SCREENING OF POPULAR MAIZE HYBRIDS AGAINST FALL ARMYWORM, *SPODOPTERA FRUGIPERDA*

Abstract

Fall armyworm (*Spodoptera frugiperda*) was the member of noctuidae family which has got economic importance as polyphagous and extreme pest of many important crops, including maize in India and elsewhere. In this context, screening experiment was conducted by using 15 different maize cultivars *viz.*, CP 818, NK 6240, GPMH 1110, GH 0727, 900 M Gold, NK 6801, SM- 2, S- 4717, GK 3207, KMH 225, KMH 8333, Sunny NMH 777, 30 B07, PMH 2244 and Kaveri minchu in MARS, Dharwad. The results revealed that PMH 2244 was recorded the least mean larval load (0.67 larvae per plant) compared to rest of the cultivars. Among fifteen different cultivars screened, Kaveri minchu recorded the highest mean leaf damage score (4.62) whereas, the hybrid PMH 224 recorded the least mean leaf damage score (0.73). The cultivars, PMH 2244, NK 6801 and 900 M Gold were recorded with the least egg mass (0.33 per plant) whereas, the hybrids SM- 2 and Kaveri minchu were recorded with the highest egg mass of 0.63 and 0.61 per plant, respectively. Biophysical parameters of plant such as plant height, leaf area, stem girth and trichome density have been implicated in maize resistance to the fall armyworm. All the plant characters except leaf area which are mentioned above showed significant negative correlation with fall armyworm infestation whereas, leaf area was found significantly positive correlation.

Keywords: Screening, Fall armyworm, Cultivars, Biophysical parameters, Maize

Introduction

Maize (*Zea mays*) is one of the utmost significant cereal crops in the global agriculture economy equally as food for man and fodder for animals and referred as “Queen of cereals” because of greater yield potential. It is being cultivated both in the tropical and subtropical climatic conditions of the world. Maize produced in the country is mainly used as human diet. Maize seeds are consumed as human food, as feed stuff for poultry birds and for cattle and also used in production of starch, glucose and edible oil from industry. An annual global production of this crop is 1016 million tons from an area of 184 million hectare with productivity of 5,520 kg per hectare. About 35 per cent of maize produce in India is utilized for consumption by humans, 48 per cent is used for poultry as well as cattle feed whereas 15-17 per cent is used for preparation corn flakes, corn oil, popcorn, corn syrup, dextrose and starch in food processing industries. India is the fourth largest producer with a production of 27.15 million tons in an area of 9.60 million hectare and productivity is 2,830 kg per hectare. The major maize growing areas in India are Karnataka, Uttar Pradesh, Andhra Pradesh, Rajasthan, Tamil Nadu and Maharashtra which contribute to the area and production of 60 and 70 per cent, respectively. Maize is grown in an area of 1.36 million hectare in Karnataka, and the production is 4.09 million tons whereas the productivity is 3020 kg per hectare (Anon., 2018). At present, the average yields of cereal grains are lower in India due to variety of factors, among which, the insect pests have been considered as one of the most important constraints. It is estimated that as many as 141 insect pests cause different degrees of damage to maize crop from sowing to harvesting (Reddy and Trivedi, 2008). Among these, stem borer (*Chilo partellus*), cob borer (*Stenachroia elongella*) and shoot fly (*Atherigona soccata*) were found to be as major pests. Stem borers are the major insect pests followed by defoliators but now, the fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Noctuidae: Lepidoptera) is a polyphagous and extreme pest of many important crops, including maize in India and elsewhere. After advent of modern agriculture, host plant resistance to various pests like insects has remained a reliable source for pest control. The use of insect resistant cultivar is an important component of IPM that provides an economic, stable and environmentally sound approach to minimizing the damage. There are several plant characters that are responsible for resistance to host plants. The systems of plants may have both a positive and negative effect on herbivores and their natural enemies, such characteristics can be divided into morphological and biochemical characters. Morphological characters are most significant in resistance to host plants. In maize these characters are responsible for feeding, oviposition and developmental suitability of a cultivar.

Methodology

Investigations were carried out on plant bio-physical resistance against fall armyworm, *S. frugiperda* during *kharif* 2019 under field condition at MARS, Dharwad comprising of fifteen different cultivars of maize. These cultivars were sown during 2nd fortnight of July and all the recommended agronomic practices were followed uniformly except plant protection measures as per the package of practice published by University of Agricultural Sciences, Dharwad. Each genotype consists of three rows of four meter length with a spacing of 60 cm X 20 cm. The experiment was laid out with Randomized Complete Block design with two replications.

Observations on incidence of fall armyworm on maize were recorded from five randomly selected plants in each cultivar at 30, 45 and 60 DAS. Further, this data was used for calculation of mean larval population per plant by using the following formula.

Incidence of larvae per plant (Nos.) = $\frac{\text{Number of larva}}{\text{Number of plants observed}}$

No. of egg mass per plant was counted by visual observation on five randomly selected plants.

Leaf damage assessment was made on 5 randomly selected plants by using visual scale ranged from 0 to 9. (Davis *et al*., 1992)

0 = no visible leaf damage
1 = only pin-hole damage to the leaves
2 = pin-hole and shot-hole damage to leaves
3 = small elongated lesions (5–10mm) on 1–3 leaves
4 = midsized lesions (10–30mm) on 4–7 leaves
5 = large elongated lesions (>30mm) or small portions eaten on 3–5 leaves
6 = elongated lesions (>30mm) and large portions eaten on 3–5 leaves
7= elongated lesions (>30cm) and 50 % of leaf eaten
8 = elongated lesions (30cm) and large portions eaten on 70 % of leaves
9 = most leaves have long lesions

Five plants were randomly selected from each cultivars for recording observations on various bio-physical parameters at different growth stages *viz*., 30, 45 and 60 DAS of the crop are mentioned below.

Plant height was recorded above ground with the help of a measuring tape from five randomly selected plants and expressed in centimeters (cm).

The stem girth was taken with the help of a vernier caliper by measuring from the center of the third inter node from five randomly selected plants and expressed in millimeters (mm).
Leaf length and width was taken from the leaf at cob node with the help of a measuring tape from five randomly selected plants and later leaf area was calculated by using the formula given below. Leaf area was expressed in centimeter square (Montgomery, 1911).

$LA = \alpha \times L \times W$

α - 0.75, L – Length of leaf, W- Width of Leaf

Leaf trichomes were counted under a binocular microscope from an area of 1 cm^2 at five different randomly selected spots on a leaf.

The data which were obtained from all the genotypes during the present study was subjected to one way ANOVA. The observations regarding incidence and egg mass were subjected to square root transformation. The differences in the above stated observations were compared by following Duncan's Multiple Range Test (DMRT). Further, the different biophysical parameters of plant were correlated with the incidence of fall armyworm.

Results and Discussion

Among 15 genotypes evaluated against fall armyworm, PMH 2244 recorded the least larval load (0.14 larvae/plant) at 30 Days after sowing (DAS). The next best cultivars were NK 6801 and CP 818 with the larval load of 0.35 and 0.49 larvae per plant, respectively. Whereas, the highest larval load of fall armyworm was recorded in Kaveri minchu (1.31) and GK 3207 (1.04). The cultivar PMH 2244 was superior over rest of the hybrids having lowest of 0.62 larvae per plant at 45 DAS, followed by CP 818, NK 6801, KMH 8333 and SM- 2 with the infestation of 1.07, 1.14, 1.18 and 1.19 larvae per plant, respectively, which were at par with each other. Whereas, the highest larval load was recorded in maize cultivars Kaveri minchu and 30 B07 (3.33 and 2.60 larvae per plant, respectively). Similarly, among the hybrids under screening for infestation of fall armyworm, the cultivar, PMH 2244 recorded the least larval load (1.45 larvae per plant) and it was followed by CP 818 and NK 6801 (1.98 and 2.16 larvae per plant, respectively) which were at par with each other. The cultivar, Kaveri minchu registered the highest larval load (5.88 larvae per plant) compared to rest of the hybrid cultivars at 60 DAS (Table 1; Fig. 1).

The screenings of level of infestation of fall armyworm reveals that, PMH 2244 was recorded the least mean larval load (0.67 larvae per plant) compared to rest of the cultivars. The difference might be due to variation in morphological characters like plant height, leaf area, stem girth and trichome density which deterred the pest preference for feeding on this crop. The present findings are conformity with Paiva *et al*. (2016) opined that transgenic genotypes which showed a moderate resistance to fall armyworm were HX 20A55, 30A91 PW, LG 6036 PRO, 20A78 HX and BR 9004 PRO where, the conventional genotypes AG 1051 and AL Bandeirante were more susceptible to fall armyworm. This is due to leaf area of corn consumed by fall armyworm was significantly lower in transgenic hybrids and also found that, the lower preference of the fall armyworm larvae for the transgenic genotypes may be associated with insect perception of the Bt protein in food or damage to the microvilli in the caterpillars gut, which is caused by the endotoxin present in the protein crystals of Bt. Xinzhi *et al.* (2014) reported that Mp708 and fall armyworm7061 were the most resistant cultivars and EPM6 and Ab24E were the most susceptible cultivars to fall armyworm feeding.

The results pertaining to leaf damage on different commercial hybrids screened, the lowest leaf damage was scored in PMH 2244 (0.70) and NK 6801 (0.95) compare to rest of the cultivars. The next best entries were CP 818 (1.00) and KMH 225 (1.00) which are at par with each other. Whereas, the highest leaf damage was recorded in Kaveri minchu (1.60) and GK 3207 (1.33) at 30 DAS. Among the different cultivars, the lowest leaf damage per plant at 45 DAS was scored in the cultivar, PMH 2244 (1.30), followed by NK 6801 and KMH 8333 (1.80 each, respectively) which were at par with each other. Whereas, Kaveri minchu hybrid was recorded the highest leaf damage (7.15), followed by GK 3207 (5.95) and GPMH 1101 (5.82) compared to other hybrid cultivars at 45 DAS. Similarly, among the different cultivars, the hybrid PMH 2244 (0.20) was scored least leaf damage per plant by fall armyworm compared to other hybrids at 60 DAS, followed by NK 6801 (1.05), CP 818 (1.15), KMH 225 (1.18) and KMH 8333 (1.29). Whereas, the highest leaf damage was registered in Kaveri minchu (2.00), GK 3207 (1.80) and GPMH 1101 (1.60) (Table 1; Fig. 1).

Results of the present study indicated that, among fifteen different cultivars screened, Kaveri minchu recorded the highest mean leaf damage score (4.62) whereas, the hybrid PMH 224 recorded the least mean leaf damage score (0.73). Paul and Deole (2020) reported that DKC-9190 (2.36) genotype recorded minimum leaf damage. However, the genotype NK-30 (8.21) recorded with maximum leaf damage by *Spodoptera frugiperda*. Kasoma *et al*. (2020) conducted screening experiment to select genotypes with fall armyworm resistance and reported that the lowest fall armyworm-leaf damage (8.87%) was recorded in genotype CML304-B.

The egg laying preference by fall armyworm was evaluated on selected commercial maize hybrids under field condition. Among them the cultivars, SM- 2, 30 B07 and GPMH 1101 recorded highest egg mass of 0.60, 0.50 and 0.50 egg mass per plant at 30 DAS. The lowest number of egg mass per plant was noticed in the hybrids, PMH 2244 (0.40), GPMH 1101 (0.40), 900 M Gold (0.40) and NK 6801 (0.40) at 45 DAS, which were at par with each other. Whereas, the highest egg mass was recorded in the cultivars, KMH 8333 (0.90) and S- 4717

(0.90) compared to rest of the hybrids.The egg mass per plant was observed significantly lowest in the hybrids, NK 6240 (0.20) and S- 4717 (0.20), followed by CP 818 (0.30), GPMH 1101 (0.30) and GH 0727 (0.30) at 60 DAS. However, highest egg mass per plant was recorded in Kaveri minchu cultivar and was followed by KMH 8333 (0.70) and GK 3207 (0.70) which were found at par with each other (Table 1; Fig. 1).

Results indicated that, the mean egg mass varied from 0.33 to 0.63 per plant. The cultivars, PMH 2244, NK 6801 and 900 M Gold were recorded with the least egg mass (0.33 per plant) whereas, the hybrids SM- 2 and Kaveri minchu were recorded with the highest egg mass of 0.63 and 0.61 per plant, respectively. This might be due to biophysical preferences as leaf area increases, fall armyworm gets more area to move horizontally and deposit its eggs at suitable place on surface of the leaf and trichomes on leaf surface play a role in fall armyworm infestation by interfering with oviposition. The review of literature pertaining to this parameter is lacking to compare with present finding.

The studies on different plant physical parameters were carried out from selected commercial maize hybrids at 30, 45 and 60 DAS. Among them, the plant height (r = -0.915, -830 and -766, respectively), stem girth (r = -0.915, -840 and -910, respectively) and trichomes (r = -0.907, -809 and -941, respectively) showed significantly negative correlation with incidence of fall armyworm at 0.01 level. Whereas leaf area showed significantly positive correlation at 0.05 level at 30, 45 and 60 DAS with the r = 0.906, 840 and 910, respectively (Table 2). Paul and Deole (2020) reported that significant positive correlation was recorded with the leaf area whereas, highly significant but negatively correlation with leaf trichomes was recorded for the incidence of fall armyworm. Sasane *et al*. (2018) opined that leaf succulency and leaf area of soybean are having significant positive correlation and significant negative correlation for trichome density and leaf thickness with respect to incidence of *Spodoptera* larvae.

Conclusion

The study revealed that, among fifteen different cultivars screened, PMH 2244 was recorded the least mean larval load (0.67 larvae per plant) compared to rest of the cultivars. Kaveri minchu recorded the highest mean leaf damage score (4.62) whereas, the hybrid PMH 224 recorded the least mean leaf damage score (0.73). The cultivars, PMH 2244, NK 6801 and 900 M Gold were recorded with the least egg mass (0.33 per plant) whereas, the hybrids SM- 2 and Kaveri minchu were recorded with the highest egg mass of 0.63 and 0.61 per plant, respectively. Biophysical parameters of plant such as plant height, leaf area, stem girth and trichome density have been implicated in maize resistance to the fall armyworm. All the plant characters except leaf area which are mentioned above showed significant negative correlation with fall armyworm infestation whereas, leaf area was found significantly positive correlation.

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Table 1. Host plant resistance of different maize cultivars against the infestation of *Spodoptera frugiperda*

Cultivars	Larval load				Leaf damage				Egg mass				Grain yield (q ha^{-1})
	30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean	30 DAS	45 DAS	60 DAS	Mean	
CP 818	0.49 (0.99)^{bc}	1.07 (1.25)^{b}	1.98 (1.58)^{bc}	1.15 (1.28)^{b}	1.00^{b}	1.95^{b}	0.50^{b}	1.15^{b}	0.30 (0.89)^{ab}	0.50 (1.00)^{ab}	0.30 (0.89)^{ab}	0.36 (0.93)^{ab}	21.00^{abc}
NK 6240	0.69 (1.09)^{cde}	1.29 (1.34)^{bc}	3.40 (1.98)^{de}	1.65 (1.47)^{cd}	1.10^{bc}	3.00^{de}	1.00^{g}	1.70^{c}	0.20 (0.84)^{a}	0.60 (1.05)^{abc}	0.20 (0.84)^{a}	0.34 (0.91)^{a}	18.70^{abc}
GPMH 1101	0.92 (1.19)^{ef}	2.22 (1.65)^{ef}	4.75 (2.29)^{gf}	2.49 (1.73)^{g}	1.20^{bc}	5.82^{h}	1.60^{h}	2.87^{ef}	0.50 (1.00)^{b}	0.40 (0.94)^{a}	0.30 (0.89)^{ab}	0.39 (0.94)^{ab}	16.30^{c}
GH 0727	0.59 (1.04)^{bcd}	1.65 (1.47)^{cd}	4.16 (2.16)^{ef}	1.92 (1.56)^{def}	1.15^{bc}	3.20^{e}	0.80^{de}	1.72^{c}	0.20 (0.84)^{a}	0.60 (1.05)^{abc}	0.30 (0.89)^{ab}	0.36 (0.93)^{ab}	18.50^{abc}
900 M Gold	0.77 (1.12)^{cdef}	2.12 (1.62)^{def}	4.08 (2.14)^{ef}	2.15 (1.63)^{defg}	1.10^{bc}	4.70^{f}	0.80^{de}	2.20^{d}	0.20 (0.84)^{a}	0.40 (0.95)^{a}	0.40 (0.95)^{abc}	0.33 (0.91)^{a}	17.90^{bc}
NK 6801	0.35 (0.92)^{ab}	1.14 (1.28)^{b}	2.16 (1.60)^{bc}	1.12 (1.27)^{b}	0.95^{ab}	1.80^{ab}	0.40^{b}	1.05^{b}	0.20 (0.84)^{a}	0.40 (0.95)^{a}	0.40 (0.95)^{abc}	0.33 (0.91)^{a}	22.50^{ab}
SM- 2	0.58 (1.04)^{bcd}	1.19 (1.30)^{b}	4.16 (2.16)^{ef}	1.76 (1.50)^{cde}	1.10^{bc}	2.60^{cd}	0.95^{fg}	1.55^{c}	0.60 (1.04)^{b}	0.80 (1.14)^{bc}	0.50 (1.00)^{abc}	0.63 (1.06)^{b}	18.65^{abc}
S- 4717	0.82 (1.15)^{def}	1.94 (1.56)^{de}	4.48 (2.23)^{f}	2.22 (1.65)^{efg}	1.10^{bc}	3.20^{e}	0.90^{efg}	1.73^{c}	0.20 (0.84)^{a}	0.90 (1.18)^{c}	0.20 (0.84)^{a}	0.41 (0.95)^{ab}	17.70^{bc}
GK 3207	1.04 (1.24)^{fg}	2.47 (1.72)^{ef}	4.77 (2.30)^{gf}	2.51 (1.73)^{g}	1.33^{c}	5.95^{h}	1.80^{i}	3.03^{f}	0.20 (0.84)^{a}	0.70 (1.09)^{abc}	0.70 (1.09)^{cd}	0.52 (1.01)^{ab}	16.00^{c}
KMH 225	0.60 (1.05)^{bcd}	1.30 (1.34)^{bc}	2.70 (1.79)^{cd}	1.44 (1.39)^{bc}	1.00^{b}	1.80^{ab}	0.75^{d}	1.18^{b}	0.20 (0.84)^{a}	0.70 (1.09)^{abc}	0.50 (1.00)^{abc}	0.45 (0.98)^{ab}	19.15^{abc}
KMH 8333	0.58 (1.04)^{bcd}	1.18 (1.30)^{b}	2.39 (1.70)^{c}	1.31 (1.34)^{bc}	1.10^{bc}	2.15^{bc}	0.63^{c}	1.29^{b}	0.20 (0.84)^{a}	0.90 (1.18)^{c}	0.70 (1.09)^{cd}	0.58 (1.04)^{ab}	20.04^{abc}
Sunny NMH 777	0.69 (1.09)^{cde}	1.36 (1.36)^{bc}	2.50 (1.73)^{c}	1.44 (1.39)^{bc}	1.00^{b}	5.00^{fg}	0.85^{def}	2.28^{d}	0.20 (0.84)^{a}	0.60 (1.05)^{abc}	0.50 (1.00)^{abc}	0.42 (0.96)^{ab}	19.38^{abc}
30B07	0.97 (1.21)^{ef}	2.60 (1.76)^{f}	4.32 (2.20)^{ef}	2.47 (1.72)^{fg}	1.19^{bc}	5.50^{gh}	1.50^{h}	2.73^{e}	0.50 (0.99)^{b}	0.60 (1.05)^{abc}	0.60 (1.04)^{bc}	0.56 (1.03)^{ab}	16.50^{c}
PMH2 244	0.14 (0.80)^{a}	0.62 (1.05)^{a}	1.45 (1.40)^{a}	0.67 (1.08)^{a}	0.70^{a}	1.30^{a}	0.20^{a}	0.73^{a}	0.20 (0.84)^{a}	0.40 (0.95)^{a}	0.40 (0.95)^{abc}	0.33 (0.91)^{a}	23.50^{a}
Kaveri minchu	1.31 (1.35)^{g}	3.33 (1.95)^{g}	5.88 (2.53)^{g}	3.27 (1.94)^{h}	1.60^{d}	7.15^{i}	2.00^{j}	4.62^{g}	0.20 (0.84)^{a}	0.70 (1.09)^{abc}	1.00 (1.22)^{d}	0.61 (1.05)^{b}	15.67^{c}

CV (%)	10.18	10.40	11.71	10.18	11.04	11.60	12.41	11.73	12.54	10.15	11.94	10.61	11.76
CD @5%	0.10	0.20	0.24	0.17	0.25	0.52	0.12	0.26	0.15	0.12	0.16	0.09	3.53
SE.m ±	0.04	0.06	0.08	0.06	0.09	0.17	0.04	0.08	0.05	0.05	0.05	0.04	1.56

Table 2. Relationship of fall armyworm infestation with biophysical parameters of maize

Sl. No.	**Parameters**	**Correlation**		
		30 DAS	**45 DAS**	**60 DAS**
1	Plant height	- 0.915**	- 0.830**	- 0.766**
2	Leaf area	0.906**	0.840**	0.910**
3	Stem girth	- 0.949**	- 0.862**	- 0.842**
4	Trichomes	- 0.907**	- 0.809**	- 0.941**

**Significant at 0.01 level   DAS – Days after sowing   N = 15

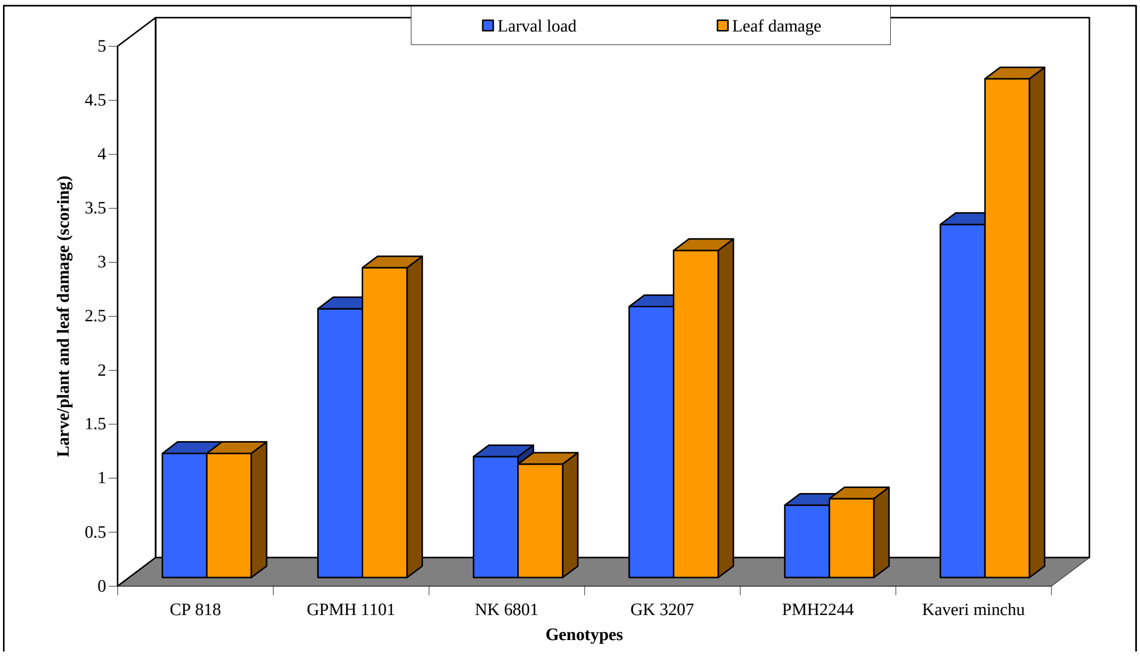

Fig 1: Host plant resistance of different maize cultivers against the infestation of ***Spodoptera frugiperda***