The Pharma Innovation Journal 2022; 11(11): 232-234

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 232-234

www.thepharmajournal.com
Received: 28-08-2022
Accepted: 03-10-2022

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A review on the role of morphological and physiological traits of maize against fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

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Abstract

Spodoptera frugiperda (J.E. Smith), commonly known as the fall armyworm (FAW), has an adverse effect on the sustainability of maize production, primarily in small and marginal farms in India. Pesticide application is currently the main method used to control FAW in India. Given the negative consequences of pesticides on natural enemies, as well as the challenges of resurgence and resistance, it is necessary to develop the resistant cultivars which provides an effective control of FAW. Host plant resistance (HPR) has typically been one of the sustainable, eco-friendly and economical technique in Integrated Pest Management (IPM). Morphological and physiological traits which represents the antixenosis & tolerance in HPR imparts resistance or tolerance against feeding and oviposition by the fall armyworm. Both morphological and physiological attributes play a key part in HPR.

Keywords: HPR, morphological, fall armyworm, resistance, correlation

Introduction

Maize (*Zea mays* L.), popularly known as the Queen of Cereals, is the world's third most significant food crop, trailing only wheat and rice (Prasanna *et al.*, 2001) [14]. It can be cultivated all over the world under a multitude of agro-climatic conditions and has a high production potential among cereals (Singh and Jaglan, 2018) [18]. Maize occupies over 193.7 million hectares globally and is grown in over 170 countries, producing 1147.7 million MT with a mean productivity of 5.75 tonnes per hectare. India placed fourth in area and seventh in production, accounting for 4.6% of global maize area and 2.4% of overall production (FAOSTAT, 2020) [9]. Maize has been identified as a crop with the potential to double farmers' income.

Several biotic and abiotic variables affected the maize productivity. Among biotic factors, nearly 141 insect pests are known to cause varied degrees of damage to maize from planting to harvest (Reddy and Trivedi, 2008) [17]. However, because of the extravagant polyphagous nature, the recent invasion of the Fall armyworm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is of utmost significance. The fall armyworm (FAW) is native to the Western Hemisphere's tropical regions (North and South America) (Nagoshi, 2009) [13]. FAW has migrated to more than 109 countries in Africa, the Middle East, and Asia (FAO, 2020) [18]. In India, it was initially recorded in Karnataka in May 2018 (Ganiger *et al.*, 2018) [10]. Afterwards, it quickly migrated across the country, infesting the maize crop in all growing areas (Rakshit *et al.*, 2019) [15]. It is a destructive polyphagous pest that feeds on over 350 plant species (Montezano *et al.*, 2018) [12], responsible for considerable yield losses in major agricultural crops like maize, cotton, soybeans, and beans (Bueno *et al.*, 2010) [5]. FAW has been observed to cause as much as 33% yield loss in maize (Aruna Balla *et al.*, 2019) [3].

In 2018-2019, Telangana witnessed outbreak of FAW on maize (*Kharif*, with 3-60% infestation and *Rabi* with 30.8% infestation) (Lavakumar *et al.*, 2019) [11]. FAW has spread to 15 Telangana districts in less than a year. Fall armyworm multiplies quickly in a short time period owing to the hot, humid weather (between 20° and 32 °C) and widespread maize cultivation in the state. As a result, Telangana is designated as one of the hotspot areas of fall armyworm infestation. A wide variety of cultivars are being grown by farmers throughout the state, however to combat FAW, the cultivars with the best crop vigour and inbuilt natural resistance are most desirable.

However, the information that is currently accessible on FAW management is inadequate and scarce. Host plant resistance has the potential to be a valuable tool in FAW management (Day *et al.*, 2017) [7].

Some of the wild Maize germplasm acts as a source of resistant genes for developing a resistant variety. The main sources of resistance were variations in physiological and morphological traits of plant, which had a significant impact on insect pest population and producing higher yield. Therefore, the development of resistant cultivars can be a safe and reliable management strategy to manage the FAW.

Some of the important morphological & physiological traits were

1. Trichome density

The reduced leaf damage in maize genotypes might be due to interference caused by trichomes during egg laying and feeding. Trichomes were observed to act as a physical barrier to the chewing damage caused by the fall armyworm, which had prevented the swallowing of leaf tissue and influenced the digestion and absorption of the food by the fall armyworm. Rasool *et al*. (2017) [16] reported similar kind of results when they studied the antixenosis mechanism in various maize genotypes against *Chilo partellus*. They stated that leaf trichomes had a significant negative correlation (r= -0.625) with stem borer infestation.

A similar study was conducted by. Ali *et al*. (2015) [2] who reported that trichome density plays a significant role in conferring resistance to stem borer in maize with a correlation value of (r= -0.866), which supports the current findings. Somashekar (2020) [19], who observed a highly significant and negative correlation between trichome density and fall armyworm leaf damage in maize (r= -0.821). These studies suggested that increased trichomes confer resistance to the fall armyworm.

2. Leaf thickness

An increase in leaf thickness could resist the feeding by damaging the mandibles of the larvae. Williams *et al*. (1998) [20], who reported that the leaves of the resistant maize genotypes (Mp 704 X Mp 707 and Mp 704 X Mp 708) have been much thicker (5.5µm and 5.6µm) than those of the susceptible ones, Ab24E X Mp 305 and SC 229 X T X 601 (2.2µm and 2.8µm), when evaluated against the fall armyworm. And also, Bergvinson *et al*. (1994) [4] recorded a significant negative relationship between leaf thickness and leaf damage caused by *O. nubilalis* was observed at mid whorl stage in maize.

Similarly, Davis *et al*. (1995) [6] who recorded that the maize lines, which have 1.7 times thicker cuticles as compared to susceptible genotypes, confer resistance to the fall armyworm. Based on above information, it can be inferred that an increase in leaf thickness minimises the fall armyworm's leaf damage by interfering with feeding.

3. Leaf length

Since fall armyworm is primarily seen in the whorl-foliar regions & confined to basal part of the leaves, leaf length seems to have no significant influence in imparting resistance to fall armyworm. So, increase or decrease in leaf length might have been no impact on fall armyworm. More recurrent research is required in this regard.

4. Cob length

Resistant genotypes had a much greater cob length than susceptible lines due to the innate mechanism called tolerance, by which plants withstand pest attack and grow normally. A better rate of photosynthesis also contributes to a higher economic yield which correlates positively with cob lengths in superior genotypes. Rasool *et al*. (2017) [16] recorded that there was a strong and negative correlation between maize cob length and leaf feeding injury caused by fall armyworm (r= -0.767). Similar results were noticed by Ali *et al*. (2015) [2], who found that cob length had a significant negative correlation with *C. partellus* infestation in maize (r= -0.585).

5. Cob width

Because of the well-developed kernels and thick rind, increased cob width could deter the fall armyworm. As a result, robust cobs were less likely to be damaged by fall armyworm. So, we can say that fall armyworm leaf damage had a negative correlation with cob width. This might be due to the fact that the higher the infestation, the lesser the kernel development in the cob. However, there isn't enough literature that correlates cob width to fall armyworm infestation.

6. Grain Yield

The reduced yield in susceptible maize genotypes was mainly due to greater infestation of fall armyworm larvae, which hinder photosynthesis by feeding on foliage. It also feeds on tassels, silk, and developing cobs. A tolerant plant with good vigour produces more grain yield. Somashekar (2020) [19] recorded the highest test weight in a partially resistant maize hybrid, P 3405 (30.22 g). Whereas the highly susceptible hybrid NK 6240 (17.33 g) produced a lower yield, which supports our findings. Afzal *et al*. (2009) [1] found a significant negative correlation (r= -0.559**) with the *C. partellus* infestation and 100 maize grains weight. Similarly, Ali *et al*. (2015) [2] also observed a significant negative correlation (r= -0.677) between *C. partellus* and 100 maize grains weight. Thus, it can be stated that grain yield had an inverse correlation with leaf damage by fall armyworm.

Conclusion

Finally, it can be inferred that, with the exception of leaf length, features such as trichome density, leaf thickness, and all other ear traits shown a negative correlation with the fall armyworm damage.

Physiological and morphological features were found to have a significant impact on damage caused by fall armyworm and played a key role in conferring resistance to fall armyworm in maize genotypes.

Acknowledgment

I give my ever-loving parents, Sri. M.C. Ashok Kumar and Smt. K.M. Dhakshayani, the utmost respect and wholehearted admiration for their selfless efforts and motivation. I believe it is my honour to express my profound respect, admiration and indebtedness to Dr. J.C. Sekhar, Principal Scientist, & I/C, Winter Nursery Centre, ICAR-IIMR, Rajendranagar, Hyderabad for his compassionate mentoring and constant assistance.

Conflict of Interest

None.

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