Original Research Article

Influence of plant resistance in certain genotypes of Greengram on insecticide tolerance on Spotted Pod Borer, *Maruca vitrata* (Geyer)

Abstract

Field screening experiments which were conducted on greengram genotypes against *Maruca vitrata* infestation revealed that WGG-42, TM-962 and MGG-360 showed resistant, moderately resistant and susceptible reaction based on number of webbings per plant and number of caterpillars per plant. Further investigation on feeding preference of *Maruca* by free-choice and no-choice techniques on selected genotypes of greengram in the laboratory to confirm the resistance ranking observed in the field screening have yielded similar resistance reaction to *Maruca* infestation. Chlorpyriphos which was applied topically on the larvae revealed that the larvae reared on susceptible greengram genotype had higher LC_{50} and LD_{50} values as compared to larvae reared on resistant genotype.

Key words: *Maruca vitrata*, Greengram, Chlorpyriphos, LC_{50} and $LD_{50,}$

1.Introduction

Greengram [*Vigna radiata* (L.)Wilczek] is also known as mungbean or moong, is a leguminous plant species belonging to the Fabaceae family. It is an excellent source of high-quality protein (25%) having high digestibility. It is consumed as whole grains as well as "Dal" in a variety of ways in our food. Greengram is also used as a green manuring crop. It is a leguminous crop that has the capacity to fix atmospheric nitrogen (30-40 kg N/ha). It also helps in preventing soil erosion. These crops grow quickly, generate good profit for farmers and contribute to agricultural and environmental sustainability [1]. India is the major producer of greengram in the world and grown in almost all the states. It is grown in about 4.5 million ha with the total production of 2.5 million tonnes with a productivity of 548 kg/ha and contributing 10% to the total pulse production. Andhra Pradesh ranks sixth in greengram production with 0.08 million tonnes under an area of 0.12 million ha with productivity of 735 kg/ha [11].

Spotted pod borer, *Maruca vitrata* (Geyer) (Lepidoptera: Crambidae) is most formidable and potential pest that causes extensive damage to greengram under field conditions. The low yield of green gram is attributed to the regular outbreaks of spotted pod borer. It is considered one of the voracious legume pests because of its broad host range, high degree of damage and worldwide distribution [7]. The webbing behaviour protects the *Maruca* larvae from both biotic and abiotic conditions and also makes it difficult to manage the insect by synthetic chemicals. The repeated use of older class chemicals such as chlorpyriphos, acephate, dichlorovos *etc*., have resulted in development of resistance to insecticides. Host Plant Resistance offers one of the best insect pest management strategy which is environmentally safe and no additional cost was incurred to the farmers [8]. A lot of work has been done on screening of various genotypes, wild relatives and germplasm of different pulses to different insect pests feeding on them. An ample amount of work has also been carried out on knowing mechanism of resistance involved and role of secondary metabolites on plant resistance to insects. Quite few numbers of insect resistant genotypes has also been released by state, national and international institutes. However not much work has been done on host plant resistance to spotted pod borer in greengram and its interaction with insecticide tolerance. Keeping these research gaps in view, the present study was carried out to understand the role of host plant resistance on usage of chemicals against damage by *M. vitrata*.

2. Materials and Methods

Field screening of certain genotypes of greengram for observing susceptibility against *M.vitrata* infestation; effect of plant resistance in popular genotypes of greengram to *M.vitrata* and its role in insecticide tolerance during 2014-2015 were conducted in Department of Entomology, S.V. Agricultural College and Regional Agricultural Research Station (RARS), Tirupati.

2.1 Screening of certain genotypes of greengram for the incidence of *M.vitrata*: A screening trial was conducted with ten genotypes of greengram *viz*., WGG-42, LGG-407, PM-115, MGG-360, PM-110, LGG-410, PM-112, TM-962, LGG-450, LGG-460 against *M.vitrata* in the wetland farm, S.V. Agricultural College, Tirupati in a randomized block design (RBD). Two crops were raised one at during last week of August-2014 and second was raised during second week of September-2014. Five randomly selected plants were tagged in each genotype for long term sampling to record the infestation of the *M.vitrata*. During the period of study, incidence of the *M.vitrata* across different genotypes was recorded from vegetative parts, flower buds and pods at different dates of sowing (DAS) of each crop. During first crop, data was observed at 71, 78, 85 and 92 DAS and during second crop, data was observed at 57, 64, 71, 78, 85 and 92 DAS. Based on the observations, the genotypes were grouped into resistant, moderate resistant and susceptible to their reaction to *Maruca* infestation and were used for further investigations.

2.2 Scrutinising mechanisms of resistance in selected genotypes of greengram: The genotypes of greengram that were grouped into resistant, moderate resistant and susceptible to *Maruca* damage from field observations were used in the present study to confirm their resistant rankings in feeding preference by free-choice and no-choice (biology) techniques.

In free-choice technique, the leaves, flowers, and developed pods of resistant, moderate resistant and susceptible genotypes of greengram were placed in a radical fashion in separate petriplates of size 18cm diameter, at equal distance. Six larvae of same instar were released in the middle of the petriplate and after 24 hours, larvae on each test genotype was recorded to test feeding preference.

In no-choice technique**,** six first instar larvae were released separately for each test genotype of greengram in six loculed cell wells and observations were recorded on biological parameters such as duration of egg stage, instar durations, pre-pupal duration, pupal duration, adult longevity of the spotted pod borer. From the day of hatching of the egg, the first and second instar larvae of spotted pod borer were provided with sufficient amount of flower buds of resistant, moderate resistant and susceptible genotypes of greengram for feeding. For third, fourth and fifth instar larvae, flower buds and developed pods were provided for feeding. The time from hatching of first instar to the final pre-pupal stage were considered as the total larval duration. Duration of each instars of larvae was recorded by observing the moulted skins of the next larval stages on test genotypes of greengram. The duration of pupation to the adult emergence was considered as the duration of pupal stage of the moth and was expressed in days. From the day of adult emergence till the death was considered as the adult longevity.

2.3 Effect of plant resistance in selected genotypes of greengram to *M.vitrata* and its role in insecticide tolerance: Based on field screening and biology studies in the laboratory, resistant and susceptible genotypes of greengram were selected and were grown in plastic pots of size 15 cm diameter and 15 cm depth in greenhouse with staggered sowing. For the insecticide bioassay study, the first instar larvae from nucleus culture were separated carefully with camel hair brush and were kept in separate trays having flower buds of resistant and susceptible genotypes separately in each tray and were allowed to feed upto ten days. Just before conducting the bio-assay test, larval weights were taken.

For topical bioassay, a serial dilution of chlorpyriphos with 5 concentrations (10, 5, 2.5, 1.25 and 0.625 mL/lit of water) were prepared and with microapplicator, 2.0 µl of each concentration of chlorpyriphos was applied to the mid dorsum of early third instar larvae. For topical application, ten larvae were taken for each concentration. After topical application, the larvae were placed in rearing boxes containing greengram flowers and pods for feeding. A group of ten larvae were kept as control with no insecticide treatment. The number of dead larvae were recorded after 24, 48 and 72 hours. The data was subjected to probit analysis by using a statistical package [10] to calculate lethal concentration (LC_{50}) values for *M.vitrata* against insecticide on various greengram genotypes having various levels of plant resistance to *M.vitrata.* From the LC_{50} values, lethal dose (LD_{50}) values were calculated by the following equation [3,4,5]

$$LD_{50} = \frac{\text{Volume of insecticide applied (µL)}}{\text{Mean larval weight (µg)}} \times LC_{50}$$

3. Results and Discussion

3.1 Field screening of different genotypes of greengram for the incidence of *M.vitrata* :

For the first crop, the observations were recorded at 71DAS as all the genotypes have attained 50% flowering at this age and for the second crop, observations were recorded from 57 DAS.

3.1.1 Screening for number of webbings per plant

From the mean data (Table 1) of first crop, lowest number of webbings per plant were observed in WGG-42(2.28 ± 0.50). Highest number of webbings per plant were found in MGG-360(5.83 ± 0.54) followed by LGG-410(4.56 ± 1.04) (significantly different) and the remaining (LGG-450, PM-115, LGG-460, LGG-407, PM-110, TM-962 and PM-112) genotypes were on par with each other. Number of webbings of *M. vitrata* in the present investigation varied from 1.07/plant to 7.80/plant between 71 DAS to 92 DAS. From the mean data of second crop (Table 2), lowest number of webbings per plant were observed in WGG-42(2.38 ± 0.63). In MGG-360(5.33 ± 0.67) highest number of webbings per plant were observed and the remaining (PM-112, LGG-450, PM-110, LGG-460, TM-962, LGG-410 PM-115 and LGG-407) genotypes were on par with each other. Number of webbings of *M. vitrata* in the present investigation varied from 1.07/plant to 7.80/plant between 57 DAS to 92

DAS. These results were in close resemblance with that of Reddy and Hariprasad [8] who observed that lowest number of webbings per plant were observed in LBG-645(2.02 ± 0.50) and highest number of webbings per plant were found in LBG-790 (4.60 ± 1.00) for one crop.

Table 1. Number of webbings of *M.vitrata* larva per plant in different genotypes of greengram during first crop

DAS / Genotypes	71 DAS	78 DAS	85 DAS	92 DAS	Mean
WGG-42	1.07[a]±0.25 (1.03)	2.53[a]±0.83 (1.57)	2.60[a]±0.73 (1.60)	2.93[a]±0.88 (1.70)	2.28[a]±0.50 (1.47)
LGG-407	1.40[ab]±0.63 (1.16)	4.20[b]±1.01 (2.04)	4.60[bc]±0.98 (2.13)	5.00[b]±1.64 (2.21)	3.80[b]±0.77 (1.88)
PM-115	1.47[ab]±0.74 (1.18)	3.87[b]±0.99 (1.95)	3.93[b]±1.03 (1.97)	4.47[b]±1.40 (2.09)	3.43[b]±0.72 (1.80)
MGG-360	2.73[c]±0.88 (1.63)	5.87[c]±1.18 (2.41)	6.93[d]±1.10 (2.63)	7.80[d]±1.14 (2.79)	5.83[d]±0.54 (2.36)
PM-110	1.27[ab]±0.45 (1.11)	4.27[b]±1.58 (2.03)	4.73[bc]±1.03 (2.16)	5.00[b]±1.25 (2.22)	3.81[b]±0.75 (1.88)
LGG-410	1.33[ab]±0.48 (1.14)	5.67[c]±1.87 (2.35)	5.07[c]±1.22 (2.23)	6.20[c]±1.42 (2.47)	4.56[c]±1.04 (2.05)
PM-112	1.53[ab]±0.64 (1.21)	4.27[b]±1.90 (2.01)	4.73[bc]±1.57 (2.14)	5.33[bc]±1.49 (2.29)	3.96[b]±1.21 (1.92)
TM-962	1.67[b]±0.81 (1.26)	4.07[b]±1.10 (2.00)	4.47[bc]±0.90 (2.15)	5.00[b]±1.60 (2.21)	3.85[b]±0.68 (1.90)
LGG-450	1.33[ab]±0.48 (1.14)	3.47[ab]±1.06 (1.84)	4.00[b]±1.06 (1.98)	4.60[b]±1.40 (2.12)	3.35[b]±0.73 (1.77)
LGG-460	1.40[ab]±0.63 (1.16)	3.87[b]±1.56 (1.93)	4.60[bc]±6.91 (2.13)	4.93[b]±1.22 (2.20)	3.70[b]±0.78 (1.86)
Grand Mean	1.52±0.74 (1.20)	4.21±1.60 (2.01)	4.59±1.46 (2.11)	5.13±1.77 (2.23)	3.86±1.16 (1.89)

Values in parenthesis are square root transformed
Values having the same alphabet are not significantly different as per DMRT.

Table 2. Number of webbings of *M.vitrata* larva per plant in different genotypes of greengram during second crop

DAS / Genotypes	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	92 DAS	Mean
WGG-42	1.07^{a}±0.25 (1.03)	1.93^{a}±0.79 (1.36)	2.67^{a}±0.97 (1.61)	2.80^{a}±0.94 (1.65)	2.93^{a}±1.22 (1.68)	2.87^{a}±0.91 (1.67)	2.38^{a}±0.63 (1.50)
LGG-407	1.47^{a}±0.74 (1.18)	2.33^{abc}±1.29 (1.47)	3.73^{b}±1.33 (1.9)	4.67^{d}±1.49 (2.13)	5.33^{c}±1.39 (2.29)	5.73^{b}±1.28 (2.38)	3.86^{b}±0.97 (1.89)
PM-115	1.47^{a}±0.64 (1.19)	2.67^{abc}±1.11 (1.60)	3.80^{b}±0.94 (1.93)	4.40^{cd}±0.91 (2.09)	4.93^{bc}±1.03 (2.21)	4.87^{b}±1.45 (2.18)	3.70^{b}±0.69 (1.87)
MGG-360	2.27^{b}±0.88 (1.48)	3.20^{c}±1.52 (1.74)	5.20^{c}±1.20 (2.27)	6.20^{e}±0.86 (2.48)	7.47^{d}±0.91 (2.73)	7.80^{c}±1.01 (2.79)	5.33^{c}±0.67 (2.25)
PM-110	1.27^{a}±0.59 (1.10)	2.27^{ab}±0.88 (1.48)	3.60^{b}±0.98 (1.88)	4.27^{cd}±1.10 (2.05)	4.53^{bc}±1.40 (2.10)	4.93^{b}±1.28 (2.20)	3.47^{b}±0.65 (1.80)
LGG-410	1.40^{a}±0.63 (1.16)	2.60^{abc}±1.18 (1.57)	3.73^{b}±1.16 (1.91)	3.93^{bcd}±1.22 (1.96)	4.93^{bc}±1.33 (2.20)	5.20^{b}±1.01 (2.27)	3.62^{b}±0.84 (1.84)
PM-112	1.27^{a}±0.45 (1.11)	2.93^{bc}±1.16 (1.68)	3.27^{ab}±1.48 (1.77)	3.07^{ab}±0.79 (1.74)	4.27^{b}±1.22 (2.04)	4.80^{b}±1.01 (2.18)	3.27^{b}±0.71 (1.75)
TM-962	1.20^{a}±0.41 (1.08)	2.27^{ab}±1.03 (1.47)	3.40^{ab}±0.98 (1.83)	4.00^{cd}±1.30 (1.97)	5.13^{bc}±1.30 (2.25)	5.27^{b}±1.53 (2.27)	3.53^{b}±0.84 (1.81)
LGG-450	1.47^{a}±0.74 (1.18)	2.07^{ab}±1.03 (1.40)	3.27^{ab}±1.10 (1.79)	3.60^{ab}±1.18 (1.87)	4.73^{bc}±1.38 (2.15)	5.47^{b}±1.18 (2.33)	3.42^{b}±0.77 (1.78)
LGG-460	1.40^{a}±0.63 (1.16)	2.13^{ab}±0.91 (1.43)	3.27^{ab}±1.03 (1.76)	3.93b^{cd}±1.03 (1.97)	5.20^{bc}±0.94 (2.27)	4.93^{b}±1.38 (2.20)	3.52^{b}±0.75 (1.80)
Grand Mean	1.43±0.67 (1.17)	2.44±1.14 (1.52)	3.59±1.26 (1.87)	4.09±1.39 (1.99)	4.95±1.60 (2.19)	5.19±1.64 (2.25)	3.61±1.01 (1.83)

Values in parenthesis are square root transformed values
Values having the same alphabet are not significantly different as per DMRT.

3.1.2 Screening for number of caterpillars per plant

From the mean data of first crop, lowest number of caterpillars per plant were found in WGG-42(1.73 ± 0.52). Highest number of caterpillars per plant were observed in MGG-360(6.08 ± 0.87) and the remaining (LGG-50, LGG-407, LGG-460, TM-962, PM-110, PM-115, PM-112 and LGG-410) genotypes were on par with each other (Table 3). From the mean data of second crop (Table 4), highest number of caterpillars per plant were obtained in MGG-360(5.02 ± 0.84). Lowest number of caterpillars per plant were observed in WGG-42(1.84 ± 0.54) and the remaining (LGG-450, PM-112, LGG-460, PM-110, TM-962, LGG-410, LGG-407 and PM-115) genotypes were on par with each other. The obtained observations were similar to the findings of Reddy and Hariprasad [8] who reported that lowest number of caterpillars per plant were found in LBG-645 (1.62 ± 0.59) followed by LBG-709 (2.48 ± 0.66) (significantly different) and the highest number of caterpillars per plant were found in LBG-790 (4.07 ± 0.74) followed by LBG-752 (3.13 ± 0.70) (significantly different), and the remaining (LBG-792, LBG-791, LBG-123, LBG-20 and PU-31) genotypes were on par with each other.

Table 3. Total number of *M.vitrata* caterpillars per plant in different genotypes of greengram during first crop

DAS / Genotype	71 DAS	78 DAS	85 DAS	92 DAS	Mean
WGG-42	1.00^{a}±0.00 (1.41)	1.07^{a}±0.88 (1.41)	3.67^{a}±1.11 (1.89)	1.20^{a}±0.94 (1.45)	1.73^{a}±0.52 (1.54)
LGG-407	1.07^{a}±0.70 (1.42)	2.13^{b}±0.99 (1.75)	6.07^{b}±1.28 (2.45)	2.93^{b}±1.90 (1.93)	3.05^{b}±0.94 (1.89)
PM-115	1.27^{a}±0.59 (1.50)	2.27^{bc}±0.88 (1.79)	5.60^{b}±1.24 (2.35)	3.73^{b}±1.71 (2.13)	3.21^{b}±0.65 (1.94)
MGG-360	3.20^{b}±0.86 (2.04)	6.53^{d}±2.47 (2.71)	7.87^{c}±1.12 (2.80)	6.73^{c}±2.52 (2.75)	6.08^{c}±0.87 (2.57)
PM-110	0.87^{a}±0.74 (1.34)	2.47^{bc}±1.40 (1.83)	5.80^{b}±1.74 (2.38)	3.33^{b}±1.54 (2.05)	3.11^{b}±0.90 (1.90)
LGG-410	0.87^{a}±0.64 (1.35)	3.33^{c}±1.71 (2.05)	6.13^{b}±1.64 (2.46)	3.33^{b}±1.17 (2.06)	3.41^{b}±1.01 (1.98)
PM-112	1.20^{a}±0.77 (1.46)	2.73^{bc}±1.28 (1.91)	5.33^{b}±1.11 (2.30)	4.13^{b}±1.88 (2.23)	3.35^{b}±0.91 (1.97)
TM-962	1.33^{a}±1.04 (1.50)	1.73^{ab}±1.16 (1.62)	5.80^{b}±1.14 (2.40)	3.60^{b}±1.92 (2.10)	3.11^{b}±0.82 (1.90)
LGG-450	1.00^{a}±0.65 (1.39)	2.00^{ab}±0.92 (1.71)	5.67^{b}±1.39 (2.36)	3.27^{b}±1.90 (2.02)	2.98^{b}±0.83 (1.87)
LGG-460	1.33^{a}±0.72 (1.51)	2.27^{bc}±0.88 (1.79)	5.67^{b}±1.44 (2.36)	3.07^{b}±1.90 (1.96)	3.08^{b}±0.80 (1.91)
Grand Mean	1.31±0.95 (1.49)	2.65±1.92 (1.86)	5.76±1.62 (2.38)	3.53±2.17 (2.07)	3.31±1.31 (1.95)

Values in parenthesis are square root transformed
Values having the same alphabet are not significantly different as per DMRT.

Table 4. Total number of *M.vitrata* caterpillars per plant in different genotypes of greengram

DAS / Genotypes	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	92 DAS	Mean
WGG-42	$0.73^{ab}\pm0.59$ (1.30)	$0.93^{a}\pm0.88$ (1.36)	$3.27^{a}\pm1.16$ (1.78)	$2.07^{a}\pm1.48$ (1.69)	$2.27^{a}\pm1.62$ (1.75)	$1.87^{a}\pm0.83$ (1.34)	$1.84^{a}\pm0.54$ (1.54)
LGG-407	$0.93^{ab}\pm0.70$ (1.37)	$2.00^{ab}\pm1.51$ (1.68)	$4.67^{b}\pm1.58$ (2.13)	$3.80^{b}\pm1.97$ (2.14)	$6.20^{c}\pm1.89$ (2.66)	$2.60^{ab}\pm1.05$ (1.58)	$3.36^{b}\pm0.68$ (1.93)
PM-115	$0.87^{ab}\pm0.74$ (3.14)	$2.40^{b}\pm1.50$ (1.8)	$4.80^{b}\pm1.20$ (2.17)	$5.13^{b}\pm1.59$ (2.45)	$5.40^{bc}\pm1.63$ (2.51)	$2.47^{ab}\pm1.12$ (1.53)	$3.45^{b}\pm0.81$ (1.97)
MGG-360	$1.80^{c}\pm0.67$ (1.66)	$2.20^{b}\pm1.61$ (1.74)	$6.40^{c}\pm2.06$ (2.48)	$6.60^{c}\pm2.02$ (2.73)	$8.20^{d}\pm2.67$ (3.01)	$4.93^{c}\pm1.28$ (2.20)	$5.02^{c}\pm0.84$ (2.30)
PM-110	$0.53^{a}\pm0.51$ (1.22)	$2.20^{b}\pm1.01$ (1.77)	$4.40^{ab}\pm1.45$ (2.07)	$4.27^{b}\pm1.83$ (2.26)	$4.87^{bc}\pm1.84$ (2.39)	$3.07^{b}\pm1.33$ (1.71)	$3.20^{b}\pm0.58$ (1.90)
LGG-410	$1.07^{b}\pm0.70$ (1.42)	$2.27^{b}\pm1.83$ (1.74)	$4.73^{b}\pm1.66$ (2.14)	$3.87^{b}\pm1.80$ (2.16)	$5.27^{bc}\pm1.66$ (2.48)	$2.60^{ab}\pm0.98$ (1.58)	$3.30^{b}\pm0.74$ (1.92)
PM-112	$0.73^{ab}\pm0.45$ (1.30)	$2.80^{b}\pm1.37$ (1.92)	$4.40^{ab}\pm1.72$ (2.06)	$3.80^{b}\pm1.52$ (2.16)	$4.20^{b}\pm1.74$ (2.25)	$3.07^{b}\pm1.16$ (1.72)	$3.14^{b}\pm0.63$ (1.90)
TM-962	$0.67^{ab}\pm0.48$ (1.28)	$2.27^{b}\pm1.38$ (1.71)	$4.27^{ab}\pm1.03$ (2.05)	$3.93^{b}\pm1.33$ (2.23)	$5.40^{bc}\pm1.40$ (2.51)	$3.07^{b}\pm1.33$ (0.71)	$3.23^{b}\pm0.69$ (1.91)
LGG-450	$1.13^{b}\pm0.64$ (1.44)	$1.93^{ab}\pm1.16$ (1.68)	$4.40^{ab}\pm1.50$ (2.07)	$2.47^{a}\pm1.12$ (1.83)	$5.40^{bc}\pm3.26$ (2.45)	$2.33^{ab}\pm0.81$ (1.50)	$2.94^{b}\pm0.80$ (1.83)
LGG-460	$0.80^{ab}\pm0.56$ (1.32)	$2.00^{ab}\pm1.25$ (1.69)	$4.20^{ab}\pm1.58$ (2.01)	$4.53^{b}\pm1.64$ (2.33)	$4.73^{bc}\pm1.94$ (2.36)	$2.60^{ab}\pm1.29$ (1.57)	$3.14^{b}\pm0.83$ (1.88)
Grand Mean	0.93 ± 0.68 (1.37)	2.08 ± 1.41 (1.71)	4.55 ± 1.65 (2.10)	4.05 ± 2.01 (2.20)	5.19 ± 2.43 (2.44)	2.86 ± 1.35 (1.65)	3.26 ± 1.01 (1.91)

Values in parenthesis are square root transformed values
Values having the same alphabet are not significantly different as per DMRT.

3.1.3 Screening for percentage infestation of *Maruca*

Lowest percentage infestation of *M.vitrata* was observed in LGG-410(34.04 ± 6.05) from the mean data followed by WGG-42(36.36 ± 1.96) (not significantly different). Highest percentage infestation was found in MGG-360(52.78 ± 0.69) followed by PM-112(47.34 ± 2.36) (not significantly different) and the remaining (LGG-460, PM-110, LGG-407, TM-962, LGG-450 and PM-115) genotypes were on par with each other (Table 5). From the mean data, lowest percentage infestation was found in PM-112(36.51 ± 2.75), TM-962(36.84 ± 3.16), LGG-450(37.61 ± 6.63), PM-115(38.52 ± 2.65), LGG-407(38.97 ± 3.57) (not significantly different). Highest percentage infestation was observed in MGG-360(46.79 ± 3.43) and the remaining (LGG-460, PM-110, WGG-42, LGG-410) genotypes were on par with each other (Table 6). These results were supported by the findings of the Reddy and Hariprasad [8] who reported that percentage infestation was found lowest in LBG-645 (33.33 ± 0.83) followed by LBG-791(33.73 ± 3.42) and highest percentage infestation was found in LBG-790 (44.60 ± 5.50) followed by LBG-709 (41.11 ± 6.08), LBG-752 (39.09 ± 2.93) and LBG-123 (38.41±3.27).

Table 5. Percentage infestation of *M.vitrata* in different genotypes of greengram

DAS / Genotypes	Total no. of plants	71 DAS	78 DAS	85 DAS	92 DAS	Mean
WGG-42	18.67^{a}±3.05 (4.31)	32.70^{a}±5.14 (34.85)	37.58^{a}±1.26 (37.83)	37.58^{a}±1.26 (37.83)	37.58^{a}±1.26 (37.83)	36.36^{a}±1.96 (37.08)
LGG-407	20.67^{ab}±3.51 (4.53)	26.07^{a}±2.95 (30.70)	46.39^{abc}±11.09 (42.93)	44.80^{ab}±12.14 (42.01)	44.80^{ab}±12.14 (42.01)	40.52^{ab}±9.50 (39.41)
PM-115	20.33^{ab}±0.57 (4.51)	27.93^{a}±6.14 (31.84)	44.20^{ab}±3.87 (41.69)	45.79^{ab}±6.22 (42.60)	50.79^{bc}±5.18 (45.48)	42.18^{ab}±4.08 (40.40)
MGG-360	21.00^{ab}±1.00 (4.58)	25.51^{a}±3.92 (30.31)	57.07^{c}±2.04 (49.10)	63.43^{c}±3.33 (52.83)	65.10^{d}±1.51 (53.82)	52.78^{c}±0.69 (46.52)
PM-110	22.33^{ab}±2.88 (4.72)	25.80^{a}±5.41 (30.46)	41.15^{ab}±10.15 (39.86)	43.93^{ab}±7.81 (41.51)	45.32^{abc}±6.33 (42.33)	39.05^{ab}±7.21 (38.54)
LGG-410	22.67^{ab}±1.52 (4.76)	25.30^{a}±6.97 (30.09)	36.91^{a}±7.22 (37.37)	35.46^{a}±5.47 (36.53)	38.510^{ab}±8.08 (38.30)	34.04^{a}±6.05 (35.57)
PM-112	20.67^{ab}±2.30 (4.54)	25.92^{a}±2.78 (30.60)	53.36^{bc}±2.95 (46.96)	53.36^{bc}±2.95 (46.96)	56.73^{cd}±3.79 (48.90)	47.34^{bc}±2.36 (43.35)
TM-962	22.67^{ab}±0.57 (4.76)	25.03^{a}±2.91 (30.01)	44.07^{ab}±3.49 (41.6)	47.03^{ab}±8.80 (43.31)	47.03^{abc}±8.80 (43.31)	40.79^{ab}±5.50 (39.56)
LGG-450	22.33^{ab}±2.88 (4.72)	24.41^{a}±6.20 (29.52)	45.68^{abc}±10.77 (42.52)	48.46^{ab}±8.42 (44.14)	48.46^{abc}±8.48 (44.14)	41.75^{ab}±8.42 (40.08)
LGG-460	21.47^{b}±2.08 (4.83)	25.85^{a}±2.40 (30.56)	38.73^{a}±4.88 (38.48)	41.45^{ab}±3.47 (40.09)	41.45^{ab}±3.47 (40.09)	36.87^{ab}±3.13 (37.31)
Grand Mean	21.47±2.34 (4.63)	26.45±4.57 (30.90)	44.51±8.50 (41.84)	46.13±9.53 (42.78)	47.57±9.86 (43.62)	41.17±7.06 (39.78)

Values in parenthesis are arc sine transformed values

Values having the same alphabet are not significantly different as per DMRT

Table 6. Percentage infestation of *M.vitrata* in different genotypes of greengram

DAS / Genotypes	Total no. of plants	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	92 DAS	Mean
WGG-42	$17.33^{a}\pm1.15$ (4.28)	$28.94^{ab}\pm2.00$ (32.55)	$42.36^{b}\pm3.02$ (40.62)	$42.36^{bc}\pm3.02$ (40.62)	$42.36^{ab}\pm3.02$ (40.62)	$42.36^{a}\pm3.02$ (40.62)	$44.21^{a}\pm0.40$ (41.70)	$40.43^{ab}\pm2.13$ (39.46)
LGG-407	$20.00^{ab}\pm1.00$ (4.58)	$30.05^{b}\pm1.50$ (33.25)	$31.72^{ab}\pm3.21$ (34.28)	$38.48^{abc}\pm4.57$ (38.34)	$41.73^{ab}\pm3.46$ (40.25)	$43.40^{a}\pm6.05$ (41.21)	$48.50^{a}\pm5.05$ (44.16)	$38.97^{a}\pm3.57$ (38.58)
PM-115	$20.00^{ab}\pm1.00$ (4.58)	$28.30^{ab}\pm1.85$ (32.14)	$31.56^{ab}\pm6.54$ (34.12)	$38.23^{abc}\pm4.10$ (38.20)	$39.90^{ab}\pm3.01$ (39.19)	$44.91^{a}\pm2.75$ (42.10)	$48.24^{a}\pm6.47$ (44.01)	$38.52^{a}\pm2.65$ (38.29)
MGG-360	$20.33^{b}\pm1.15$ (4.62)	$24.64^{a}\pm1.44$ (29.77)	$41.19^{b}\pm5.35$ (39.93)	$45.95^{c}\pm2.68$ (42.70)	$47.54^{b}\pm4.76$ (43.61)	$57.39^{b}\pm4.78$ (49.29)	$64.08^{b}\pm6.06$ (53.24)	$46.79^{b}\pm3.43$ (43.09)
PM-110	$18.00^{ab}\pm1.00$ (4.36)	$31.53^{b}\pm1.68$ (34.17)	$35.88^{ab}\pm9.73$ (36.68)	$39.21^{abc}\pm4.38$ (38.77)	$39.21^{ab}\pm4.38$ (38.77)	$46.48^{a}\pm3.06$ (43.00)	$46.48^{a}\pm3.06$ (43.00)	$39.79^{ab}\pm3.95$ (39.07)
LGG-410	$19.33^{ab}\pm0.57$ (4.51)	$29.05^{ab}\pm4.83$ (32.58)	$37.49^{ab}\pm8.30$ (37.69)	$40.93^{abc}\pm6.58$ (39.76)	$42.51^{ab}\pm3.83$ (40.71)	$47.62^{a}\pm4.12$ (43.65)	$51.06^{a}\pm4.07$ (45.63)	$41.44^{ab}\pm4.96$ (40.00)
PM-112	$20.67^{b}\pm2.51$ (4.65)	$27.84^{ab}\pm1.54$ (31.85)	$31.44^{ab}\pm1.96$ (34.12)	$35.25^{ab}\pm3.65$ (36.42)	$35.25^{a}\pm3.65$ (36.42)	$42.78^{a}\pm5.30$ (40.85)	$46.50^{a}\pm5.70$ (43.01)	$36.51^{a}\pm2.75$ (37.11)
TM-962	$19.33^{ab}\pm1.15$ (4.51)	$27.54^{ab}\pm2.12$ (31.66)	$27.63^{a}\pm3.48$ (31.70)	$32.81^{a}\pm3.58$ (34.94)	$36.32^{a}\pm6.07$ (37.03)	$44.91^{a}\pm4.25$ (42.09)	$51.84^{a}\pm6.48$ (46.08)	$36.84^{a}\pm3.16$ (37.25)
LGG-450	$20.67^{b}\pm2.51$ (4.65)	$29.33^{ab}\pm3.68$ (32.78)	$30.92^{ab}\pm4.18$ (33.76)	$34.36^{ab}\pm7.17$ (35.82)	$37.80^{a}\pm10.17$ (37.83)	$42.55^{a}\pm7.61$ (40.70)	$50.74^{a}\pm9.22$ (45.46)	$37.61^{a}\pm6.63$ (37.72)
LGG-460	$19.33^{ab}\pm1.15$ (4.51)	$31.11^{b}\pm1.92$ (33.91)	$36.48^{ab}\pm7.33$ (37.12)	$39.81^{abc}\pm4.72$ (39.12)	$39.63^{ab}\pm0.64$ (39.03)	$41.48^{a}\pm2.56$ (40.11)	$48.52^{a}\pm6.09$ (44.17)	$39.50^{ab}\pm3.57$ (38.91)
Grand Mean	19.27±1.59 (4.50)	28.83±2.80 (32.47)	34.67±6.70 (36.00)	38.74±5.41 (38.47)	40.23±5.31 (39.35)	45.39±5.89 (42.36)	50.02±7.09 (45.05)	39.64±4.30 (38.95)

Values in parenthesis are arc sine transformed values
Values having the same alphabet are not significantly different as per DMRT.

Based on observations on number of webbings; number of caterpillars; per cent infestation of two crops, different greengram genotypes were arranged into plant resistant groups (Table 7)

Table 7: Categorization of greengram genotypes into resistant, moderate resistant and susceptible groups

	1st crop			2nd crop		
Characters	**Resistant**	**Moderate resistant**	**Susceptible**	**Resistant**	**Moderate Resistant**	**Susceptible**
Number of webbings	WGG-42 LGG-450 PM-115	LGG-460 LGG-407 PM-110 TM-962	PM-112 LGG-410 MGG-360	WGG-42 PM-112 LGG-450	PM-110 LGG-460 TM-962 LGG-410	PM-115 LGG-407 MGG-360
Number of caterpillars	WGG-42 LGG-450 LGG-407	LGG-460 TM-962 PM-110 PM-115	PM-112 LGG-410 MGG-360	WGG-42 LGG-450 PM-112 LGG-460	PM-110 TM-962 LGG-410	LGG-407 PM-115 MGG-360
Per cent infestation	LGG-410 WGG-42 LGG-460	PM-110 LGG-407 TM-962 LGG-450	PM-115 PM-112 MGG-360	PM-112 TM-962 LGG-450	PM-115 LGG-407 LGG-460 PM-110	WGG-42 LGG-410 MGG-360

From the different categories of greengram genotypes (Table 7), the genotypes WGG-42, TM-962 and MGG-360 that were consistent in their rankings were classified as resistant, moderate resistant and susceptible genotypes based on number of webbings per plant and number of caterpillars per plant. The observed classification was in accordance with the work done by Reddy and Hariprasad [8] who classified the blackgram genotypes *viz.,* LBG-645, LBG-791 and LBG-790 as resistant, moderate resistant and susceptible genotypes based on number of webbings per plant and total number of caterpillars per plant. These genotypes were taken for further investigation in the laboratory for confirmation of resistance that has been observed in the field condition.

3.2 Mechanisms of resistance in selected genotypes of greengram

It was observed that more number of *Maruca* larvae preferred the genotype MGG-360 (2.57 ± 0.79) (susceptible) which were significantly different from WGG-42 (resistant) which were preferred by few number of *Maruca* larvae (1.57 ± 0.53) (Table 8). Larval preference of genotype TM-962 (1.86 ± 0.69) (moderate resistant) were in between MGG-360 and WGG-42. The present results were in close agreement with the findings of Reddy and Hariprasad [8] who reported that the highest larval orientation of *Maruca* larvae observed in LBG-790 (susceptible genotype of blackgram) both in pods and flowers than the tolerant genotype (LBG-645).

Table 8. Larval preference of *Maruca vitrata* on different genotypes of greengram in free- choice experiment

Genotypes	No. of larvae after 24 hrs
WGG-42 (Resistant)	1.43[a] ± 0.53 (1.18)
TM-962 (Moderate resistant)	1.71[a] ± 0.75

	(1.28)
MGG-360 (Susceptible)	2.57^{b} ± 0.83 (1.58)
Total mean	1.90 ± 0.83 (1.34)
LSD	0.77

Values in parenthesis are square root transformed
Values having the same alphabet are not significantly different

In case of greengram genotypes (Table 9), it was observed that more number of larvae preferred the genotype MGG-360 (2.57 ± 0.79) (susceptible) which were significantly different from WGG-42 (resistant) which were preferred by few number of *Maruca* larvae (1.57 ± 0.53). Larval preference of genotype TM-962 (1.86 ± 0.69) (moderate resistant) were in between MGG-360 and WGG-42. The study of biology on greengram genotypes revealed that the duration of the second instar larva of spotted pod borer is 3.00 ± 0.00 days, when reared on MGG-360 (susceptible) followed by 3.14 ± 0.38 days on WGG-42 (resistant) and 3.57 ± 0.53 days in TM-962 (moderate resistant) genotypes. The duration of third instar larva was 3.29 ± 0.49 days on TM-962 (moderate resistant) followed by 3.43 ± 0.53 days in MGG-360 (susceptible) and 3.71 ± 0.49 days in WGG-42 (resistant). The duration of the fourth instar larva was 2.14 ± 0.38 days on MGG-360 (susceptible) followed by 2.71 ± 0.49 days in TM-962 (moderate resistant) and 2.86 ± 0.38 days on WGG-42 (resistant). The duration of the fifth instar larva was 2.57 ± 0.53 days on MGG-360 (susceptible) (significantly different) followed by 3.43 ± 0.53 days on TM-962 (moderate resistant) and 3.71 ± 0.49 days on WGG-42 (resistant). The total duration of the larvae was 11.14 ± 1.21 days on MGG-360 (susceptible) followed by 13.00 ± 1.15 days on TM-962 (moderate resistant) and 13.43 ± 0.53 days on WGG-42 (resistant). The lowest larval weight of the third instar (0.0342 ± 0.0018 gms) was observed, when larvae were reared on WGG-42 (resistant) followed by 0.0380 ± 0.0035 gms on TM-962 (moderate resistant). Highest larval weights (0.0440 ± 0.0021 gms), were observed, when larvae were reared on MGG-360 (susceptible). The lowest larval weight of the third instar (0.0444 ± 0.0026 gms) was observed, when larvae were reared on WGG-42 (resistant) followed by 0.0459 ± 0.0031 gms on TM-962 (moderate resistant). Highest larval weights (0.0525 ± 0.0016 gms) were observed when larvae were reared on MGG-360 (susceptible). Lowest pupal weight (0.0397 ± 0.0020) were observed, when insects were reared on WGG-42 (resistant) followed by TM-962 (moderate resistant) (0.0425 ± 0.0019) and (0.0468 ± 0.0012) gms, when insects were reared on MGG-360 (susceptible). The duration of the pupa was 4.52 ± 0.5 days on MGG-360 (susceptible) followed by 5.21 ± 0.47 days in TM-962 (moderate resistant) and 5.55 ± 0.55 days on WGG-42 (resistant) genotypes. The longivity of the adults was 5.21 ± 0.52 days on MGG-360 (susceptible) followed by 5.79 ± 0.64 days on TM-962 (moderate resistant) and 6.45 ± 0.6 days on WGG-42 (resistant). The results of the findings were supported by the observations of Sonune *et al* [9] who reported that the second, third, fourth, fifth instar and mean larval durations were 2.80 ± 0.70, 2.80 ± 0.66 , 2.76 ± 0.72 , 3.60 ± 0.64 and 14.04 ± 0.97 days on greengram. The pupal weight was 0.04 ± 0.01 g according to the observations of Long *et al* [6]. Sonune *et al* [9] reported that the pupal duration was 10.84 ± 1.79 days in greengram. The results of the findings were strongly supported by the observations of Chaitanya *et al* [2] who reported that the mean longevity of the adult was 8.83 ± 0.82 days.

Table 9. Biology of *M.vitrata* in resistant, moderate resistant and susceptible genotypes of greengram in no-choice technique

Genotype	2nd instar larva duration (days)	3rd instar larva duration (days)	4th instar larva duration (days)	5th instar larva duration (days)	Larval duration (days)	3rd instar larval weight (gms)	4th instar larval weight (gms)	Pupal weight (gms)	Pupal duration (days)	Adult longevity (days)
WGG-42 (Resistant)	$3.14^{a} \pm 0.38$	$3.71^{a} \pm 0.49$	$2.86^{b} \pm 0.38$	$3.71^{b} \pm 0.49$	$13.43^{b} \pm 0.53$	$0.0342^{a} \pm 0.0018$	$0.0444^{a} \pm 0.0026$	$0.0397^{a} \pm 0.0020$	$5.55^{c} \pm 0.55$	$6.45^{c} \pm 0.6$
TM-962 (Moderate resistant)	$3.57^{b} \pm 0.53$	$3.29^{a} \pm 0.49$	$2.71^{b} \pm 0.49$	$3.43^{b} \pm 0.53$	$13.00^{b} \pm 1.15$	$0.0380^{b} \pm 0.0035$	$0.0459^{a} \pm 0.0031$	$0.0425^{b} \pm 0.0019$	$5.21^{b} \pm 0.47$	$5.79^{b} \pm 0.64$
MGG-360 (Susceptible)	$3.00^{a} \pm 0.00$	$3.43^{a} \pm 0.53$	$2.14^{a} \pm 0.38$	$2.57^{a} \pm 0.53$	$11.14^{a} \pm 1.21$	$0.0440^{c} \pm 0.0021$	$0.0525^{b} \pm 0.0016$	$0.0468^{c} \pm 0.0012$	$4.52^{a} \pm 0.5$	$5.21^{a} \pm 0.52$
Grand mean	3.24 ± 0.44	3.48 ± 0.51	2.57 ± 0.51	3.24 ± 0.7	12.52 ± 1.4	0.0387 ± 0.0048	0.0476 ± 0.0043	0.0430 ± 0.0034	5.1 ± 0.66	5.82± 0.77
LSD	0.42	0.56	0.47	0.58	1.14	0.002	0.002	0.002	0.12	0.21

Values having the same alphabet are not significantly different

3.3 Effect of plant resistance in selected genotypes of greengram to *M.vitrata* and its role in insecticide tolerance

From the table 10, it was clear that LC_{50} (µl/ml) of Chlorpyriphos was less 1.39 µl/ml on *Maruca* larvae reared on resistant greengram genotype, WGG- 42 as compared to susceptible genotype, MGG-360 (1.62 µl/ml). No significant differences were observed in LD_{50} values of Chlorpyriphos to *M.vitrata* larvae reared on resistant and susceptible genotypes. This probably is due to the fact on resistant genotype WGG-42, the larvae were much smaller and weighed less (Table 10) due to the stress imposed on them by plant resistance factor present in WGG-42. As the insects were much smaller, low amount of insecticide is needed to get 50 per cent mortality and hence low LC_{50} values were recorded. The results of the observations were strongly supported by the observations of Reddy and Hariprasad [8] who reported that *M.vitrata* which is a insect pest on Blackgram shows lower LC_{50} and LD_{50} values for insects reared on resistant (LBG-645) than on the susceptible (LBG-790) genotype against Chlorpyriphos.

Table 10. Tolerance of larvae of *Maruca* to chlorpyriphos on resistant and susceptible genotypes of greengram

Genotypes	LC_{50} (µL/ml)	Lower Fiducial limits	Higher Fiducial limits	LD_{50} (µg/g)
WGG-42 (Resistant)	1.39	1.05	1.78	36.98
MGG-360 (Susceptible)	1.63	1.07	1.85	36.85
LSD	0.07	-	-	2.32

4.Conclusion

The results of the present investigation reinstates about the importance of role of insect resistant genotypes in managing insect pest population. Insects on resistant genotype would be much smaller, have slow developmental period and hence low doses of insecticides are sufficient to achieve an effective control as against on a susceptible genotype that may require higher doses of insecticide to achieve an effective control as insects on a susceptible genotype would be much bigger and hence fast developmental period.

5.References

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