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Screening of different genotypes of maize against fall armyworm, *Spodoptera frugiperda* (J. E. Smith)

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Abstract
At the N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, during the summer of 2022, an investigation on the screening of eight different maize genotypes (GYH-1803, GYH-2009, GYH-1603, GYH-0952, GYH-1915, GYH-1801, GYH-1701, and GYH-1509) against fall armyworm was conducted. Three replications and a randomized block design were used to set up the experiment. The crop was planted with a 60 x 20 cm spacing. Based on leaf damage the maize genotypes, GYH-1509 and GYH-1701 were found moderately resistant however based on cob damage GYH-1801 genotype was found moderately resistant against fall armyworm. The ascending order of different maize genotypes was GYH-0952 > GYH-1603 = GYH-2009 = GYH-1701 > GYH-1915 = GYH-1509 = GYH-1803 > GYH-1801 as far as larval population on vegetative parts whereas, GYH-1509 > GYH-1803 = GYH-2009 = GYH-1603 = GYH-1915 > GYH-0952 = GYH-1801 = GYH-1701 on larval population in cob. In relation to susceptibility based on leaf damage, the descending order of genotype was GYH-1603 > GYH-1803 > GYH-2009 =GYH-0952 > GYH-1915 > GYH-1801 > GYH-1701 > GYH-1509 whereas based on damage in cob it was GYH-1803 = GYH-2009 > GYH-0952 > GYH-1603 = GYH-1915 > GYH-1701 = GYH-1509 > GYH-1801.

Keywords: Fall armyworm, *Spodoptera frugiperda*, screening, maize

Introduction
The name “fall armyworm” originates from the nature of the damage, where infestations sometimes look like an army, as they move across large agricultural fields and earned their common name by eating all plant materials, they encounter in their wide dispersals, like a large army (Smith, 1797) [27]. Due to its migrant behavior, the fall armyworm is considered as sporadic pest.

The fall armyworm, *S. frugiperda* is an insect native to tropical and subtropical regions of America. Fall armyworm larvae can feed on more than 100 plant species, including maize, rice, sorghum, millet, sugarcane, vegetable crops and cotton. It can cause substantial yield losses. Recently, Montezano *et al*. (2018) [16] reported 353 plant species as hosts in America, distributed in 76 families, mainly Poaceae (106 species), Asteraceae (31 species) and Fabaceae (31 species). As a polyphagous pest, *S. frugiperda* consumes almost any plant parts of its hosts. On young corn, larvae feed on the surface of leaves leaving only white papery patches, called window panes. Older larvae consume more tissues, with stronger mandibles, cut large portions of plant tissues with high silica content and include seedlings, foliage, tassels, cobs, husks, and developing kernels (Pogue 2002; Brown and Dewhurst 1975, Goergen *et al.* 2016) [22, 3, 10]. The scientific name fall armyworm, *S. frugiperda* is derived from the feeding habits of the larval life stage, *frugiperda* meaning “lost fruit” in Latin, as the pest can cause damage to crops resulting in severe yield loss. FAW is a caterpillar, not a “worm”. As befits its name, which evokes an impression of mass trooping of larvae alike to an army, creating havoc in its path. (Naganna *et al*., 2020) [17]. *S. frugiperda* is widely distributed in the Americas, occurring from South Central to Eastern Canada, coast to coast in the United States, south to Argentina and throughout the Caribbean (EPPO, 2015) [7]. The fall armyworm was first detected in Central and Western Africa in early 2016 (Benin, Nigeria, Sao Tome and Principe, and Togo). In 2018, this notorious pest has reported for the first time in the Shivamogga district of Karnataka in South India (Sharanabasappa *et al*., 2018a) [24]. It is also reported from various states of India *viz*., Karnataka, Tamil Nadu, Maharashtra, Telangana, Andhra Pradesh and Gujarat infesting maize crop (Sisodiya *et al*., 2018; Ganiger *et al*., 2018; Sharanabasappa *et al*., 2018b, Mahadevaswamy *et al*., 2018) [26, 8, 25, 14].

The pest has been reported on other hosts *viz*., sorghum, bajra (Venkateswarlu *et al*., 2018) and sugarcane (Chormule *et al*., 2019) [32, 5] from India.

Farmers are growing a wide variety of commercial hybrids across the state, but the hybrids with good plant vigor and genetic resistance to crop pests were most preferred to combat the invasive alien insect pests. The use of insect-resistant cultivars is an important component of Integrated Pest Management (IPM) which provides an economic, stable and environmentally sound approach to minimize damage from borer pests (Rasool *et al*., 2017) [23]. The morphological traits play an important role in host plant resistance. Morphological traits are responsible for the suitability/preference of a cultivar for feeding and oviposition to fall armyworms. Moreover, as the fall armyworm is a devastating pest it is desirable to explore viable alternative and environmentally friendly methods like plant resistance.

Materials and Methods

The investigation was undertaken at Navsari, which is geographically situated in the coastal region of South Gujarat at 20°92' North latitude and 72°90' East longitude with an altitude of 11.98 meters above the mean sea level. The weather during the growing season was normal and favorable for crop growth. Five plants from the net plot were randomly selected for the observation of a number of larvae. The observation was recorded at weekly intervals starting from two weeks after sowing till the harvest of the crop. The infestation of fall armyworm on different genotypes of maize was recorded at the phenological stages of the plant based on leaf and cob damage under natural infestation. The highest values of the observed pest population of the respective genotype were considered for the statistical analysis.

The data regarding the foliar damage by the fall armyworm was recorded with a few modifications in the damage scale given by Davis and Williams (1992) [6] and finally damage index was worked out.

Table 1: Score rating of leaf damage by the *S. frugiperda*

Scale	Description
0	No damage
1	Pinholes on leaf
2	Shot holes on leaf
3	Elongated lesion(s) up to 2.5 cm
4	Lesion(s) measurement: 2.5 to 5.0 cm and/or 2 to 5 ears/5 plants damaged at growing stage
5	Lesion measurement: >5 cm and/or >6 ears/5plants damaged at growing stage or total destruction with dead heart

$$\text{Damage Index} = \frac{0 \times (No.of\ leaves) + 1 \times (No.of\ leaves) + 2 \times (No.of\ leaves) + 3 \times (No.of\ leaves) + 4 \times (No.of\ leaves) + 5 \times (No.of\ leaves)}{Total\ No.of\ leaves}$$

The genotypes were categorized as highly resistant, moderately resistant, less resistant, less susceptible, moderately susceptible and highly susceptible.

Table 2: Categories based on leaf damage grade rating

Grade	Category
0	Highly resistant
0.1-1.0	Moderately resistant
1.1-2.0	Less resistant
2.1-3.0	Less susceptible
3.1-4.0	Moderately susceptible
4.1-5.0	Highly susceptible

The data regarding the damage of cob was scored as per the damage scale given by Davis and Williams (1992) [6] with minute changes at the harvesting time of the crop. The genotype was categorized as highly resistant, moderately resistant, less resistant, moderately susceptible and highly susceptible.

Table 3: Score rating of corn damage and categories based on cob damage grade rating (observations of 5 plants at harvest)

Grade	Description	Category
0	No damage to any ears	Highly resistant
1	Tip (<3 cm) damage to 1-3 ears	Moderately resistant
2	Tip (<3 cm) damage to 4-7 ears and tip (>3 cm) damage to 1-3 ears	Less resistant
3	Tip damage to 7 and/or more ears and damage to 1-5 kernels below ear tips on 1 to 5 ears	Moderately susceptible
4	Ear tip damage to all ears and 5 or more kernel destroyed below tips of 6-10 ears	Highly susceptible

Categorization

Descriptive statistics was applied through the calculation of the arithmetic mean ($\bar{X}$) and standard deviation (σ) of observations. Based on the computation of $\bar{X}$ and σ, the categorization of different varieties was done using the following methods of susceptibility (Ghetiya, 2010).

Table 4: Categorization of genotypes/ cultivar

Category of resistance	Scale for resistance
$X_i < \bar{X} - 2\sigma$	Highly resistance
$X_i < \bar{X} - 1\sigma$	Moderately resistance
$\bar{X} - 1\sigma < X_i < \bar{X}$	Less resistance
$\bar{X} + 1\sigma > X_i > \bar{X}$	Less susceptible
$\bar{X} + 1\sigma < X_i < \bar{X} + 2\sigma$	Moderately susceptible
$X_i > \bar{X} + 2\sigma$	Highly susceptible

X_i = i^{th} number of observations

Results and discussion

Categorization of maize genotypes

Based on the intensity of larval population, leaf damage and cob damage the maize genotypes were categorized into five different groups.

Larval population at the vegetative stage

The details of categorization based on the larval population is presented in Table 1 and depicted in fig. 1.

At three weeks after sowing, the genotypes GYH-0952, GYH-1603 and GYH-1801 were categorized as less resistant (1.88 to 2.87 larvae/plant) on the larval population (Table 1). While, GYH-1509, GYH-1701, GYH-1915 and GYH-2009 showed 2.87 to 3.86 larvae/plant and were categorized as less susceptible. The larval population of GYH-1803 was recorded as greater than 4.85 larvae/plant and it was categorized as highly susceptible genotype against fall armyworm. None of the genotypes was reported as highly resistant, moderately resistant and moderately susceptible categories.

Larval population at four weeks after sowing was 3.65 to 5.88 larvae/plant on the genotypes GYH-0952, GYH-1509, GYH-1603 and GYH-1915 and these genotypes were placed in the less resistant category (Table 1). While, GYH-1803, GYH-1801 and GYH-1701 recorded larval population between 5.88 to 8.11 larvae/plant and categorized as less susceptible genotypes. The GYH-2009 ranked as a highly susceptible genotype which had more than 10.34 larvae/plant. In the remaining groups *i.e*., highly resistant, moderately resistant and moderately susceptible none of the genotypes was customized.

The larval population at five weeks after sowing, GYH-1701 displayed less than 5.99 larvae/plant, which was categorized as moderately resistant against fall armyworm (Table 1). The genotypes GYH-1509, GYH-1915 and GYH-0952 showed less resistance reaction (5.99 to 8.38 larvae/plant), however, GYH-1603 and GYH-2009 exhibited less susceptible reaction against fall armyworm (8.38 to 10.77 larvae/plant). Whereas, GYH-1803 and GYH-1801 were stated as moderately susceptible genotypes as they recorded 10.77 to 13.16 larvae/plant. None of the genotypes exhibited highly resistance and highly susceptible response to fall armyworm.

At six weeks after sowing, the larval population in the genotypes GYH-1701, GYH-1603, GYH-2009, GYH-1803 and GYH-1801 were 4.32 to 6.75 larvae/plant which ranked as less resistant against fall armyworm. Similarly, GYH-0952 had 6.75 to 9.18 larvae/plant and was placed as a less susceptible genotype, whereas GYH-1509 and GYH-1915 were found moderately susceptible genotypes against fall armyworm with a record of 9.18 to 11.61 larvae/plant. None of the genotypes was reported as highly resistant, moderately resistant and highly susceptible against fall armyworms.

The larval population at seven weeks after sowing showed less than 2.46 larvae/plant in GYH-1701 which was categorized as a moderately resistant genotype. While, GYH-0952, GYH-2009, GYH-1801 and GYH-1509 were categorized as less resistant genotypes against fall armyworms in which population ranged from 2.46 to 3.38 larvae/plant. The genotypes GYH-1915 and GYH-1803 exhibited 3.38 to 4.30 larvae/plant which placed them in a less susceptible category. A genotype GYH-1603 was found moderately susceptible to fall armyworm (4.30 to 5.22 lavae/plant). None of the genotypes occupied their place in highly resistant and highly susceptible groups.

The larval population at eight weeks after sowing, GYH-1803 (less than 4.79 larvae/plant), GYH-1603, GYH-1701 and GYH-1801 (4.79 to 7.75 larvae/plant), GYH-2009 and GYH-1509 (7.75 to 10.71 larvae/plant), GYH-0952 and GYH-1915 (10.71 to 13.67 larvae/plant) categorized as moderately resistant, less resistant, less susceptible and moderately susceptible against fall armyworm**,** respectively.

At nine weeks after sowing, GYH-1801 (less than 2.44 larvae/plant), GYH-1915, GYH-1509 and GYH-1803 (larval population between 2.44 and 3.63 larvae/plant), GYH-1603, GYH-2009 and GYH-1701 (3.63 to 4.82 larvae/plant), GYH-0952 (4.82 to 6.01 larvae/plant) categorized moderately resistant, less resistant, less susceptible and moderately susceptible respectively, against fall armyworm.

Larval population at the cob stage

At ten weeks after sowing, the larval population in the genotypes GYH-1509, GYH-1801 and GYH-1803 1.93 to 3.00 larvae/plant and were categorized as less resistant against fall armyworm (Table 1). Similarly, GYH-1603, GYH-1915, GYH-1701 and GYH-2009 recorded 3.00 to 4.07 larvae/plant and were categorized as less susceptible. Moderately susceptible ranked attained by GYH-0952 with a larval population from 4.07 to 5.14 larvae/plant. None of the genotypes exhibited highly resistance, moderately resistance and highly susceptible reactions.

The larval population at eleven weeks after sowing, GYH-1701 recorded less than 0.64 larvae/plant and hence it was considered as moderately resistant genotype. GYH-1801, GYH-1915, GYH-0952, GYH-1603 and GYH-1803 placed in the less resistant category (0.64 to 1.13 larvae/plant). In the moderately susceptible group, GYH-1509 and GYH-2009 showed 1.77 to 2.41 larvae/plant. None of the genotypeswere placed under highly resistant, less resistant and highly susceptible categories.

At twelve weeks after sowing the larvae/plant was less than 0.05 in GYH-1701, GYH-1801 and GYH-0952 which was categorized as a moderately resistant genotype. Less susceptible category included GYH-1915, GYH-1603, GYH-2009 and GYH-1803 (0.75 to 1.45 larvae/plant). Similarly, moderately susceptible genotype GYH-1509 showed a larval population between 1.45 to 2.15 larvae/plant. None of the genotypes were noticed under the highly resistant as well as highly susceptiblecategories.

In general, the infestation of *S. frugiperda* observed throughout crop development stages and indicated that the larval population in the vegetative phase was remained higher as compared to the reproductive phase irrespective of the genotypes. The highest (12.0 larvae/plant) larval population of fall armyworm in vegetative stage was noted in GHY-1801, whereas the lowest (6.0 larvae/plant) in GHY-1701.

Similarly, the highest (5.0 larvae/plant) larval population of fall armyworm as cob damage was noted in GHY-0952 whereas the lowest (2.00 larvae/plant) in GHY-1803, GHY-1801 and GHY-1509. Somashekhar (2020) [28] reported 1.75 to 5.95 larvae per plant in different hybrids at the vegetative phase. Ghetiya (2010) [9] observed variation in larval population of different pod borer (*Helicoverpa armigera* (Hubner), *Exelastis atomosa* and *Lampides boeticus* L.) at the reproductive phase in 16 genotypes of pigeonpea. Wiseman *et al.* (1981) [33] who recovered fewer larvae of fall armyworm from the resistant genotypes and a higher number of larvae from the susceptible lines after artificial infestation at five and ten leaf stage of the crop.

Categorization based on extent of damage

Leaf damage

At three weeks after sowing the leaf damage in GYH-1603 and GYH-1915 showed moderately resistance reaction with less than 1.49 damage index. Similarly, GYH-2009 had 1.49 to 1.78 damage index and was placed in less resistant category. Similarly, GYH-1803, GYH- 1701, GYH-1801 and GYH-1509 were found less susceptible by accounting 1.78 to 2.07 damage index. GYH-0952 was found moderately susceptible by accounting 2.07 to 2.36 damage index (Table 2).

GYH-1915 showed less than 2.10 damage index at four weeks after sowing and was ranked in the moderately resistant category (Table 2). Similarly, the damage index for GYH-1803, GYH-1603, GYH-1801 and GYH-1509 was found between 2.10 to 2.88 and placed in less resistant category. Whereas, GYH-1701 ranked as a less susceptible genotype (2.88 to 3.66 damage index). GYH-0952 and GYH-2009 ranked as moderately susceptible genotypes (3.66 to 4.44 damage index).

At five weeks after sowing GYH-1701, GYH-1915 and GYH-1509 genotupes showed less than 3.56 damage index and was categorized as moderately resistant. While GYH-1803 displayed between 3.56 to 4.13 damage index and was categorized as a less resistant genotype. GYH-1603 and

GYH-0952 exhibited 4.13 to 4.70 damage index and hence they were placed in the less susceptible category (Table 2). GYH-1801 and GYH-2009 showed moderately susceptible reactions with 4.70 to 5.27 damage index.

Less than 3.74 damage index was exhibited by GYH-1603 at six weeks after sowing and exhibited moderately resistance reaction (Table 2). Similarly, GYH-1509, GYH-1701 and GYH-0952 showed 3.74 to 4.08 damage index and were placed in the less resistant category. The less susceptible reaction was noticed in GYH-1803, GYH-2009 and GYH-1915 with 4.08 to 4.42 damage index. GYH-1801 recorded 4.42 to 4.76 damage index and was classified as a moderately susceptible category.

At seven weeks after sowing, the leaf damage in GYH-2009, GYH-0952, GYH-1801, GYH-1701 and GYH-1509 showed 2.84 to 3.38 damage index, which categorized as less resistant. Similarly, GYH-1803 displayed 3.38 to 3.92 damage index and was placed in the less susceptible category. GYH-1915 and GYH-1603 exhibited moderately susceptible reactions with 3.92 to 4.46 damage index (Table 2). The leaf damage indices were reduced as the plant growth increased at seven weeks after sowing in comparison with the younger stage of maize.

The leaf damage at eight weeks after sowing in GYH-1801 (less than 1.52 damage index), GYH-1701, GYH-1509, GYH-1915 and GYH-2009 (1.52 to 2.55 damage index), GYH-0952, GYH-1803 and GYH-1603 (3.58 to 4.61 damage index) categorized moderately resistant, less resistant and moderately susceptible, respectively.

Similarly leaf damage at nine weeks after sowing in GYH-1509 and GYH-1701 (less than 2.69 damage index), GYH-1801 (2.69 to 3.28 damage index), GYH-1915, GYH-0952, GYH-2009 and GYH-1803 (3.28 to 3.87 damage index), GYH-1603 (3.80 to 4.46 damage index) categorized moderately resistant, less resistant, less susceptible and moderately susceptible, respectively (Table 2).

Table 1: Categorization of maize genotypes for susceptibility to fall armyworm, *S. frugiperda* based on larval population

Category of susceptibility/resistance	Range of larval population	No. of larvae/plant	No. of Genotypes	Name of Genotypes
A. Vegetative stage				
3 WAS ($\bar{X}$ = 2.87, σ = 0.99, $\bar{X}$ - σ =1.88, $\bar{X}$ - 2σ = 0.89, $\bar{X}$ + σ = 3.86, $\bar{X}$+2σ = 4.85)				
HR	X_i< 0.89	-	0	---
MR	X_i< 1.88	-	0	---
LR	1.88 < X_i< 2.87	2	3	GYH-0952, GYH-1603, GYH-1801
LS	3.86 > X_i> 2.87	3	4	GYH-1509, GYH1701, GYH-1915, GYH-2009
MS	3.86 < X_i< 4.85	-	0	---
HS	> 4.85	5	1	GYH-1803
4 WAS ($\bar{X}$ = 5.88, σ = 2.23, $\bar{X}$ - σ = 3.65, $\bar{X}$ - 2σ = 1.22, $\bar{X}$ + σ = 8.11, $\bar{X}$ + 2σ = 10.34)				
HR	X_i< 1.42	-	0	---
MR	X_i< 3.65	-	0	---
LR	3.65 < X_i< 5.88	4 and 5	4	GYH-0952, GYH-1509. GYH-1603, GYH-1915
LS	8.11 > X_i> 5.88	6	3	GYH-1803, GYH-1801 GYH-1701
MS	8.11 < X_i< 10.34	-	0	---
HS	>10.34	11	1	GYH-2009
5 WAS ($\bar{X}$ = 8.38, σ = 2.39, $\bar{X}$ - σ = 5.99, $\bar{X}$ - 2σ = 3.60, $\bar{X}$ + σ =10.77, $\bar{X}$ + 2σ = 13.16)				
HR	X_i< 3.60	-	0	---
MR	X_i< 5.99	5	1	GYH-1701
LR	5.99 < X_i< 8.38	6, 7 and 8	3	GYH-1509, GYH-1915 GYH-0952
LS	10.77 > X_i> 8.38	9	2	GYH-1603, GYH-2009
MS	10.77 < X_i< 13.16	11 and 12	2	GYH-1803, GYH-1801
HS	>13.16	-	0	---
6 WAS ($\bar{X}$ = 6.75, σ = 2.43, $\bar{X}$ - σ = 4.32, $\bar{X}$ - 2σ = 1.89, $\bar{X}$ + σ = 9.18, $\bar{X}$ + 2σ = 11.61)				
HR	X_i< 1.89	-	0	---
MR	X_i< 4.32	-	0	---
LR	4.32 < X_i< 6.75	5 and 6	5	GYH-1701, GYH-1603, GYH-2009, GYH-1803, GYH-1801
LS	9.18 > X_i> 6.75	7	1	GYH-0952
MS	9.18 < X_i< 11.61	10 and 11	2	GYH-1509, GYH-1915
HS	>11.61		0	---
7 WAS ($\bar{X}$ = 3.38, σ = 0.92, $\bar{X}$ - σ = 2.46, $\bar{X}$ - 2σ = 1.54, $\bar{X}$ + σ = 4.30, $\bar{X}$ + 2σ = 5.22)				
HR	X_i< 1.54	-	0	---
MR	X_i< 2.46	2	1	GYH-1701
LR	2.46 < X_i< 3.38	3	4	GYH-0952, GYH-2009 GYH-1801, GYH-1509
LS	4.30 > X_i> 3.38	4	2	GYH-1915, GYH-1803
MS	4.30 < X_i< 5.22	5	1	GYH-1603
HS	>5.22	-	0	---
8 WAS ($\bar{X}$ = 7.75, σ = 2.96, $\bar{X}$ - σ = 4.79, $\bar{X}$ - 2σ = 1.83, $\bar{X}$ + σ = 10.71 $\bar{X}$ + 2σ = 13.67)				
HR	X_i< 1.83	-	0	---
MR	X_i< 4.79	3	1	GYH-1803
LR	4.79 < X_i< 7.75	5, 6 and 7	3	GYH-1603, GYH-1701 GYH-1801

LS	$10.71 > X_i > 7.75$	9 and 10	2	GYH-2009, GYH-1509
MS	$10.71 < X_i < 13.67$	11	2	GYH-0952, GYH-1915
HS	>13.67	-	0	---
9 WAS ($\bar{X}$ = 3.63, σ = 1.19, $\bar{X}$ - σ = 2.44, $\bar{X}$ - 2σ = 1.25, $\bar{X}$ + σ = 4.82, $\bar{X}$ + 2σ = 6.01)				
HR	$X_i < 1.25$	-	0	---
MR	$X_i < 2.44$	2	1	GYH-1801
LR	$2.44 < X_i < 3.63$	3	3	GYH-1915, GYH-1509, GYH-1803
LS	$4.82 > X_i > 3.63$	4	3	GYH-1603, GYH-2009, GYH-1701
MS	$4.82 < X_i < 6.01$	6	1	GYH-0952
HS	>6.01	-	0	---
B. Cob damage				
10 WAS ($\bar{X}$ = 3.00, σ = 1.07, $\bar{X}$ - σ = 1.93, $\bar{X}$ - 2σ = 0.86, $\bar{X}$ + σ = 4.07, $\bar{X}$ + 2σ = 5.14)				
HR	$X_i < 0.86$	-	0	---
MR	$X_i < 1.93$	-	0	---
LR	$1.93 < X_i < 3.00$	2	3	GYH-1509, GYH-1801, GYH-1803
LS	$4.07 > X_i \geq 3.00$	3	4	GYH-1603, GYH-1915, GYH-1701, GYH-2009
MS	$4.07 < X_i < 5.14$	5	1	GYH-0952
HS	>5.14	-	0	---
11 WAS ($\bar{X}$ = 1.13, σ = 0.64, $\bar{X}$ - σ = 0.64, $\bar{X}$ - 2σ = -0.15, $\bar{X}$ + σ = 1.77, $\bar{X}$ + 2σ = 2.41)				
HR	$X_i < -0.15$	-	0	---
MR	$X_i < 0.64$	0	1	GYH-1701
LR	$0.64 < X_i < 1.13$	1	5	GYH-1801, GYH-1915, GYH-0952, GYH-1603 GYH-1803
LS	$1.77 > X_i > 1.13$	-	0	---
MS	$1.77 < X_i < 2.41$	2	2	GYH-1509, GYH-2009
HS	>2.41	-	0	---
12 WAS ($\bar{X}$ = 0.75, σ = 0.70, $\bar{X}$ - σ = 0.05, $\bar{X}$ - 2σ = -0.65, $\bar{X}$ + σ = 1.45, $\bar{X}$ + 2σ = 2.15)				
HR	$X_i < -0.65$	-	0	---
MR	$X_i < 0.05$	0	3	GYH-1701, GYH-1801, GYH-0952
LR	$0.05 < X_i < 0.75$	-	0	---
LS	$1.45 > X_i > 0.75$	1	4	GYH-1915, GYH-1603, GYH-2009, GYH-1803
MS	$1.45 < X_i < 2.15$	2	1	GYH-1509
HS	>2.15	-	0	---

HR- Highly resistance, MR- Moderately resistance, LR- Less resistance, LS- Less susceptible, MS- Moderately susceptible, HS- Highly susceptible

Table 2: Categorization of maize genotypes for susceptibility/resistance to fall armyworm, *S. frugiperda* based on leaf and cob damage

Category of Susceptibility/ Resistance	Index range	Damage Index	No. of Genotypes	Name of Genotypes
3 WAS ($\bar{X}$ = 1.78, σ = 0.29, $\bar{X}$ - σ = 1.49, $\bar{X}$ - 2σ = 1.20, $\bar{X}$ + σ = 2.07, $\bar{X}$ + 2σ = 2.36)				
HR	$X_i < 1.20$	-	0	---
MR	$X_i < 1.49$	1.40	2	GYH-1603, GYH-1915
LR	$1.49 < X_i < 1.78$	1.60	1	GYH-2009
LS	$2.07 > X_i > 1.78$	1.80 and 2.00	4	GYH-1803, GYH-1701 GYH-1801, GYH-1509
MS	$2.07 < X_i < 2.36$	2.20	1	GYH-0952
HS	>2.36	-	0	---
4 WAS ($\bar{X}$ = 2.88, σ = 0.78, $\bar{X}$ - σ = 2.10, $\bar{X}$ - 2σ = 1.32, $\bar{X}$ + σ = 3.66, $\bar{X}$ + 2σ = 4.44)				
HR	$X_i < 1.32$	-	0	---
MR	Xi < 2.10	1.60	1	GYH-1915
LR	$2.10 < X_i < 2.88$	2.40, 2.60 and 2.80	4	GYH-1803, GYH-1603 GYH-1801, GYH-1509
LS	$3.66 > X_i > 2.88$	3.20	1	GYH-1701
MS	$3.66 < X_i < 4.44$	3.80 and 4.00	2	GYH-0952, GYH-2009
HS	>4.44	-	0	---
5 WAS ($\bar{X}$ = 4.13, σ = 0.57, $\bar{X}$ - σ = 3.56, $\bar{X}$ - 2σ = 2.99, $\bar{X}$ + σ = 4.70, $\bar{X}$ + 2σ = 5.27)				
HR	$X_i < 2.99$	-	0	---
MR	$X_i < 3.56$	3.40 and 3.60	3	GYH-1701, GYH-1915 GYH-1509
LR	$3.56 < X_i < 4.13$	4.00	1	GYH-1803
LS	$4.70 > X_i > 4.13$	4.20 and 4.60	2	GYH-1603, GYH-0952
MS	$4.70 < X_i < 5.27$	4.80	2	GYH-1801, GYH-2009
HS	>5.27	-	0	---
6 WAS ($\bar{X}$ = 4.8, σ = 034, $\bar{X}$ - σ = 3.74, $\bar{X}$ - 2σ = 3.40, $\bar{X}$ + σ = 4.42, $\bar{X}$ + 2σ = 4.76)				
HR	$X_i < 3.40$	-	0	---
MR	Xi < 3.74	3.60	1	GYH-1603
LR	$3.74 < X_i < 4.08$	3.80 and 4.00	3	GYH-1509, GYH-1701 GYH-0952
LS	$4.42 > X_i > 4.08$	4.20 and 4.40	3	GYH-1803, GYH-2009

				GYH-1915
MS	$4.42 < X_i < 4.76$	4.60	1	GYH-1801
HS	>4.76	-	0	---
7 WAS ($\bar{X}$ = 3.38, σ = 0.54, $\bar{X}$ - σ = 2.84, $\bar{X}$ - 2σ = 2.30, $\bar{X}$ + σ = 3.92, $\bar{X}$ + 2σ = 4.46)				
HR	$X_i < 2.30$	-	0	---
MR	$X_i < 2.84$	-	0	---
LR	$2.84 < X_i < 3.38$	3.00 and 3.20	5	GYH-2009, GYH-0952 GYH-1801, GYH-1701 GYH-1509
LS	$3.92 > X_i > 3.38$	3.40	1	GYH-1803
MS	$3.92 < X_i < 4.46$	4.00 and 4.40	2	GYH-1915, GYH-1603
HS	>4.46	-	0	---
8 WAS ($\bar{X}$ = 2.55, σ = 1.03, $\bar{X}$ - σ = 1.52, $\bar{X}$ - 2σ = 0.49, $\bar{X}$ + σ = 3.58, $\bar{X}$ + 2σ = 4.61)				
HR	$X_i < 0.49$	-	0	---
MR	$X_i < 1.52$	1.40	1	GYH-1801
LR	$1.52 < X_i < 2.55$	1.60, 1.80, 2.00 and 2.40	4	GYH-1701, GYH-1509 GYH-1915, GYH-2009
LS	$3.58 > X_i > 2.55$	-	0	---
MS	$3.58 < X_i < 4.61$	3.60 and 4.00	3	GYH-0952, GYH-1803 GYH-1603
HS	>4.61	-	0	---
9 WAS ($\bar{X}$ = 3.28, σ = 0.59, $\bar{X}$ - σ = 2.69, $\bar{X}$ - 2σ = 2.10, $\bar{X}$ + σ = 3.87, $\bar{X}$ + 2σ = 4.46)				
HR	$X_i < 2.10$	-	0	---
MR	$X_i < 2.69$	2.40 and 2.60	2	GYH-1509, GYH-1701
LR	$2.69 < X_i < 3.28$	2.80	1	GYH-1801
LS	$3.87 > X_i > 3.28$	3.40, 3.60 and 3.80	4	GYH-1915, GYH-0952 GYH-2009, GYH-1803
MS	$3.87 < X_i < 4.46$	4.00	1	GYH-1603
HS	>4.46	-	0	---
10 WAS ($\bar{X}$ = 1.08, σ = 0.37, $\bar{X}$ - σ = 0.71, $\bar{X}$ - 2σ = 0.34, $\bar{X}$ + σ = 1.45, $\bar{X}$ + 2σ = 1.82)				
HR	$X_i < 0.34$	-	0	---
MR	$X_i < 0.71$	0.60	1	GYH-1701
LR	$0.71 < X_i < 1.08$	0.80 and 1.00	3	GYH-1803, GYH-2009 GYH-1801
LS	$1.45 > X_i > 1.08$	1.20	3	GYH-1915, GYH-1603 GYH-1509
MS	$1.45 < X_i < 1.82$	1.80	1	GYH-0952
HS	> 1.82	-	0	---
11 WAS ($\bar{X}$ = 1.88, σ = 0.43, $\bar{X}$ - σ = 1.45, $\bar{X}$ - 2σ = 1.02, $\bar{X}$ + σ = 2.31, $\bar{X}$ + 2σ = 2.74)				
HR	$X_i < 1.02$	-	0	---
MR	$X_i < 1.45$	1.20 and 1.40	2	GYH-1701, GYH-1801
LR	$1.45 < X_i < 1.88$	1.60	1	GYH-1509
LS	$2.31 > X_i > 1.88$	2.00 and 2.20	4	GYH-1915, GYH-1603 GYH-0952, GYH-2009
MS	$2.31 < X_i < 2.74$	2.40	1	GYH-1803
HS	> 2.74	-	0	---
12 WAS ($\bar{X}$ = 1.95, σ = 0.38, $\bar{X}$ - σ = 1.57, $\bar{X}$ - 2σ = 1.19, $\bar{X}$ + σ =2.33, $\bar{X}$ + 2σ = 2.71)				
HR	$X_i < 1.19$	-	0	---
MR	$X_i < 1.57$	1.40	1	GYH-1801
LR	$1.57 < X_i < 1.95$	1.60	2	GYH-1509, GYH-1701
LS	$2.33 > X_i > 1.95$	2.00 and 2.20	3	GYH-1915 GYH-0952, GYH-1603
MS	$2.33 < X_i < 2.71$	2.40	2	GYH-1803, GYH-2009
HS	>2.71	-	0	---

HR- Highly resistance, MR- Moderately resistance, LR- Less resistance, LS- Less susceptible, MS- Moderately susceptible, HS- Highly susceptible

Cob damage

The cob damage at ten weeks after sowing in GYH-1701 exhibited less than 0.71 damage index that was categorized as a moderately resistant genotype. Similarly, GYH-1803, GYH-2009 and GYH-1801 were demonstrated 0.71 to 1.08 damage index and placed in the less resistant category. GYH-1915, GYH-1603 and GYH-1509 were categorized as less susceptible genotypes (1.08 to 1.45 damage index). GYH-0952 took place in the moderately susceptible category having 1.45 to 1.82 damage index.

The cob damage at eleven weeks after sowing in GYH-1701 and GYH-1801 displayed less than 1.45 damage index. These genotypes were categorized as moderately resistant genotypes. Similarly, GYH-1509 exhibited 1.45 to 1.88 damage index and placed in a less resistant category. A less susceptible reaction was exhibited by GYH-1915, GYH-1603, GYH-0952 and GYH-2009 with 1.88 to 2.31 damage index. Whereas, GYH-1803 showed moderately susceptible reaction with 2.31 to 2.74 damage index.

The cob damage at twelve weeks after sowing, GYH-1801 displayed less than 1.57 damage index which was categorized as a moderately resistant genotype. Similarly, GYH-1509 and GYH-1701 placed in a less resistant category which had 1.57

to 1.95 damage index. GYH-1915, GYH-0952 and GYH-1603 were categorized as less susceptible genotypes (1.95 to 2.33 damage index). Similarly, GYH-1803 and GYH-2009 were placed in the moderately susceptible category (2.33 to 2.71 damage index).

The present findings are utterly in confirmation with the results stated by Varma *et al.* (2022) at Anand who found GYH 1603 maize inbred line as moderately resistant against fall armyworm. Kasoma *et al.* (2020) [13] in Zambia also found potential sources of FAW resistance with the lowest FAW-leaf damage and cob damage. Similarly, Gowda *et al.* (2022) [11] screened out 8 maize genotypes as moderate resistance and 14 genotypes as susceptible to maize fall armyworm at Rajendranagar, Telangana. Soujanya *et al.* (2022) [22] showed lower LDR (Light Dependent Resistor) ratings against FAW and recommended exploiting for resistance breeding in maize at ICAR-IIMR and CIMMYT, India. The hybrids and open-pollinated varieties as more vulnerable to FAW damage in maize at early growth stages were observed by Matova *et al.* (2022) [15] in Zimbabwe. The results obtained by Ni *et al.* (2008), Ni *et al.* (2010), Ni *et al.* (2010), Ni *et al.* (2011), Xinzhi *et al*. (2014), Oliveira *et al.* (2018) [21], Abel *et al.* (2019) [1], Chapwa *et al*. (2020) [4], Paul and Deole (2020) [30] at Raipur, Chhattisgarh and Asare *et al*. (2023) [2] at PPRSD, Accra Ghanaare confirmed by the current research outcomes, who reckoned an important source of native resistance to the FAW. Thus, the consequences of the present investigation are in complete confirmation of the results of the earlier research work carried out elsewhere in Gujarat, India and abroad.

Conclusion

Based on leaf damage in maize, GYH-1509 and GYH-1701 genotypes were found moderately resistant. Though based on cob damage, the GYH-1801 genotype was moderately resistant against fall armyworm. The findings suggested that maize germplasm is an important source of native resistance to the fall armyworm.

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