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Field screening of some green gram [*Vigna radiata* (L.) Wilczek] Genotypes against spotted pod borer, *Maruca vitrata* (Fabricius)

Satyapriya Singh and CP Srivastava

Abstract
Twenty-four green gram genotypes were screened under field conditions to identify sources of resistance against spotted pod borer during *Kharif* season of 2015-16 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The first incidence of spotted pod borer, *Maruca vitrata* (Fabricius) was observed in 38th standard week in nineteen genotypes out of the total twenty-four genotypes. The population of spotted pod borer was found to be highest in genotype KM 2348 in 41st standard week with population of 1.63 larvae/plant. The pooled mean of the larval population of pod borer was recorded highest in genotype KM 2348 i.e. (0.88 larvae/plant) and lowest in genotype VGG 10-008 (0.07 larvae/plant). The highest per cent pod damage caused by *M. vitrata* was found in KM 2348 (19.26 %), followed by BM 2012-9 (16.51 %), AKM 12-17 (16.40 %), PM 4 (15.06 %) and IPM 312-20 (14.22 %). On the basis of per cent pod damage and Pest Susceptibility Rating (PSR) index, VGG 10-008 was ascertained a least susceptible genotype against spotted pod borer i.e. PSR-4. The grain yield of different genotypes differed significantly and ranged from 819 kg/ha in the genotype VGG 10-008 to 416 kg/ha in KM 2348.

Keywords: Green gram, population, pod damage, grain yield, spotted pod borer

Introduction
Pulses, the food legumes, have been grown by farmers since millennia providing nutritionally balanced food to the people of India [1] and many other countries in the world. Among them green gram [*Vigna radiata* (L.) Wilczek] is the important one which has vast geographical diversity, high nutritional value and low water requirements, and tendency to reduce greenhouse gases and increase carbon sequestration which is good for the planet along with maintaining health benefits over a long shelf life. Being leguminous, this crop maintains soil fertility by fixing the atmospheric nitrogen [2]. In India, green gram is third largely grown pulse crop cultivated in an area of 3.02 million hectares with an annual production of 1.50 million tonnes and average productivity of 498kg/ha. Among the several reasons for low productivity of green gram in the country, the damage caused by insect pests is one of the major causes. In India nearly 60 species of insect pest have been recorded from green gram but only a few are known to cause economic damage and commonly covers large areas [3, 4]. On an average 2-2.1 million tonnes of pulses with a monetary value of nearly Rs 6,000 crore are lost annually due to the ravages of insect pest complex [5]. Legume pod borer *Maruca vitrata* (Fabricius), is the most formidable and potential pest cause extensive damage to green gram under field conditions. The low yield of green gram is attributed to the regular outbreaks of spotted pod borer, *M. Vitrata*. Because of its extensive host range and destructiveness, it became a persistent pest in green gram. It is known to cause economic loss of 20 - 25 % and yield loss of 2- 84% in green gram [6] and accounting to US $ 30 million. It is also reported that 20–30% pod damage in green gram is caused due to spotted pod borer [7].

The continuous and indiscriminate use of large quantities of chemical insecticides, besides creating health hazards to human and animal life, development of resistance and destruction of natural enemies as well as environmental pollution has also resulted in the green gram crop failure in different parts of the country. Hence, chemical measures are often termed as a necessary evil in present green gram pest management scenario. It has long been recognized that host plant resistance holds a great promise for exploitation in integrated pest management programmes because the use of resistant varieties provide crop protection that is biologically, ecologically, economically and socially acceptable.

This strategy also provides a low-cost, practical, long-term solution for maintaining lower pest population and reducing crop losses. Several thousand years ago likely recognized that the plants they selected for agricultural purposes varied in susceptibility to pests [8, 9]. Resistant varieties have their greatest value in crops of low values per hectare or in situations when the yield varies greatly due to uncertainties of weather or other intermittent hazard. Thus, green gram is ideally suited for exploiting the resistance phenomenon to control spotted pod borer ideally and economically. Thus, keeping these views in mind, the present study was conducted to identify the resistant cultivars that are less susceptible to spotted pod borer in green gram

Materials and Methods

The present investigation was carried out under field conditions at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, (UP) during *Kharif* season of 2015-16. Twenty four Green gram genotypes were grown each in plots having a size of (4m×1.80) m^2 following row to row and plant to plant spacing of 30 cm and 10 cm, respectively. One main irrigation channel of 1m width was prepared at outside in the experimental field and two sub irrigation channels were provided in between three replications. The crop was grown following the normal agronomic practices in "Randomized Block Design (RBD)". The crop was shown on 12^{th} August, 2015 (32^{nd} Standard Week). The experimental field was manifested to natural infestation and no insecticide applications were applied. Genotypes are procured from Indian Institute of Pulse Research, Kanpur. Genotypes are AKM 12-17, IPM 312-20, Pusa 1572, PM 12-2, GM 05-08, IPM 312-19, Pusa 1571, PM 4, COGG 11-02, NDMK 14-24, BM 2012-9, VGG 10-008, ML 2412, IGKM 06-4-2, MH 729A, MH 921, PM 10-18, IPM 2-3, NVL 825, LGG 574, KM 2348, RMG 1082, ML 2410 and HUM-12 (Check cultivar).

The data were recorded on incidence pattern and population build up of *M. vitrata*, percentage pod damage and yield of various genotypes. For recording observations regarding population build up of spotted pod borer five plants were selected from each plot and number of larvae present on each plant were counted. Then it was averaged for each block and recorded on standard week basis. Pod damage at maturity of the crop was recorded from total pods of five plants selected at random in each plot.

$$\text{Percent pod damage} = \frac{\text{no. of healthy pods} - \text{no. of damaged pods}}{\text{no. of healthy pods}} \times 100$$

The grain yield of different treatments was obtained by harvesting the central rows after leaving the border rows on each side at maturity. After performing the post harvest operations, the grains were kept in cloth bags and dried in open sunlight to stabilize the moisture content. The weight of the grains was taken after this period. The total yield per plot including the yield of pods sampled earlier for assessment of pod damage was then computed on kilogram per hectare basis. The insect pest resistance/susceptibility rating was done on 1-9 scale as given below:

$$\text{Insect pest resistance/susceptibility} = \frac{\text{Percent PD in Check cultivar} - \text{Percent PD in test genotype}}{\text{Percent PD in Check cultivar}} \times 100$$

Where, PD = Pod damage

Statistical Analysis

All the data recorded were subjected to statistical analysis as per the Randomized Block Design procedure and insect population data were transformed with square root transformed $\sqrt{x+0.5}$ method and the per cent pod damage data was angular transformed. Standard error of mean and the critical difference were computed at 5% level of probability. The significance difference has been judged by using Duncan Multiple Range Test (SPSS).

Results and Discussion

Twenty four green gram genotypes were screened under unprotected conditions for their resistance or tolerance to spotted pod borer along with one check (HUM-12) during 2015-16. The results obtained from the investigation as well as relevant discussion have been summarized under the following headings:

Incidence and population dynamics of spotted pod borer, *M. vitrata*

The data was recorded from the time of build up of the insect population to the time of maturity of the crop. The first incidence of spotted pod borer, *Maruca vitrata* was observed in 38th standard week in 2015-16 in all genotypes except Pusa 1572, PM 12-2, IPM 312-19, Pusa 1571, VGG 10-008 and LGG 574 (Table 1). The peak of population of *M. vitrata* was recorded during 41^{st} standard week in almost all genotypes. Highest mean population was recorded on KM 2348 (1.63 larvae/plant) and lowest on VGG 10-008 (0.16 larvae/plant) as compared to check cultivar, HUM-12 (0.60 larvae/plant). These results are in close agreement with Sravani *et al.* [10] who reported that the larval incidence of *M. vitrata* was observed from 33 days after sowing (DAS) and continued till the end of the crop growth. The peak larval incidence was observed at 53 DAS i.e., first week of December coinciding with peak flowering and pod development stage.

The data presented in Table 1 revealed that the overall pooled mean of the larval population of *M. vitrata* on different green gram genotypes varied significantly from 0.07 to 0.88 larvae/plant. The minimum larval population (0.07 larvae/plant) was counted from the genotype VGG 10-008 and it was closely followed by the genotype IPM 312-19 but the maximum larval population (0.88 larvae/plant) was counted from the genotype KM 2348. The findings also support to Kumar and Singh [11] who reported that the minimum infestation was recorded in KUG-503 and UH-08-05, followed by COBG-10-5 and VBG10-024, and the maximum in TU 631.

Table 1: Mean population of spotted pod borer, *Maruca vitrata* (Fabricius) on different green gram genotypes at Varanasi during *Kharif* 2015-16

S. No	Genotypes	Date / Standard week					Overall mean
		17.09.15/ 38 SW	24.09.15/ 39 SW	01.10.15/ 40 SW	08.10.15/ 41 SW	15.10.15/ 42 SW	
1	AKM 12-17	0.20 (0.83)$^{a-d}$	0.16 (0.81)$^{a-d}$	0.93 (1.19)^{e}	0.83 (1.15)^{e}	0.13 (0.79)^{abc}	0.45 (0.97)^{efg}
2	IPM 312-20	0.33 (0.91)^{cd}	0.30 (0.89)^{cd}	0.73 (1.10)^{cde}	0.80 (1.13)^{de}	0.26 (0.87)^{bcd}	0.48 (0.99)^{fg}
3	Pusa 1572	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.53 (1.01)^{bcd}	0.50 (0.99)^{bc}	0.06 (0.75)^{a}	0.22 (0.84)$^{a-d}$
4	PM 12-2	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.53 (1.01)^{bcd}	0.53 (1.01)^{bcd}	0.03 (0.72)^{a}	0.22 (0.84)$^{a-d}$
5	GM 05-08	0.20 (0.83)$^{a-d}$	0.16 (0.81)$^{a-d}$	0.60 (1.05)^{cd}	0.66 (1.07)^{cde}	0.16 (0.81)$^{a-d}$	0.36 (0.92)$^{c-g}$
6	IPM 312-19	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.20 (0.83)^{ab}	0.30 (0.89)^{ab}	0.10 (0.77)^{ab}	0.12 (0.78)^{a}
7	Pusa 1571	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.46 (0.98)^{abc}	0.50 (0.99)^{bc}	0.06 (0.75)^{a}	0.20 (0.84)^{abc}
8	PM 4	0.06 (0.75)^{ab}	0.36 (0.92)^{ab}	0.46 (0.98)^{abc}	0.43 (0.96)^{bc}	0.06 (0.75)^{a}	0.22 (0.84)$^{a-d}$
9	COGG 11-02	0.33 (0.91)^{cd}	0.33 (0.91)^{cd}	0.53 (1.01)^{bcd}	0.63 (1.06)^{cde}	0.30 (0.89)^{cde}	0.42 (0.96)^{efg}
10	NDMK 14-24	0.40 (0.83)$^{a-d}$	0.23 (0.85)^{bcd}	0.53 (1.01)^{bcd}	0.60 (1.04)^{cde}	0.30 (0.89)^{cde}	0.37 (0.93)$^{d-g}$
11	BM 2012-9	0.13 (0.79)^{abc}	0.13 (0.79)^{abc}	0.86 (1.16)^{de}	0.80 (1.13)^{de}	0.16 (0.81)^{abcd}	0.42 (0.95)^{efg}
12	VGG 10-008	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.13 (0.79)^{a}	0.16 (0.81)^{a}	0.06 (0.75)^{a}	0.07 (0.75)^{a}
13	ML 2412	0.13 (0.79)^{abc}	0.13 (0.79)^{abc}	0.53 (1.01)^{bcd}	0.53 (1.01)^{bcd}	0.13 (0.79)^{abc}	0.29 (0.89)$^{b-e}$
14	IGKM 06-4-2	0.13 (0.79)^{abc}	0.13 (0.79)^{abc}	1.53 (1.01)^{bcd}	0.56 (1.03)^{bcd}	0.16 (0.81)$^{a-d}$	0.30 (0.89)$^{b-e}$
15	MH 729A	0.20 (0.83)$^{a-d}$	0.20 (1.83)$^{a-d}$	0.50 (0.99)^{bc}	0.53 (1.01)^{bcd}	0.20 (0.83)$^{a-d}$	0.32 (0.90)$^{b-f}$
16	MH 921	0.26 (0.86)^{bcd}	0.26 (0.86)^{bcd}	0.46 (0.98)^{abc}	0.46 (0.98)^{bc}	0.33 (0.91)^{de}	0.36 (0.92)$^{c-g}$
17	PM 10-18	0.26 (0.87)^{bcd}	0.23 (0.85)^{bcd}	0.46 (0.98)^{abc}	0.46 (0.98)^{bc}	0.26 (0.87)^{bcd}	0.34 (0.91)$^{c-g}$
18	IPM 2-3	0.26 (0.87)^{bcd}	0.23 (0.95)^{bcd}	0.46 (0.98)^{abc}	0.46 (0.99)^{bc}	0.20 (0.83)$^{a-d}$	0.32 (0.90)$^{b-f}$
19	NVL 825	0.13 (0.79)^{abc}	0.16 (0.81)$^{a-d}$	0.53 (1.01)^{bcd}	0.46 (0.98)^{bc}	0.20 (0.83)$^{a-d}$	0.30 (0.89)$^{b-e}$
20	LGG 574	0.00 (0.70)^{a}	0.00 (0.70)^{a}	0.40 (0.94)^{abc}	0.40 (0.94)^{abc}	0.03 (0.72)^{a}	0.16 (0.81)^{ab}
21	KM 2348	0.40 (0.94)^{d}	0.36 (0.93)^{d}	0.60 (1.44)^{f}	1.63 (1.45)^{f}	0.43 (0.96)^{e}	0.88 (1.17)^{h}
22	RMG 1082	0.26 (0.87)^{bcd}	0.26 (0.87)^{bcd}	0.46 (0.98)^{abc}	0.46 (0.98)^{bc}	0.26 (0.87)^{bcd}	0.34 (0.91)$^{c-g}$
23	ML 2410	0.33 (0.91)^{cd}	0.20 (0.83)$^{a-d}$	0.60 (1.04)^{cd}	0.53 (1.01)^{bcd}	0.33 (0.91)^{de}	0.40 (0.94)^{efg}
24	HUM-12 (Check cultivar)	0.40 (0.94)^{d}	0.36 (0.94)^{d}	0.66 (1.07)^{cde}	0.60 (1.04)^{cde}	0.43 (0.96)^{e}	0.49 (0.99)^{g}
S.Em.±		(0.03)	(0.03)	(0.04)	(0.03)	(0.02)	(0.02)
CD at 5%		(0.10)	(0.09)	(0.14)	(0.10)	(0.08)	(0.07)

Data presented in parentheses are square root transformed value $\sqrt{n+0.5}$;
In a column, transformed values followed by the common letter (s) are not significant in DMRT @ 5% level of significance, SW- Standard week

Percent pod damage due to spotted pod borer, *M. vitrata*

Per cent pod damage due to *M. vitrata* varied significantly from 7.27 % on VGG 10-008 to 19.26 % on KM 2348 as compared to 13.35% on check cultivar HUM-12 (Table 2). Minimum per cent pod damage was observed in VGG 10-008 (7.27 %), followed by IPM 312-19 (8.09 %), Pusa 1571 (8.48 %) and ML 2412 (8.50 %) while maximum pod damage was observed in KM 2348 (19.26 %) followed by BM 2012-9 (16.51 %), AKM 12-17 (16.40 %), PM 4 (15.06 %) and IPM 312-20 (14.22 %). The genotypes PM 12-2, GM 05-08, NDMK 14-24, MH 921, PM 10-18, IPM 2-3 and LGG 574 are significantly at par with each other. These findings are more or less similar with the results found by Singh and Singh [12] reported minimum damage was recorded in RVSm-11-9, followed by IPM-306-6, IPM 2K-15-4, MH-805, BM-4, DGGS-4 and BM-2002-2, and maximum in Pusa-1171, followed by HUM-12, BM-2003-2, Unnati, KM-2293 and ML-1628.

In this study, out of twenty four genotypes (including check) eleven genotypes were found least susceptible to *M. vitrata* damage as they showed a damage rating of 4-5 on a Pest Susceptibility Rating Scale of 1-9 (Table 2). VGG 10-008, IPM 312-19, Pusa 1571, ML 2412, Pusa 1572, NVL 825, ML 2410, MH 729A received score of 4 while COGG 11-02, RMG 1082 and IGKM 06-4-2 got grade 5. While KM 2348 was found to be highly susceptible to *M. Vitrata* damage with damage rating of 8 over the check cultivar, HUM-12. Remaining genotypes are moderately susceptible as shown in pest susceptibility rating (Table-2). These findings are in close agreement with Mandal [13] who reported cultivars ML 5, ML 408 and RMG 266 were resistant (less than 5 % pod damage) against pod borers. The cultivars ML 131, ML 505, RMG 275, Pusa 8971 and Pusa 8972 were moderately resistant (5.1-10 % pod damage); PDM 219, RMG 175, RMG 202, Pusa 8974, Pusa Baisakhi and K851 were moderately susceptible (10.1-15 % pod damage); PDM 216, ML 537, PDM 86-199 and WBM 202 were susceptible (>15 % pod damage). Sahoo *et al.* [14] & Jeswani and Baldev[15] in their experiments obtained identical results to the results of the present studies, although, they used different mungbean varieties.

Sandhya *et al*. [16] reported that, the five genotypes, KM-9-128 (3.5%), KM-9-136 (5.8%), RMG-492 (8.34%), LGG-527 (9.5%) and LGG-538 (10.0%) were found as tolerant and twenty one genotypes showed susceptibility with a range from 12.59 (MGG-332) to 20.0 (IPM-02-03 and LGG-522) percent and 13 genotypes were highly susceptible with a range from 43.25 (KM-8-662) to 68.39% (KM-173) pod damage. The remaining showed moderate susceptibility with a range from 20.21 (UPM-99-3) to 40.0 (KM-2241) percent.

Table 2: Percent pod damage due to spotted pod borer *Maruca vitrata* (Fabricius) and pest susceptibility rating in different green gram genotypes during *kharif*, 2015-16

S. No	Genotypes	Per cent pod damage	Pest resistant/ susceptibility rating	Susceptibility category
1	AKM 12-17	16.40 (23.88)^{ij}	7	MS
2	IPM 312-20	14.22 (22.15)^{h}	7	MS
3	Pusa 1572	9.64 (18.06)$^{b-e}$	4	LS
4	PM 12-2	13.42 (21.48)^{fg}	6	MS
5	GM 05-08	13.44 (21.49)^{fg}	6	MS
6	IPM 312-19	8.09 (16.48)^{ab}	4	LS
7	Pusa 1571	8.48 (16.91)^{abc}	4	LS
8	PM 4	15.06 (22.83)^{hi}	7	MS
9	COGG 11-02	10.37 (18.78)^{de}	5	LS
10	NDMK 14-24	13.81 (21.81)^{fg}	6	MS
11	BM 2012-9	16.51 (23.46)^{ij}	7	MS
12	VGG 10-008	7.27 (15.62)^{a}	4	LS
13	ML 2412	8.50 (16.93)^{abc}	4	LS
14	IGKM 06-4-2	11.15 (19.50)^{ef}	5	LS
15	MH 729A	9.80 (18.24)^{cde}	4	LS
16	MH 921	12.33 (24.22)^{fg}	6	MS
17	PM 10-18	13.74 (21.75)^{fg}	6	MS
18	IPM 2-3	13.35 (21.42)^{fg}	0	MS
19	NVL 825	9.16 (17.61)^{bcd}	4	LS
20	LGG 574	13.57 (21.60)^{fg}	6	MS
21	KM 2348	19.26 (26.02)^{k}	8	HS
22	RMG 1082	10.72 (19.08)^{de}	5	LS
23	ML 2410	9.62 (18.06)$^{b-e}$	4	LS
24	HUM-12 (Check cultivar)	13.35 (24.22)^{j}	-	-
S.Em.±		(0.46)		
CD at 5%		(1.32)		

Data presented in parentheses are angular transformed value;
In a column, transformed values followed by the common letter(s) are not significant in DMRT @ 5% level of significance.
LS = Least susceptible, MS = Moderately susceptible, HS = Highly susceptible

Grain yield in green gram genotypes

The data on grain yield per hectare of different genotypes are given in Table 3. There was significant difference in grain yield between genotypes and checks. The highest grain yield was recorded from VGG 10-008 (819 kg/ha) which was significantly different from other genotypes where as lowest grain yield was recorded from KM 2348 (416 kg/ha), as compared to check cultivar, HUM-12 (590 kg/ha). These findings are in close agreement with Kumar and Singh [11] who reported that the highest yield was obtained from RVSU-11-8 (7.82 q/ha), followed by KPU-1-10 (7.51 q/ha) and AKU10-4 (6.87 q/ha), and the lowest yield from TU-631 (2.33 q/ha). Singh and Singh [12] also noticed that, highest yield was recorded in AKM-4, followed by KM-2293, AKM-09-2, IPM-3066 and ML-1628.

Table 3: Yield of green gram genotypes during *Kharif* 2015-16.

S. No	Genotypes	Yield (Kg/ha)
1	AKM 12-17	520^{b}
2	IPM 312-20	536^{b}
3	Pusa 1572	695^{hi}
4	PM 12-2	557^{b-e}
5	GM 05-08	547^{b}
6	IPM 312-19	764^{k}
7	Pusa 1571	761^{jk}
8	PM 4	523^{b}
9	COGG 11-02	711^{hij}
10	NDMK 14-24	605^{ef}
11	BM 2012-9	504^{b}
12	VGG 10-008	819^{l}
13	ML 2412	663^{gh}
14	IGKM 06-4-2	510^{bc}
15	MH 729A	700^{hi}
16	MH 921	616^{fg}
17	PM 10-18	559^{cde}
18	IPM 2-3	746^{ijk}
19	NVL 825	720^{ijk}
20	LGG 574	555^{b-e}
21	KM 2348	416^{a}
22	RMG 1082	615^{fg}
23	ML 2410	638^{fg}
24	HUM-12 (Check cultivar)	590^{def}
S.Em.±		16.45
CD at 5%		46.99

Data presented in parentheses are angular transformed value;
In a column, values followed by the common letter(s) are not significant in DMRT @ 5% level of significance

Conclusion

On the basis of the above investigation it may be concluded that host plant resistance plays a very important role in governing the pest infestation level in green gram and screening is an appropriate method to identify resistant genotypes. The incidence of spotted pod borer increases with the advancement of crop age and the actual damage to the economic produce take place after flowering of the crop. The spotted pod borer, *Maruca vitrata* (Fabricius) is the most damaging insect in green gram in this region. Among the twenty four genotypes screened, VGG 10-008 was found to be the most suitable one against spotted pod borer damage and it also gave the highest grain yield and hence can be recommended as a source of resistance to spotted pod borer. Thus, this finding can be used very effectively in resistance breeding programmes against spotted pod borer in green gram crop.

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