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Influence of plant resistance in certain genotypes of Blackgram on insecticide tolerance on *Maruca vitrata* (Geyer)

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Abstract
Observations from field screening experiments revealed that blackgram genotypes, LBG-645, LBG-791 and LBG-790 showed resistant, moderately resistant and susceptible reaction to *Maruca* infestation. Further investigation on feeding preference of *Maruca* by free-choice and no-choice techniques on selected genotypes of blackgram in the laboratory to confirm the resistance ranking observed in the field screening, have yielded similar resistance reaction to *Maruca* infestation. Studies on topical bioassay with chlorpyriphos revealed that the larvae reared on resistant genotype of blackgram had lower LC_{50} and LD_{50} values as compared to larvae reared on susceptible genotype of blackgram.

Keywords: *Maruca vitrata*, black gram, LC_{50} and LD_{50}, resistance

1. Introduction
India grows a variety of pulse crops under a wide range of agro-climatic conditions and has a pride of being the world's largest producer of pulses. India cultivated pulses in 238.52 lakh hectares with an average production of 19.34 million tonnes (Indiastat.com) [14]. Blackgram (*Vigna mungo* (L) Hepper) is the important short-duration pulse crop grown in many parts of India. In India, blackgram is very popularly grown in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Punjab, Haryana, Tamil Nadu and Karnataka. In Andhra Pradesh, it is grown in an area of about 4.15 m ha with a total production of 1.78 million tonnes with an average productivity of 946 kg ha^{-1} (Indiastat.com) [14].

The Spotted pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) is considered one of the voracious legume pests because of its broad host range, high degree of damage and worldwide distribution (Saleesha *et al.*) [11]. The webbing behaviour protects the larvae from both biotic and abiotic conditions and this behaviour 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. Presently, attempts are being focused on use of safer insecticides, plant products and microbial pesticides to reduce the resistance development and to maintain safety of the environment. Host Plant Resistance offers one of the best insect pest management strategy which is environmentally safe and with no additional cost incurred to the farmers. A lot of work has been done on screening of various genotypes, germplasm, wild relatives 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 black gram 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
Screening of different genotypes of blackgram for susceptibility against *M.vitrata* infestation; effect of plant resistance in popular varieties of blackgram 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 different genotypes of blackgram for the incidence of *M. vitrata*: A screening trial was laid out with nine genotypes of blackgram *viz*., LBG-685, PU-31, LBG-20, LBG-790, LBG-752, LBG-792, LBG-123, LBG-791 and LBG-645 against M.*vitrata* in the wetland farm, S.V. Agricultural College, Tirupati in a randomized block design (RBD). 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) *viz*., 57, 64, 71, 78, 85 and 92 DAS. Five randomly selected plants were tagged in each genotype for long term sampling to record the infestation of the *M.vitrata*. 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 Mechanisms of resistance in selected genotypes of blackgram: The genotypes of blackgram that were grouped into resistant, moderate resistant and susceptible to Maruca damage from field observation were used in the present study to confirm their resistant rankings in feeding preference by free-choice and no-choice (biology) techniques**.**

In free-***c***hoice technique, the leaves, flowers, and developed pods of resistant, moderate resistant and susceptible genotypes of blackgram 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 ***t***echnique, ***s***ix first instar larvae were released separately for each test genotype of blackgram 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 blackgram 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 blackgram. 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 blackgram to *M. vitrata* and its role in insecticide tolerance: Based on field screening and biology studies in the laboratory, resistant and susceptible genotypes of blackgram 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 blackgram 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 (SPSS 2004) [13] to calculate lethal concentration (LC_{50}) values for *M. vitrata* against insecticide on various blackgram 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 (Gast; Heinrichs *et al.*) [3, 6, 7].

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

3. Results and Discussion

3.1 Screening of different genotypes of blackgram for the incidence of *M. vitrata*

From the mean data (Table 1), it was observed that lowest and highest number of webbings per plant were observed in LBG-645(2.02 ± 0.50) and LBG-790 (4.60 ± 1.00) and the remaining (LBG-709, LBG-792, LBG-791, LBG-20, PU-31, LBG-752 and LBG-123) genotypes were on par with each other. Number of webbings of *M. vitrata* in the present investigation varied from 1.20/plant to 7.67/plant between 57 DAS to 92 DAS. These results were in close resemblance with that of Manjunath and Mallapur [9] who reported highest number of webs of spotted pod borer in VBG10-024 and lowest number of webs in WBU-108 blackgram genotypes.

Table 1: Number of webbings of *M.vitrata* larva per plant in different genotypes of blackgram

Genotypes \ DAS	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	92 DAS	Mean
LBG-709	$1.40^{a} \pm 0.74$ (1.53)	$1.80^{ab} \pm 0.94$ (1.65)	$2.00^{ab} \pm 0.93$ (1.38)	$2.87^{b} \pm 0.99$ (1.67)	$3.73^{b} \pm 1.34$ (1.90)	$4.40^{b} \pm 1.35$ (2.07)	$2.70^{b} \pm 0.79$ (1.70)
PU-31	$1.60^{a} \pm 0.74$ (1.60)	$1.73^{ab} \pm 0.96$ (1.63)	$2.60^{b} \pm 1.06$ (1.58)	$2.87^{b} \pm 0.99$ (1.67)	$3.87^{b} \pm 1.06$ (1.95)	$5.00^{b} \pm 1.00$ (2.22)	$2.95^{b} \pm 0.76$ (1.78)
LBG-20	$1.20^{a} \pm 0.56$ (1.47)	$1.67^{ab} \pm 0.90$ (1.61)	$2.13^{ab} \pm 0.83$ (1.43)	$3.47^{b} \pm 1.25$ (1.83)	$4.00^{b} \pm 1.65$ (1.95)	$5.07^{b} \pm 1.67$ (2.22)	$2.92^{b} \pm 0.81$ (1.75)
LBG-790	$1.33^{a} \pm 0.62$ (1.52)	$2.93^{c} \pm 0.96$ (1.97)	$3.73^{c} \pm 1.34$ (1.90)	$5.07^{c} \pm 1.62$ (2.22)	$6.80^{c} \pm 1.37$ (2.6)	$7.67^{c} \pm 1.95$ (2.74)	$4.60^{c} \pm 1.00$ (2.16)
LBG-752	$1.47^{a} \pm 0.74$ (1.56)	$1.60^{ab} \pm 0.63$ (1.60)	$2.53^{ab} \pm 0.83$ (1.57)	$3.60^{b} \pm 1.40$ (1.85)	$4.73^{b} \pm 1.34$ (2.16)	$5.40^{b} \pm 1.35$ (2.31)	$3.20^{b} \pm 0.78$ (1.84)
LBG-792	$1.27^{a} \pm 0.59$ (1.50)	$1.33^{a} \pm 0.49$ (1.52)	$2.20^{ab} \pm 0.86$ (1.46)	$3.00^{b} \pm 1.07$ (1.70)	$4.00^{b} \pm 1.36$ (1.97)	$5.07^{b} \pm 1.34$ (2.23)	$2.81^{b} \pm 0.6$ (1.73)
LBG-123	$1.60^{a} \pm 0.74$ (1.60)	$2.20^{b} \pm 1.01$ (1.77)	$2.73^{b} \pm 1.03$ (1.63)	$3.53^{b} \pm 1.06$ (1.86)	$4.40^{b} \pm 0.91$ (2.09)	$5.33^{b} \pm 0.9$ (2.30)	$3.30^{b} \pm 0.54$ (1.87)

LBG-791	1.40^{a}±0.63 (1.54)	1.73^{ab} ±0.70 (1.64)	2.20^{ab}±0.86 (1.46)	2.93^{b}±0.88 (1.69)	4.07^{b}±1.22 (1.99)	4.67^{b}±0.98 (2.15)	2.83^{b}±0.62 (1.74)
LBG-645	1.33^{a}±0.49 (1.52)	1.40^{a}±0.63 (1.54)	1.73^{a}±0.96 (1.27)	1.73^{a}±0.80 (1.29)	2.60^{a}±0.99 (1.59)	3.33^{a}±0.98 (1.81)	2.02^{a}±0.50 (1.50)
Grand Mean	1.40 ± 0.65 (1.54)	1.82 ± 0.92 (1.66)	2.43 ± 1.09 (1.52)	3.22 ± 1.39 (1.75)	4.24 ± 1.62 (2.02)	5.10 ± 1.68 (2.23)	3.04 ± 0.96 (1.79)

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

Table 2: Total number of *M.vitrata* caterpillars per plant in different genotypes of blackgram

Genotypes / DAS	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	92 DAS	Mean
LBG-709	0.80^{a}±0.86 (1.31)	0.80^{a}±0.68 (1.32)	1.87^{a}±1.30 (1.64)	4.33^{b}±1.72 (2.27)	3.87^{b}±1.81 (2.17)	3.27^{b}±1.58 (1.75)	2.48^{b}±0.66 (1.74)
PU-31	1.07^{a}±0.80 (1.41)	1.27^{a}±1.53 (1.44)	3.20^{bc}±1.15 (2.03)	3.93^{b}±1.53 (2.20)	3.93^{b}±1.58 (2.19)	3.07^{b}±1.22 (1.72)	2.74^{bc}±0.78 (1.83)
LBG-20	0.73^{a}±0.59 (1.30)	0.93^{a}±0.59 (1.37)	2.87^{abc}±1.51 (1.92)	4.07^{b}±2.22 (2.19)	4.40^{b}±1.81 (2.29)	3.40^{b}±1.60 (1.79)	2.73^{bc}±0.82 (1.81)
LBG-790	1.00^{a}±0.93 (1.38)	1.20^{a}±0.68 (1.46)	3.73^{c}±1.71 (2.14)	6.80^{c}±1.61 (2.78)	7.00^{c}±1.20 (2.82)	4.73^{c}±1.71 (2.14)	4.07^{d}±0.74 (2.12)
LBG-752	1.13^{a}±1.19 (1.41)	0.87^{a}±0.52 (1.35)	3.07^{bc}±1.03 (2.00)	4.80^{b}±2.01 (2.37)	5.87^{c}±1.46 (2.61)	3.07^{b}±1.71 (1.69)	3.13^{c}±0.70 (1.91)
LBG-792	0.87^{a}±0.74 (1.34)	0.73^{a}±0.46 (1.30)	2.40^{ab}±1.30 (1.81)	4.33^{b}±1.68 (2.28)	4.67^{b}±2.02 (2.33)	3.20^{b}±1.61 (1.74)	2.70^{bc}±0.56 (1.80)
LBG-123	0.67^{a}±0.72 (1.26)	0.93^{a}±0.59 (1.37)	3.60^{c}±1.55 (2.12)	4.33^{b}±1.76 (2.28)	3.87^{b}±1.73 (2.17)	2.87^{b}±1.06 (1.67)	2.71^{bc}±0.71 (1.81)
LBG-791	1.00^{a}±0.85 (1.39)	0.67^{a}±0.49 (1.28)	3.20^{bc}±1.27 (2.03)	3.93^{b}±1.75 (2.19)	4.47^{b}±1.30 (2.32)	2.93^{b}±1.34 (1.67)	2.70^{bc}±0.62 (1.81)
LBG-645	0.80^{a}±0.68 (1.32)	0.73^{a}±0.70 (1.29)	2.27^{ab}±1.10 (1.78)	2.27^{a}±1.49 (1.76)	2.07^{a}±1.44 (1.70)	1.60^{a}±0.99 (1.19)	1.62^{a}±0.59 (1.51)
Grand Mean	0.89 ± 0.82 (1.35)	0.90 ± 0.76 (1.35)	2.91 ± 1.42 (1.94)	4.31 ± 2.04 (2.26)	4.46 ± 2.04 (2.29)	3.12 ± 1.59 (1.19)	2.76 ± 0.90 (1.82)

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

From the mean data, 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). 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 2). Number of *M. vitrata* larvae in the present investigation varied from 0.73/plant to 7.00 larvae/plant, between 57 DAS to 92 DAS. The results of the present investigation were in close accordance with Halder and Srinivasan [5], who reported that the highest number of *Maruca* larval population was noticed on cowpea (20.4/plant), followed by urd bean (8.0/plant) and mung bean (7.1/plant), while field bean (4.3/plant) and pigeon pea (2.6/plant) were on par with each other.

Table 3: Percentage infestation of *M.vitrata* in differen *genotypes* of blackgram

Genotypes / DAS	Total no. of plants	57 DAS	64 DAS	71 DAS	78 DAS	85 DAS	92 DAS	Mean
LBG-709	19.00^{a}±1.00 (4.36)	35.06^{b}±1.75 (36.32)	31.63^{a}±1.66 (34.24)	37.00^{a}±6.66 (37.44)	42.46^{ab}±11.37 (40.63)	45.88^{bc}±8.43 (42.65)	54.67^{bc}±10.46 (47.46)	41.11^{bc}±6.08 (39.84)
PU-31	20.67^{ab}±1.52 (4.54)	30.48^{ab}±3.69 (33.5)	29.38^{a}±7.09 (32.73)	30.89^{a}±5.19 (33.74)	35.75^{ab}±5.55 (36.70)	40.60^{ab}±5.91 (39.58)	45.29^{ab}±3.80 (42.31)	35.39^{ab}±3.85 (36.43)
LBG-20	19.67^{ab}±1.52 (4.43)	25.60^{a}±5.79 (30.31)	27.11^{a}±1.87 (31.39)	30.63^{a}±2.44 (33.61)	37.32^{ab}±2.05 (37.67)	40.76^{ab}±5.05 (39.68)	45.95^{ab}±3.66 (42.69)	34.56^{ab}±2.13 (35.89)
LBG-790	19.67^{ab}±1.52 (4.43)	30.63^{ab}±2.44 (33.61)	35.92^{a}±7.56 (36.78)	37.59^{a}±5.99 (37.80)	44.28^{b}±5.15 (41.73)	54.50^{c}±5.85 (47.62)	64.71^{c}±6.57 (53.64)	44.60^{c}±5.50 (41.86)
LBG-752	19.67^{ab}±1.52 (4.43)	25.52^{a}±2.03 (30.35)	35.47^{a}±2.41 (36.57)	37.32^{a}±2.05 (37.67)	38.99^{ab}±0.96 (38.66)	46.03^{bc}±6.87 (42.72)	51.21^{b}±11.58 (45.71)	39.09^{abc}±2.93 (38.61)
LBG-792	20.33^{ab}±0.57 (4.51)	27.86^{a}±2.57 (31.86)	29.36^{a}±7.55 (32.72)	32.70^{a}±4.67 (34.86)	32.86^{a}±3.71 (34.97)	39.36^{ab}±5.12 (38.86)	49.20^{ab}±5.18 (44.57)	35.22^{ab}±1.67 (36.30)
LBG-123	20.00^{ab}±1.00 (4.47)	29.97^{ab}±4.39 (33.17)	33.56^{a}±7.43 (35.34)	33.56^{a}±7.43 (35.34)	38.40^{ab}±3.56 (38.30)	43.32^{ab}±1.50 (41.18)	51.67^{b}±1.45 (45.98)	38.41^{abc}±3.27 (38.22)
LBG-791	22.00^{b}±2.00 (4.69)	25.76^{a}±1.31 (30.51)	30.32^{a}±1.35 (33.43)	31.84^{a}±3.93 (34.34)	33.51^{a}±3.80 (35.36)	36.69^{ab}±6.53 (37.24)	44.32^{ab}±6.32 (41.74)	33.73^{a}±3.42 (35.44)
LBG-645	20.33^{ab}±0.57 (4.51)	31.19^{ab}±3.37 (33.95)	31.11^{a}±5.35 (33.86)	32.78^{a}±2.54 (34.93)	32.78^{a}±2.54 (34.93)	34.44^{a}±0.96 (35.95)	37.70^{a}±2.52 (37.89)	33.33^{a}±0.83 (35.25)
Grand Mean	20.15 ± 1.38 (4.49)	29.12 ± 4.14 (32.62)	31.54 ±5.31 (34.12)	33.81 ±4.88 (35.53)	37.37 ± 5.84 (37.66)	42.40 ± 7.39 (40.61)	49.41 ± 9.13 (44.70)	37.28 ± 4.77 (37.54)

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

From the mean data, percentage infestation was found lowest in LBG-645 (33.33 ± 0.83) followed by LBG-791(33.73 ± 3.42) (not significantly different). 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) (not significantly different) and the remaining (LBG-20, LBG-792 and PU-31) genotypes were on par with each other (Table 3)**.** The per cent infestation in the present investigations varied from 29.12 to 49.41% from 57 DAS to 92 DAS in blackgram. These results were in close resemblance with that of Manjunath and Mallapur [9] who reported highest per cent infestation of spotted pod borer in VBG10-024 and lowest per cent infestation in COBG-653 blackgram genotypes.

The genotypes LBG-645, LBG-791 and LBG-790 were classified as resistant, moderate resistant and susceptible genotypes based on number of webbings per plant and number of caterpillars per plant and per cent infestation. These genotypes were further experimented in the laboratory in free-choice and no- choice experiments to confirm the resistant rankings which were observed in the field condition.

3.2 Mechanisms of resistance in selected genotypes of blackgram

In larval free-choice experiment of blackgram (Table 4), it was observed that more number of larvae of *Maruca* preferred the genotype LBG-790 (2.57 ± 0.98) (susceptible) which were significantly different from LBG-645 (resistant) which were preferred by few number of *Maruca* larvae (1.57 ± 0.54). Larval preference of variety LBG-791 (1.86 ± 0.69) (moderate resistant) was in between LBG-790 and LBG-645 (Table 4). The present results were in close agreement with the findings of Halder and Srinivasan [4] who reported that the highest larval orientation was observed in GC-9708 (susceptible variety of cowpea) both in pods (18%) and flowers (13%) than the tolerant variety (HC-270).

Table 4: Larval preference of *Maruca vitrata* on different genotypes of blackgram in free- choice experiment

Genotypes	No. of larvae after 24 hrs
LBG-645 (Resistant)	1.57^{a} ± 0.53 (1.24)
LBG-791 *(*Moderate resistant*)*	1.86^{ab} ± 0.69 (1.34)
LBG-790 (Susceptible*)*	2.57^{b} ± 0.97 (1.57)
Total mean	2.00 ± 0.83 (1.38)
LSD	0.77

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

The results of investigation of the biology of *Maruca* in blackgram (Table 5) infers that there is no significant difference in second instar and third instar larval duration in all the genotypes. The duration of the fourth instar larva was less on LBG-790 (2.43 ± 0.54 days) (susceptible) followed by 2.57 ± 0.54 days on LBG-791 (on par with) (moderate resistant). Highest larval duration (3.00 ± 0.54 days) of fourth instar was observed when larvae were reared on LBG-645 (resistant). The duration of the fifth instar larva was least 2.86 ± 0.54 days when larvae were reared on LBG-790 (susceptible) followed by 3.00 ± 0.54 days on LBG-645 (resistant) and 3.57 ± 0.54 days on LBG-791 (moderate resistant). The total duration of the larvae was least (11.86 ± 0.54 days) on LBG-790 (susceptible) followed by 12.71 ± 0.54 days in LBG-791 (moderate resistant) and 13.00 ± 0.54 days in LBG-645 (resistant). The lowest larval weight of the third instar (0.0325 ± 0.019 gms) was observed, when larvae were reared on LBG-645 (resistant) followed by 0.0362 ± 0.0022 gms on LBG-791 (moderate resistant). Highest larval weights (0.0418 ± 0.0058 gms) were observed, when larvae were reared on LBG-790 (susceptible) genotype. The lowest larval weight of the fourth instar (0.0449 ± 0.0021 gms) was observed when larvae were reared on LBG-645 (resistant) followed by (0.0483 ± 0.0013 gms) on LBG-791 (moderate resistant). Highest larval weights of fourth instar was observed as 0.0556 ± 0.0053 gms, when larvae were reared on LBG-790 (susceptible). The pupal weight was lowest (0.0398 ± 0.0021 gms) when they were reared on LBG-645 (resistant) followed by LBG-791 (moderate resistant) (0.0422 ± 0.0021 gms). Highest pupal weights were observed, when the insects were reared on LBG-790 (susceptible) (0.0447 ± 0.0033 gms). The duration of the pupae was 4.52 ± 0.5 days on LBG-790 (susceptible) followed by 5.21 ± 0.47 days on LBG-791 (moderate resistant) and 5.57 ± 0.54 days in LBG-645 (resistant) varieties. The longevity of the adults was 4.98 ± 0.56 days on LBG-790 (susceptible) followed by 5.79 ± 0.64 days on LBG-791 (moderate resistant). Highest adult longevity was observed 6.45 ± 0.59 days, when insects were reared on LBG-645 (resistant). The results of the findings were supported by the observations of Sonune *et al.* [12] 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 blackgram. The pupal weight was 0.04 ± 0.01 g according to the observations of Long *et al.* [8]. Sonune *et al.* [12] reported that the pupal duration was 10.84 ± 1.79 days in blackgram. 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 5: Biology of M.vitrata in resistant, moderate resistant and susceptible genotypes of blackgram 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)**
LBG-645 (*Resistant*)	3.43^{a} ±0.54	3.57^{a} ±0.54	3.00 ^{b}± 0.54	3.00^{ab} ± 0.54	13.00 ^{a} ± 0.54	0.0325^{a} ± 0.0019	0.0449^{a} ± 0.0021	0.0398^{a} ± 0.0021	5.57^{c} ± 0.54	6.45^{c} ± 0.59
LBG-791 (*Moderate resistant*)	3.29^{a} ±0.54	3.29^{a} ±0.54	2.57^{ab} ± 0.54	3.57^{b} ± 0.54	12.71^{a} ± 0.54	0.0362^{b} ± 0.0022	0.0483^{a} ± 0.0013	0.0422^{a} ± 0.0021	5.21^{b} ± 0.47	5.79^{b} ± 0.64
LBG-790 (*Susceptible*)	3.43^{a} ±0.54	3.14^{a} ±0.54	2.43^{a} ± 0.54	2.86^{a} ± 0.54	11.86^{a} ± 0.54	0.0418^{c} ± 0.0058	0.0556^{b} ± 0.0053	0.0447^{a} ± 0.0033	4.52^{a} ± 0.5	4.98^{a} ± 0.56
Grand mean	3.38 ±0.54	3.33 ±0.54	2.67 ± 0.54	3.14 ± 0.54	12.52 ± 0.54	0.0369 ± 0.0053	0.0496 ± 0.0056	0.0422 ± 0.0032	5.1 ± 0.67	5.74 ± 0.85
LSD	0.58	0.52	0.49	0.68	1.25	0.0042	0.0042	0.0042	0.11	0.22

Values having the same alphabet are not significantly different

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

From the table 6, it was observed that LC_{50} (µl/ml) and LD_{50} (µg/g) of chlorpyriphos was less *i.e.*, 1.06 µl/ml and 29.39 (µg/g) on *Maruca* larvae reared on resistant blackgram genotype, LBG-645 as compared to susceptible blackgram genotype, LBG-790 *i.e.*, 1.57 (µl/ml) and 35.72 (µg/g). This probably is due to the fact on resistant genotype of blackgram (LBG-645) the larvae were much smaller and weighed less due to the stress imposed on them by plant resistance factor present in LBG-645. As the insects were much smaller, low amount of insecticide is needed to get 50 per cent mortality and hence low LC_{50} values. Whereas the 3rd instar larvae reared on susceptible blackgram genotype, LBG-790, were much bigger and hence more dose of chemical was required to get 50 per cent mortality and hence more LC_{50} values were obtained. The results of the investigations were strongly supported by the observations of Attah [1] who reported that *Metopolophium dirhodum* (Walker) which is a sucking insect pest on wheat shows lower LC_{50} and LD_{50} values for insects reared on partially resistant than on the susceptible genotypes against Malathion. Nicol *et al.* [10] reported that nymphs of wheat grain aphid reared on resistant variety, Altar were more susceptible to deltamethrin than nymphs reared on the susceptible variety, Dollarbird.

Table 6: Tolerance of larvae of Maruca to chlorpyriphos on resistant and susceptible *genotypes* of blackgram

Genotypes	LC_{50} (µL/ml)	Lower *Fiducial limits*	Higher *Fiducial limits*	LD_{50} *(µg/g)*
LBG-645 (Resistant)	1.06	0.68	1.70	29.39
LBG-790 (Susceptible)	1.57	0.86	1.88	35.72
LSD	0.31	-	-	6.39

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.

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