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Assessment of yield losses due to fall armyworm in maize

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Abstract
Field experiments were carried out to evaluate the avoidable yield losses caused by fall armyworm, *Spodoptera frugiperda* on maize during *Kharif*, 2019-20 and 2020-21. The results of pooled data of both the years revealed that the mean larval population (1.04 larvae/plant), leaf and cob damage rating (2.40 and 1.22, respectively) at V_9 and R_3 crop stage respectively, were significantly lowest in protected plots over the unprotected plots (3.64 larvae/plant, 5.68 and 3.54, respectively). Highest grain yield was recorded in protected plots in comparison to the unprotected plots (50.62 and 33.93 q/ha, respectively) with an overall reduction of 32.93 %.

Keywords: Maize, *Spodoptera frugiperda*, leaf and ear damage rating, assessment of yield losses

1. Introduction
Maize (*Zea mays* L.) is one of the most important cereal crops which is able to thrive in a wide range of agro-climatic conditions. Maize is recognized as the "Queen of Cereals" around the world as it has the highest production potential among all the cereals. The United States of America (USA) is the world's largest producer of maize, accounting for over 36% of global production, and is also the backbone of the US economy. In India, maize is the third most important cereal crop after rice and wheat and is cultivated throughout the year. It accounts for about 10% of the country's total food grain production. It is used as a basic raw material in hundreds of industrial goods, including starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper sectors *etc.* (https://apeda.gov.in) [1].
During 2020, the world's total area, production and productivity under maize crop were 193.77 million hectare (mha), 1147 million metric tonnes (mmt) and 5.75 tonnes per ha, respectively. While India's total area, production and productivity were 9.72 mha, 29.00 mt and 2945 kg / ha, respectively. In Madhya Pradesh, maize is grown in about 1.34 mha, with an average yield of 3.91mt and an average productivity of 2921 kg/ha (http://www.mospi.gov.in) [9].
The fall armyworm (FAW), *Spodoptera frugiperda* (Smith) (Noctuidae: Lepidoptera**)** is one of the most serious insect pest 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) [10]. It's native to tropical and subtropical regions of Americas. In January 2016, FAW was first recorded on the African continent (Goergen *et al.*, 2016) [4]. In India *S. frugiperda* was reported for the first time in May 2018 in the maize fields of the University of Agricultural and Horticultural Sciences in Shivamogga, Karnataka (Sharanabasappa *et al.*, 2018) [11]. In Madhya Pradesh, it was first reported by Vishwakarma *et al.*, (2020) [13] on maize.

2. Material and Methods
During *kharif*, 2019-20 and 2020-21, field trials were conducted at the Zonal Agriculture Research Station, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Chandangaon, Chhindwara (MP). Studies on losses in maize grain yield due to *S. frugiperda* were carried out on variety JM-218 in 20 plots each of 60 m^2 size with spacing of 60 cm x 20 cm in two sets. One set of 10 plots were kept protected from insect infestation by applying insecticides on a regular basis and the remaining 10 plots were left as unprotected *i.e.*, natural infestation. At V_9 crop growth stage larval population and leaf damage whereas at R_3 crop stage, ear damage rating were recorded on 25 randomly selected plants from each plot from both the protected and

unprotected plots and were subjected to paired' test analysis. Leaf damage and ear damage were visually rated on 0 to 9 scale basis as proposed by Davis and Williams (1992) [3].Observations on number of larvae per plant were recorded by destruction sampling method as suggested by Hardke *et al.*, (2011) [5].The loss in grain yield due to *S. frugiperda* was calculated as follows:

$$\text{Loss in grain yield} = \frac{X_1 - X_2}{X_1} \times 100$$

Where, X_1 = Yield of protected plot
X_2 = Yield of unprotected plot

3. Result and Discussion

The data on larval counts, leaf and ear damage rating are presented Table 3.1 and depicted in Fig 3.1.

3.1. FAW larval population: The mean larval population during *kharif*, 2019-20 and 2020-21 was recorded to be 0.96 and 1.12 larvae/plant in protected plots whereas it was 3.24 and 4.04 larvae/plant in unprotected plots, respectively. The pooled mean larval population over both the years was significantly lowest in protected plots (1.04 larvae / plant), whereas it was 3.64 larvae / plant in unprotected plots and the reduction in the larval counts was 71.42%. Similar findings have been reported by Kumari *et al.*, (2020) [7], as they reported 68.30% reduction in larval population of FAW.

3.2. Leaf damage rating: The mean leaf damage rating during *kharif*, 2019-20 and 2020-21 was recorded to be 2.12 and 2.68 in protected plots, whereas it was 5.20 and 6.16 in unprotected plots, respectively. The mean rating of the pooled data revealed that it was significantly lowest in protected plots as compared to the unprotected plots (2.40 and 5.68, respectively). The extent of reduction in the leaf damage rating was about 57.74 %. Similar findings have been reported by Kumar *et al*., (2020) [6], as they found that the reduction in leaf damage due to FAW infestation was about 74.20 %.

3.3. Ear damage rating: The mean ear damage rating during *kharif*, 2019-20 and 2020-21 was recorded to be 1.16 and 1.28 in protected plots whereas it was 3.12 and 3.96 in unprotected plots, respectively. Perusal of the pooled data revealed that it was significantly lowest in protected plots (1.22), whereas it was 3.54 in unprotected plots with reduction of about 65.53%. The results are in agreement with the findings of Suthar *et al.*, (2020) [12], as they reported that the reduction in ear damage due to *S. frugiperda* infestation was about 45.10%.

3.4. Grain yield: The mean grain yield during *kharif*, 2019-20 and 2020-21 was recorded to be 51.60 and 49.65 q/ha in protected plots, whereas it was 35.45 and 32.42 q/ha in unprotected plots, respectively. Pooled mean grain yield over years was significantly highest in protected plots (50.62 q/ha), whereas it was 33.93 q/ha in unprotected plots, and about 50% yield losses were registered. The present findings confirms the findings of Lima *et al*., (2010) [8] and Balla *et al.*, (2019) [2], as they recorded grain yield losses of 34 and 32% due to FAW infestation, respectively.

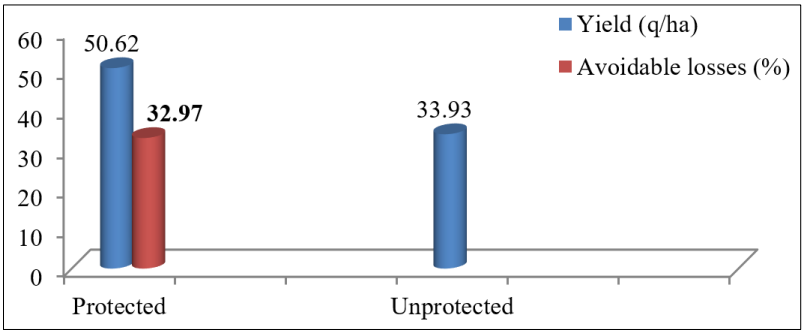

Fig 3.1: Maize grain yield avoidable losses due to *S. frugiperda* (Pooled data of two years)

Table 3.1: Impact of plant protection on *S. frugiperda* damage and grain yield in *kharif* maize.

Parameters	Crop stage	Protected			Unprotected			t cal #			Reduction (-) / increase over unprotected (+) #		
		I	II	Pooled	I	II	Pooled	I	II	Pooled	I	II	Pooled
Mean no. of larvae/plant	V_9	0.96	1.12	1.04	3.24	4.04	3.64	12.79	16.93	17.02	(-)70.37	(-)72.27	(-) 71.42
Mean leaf damage rating*	V_9	2.12	2.68	2.40	5.20	6.16	5.68	11.14	13.78	15.31	(-)59.23	(-)56.49	(-) 57.74
Mean ear damage rating*	R_3	1.16	1.28	1.22	3.12	3.96	3.54	11.65	11.70	17.18	(-)62.82	(-)67.67	(-) 65.53
Yield (q/ha)	At maturity	51.60	49.65	50.62	35.45	32.42	33.93	8.34	8.28	8.44	(+)31.39	(+)34.70	(+)32.97

*Damage rating = 1-9 scale I= 2019-20 II= 2020-21
V9 = Collar of 9th leaf visible R3 = Milking stage # Significant at 1%
t tab value at 5% df = 2.06 and at 1% df = 2.79

4. Conclusion

In the present study, protected plots registered a considerable reduction in damage caused by *S. frugiperda* when compared to unprotected plots and registered about 50 percent grain yield losses, which can be avoided by adopting integrated management strategies.

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