Original Research Article

Screening of Different Varietiesof Maizeagainst Fall armyworm, *Spodopterafrugiperda* in the Gird Region of the Madhya Pradesh, India

Comment [A1]: The evaluation was conducted at Research Farm, College of Agriculture, Gwalior. But the title refers to Gird region? What it means?

ABSTRACT

Aims: To identifyyiedtholess susceptible varieties, allowing for targeted pest management strategies, reduced pesticide use, increased resilience to pest outbreaks, and long-term sustainable pest control solutions.

Study design: Randomized Block Design

Place and duration of study: Research Farm, College of Agriculture, Gwalior (Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior) during two consecutive years i.e., *Kharif*, 2021-22 and *Kharif* 2022-23.

Methodology: In the experiment, twelve different varieties were sowned on17th July 2021 and 17th July 2022 during both the consecutive years respectively.Observations were recorded against on the number of fall armyworm, Spodoptera frugiperdalarvae on the number of larvaeandplant damage per cent were recorded counted from randomly selected ten plants at weekly intervals. Observations for FAW was also be recorded with visual scoring method. A numerical scale (0-9), also known as the Davis scale, was used to evaluate leaf damage.

Results: The result of both the year indicated that not all varieties were found to be completely resistant to fall armyworm. For the purpose of interpreting the results, all the varieties were categorized for their reaction based on average data of both the years (*Kharif* 2021 and *Kharif* 2022) of mean larval population, mean plant damage percent, and leaf damage scoring. Based on statistical categorization, it was determined that the varieties NWMH-2002 and JM 218 exhibited lower susceptibility. On the other hand, the varieties Dkc-9141, Maize 3845, PAC 740, Yashoda gold, PM 303, Maize Ranker, Maize 5402, and Maize 3046 were classified as moderately susceptible. Lastly, Sona 5101 and M-909 were identified as highly susceptible varieties.

Conclusions: It concluded that the varieties NWMH-2002 and JM 218 exhibited lower susceptibility against fall armyworm.

Keywords: susceptibility, leaf damage, larval population, plant damage

INTRODUCTION

Maize is referred to as the "Queen of Cereals" throughout the world due to its great genetic yield potential among cereals. Due to its wide genetic base and high level of genetic diversity, it is more adaptive and versatile in a variety of agro-climatic conditions. Maize is a member of the Poaceae family. It originated in South America and spread throughout the world. In 70 countries, including 53 developing countries, more than 100,000 ha of maize are grown (Dowswell*etal*., 2019). According to Shah *etal*. (2015), 100 g of the edible component of maize includes 71.88 g of carbohydrates, 8.84 g of protein, 4.57 g of fat, 2.15 g of crude fibre, 2.33 g of ashes, and different vitamins and minerals.

With an average productivity of 3199 kg/ha, maize is grown on 98.91 million ha of land in India on an annual average basis, producing 316.46 million tonnes (Anonymous, 2021). Karnataka is the top producer of maize among the Indian states that grow it, followed by Madhya Pradesh, Maharashtra, Tamil Nadu, and West Bengal. With a productivity of 2763 kg/ha and a yield of 38.81 million tonnes, maize is grown on 14.05 million ha of land in Madhya Pradesh (Anonymous, 2021). Some of the insect pests that target maize fields include cutworms, maize stem borer, white grub and chaffer beetles, armyworm, gram pod borer, wireworm, hairy caterpillars, etc. (Arifie *etal*., 2019). In India, the fall armyworm *Spodopterafrugiperda* was recently discovered on a maize field in August 2018 close to Shivammoga, Bangalore, Karnataka state (Ganiger *etal*., 2018). The maize crop has been severely damaged by this

new invasive species, which is posing an important threat to the nation's ability to produce maize. Plants are harmed when larvae of fall armyworm(FAW) consume the leaf. Young larvae typically harm leaves by boring holes in them and primarily eating on the epidermis of the leaf. Small holes in the leaves can be used to identify leaf damage. Around the damaged region, the larvae are frequently simple to find. The larger larvae in the whorls eating on the maize cob or kernels can reduce the yield and quality of older plants. Due to lower yields, higher costs of inputs for pesticide applications, and the demand for more labour and resources to control pest infestations, farmers suffer financial losses. The identification of resistant or tolerant varieties of maize by pest control screening provides specific pest management techniques, less pesticide use, enhanced resilience to pest outbreaks, and long-term sustainable pest control solutions. Varieties of maize show varied degrees of tolerance or resistance to particular pests. Thus, the present study is meant to examine with the aim of screening out the susceptible varieties of maize against fall armyworm.

2.MATERIAL AND METHODS

A This evaluation present research experiment was conducted at the Entomological Research Farm of College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, M.P. during two consecutive years i.e., *Kharif*, 2021-22 and *Kharif* 2022-23.In the experiment, twelve varieties of maize were sownon17th July 2021 and 17th July 2022, maintaining 60 cm plant to plant and 20 cm row to row distance. The size of each replicated plot was maintained as 5.0m x 3.0m. After sowing,moderatelight irrigation was done for the setting of seed. Fertilizers were applied at the rate of 120 kg N, 60 kg P and 30 kg K per hectare. For the observations of fall armyworm,the number of FAW larvae and damaged plants were counted from randomly selected ten plants at weekly intervals starting from germination till harvest of the crop.Also, the fall armyworm infestationinvasion on different maize varieties was noted on the basis of leaf damage under natural infestation. A numerical scale (0-9), also known as the Davis scale, was used to evaluate leaf damage. (Davis and Williams, 1992) as described in the table below.

Comment [A2]: What is setting of seed?

List 1 : Rating scale showingleafdamage

Rating	Explanation/definition of damage
0	No visible leaf damage;
1	Only pin-hole damage;
2	Pin-hole and small circular hole damage to leaves.
3	Pinholes, small circular lesions and a few small elongated (rectangular shaped) lesions of up to 1.3 cm in length present on whorl and furl leaves.
4	Several small to mid-sized 1.3 to 2.5 cm in length elongated lesions present on a few whorl and furl leaves
5	Several large elongated lesions greater than 2.5 cm in length present on a few whorl and furl leaves and/or a few small to mid-sized, uni-form to irregular shaped holes (basement membrane consumed) eaten from the whorl and/or furl leaves.
6	Several large elongated lesions present on several whorl and furl leaves and/or several large uniforms to irregular shaped holes eaten from furl and whorl leaves.
7	Many elongated lesions of all sizes present on several whorl and furl leaves and/or several large uniforms to irregular shaped holes eaten from the whorl and furl leaves.
8	Many elongated lesions of all sizes present on most whorl and furl leaves plus many mid to large sized uniform to irregular shaped holes eaten from the whorl and furl leaves.
9	Whorl and furl leaves almost totally destroyed.

3. RESULTS AND DISCUSSION

It was noteworthy from the results that none of the studied types varieties were fully free of pest infestation.The data regarding number of larvae per plant, plant damage (%) and leaf damage rating scaleare shown in the table1 and 2.

3.1 Average larval population during *Kharif* 2021 and *Kharif* 2022

~~According to the data presented in table 1,~~ average mean ~~of both the year,~~ least larval population was recorded in NWMH-2002 (0.87 larvae) followed by JM 218 (0.98),Dkc-9141 (1.18), Maize 3845 (1.28) and PAC 740 (1.38). Although, PAC 740 was statistically at par with Yashoda gold (1.43). After this, next effective varieties were PM 303 (1.49), Maize Ranker (1.58), Maize 5402 (1.63), Maize 3046 (1.69) and M-909 (1.77). However highest larval population was recorded in Sona 5101 (1.89) (Table 1). For the purpose of interpreting the results, all the varieties were categorized for their reaction based on average data of both the years (*Kharif* 2021 and *Kharif* 2022) of mean larval population . The statistical formula $\bar{X} \pm \sigma$ was used to categorize the varieties , with the average value being ($\bar{X}$ =1.43) and the standard deviation being (σ = 0.30). As a result, three separate groupings of larval population—below 1.13, between 1.13 and 1.73, and above 1.73—were identified. Based on this statistical categorization method, it was determined that the varieties NWMH-2002 and JM 218 exhibited lower susceptibility. On the other hand, the varieties Dkc-9141, Maize 3845, PAC 740, Yashoda gold, PM 303, Maize Ranker, Maize 5402, and Maize 3046 were classified as moderately susceptible. Lastly, Sona 5101 and M-909 were identified as highly susceptible varieties.

Comment [A3]: Mere repetition of data given in Table

3.2 Average Plant damage (%) during *Kharif* 2021 and *Kharif* 2022

~~According to the data presented in table 1, average of both the year data obtained showed that~~ the minimum plant damage % was found in NWMH-2002 (9.29%) which recorded as significantly less effective in comparison to rest of the varieties. Next best effective varieties were found as JM 218 (12.50%), DEKALB Dkc-3141 (15.71%) and Maize 3845 (17.74%). The variety Maize 3845 was followed by PAC 740 (18.81%), but statistically at par with Yashoda gold (20.60%) and PM 303 (22.38%). Although, all the other varieties were recorded with medium level of damage % such as Maize ranker (25%), Maize 5402 (27.26%), Maize 3046 (30%) and M-909 (33.45%). However, maximum and significantly high larval population was found in Sona 5101 (38.69%) among all the varieties (Table 1).For the purpose of interpreting the results, all the varieties were categorized for their reaction based on average data of both the years (*Kharif* 2021 and *Kharif* 2022) of percent plant damage . The statistical formula $\bar{X} \pm \sigma$ was used to categorize the varieties , with the average value being ($\bar{X}$ = 22.62) and the standard deviation being (σ = 8.31). As a result, three separate groupings of average data of two year of plant damage (%) due to fall armyworm —below 14.31 (less susceptible), between 14.31 and 30.92 (moderately susceptible), and above 30.92 (highly susceptible)- were discovered. The varieties NWMH-2002 and JM 218 were found to be less susceptible. The varieties Dkc-9141, Maize 3845, PAC 740, Yashoda gold, PM 303, Maize Ranker, Maize 5402 and Maize 3046 were found as moderately susceptible and Sona 5101 and M-909 were highly susceptible.

3.3 Leaf damage scoring during *Kharif* 2021 and *Kharif* 2022

According to the data presented in table 2, on different varieties, the leaf damage rating of all observations in the average data of both the year ranged from 1.33 to 5.10. NWMH-2002 had the lowest leaf damage rating (1.33), followed by JM 218 (1.49), although they were statistically different. However, Sona 5101 (5.10) has the highest leaf damage rating (Table 2). Despite the fact that the other cultivars scored in the middle of the class in regards to leaf damage. The order of leaf damage rating from lowest to highest among all the varieties was NWMH-2002 (1.33), JM 218 (1.49), Dkc-9141 (1.86), Maize 3845 (2.14), PAC 740 (2.35), Yashoda gold (2.56), PM 303 (3.03), Maize Ranker (3.31), Maize 5402 (3.79), Maize 3046 (4.13), M-909 (4.47) and Sona 5101 (5.10).For the purpose of interpreting the results, all the varieties were categorized for their reaction based on average data of both the years (*Kharif* 2021 and *Kharif* 2022) of leaf damage scoring . The statistical formula $\bar{X} \pm \sigma$ was used to categorize the varieties, with the average value being ($\bar{X}$ = 2.96) and the standard deviation being (σ = 1.17) as shown in the table. As a result, three unique groupings of leaf damage ratings were obtained: <1.80, between 1.80 - 4.13, and >4.13. According to this, the varieties NWMH-2002 and JM 218 have been found to be less susceptible. The varieties Dkc-9141, Maize 3845, PAC 740, Yashoda gold, PM 303, Maize Ranker, Maize 5402 and Maize 3046 were found as moderately susceptible and Sona 5101 and M-909 were highly susceptible.

During this investigation, twelve varieties of maize were screened against fall armyworm. The result of both the year indicated that not all varieties were found to be completely resistant to fall armyworm. For the purpose of interpreting the results, all the varieties were categorized for their reaction based on average data of both the years (*Kharif* 2021 and *Kharif* 2022) of mean larval population , mean plant damage percent , and leaf damage scoring . Based on statistical categorization by using $(\overline{X} \pm \sigma)$, it was determined that the varieties NWMH-2002 and JM 218 exhibited lower susceptibility. On the other hand, the varieties Dkc-9141, Maize 3845, PAC 740, Yashoda gold, PM 303, Maize Ranker, Maize 5402, and Maize 3046 were classified as moderately susceptible. Lastly, Sona 5101 and M-909 were identified as highly susceptible varietiesas mentioned in the table below.

The current findings are consistent with Gowda *etal*. (2022) who observed that of the twenty-two maize genotypes evaluated, CML 71, CML 67, and DMRE63 had considerably reduced leaf damage scores to fall armyworm of 3.93, 4.00, and 4.17, respectively. CML 71, CML 67, DMRE63, CML 561, AEBY-1, CML 335, CML 345, and CML 337 had mean leaf damage scores of 3.93, 4.00, 4.17, 4.36, 4.42, 4.57, 4.72, and 4.80, respectively, and were classified as moderately resistant genotypes. When Paul and Deole (2020) tested maize genotypes for fall armyworm, they recorded~~found~~ similar findings. The genotype DKC-9190 exhibited the lowest leaf damage score of 2.36, suggesting resistance, whereas the genotype NK-30 had the highest leaf damage score of 8.21, indicating significant susceptibility. Somashekar (2020) discovered that partially resistant hybrids LG 36607, P3550, Tata Dhanya, and S 6668 had significantly higher leaf damage scores of 3.38, 3.66, 3.80, and 7.13 at V6 leaf stage when compared to leaf damage scores of LG 36607 (2.60), P3550 (3.28), Tata Dhanya (2.93), and S 6668 (4.33) at V8 stage.

Table 1: ~~Average data on the~~Incidence of fall armyworm ~~recorded~~ on different varieties of Maize during *Kharif* 2021 and *Kharif* 2022~~.~~

Varieties	Larval Population per plant			Plant damage (%)		
	2021	2022	Average	2021	2022	Average
Dkc- 9141	1.13 (1.28)*	1.23 (1.32)	1.18 (1.30)	14.52 (22.39)**	16.90 (24.28)	15.71 (23.35)
Maize 5402	1.57 (1.44)	1.70 (1.48)	1.63 (1.46)	27.38 (31.55)	27.14 (31.39)	27.26 (31.47)
NWMH-2002	0.83 (1.15)	0.90 (1.18)	0.87 (1.17)	8.57 (16.95)	10.00 (18.43)	9.29 (17.73)
PM 303	1.45 (1.40)	1.54 (1.43)	1.49 (1.41)	21.43 (27.57)	23.33 (28.87)	22.38 (28.23)
Sona 5101	1.83 (1.53)	1.95 (1.57)	1.89 (1.55)	37.14 (37.55)	40.24 (39.37)	38.69 (38.46)
PAC 740	1.34 (1.36)	1.43 (1.39)	1.38 (1.37)	17.86 (24.99)	19.76 (26.38)	18.81 (25.7)
Yashoda Gold	1.39 (1.37)	1.47 (1.40)	1.43 (1.39)	19.76 (26.39)	21.43 (27.57)	20.60 (26.98)
JM 218	0.95 (1.21)	1.01 (1.23)	0.98 (1.22)	11.67 (19.96)	13.33 (21.41)	12.50 (20.7)
Maize 3046	1.63 (1.46)	1.75 (1.50)	1.69 (1.48)	29.76 (33.05)	30.24 (33.26)	30.00 (33.21)
Maize ranker	1.54 (1.43)	1.63 (1.46)	1.58 (1.44)	24.52 (29.67)	25.48 (30.31)	25.00 (30)
M-909	1.71 (1.49)	1.82 (1.52)	1.77 (1.51)	33.10 (35.11)	33.81 (35.55)	33.45 (35.33)
Maize 3845	1.24 (1.32)	1.33 (1.35)	1.28 (1.34)	16.90 (24.26)	18.57 (25.52)	17.74 (24.9)
SEm ±	**0.01**	**0.01**	**0.01**	**0.85**	**0.53**	**0.59**
C.D. (at 5%)	**0.03**	**0.03**	**0.03**	**2.58**	**1.62**	**1.80**

*figures in parentheses are square root transformed values; **figures in parentheses are arc sine transformed values

Table 2: ~~Average~~ Rating of leaf damage by fall armyworm on ~~rating to~~ different varieties of Maize ~~against fall armyworm~~ during *Kharif* 2021 and *Kharif* 2022~~.~~

Varieties	Leaf damage scoring		
	2021	2022	Average
Dkc- 9141	1.79	1.94	1.86
Maize 5402	3.69	3.90	3.79
NWMH-2002	1.23	1.43	1.33
PM 303	2.93	3.14	3.03

Sona 5101	5.03	5.18	5.10
PAC 740	2.29	2.42	2.35
Yashoda Gold	2.48	2.63	2.56
JM 218	1.37	1.60	1.49
Maize 3046	4.05	4.21	4.13
Maize ranker	3.19	3.44	3.31
M-909	4.39	4.55	4.47
Maize 3845	2.06	2.22	2.14
SEm ±	**0.06**	**0.02**	**0.04**
C.D. (at 5%)	**0.17**	**0.07**	**0.11**

4. CONCLUSION

It was concluded that the varieties NWMH-2002 and JM 218 exhibited lower susceptibility. On the other hand, the varieties Dkc-9141, Maize 3845, PAC 740, Yashoda gold, PM 303, Maize Ranker, Maize 5402, and Maize 3046 were classified as moderately susceptible. Lastly, Sona 5101 and M-909 were identified as highly susceptible varieties.

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Comment [A4]: To redraft as per the standard journal format uniformly

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