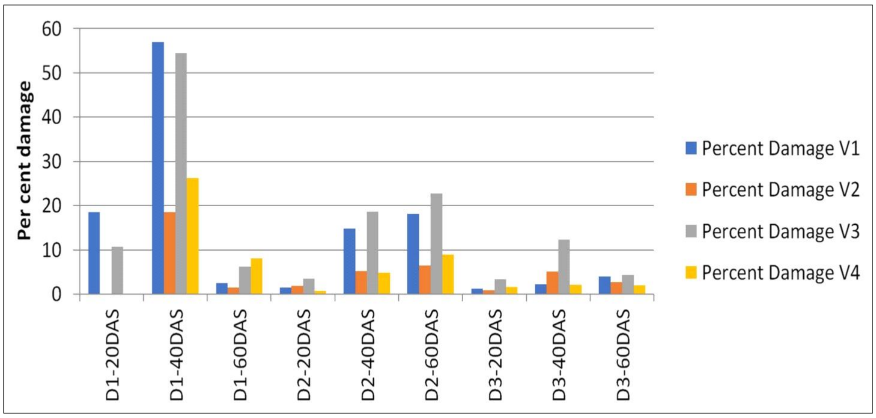


Fig 3: Per cent damage of maize and sorghum as affected by *S. frugiperda* in different dates of sowing during 2021.

Table 1: Regression equations with 7-day lead period for *S. frugiperda* incidence.

Treatment	Equation developed	R^2
V1 (Sorghum)	Y = -42.9 -7.26 Tmax - 5.47 Tmin + 13.7 Tmean + 0.31 RHmin - 0.05 RHmax + 0.09 WV + 0.29 SSH + 0.007 RH + 0.52 EVP	0.45
V2 (Maize)	Y = -102.6 +8.31Tmax +0.87 Tmin - 8.6Tmean + 0.73RHmin + 0.15RHmax + 1.00WV - 2.2SSH + 0.05RF + 0.7EVP	0.48
V3 (Sorghum)	Y= 66.6 +21.0Tmax +20.2Tmin - 43.4Tmean - 0.01RHmin -0.09RHmax + 0.08 WV + 0.09SSH - 0.003RF + 2.0EVP	0.63
V4 (Maize)	Y= - 78.5 + 16.0Tmax + 10.4Tmin - 25.53Tmean + 0.62RHmin +0.019RHmax - 0.38WV - 2.0SSH - 0.037RF + 0.21EVP	0.41

link with the insect population. Similar to this, Table 6's correlation coefficients between insect population and weather variables for the maize crop showed that relative humidity had a negative impact on pest population growth whereas maximum and minimum temperatures, wind speed, sunshine and evaporation had favourable effects.

Studies of correlation with 3-day and 7-day lead times revealed that temperature (maximum and minimum), wind velocity and BSSH have significant positive effects on pest incidence, whereas morning and afternoon relative humidity, mean relative humidity and rainfall have significant negative effects on *S. frugiperda* in maize crop. Similar to how minimum temperature affects crops of sorghum positively, morning and evening relative humidity and rainfall affect insect incidence negatively. Anandhi *et al.* (2020) during their study in Tamil Nadu also reported that maximum temperature has positive impact on pest and rainfall has negative correlation. The current study indicated that only relative humidity was positively significant, while temperature, wind speed, sunshine and evaporation were all found to be negatively significant. Rainfall during the same week and the week before had a significant and adverse relationship with the number of *S. frugiperda* larvae and the similar results were reported by Anandhi *et al.* (2020).

Table 2: Regression equations with 3-day lead period for *S. frugiperda* incidence.

Treatment	Equation developed	R^2
V1 (Sorghum)	Y= -42.2 - 5.1 Tmax - 3.9 Tmin + 10.04 Tmean + 0.16 RHmin + 0.09 RHmax - 0.37 WV + 0.061 SSH + 0.25 RH + 1.097 EVP	0.50
V2 (Maize)	Y= - 9.8 + 12.2Tmax + 14.7 Tmin - 25.1Tmean - 0.12RHmin -0.10RHmax - 0.6WV + 0.61SSH + 0.02RF - 1.7EVP	0.38
V3 (Sorghum)	Y= -90.3 - 2.9Tmax - 0.18Tmin + 5.8Tmean + 0.28RHmin + 0.08RHmax - 0.15WV - 0.41SSH + 0.02RF + 0.66EVP	0.53
V4 (Maize)	Y= - 165.2 + 20.0Tmax + 23.6Tmin - 38.2Tmean + 0.13RHmin + 0.37RHmax - 1.59WV - 0.10SSH + 0.06RF + 2.77EVP	0.53

Table 3: Correlation between *S. frugiperda* incidence and weather parameters (7 dlp).

Varieties	Tmax	Tmin	Tmean	RHmin	RHmax	RHmean	WV	SSH	RF	EVP
V1	0.30	0.47**	0.39*	-0.36	-0.34	-0.36	0.43*	0.31	-0.26	0.36
V2	0.50**	0.63**	0.59**	-0.57**	-0.52**	-0.56**	0.59**	0.49**	-0.22	0.49**
V3	0.30	0.47**	0.39*	-0.41*	-0.37*	-0.40*	0.51**	0.30	-0.26	0.33
V4	0.46*	0.62**	0.56**	-0.54**	-0.46*	-0.51**	0.50**	0.47**	-0.28	0.54**

**Correlation is significant at 0.01 level (2-tailed). *Correlation is significant at 0.05 level (2-tailed).

Table 4: Correlation between *S. frugiperda* incidence and weather parameters (3 dlp).

Varieties	Tmax	Tmin	Tmean	RHmin	RHmax	RHmean	WV	SSH	RF	EVP
V1	0.18	0.48**	0.31	-0.27	-0.20	-0.24	0.32	0.20	-0.20	0.23
V2	0.37*	0.58**	0.48**	-0.52**	-0.42*	-0.50**	0.52**	0.31	-0.23	0.34
V3	0.25	0.55**	0.39*	-0.39*	-0.30	-0.36	0.44*	0.20	-0.22	0.28
V4	0.37*	0.59**	0.49**	-0.48**	-0.37*	-0.45*	0.40*	0.33	-0.24	0.40*

**Correlation is significant at 0.01 level (2-tailed). *Correlation is significant at 0.05 level (2-tailed).

Table 5: Combined correlation average sorghum (V1 and V3).

Varieties	Tmax	Tmin	Tmean	RHmin	RHmax	RHmean	WV	SSH	RF	EVP
3-day period	0.23	0.52**	0.36	-0.34	-0.26	-0.31	0.39	0.20	-0.21	0.26
7-day period	0.30	0.48**	0.40*	-0.39*	-0.36	-0.39*	0.48**	0.31	-0.26	0.35

**Correlation is significant at 0.01 level (2-tailed). *Correlation is significant at 0.05 level (2-tailed).

Table 6: Combined correlation average maize (V2 and V4).

Varieties	Tmax	Tmin	Tmean	RHmin	RHmax	RHmean	WV	SSH	RF	EVP
3-day period	0.37*	0.60**	0.49**	-0.51**	-0.40	-0.48**	0.46*	0.32	-0.24	0.38
7-day period	0.45**	0.63**	0.58**	-0.56**	-0.49**	-0.54**	0.55**	0.48**	-0.26	0.52**

**Correlation is significant at 0.01 level (2-tailed).*Correlation is significant at 0.05 level (2-tailed).

Table 7: Per cent damage and number of leaves affected by *Spodoptera frugiperda* on maize and sorghum in different dates of sowing and varieties (pooled).

Dates of	No. of leaves affected			Per cent damage		
sowing	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
D1	2.50b	2.79a	2.25a	25.34a	15.64b	8.40c
D2	1.92c	3.25a	2.33a	17.80b	20.49a	13.26b
D3	3.38a	3.46a	2.17a	23.03ab	21.13a	21.32a
V1 (Dhanvi)	2.89a	4.06a	2.06a	21.13b	21.59a	13.84ab
V2 (NTJ-2)	2.17b	2.61bc	2.50a	20.92b	17.82a	17.37a
V3 (Kaveri)	3.39a	3.44b	1.89a	27.85a	20.07a	11.50b
V4 (NTJ-5)	1.94b	2.56c	2.56a	18.33b	16.87a	14.60ab
Year	0.24	0.308	0.017	0	0	0
Year*DOS	0.01	0.01	0	0	0	0
Year*Variety	0.04	0.24	0.001	0.12	0.007	0.292
Year*DOS*Variety	0.021	0.42	0.189	0.03	0.407	0.311

Table 7 shows the combined data on the percentage of leaves damaged and impacted by *S. frugiperda* on maize and sorghum crops. It demonstrated that the August seeded crop has the fewest number of affected leaves and damaged plants, while NTJ-5 demonstrated the least amount of damage.

CONCLUSION

S. frugiperda incidence began during the tillering stage and continued through the ripening stage, with rainfall, afternoon relative humidity and morning relative humidity all significantly negatively correlated with *S. frugiperda* incidence. The *S. frugiperda* infestation is exacerbated by moderate rainfall for 7-10 days before to the pest's onset, as well as a rise in maximum and minimum temperatures, bright sunshine hours and wind speed. Rainfall and an increase in relative humidity in the morning and evening will both lower the occurrence of pest. It was discovered that plant growth phases had a considerable impact on the incidence of insect pests, in addition to meteorological conditions. The timely and effective treatment of pests as well as weather-based forecasts may benefit from these discoveries. It is important to spread knowledge about fall armyworm controlling pesticides that are easily accessible in particular areas where the incidence is high.

Conflict of interest: None.

REFERENCES

Adhikari, K., Bhandari, S., Dhakal, L. and Shrestha, J. (2020). Fall armyworm (*Spodoptera frugiperda*): A threat in crop production in Africa and Asia. Peruvian Journal of Agronomy. 4(3): 121-133.DOI: http://dx.doi.org/10.21704/pja.v4i3. 1495.

Anandhi, S., Saminathan, V.R., Yasodha, P., Roseleen, S.S.J., Sharavanan, P.T. and Rajanbabu, V. (2020). Correlation of fall armyworm *Spodoptera frugiperda* (J.E. Smith) with weather parameters in maize ecosystem. International Journal of Current Microbiology and Applied Sciences. 9(8): 1213-1218. doi: ttps://doi.org/10.20546/ijcmas.2020. 908.135.

Chimweta, M., Nyakudya, I., Jimu, L. and Mashingaidze, A.B. (2019). Fall armyworm [*Spodoptera frugiperda* (J.E. Smith)] damage in maize: Management options for flood-recession cropping smallholder farmers. International Journal of Pest Management. 66(2): 142-154. https:// doi.org/10.1080/09670874.2019.15 77514.

Deshmukh, S.S., Kalleshwaraswamy, C.M., Prasanna, B.M., Sannathimmappa, H.G., Kavyashree, B.A., Sharath, K.N. and Patil, K.K.R. (2021). Economic analysis of pesticide expenditure for managing the invasive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) by maize farmers in Karnataka, India. Current Science. 121(11): 1487-1492.

Deshmukh, S.S., Prasanna, B.M., Kalleshwaraswamy, C.M., Jaba, J., Choudhary, B. (2021b). Fall Armyworm (*Spodoptera frugiperda*). In: Polyphagous Pests of Crops. [Omkar, (ed)]. Springer, Singapore. pp 349-372. https://doi.org/ 10.1007/978-981-15-8075-8_8.

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y. *et al.* (2017). Fall armyworm: Impacts and implications for Africa. Outlooks on Pest Management. 28(5): 196-201.https://doi. org/10.1564/v28_oct_02.

Food and Agriculture Organization. (2018). Integrated management of the fall armyworm on maize a guide for farmer field schools in Africa. http://www.fao.org/ faostat/en/.

Narayanasamy, M., Kennedy, J.S. and Geethalakshmi, V. (2017). Weather based pest forewarning model for major insect pests of rice-an effective way for insect pest prediction. Annual Research and Review in Biology. 21(4): 1-13.DOI: 10.9734/ARRB/2017/37365.

Prasanna, B.M., Huesing, J.E., Eddy, R., andPeschke, V.M. (2018). Fall Armyworm in Africa: A Guide for Integrated Pest Management. 1st ed.; CIMMYT: Edo Mex, Mexico. https:/ /repository.cimmyt.org/xmlui/ bitstream/handle/10883/ 19204/59133.pdf.

Raj Kumar, K.C., Kafle, K., Subedi, R.K.C.B., Sapkota, B. and Shahi. S. (2018). Effects of various weather factors in seasonal variation of insects pest in rice in Sundar Bazar, Lamjung. International Journal of Research in Agricultural Sciences. 5(4): 2348-3997.

Sharanabasappa, Kalleshwaraswamy, C.M., Asokan,R., Mahadeva Swamv., H.M., Marutid, M.S., Pavithra, H.B., Kavita Hegde,Shivaray Navi, Prabhu, S.T. and Goergen, G. (2018). 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. 24(l): 23-29.ISSN 0971-6831.

Sparks, AN. (1979). A review of the biology of the fall armyworm. Florida Entomologist. 62: 82-87.

Suby, S.B., Soujanya, P.L., Yadava, P., Patil, K.J., Subaharan, G., Prasad, K.S. *et al*. (2020). Invasion of fall armyworm (*Spodoptera frugiperda*) in India: Nature, distribution, management and potential impact. Current Science. 119(1): 44-51. DOI: 10.18520/cs/v119/i1/44-51.