

EFFECT OF LEAF CHARACTERISTICS OF SWEET GOURD GERMPLASMS ON THE POPULATION ABUNDANCE AND INFESTATION OF EPILACHNA BEETLE (*Epilachna* spp.)

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ABSTRACT

The phytophagous insect epilachna beetle (*Epilachna* spp.) is a threat to the cultivation of different cucurbit crops including sweet gourd (*Cucurbita moschata*). Host plant itself can influence the infestation of insect by different means. Therefore, investigations were done on the population abundance and infestation level of epilachna beetle on sweet gourd and to find out the relationship between the abundance of the beetle and the morphological as well as biochemical characteristics of the leaves. The study was conducted in the field and laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh from July 2018 to June 2019 with 12 sweet gourd germplasms. Among the germplasms, BD 264 showed the lowest abundance of grub (3.1 ± 0.3 grubs/ 3 leaves), and BD 264 and BD 266 revealed statistically similar and the lowest abundance of the adult beetles (1.7 ± 0.1 adults/ 3 leaves in both the cases). The level of leaf infestation among the germplasms varied significantly and ranged from 6.2% to 16.4%. The abundance of adult beetles was positively correlated with the number of leaf plant⁻¹, but leaf area and trichomes ($r = -0.994$ and -0.991 for BD 264 and BD 266, respectively) exerted negative relationship. Moisture ($r = 0.998$ for BD 269), total chlorophyll, reducing sugar and ash content ($r = 0.997$ for BD 269) in the leaves of the germplasms showed positive influence on the abundance of beetle, but protein content was negatively correlated. The leaf characteristics of sweet gourd which were found to be responsible to alter the infestation of *Epilachna* spp. can be incorporated in Integrated Pest Management (IPM) strategy.

Keywords: Abundance, *Cucurbita moschata*, *Epilachna* spp., resistance

ABSTRAK

Kumbang epilachna (*Epilachna* spp.) merupakan spesies fitofagus dan memberikan ancaman ke atas penanaman spesies tanaman Cucurbitaceae termasuk spesies labu (*Cucurbita moschata*). Pokok perumah boleh mempengaruhi infestasi serangga bergantung kepada

pelbagai faktor. Oleh itu, kajian telah dijalankan untuk mengetahui kelimpahan dan tahap infestasi kumbang *Epilachna* ke atas labu air dan untuk mengenalpasti hubungan antara kelimpahan dan spesies kumbang dengan ciri morfologi dan biokimia daun yang diinfestasi. Kajian dijalankan di lapangan dan makmal Jabatan Entomologi, Bangabhadhu Sheikh Mujibur Rahman, Universiti Pertanian, Gazipur, Bangladesh dari Julai 2018 hingga Jun 2019 dengan 12 germplasma labu. Antara germplasma tersebut, BD 264 telah menunjukkan kelimpahan terendah larva kumbang (3.1 ± 0.3 larva/3 daun) dan BD 264 serta BD 266 mendedahkan persamaan secara signifikan dengan kelimpahan terendah spesies dewasa kumbang (1.7 ± 0.1 dewasa/3 daun pada kedua-dua kes). Peringkat infestasi antara germplasma bervariasi secara signifikan di antara 6.2% ke 16.4%. Kelimpahan kumbang dewasa menunjukkan korelasi positif dengan bilangan daun⁻¹ ($r = -0.994$ dan -0.991 untuk BD 264 serta BD 266, masing-masing), tetapi kawasan daun dan trikoma menunjukkan hubungan negatif. Kelembapan, jumlah klorofil, pengurangan gula dan kandungan abu pada daun germplasma juga menunjukkan kesan positif dengan kelimpahan kumbang ($r = 0.997$ untuk BD 269), tetapi kandungan protein menunjukkan korelasi negatif. Dapatan kajian ini sangat membantu dalam melakarakan pengurusan strategi Pengurusan Perosak Bersepadu (PPB) dengan memfokus ke atas ciri daun labu di mana ia membantu dan bertanggungjawab mengubah tahap kerintangan ke atas tanaman yang di infestasi *Epilachna* spp.

Kata kunci, Kelimpahan, *Cucurbita moschata*, *Epilachna* spp., kerintangan

INTRODUCTION

Sweet gourd *Cucurbita moschata* occupies a large portion of the preferred vegetables of people around the world. The fruits are valued for their richness in carotenoids, vitamin C, carbohydrate, and proteins, and the seeds are consumed as they contain protein, fibres, and minerals (Sharma & Rao 2013). In Bangladesh, both the production and cultivation area of sweet gourd are increasing (BBS 2020). A total of 28.6 thousand hectares of land were occupied for sweet gourd cultivation with an annual production of 320.1 thousand tons in the year of 2018-19 which was higher than the previous years. Like other important agricultural crops, the production of sweet gourd is constrained due to continuous pest attack. Two species of *Epilachna* viz., *E. dodecastigma* (Wied.) and *E. vigintioctopunctata* (Fab.) are the major pests of cucurbits in Bangladesh. Among them, *E. dodecastigma* is more frequent and causes damage to the solanaceous and cucurbitaceous crops, such as brinjal, tomato, cucumber, sweet gourd, and melon (Khan et al. 2000; Rath 2005). Kato et al. (2014) described the species of *Epilachna* genera as phytophagous and host specific. Both larvae and adults of the beetle are damaging to the host plants (Rahman & Uddin 2016). They feed on the foliage of crop throughout the crop growing season and skeletonize the leaves by scraping their epidermis (Ghule et al. 2014).

Nancy et al. (2018) reported *Epilachna* beetle as one of the most abundant insect pests in sweet gourd field. Asafuddaullah et al. (2015) observed 8.9 to 11.8% leaf infestation by *Epilachna* species on sweet gourd which was slightly higher than the infestation on bitter gourd and bottle gourd in their study. It is reported that severe infestation by *E. dodecastigma* can cause up to 80% yield loss in bitter gourd (Hossain et al. 2009). Thus, it is of importance to explore the management strategies to check the severity of the infestation by *E. dodecastigma* on its host plants. Although in recent days the use of chemical pesticides is getting interest for their quick performance against insect pests, it may give rise to several environmental and animal health hazards. In this regard, host plant resistance against insect pests can be an alternative way which is ecofriendly and shows almost no human health hazard.

It is well known that insects have everlasting association with plants; as a result, plants evolved some morphological and physiological characteristics which help them to resist pest attack by themselves. Bindu and Pramanik (2017) reported that the thickness, area, and trichome density of leaf of brinjal negatively affected the population of *Epilachna* spp. Another research on brinjal revealed that genotypes having the maximum trichome density were less susceptible to the infestation of *Epilachna* species (Ali et al. 2017). Amin et al. (2011) reported that the nutrient contents of host plants affect the growth and development of insects. Thus, it opens up the door to conduct research on sweet gourd as it may have also certain physico-chemical characteristics that can resist the attack of *Epilachna* spp. Therefore, the objectives of the current study were to know the population abundance and infestation of *Epilachna* spp. on the sweet gourd germplasms, and to find out the relationship of the abundance of the beetles with physico-chemical characteristics of the germplasms.

MATERIALS AND METHODS

Study Site and Conditions

The study was conducted from July 2018 to June 2019 in the field and laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh. The site is located almost at the center of Bangladesh at 25°25' N and 89°5' E. Annual mean maximum and minimum temperatures, relative humidity, and rainfall of the site are 36.0°C, 12.7°C, 65.8%, and 2376 mm, respectively (Amin et al. 2019).

Cultivation of Sweet Gourd

In the study, 12 germplasms of sweet gourd namely BD 264, BD 265, BD 266, BD 268, BD 269, BD 274, BD 275, BD 277, BARI Mistikumra 1, BARI Mistikumra 2, Gazipur local line, and China line were evaluated against *Epilachna* infestation. The seedlings of the germplasms were raised in polybags and 3-week-old seedlings were transplanted to the field in randomized complete block design with three replications. The size of each plot was 4.0 m × 3.0 m maintaining a space of 1.0 m for each case of block to block and plot to plot distance. Fertilizers were applied according to Fertilizer Recommendation Guide (FRG 2018) (N, 120 kg; P, 70 kg; K, 40 kg; and S, 20 kg per hectare). No pest control measure was undertaken during the entire study period.

Observation of *Epilachna* spp.

Data on *Epilachna* spp. were collected from five randomly selected plants of each germplasm. The grubs (Figures 1 and 2) and adults (Figure 3) of the beetle irrespective of the species were counted on each of five plants from three selected leaves (top, middle and bottom). The observations were done at weekly intervals. The number of total leaves and infested leaves was counted on each observation day to calculate the leaf infestation level.



Figure 1. Grubs (first instar) of *Epilachna* beetle observed on sweet gourd leaf



Figure 2. Observed grub (final instar) of epilachna beetle on sweet gourd leaf



Figure 3. Adult epilachna beetle infesting sweet gourd leaf

Characteristics of the Leaves of the Germplasms

Leaf areas of three healthy leaves from each of five selected plants of the germplasms were measured using a digital Leaf Area Measuring Machine (LI-3100C Area Meter). The trichomes present on one square centimeter (both abaxial and adaxial surfaces) of three healthy leaves from each of five selected plants of the germplasms were observed under a stereo microscope (BOE3200, BOECO, Germany) and counted using a manual counting machine.

Estimation of Biochemical Properties of the Leaves of the Germplasms

Moisture content of leaf was determined using oven dry method. Reducing sugar content of leaf was estimated following Bertrand's method (Kumar et al. 2011). Content of Chlorophyll (chlorophyll a and chlorophyll b) of leaf was estimated using the procedure explained by Gagoi and Basumatary (2018). The nitrogen content of leaf was estimated using Micro Kjeldahl

method (Maehre et al. 2018). Each of nitrogen content values was then multiplied by 6.25 to get the percentage of protein. The ash content of leaf samples was estimated in wet basis using Muffle Furnace (Nielsen 2010).

Data Analysis

Data on the abundance of grub and adult beetle, and the infestation level were analyzed using a one-way analysis of variance followed by Tukey's HSD post hoc test at 5% level of significance. Pearson's correlation coefficients were worked out to determine the relationship between the abundance of adult *Epilachna* spp. and the physico-chemical characteristics of the germplasms. The analyses were performed using IBM SPSS 21.0 software (IBM SPSS Statistics, Armonk, NY, USA).

RESULTS

The abundance of grub of *Epilachna* spp. among the 12 sweet gourd germplasms differed significantly ($F_{11,708} = 24.1$, $P < 0.001$) (Figure 4). The lowest abundance of grub was found on BD 264 (3.1 ± 0.3 grubs/ plant), followed by BD 277 and BD 274 (3.4 ± 0.2 and 3.5 ± 0.2 grubs/ plant, respectively).

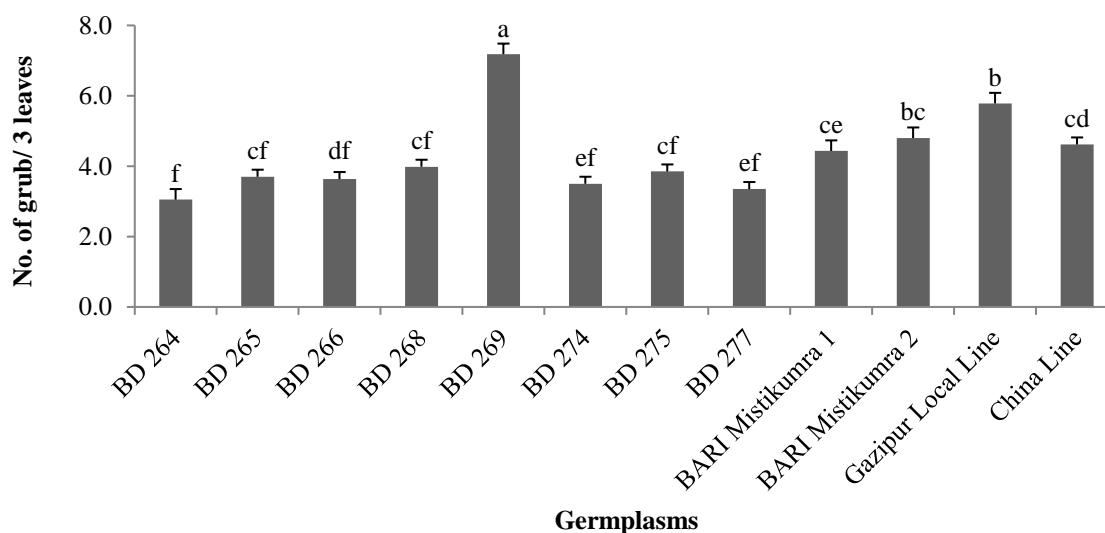


Figure 4. Abundance of grub of *Epilachna* beetle (mean \pm SE) on 12 sweet gourd germplasms during December 2018 to March 2019

The abundance of adult *Epilachna* spp. among the tested germplasms showed significant variation ($F_{11,708} = 2.6$, $P < 0.01$) (Figure 5). BD 264 and BD 266 showed similar and the lowest adult abundance (1.7 ± 0.1 adults/ plant in both cases), conversely, the highest adult abundance was found on BD 269 (2.3 ± 0.1 adults/ plant).

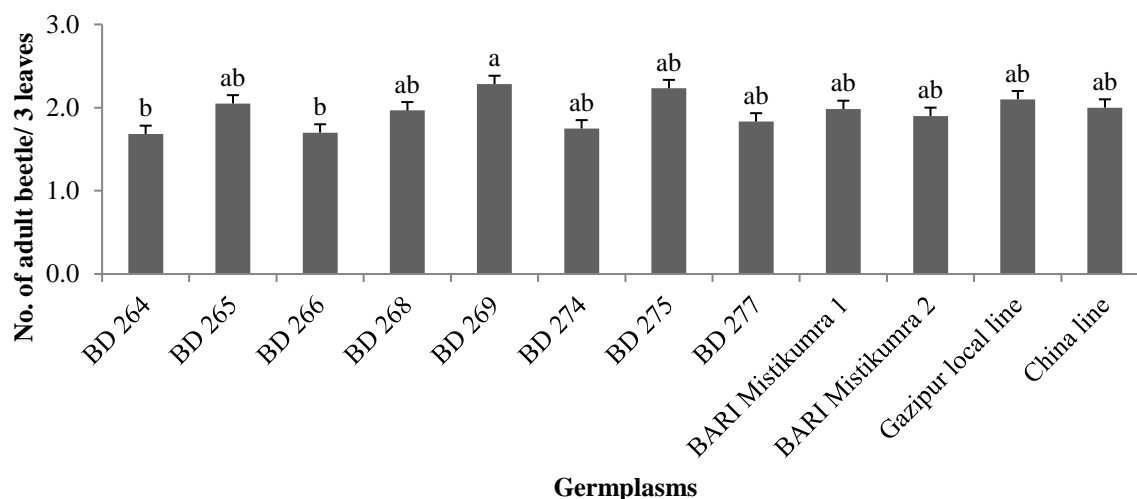


Figure 5. Abundance of adult *Epilachna* beetle (mean±SE) on 12 sweet gourds germplasms during December 2018 to March 2019

The percent leaf infestation by *Epilachna* spp. among the germplasms also varied significantly ($F_{11,708} = 21.2$, $P < 0.001$) (Figure 6). BD 275, BARI Mistikumra 1, China line, BD 277, BD 264, BARI Mistikumra 2, Gazipur local line and BD 274 showed statistically similar, and the lowest level of infestation ranged from 6.2% to 8.4%. In contrast, the highest level of leaf infestation was found on BD 269 ($16.4 \pm 0.4\%$).

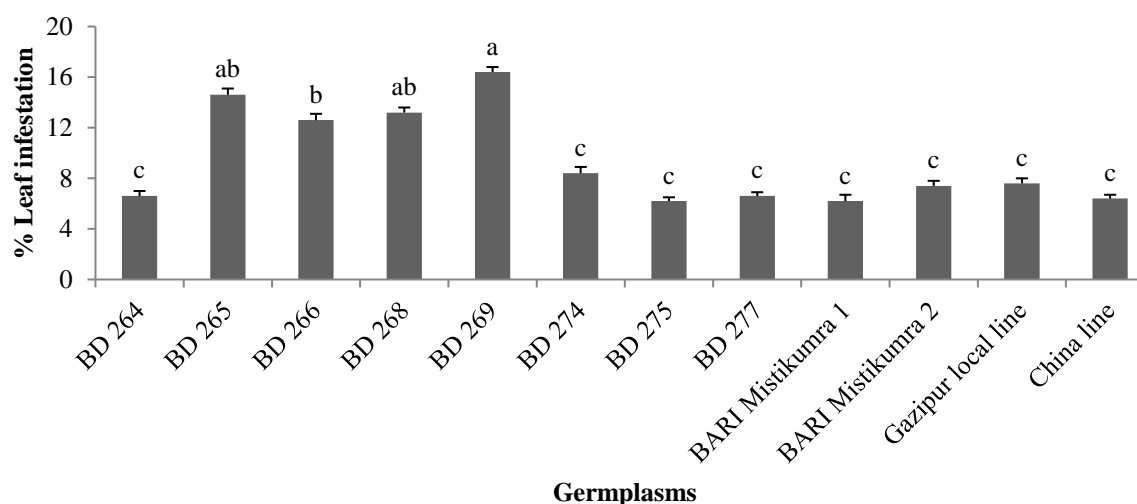


Figure 6. Leaf infestation of *epilachna* beetle (% mean ± SE) on 12 sweet gourd germplasms from December 2018 to March 2019

The abundance of *Epilachna* spp. on sweet gourd was positively correlated with the number of leaf/plant but showed negative correlation with leaf area, and abaxial and adaxial leaf trichomes (Table 1). Among the germplasms, BD 264 and BD 266 showed statistically significant negative correlation between the abundance of *Epilachna* spp. and abaxial leaf trichome of the germplasms ($r = -0.994$ and -0.991 , respectively).

Table 1. Correlation coefficients (r values) between plant morphological characteristics and the abundance of adult epilachna beetle on 12 germplasms of sweet gourd

Germplasms	Leaf/plant	Leaf area (cm ²)	Trichome (number/ cm ²)	
			Abaxial	Adaxial
BD 264	0.934 ^{NS}	-0.409 ^{NS}	-0.994*	-0.962 ^{NS}
BD 265	0.945 ^{NS}	-0.893 ^{NS}	-0.871 ^{NS}	-0.800 ^{NS}
BD 266	0.339 ^{NS}	-0.416 ^{NS}	-0.991*	-0.500 ^{NS}
BD 268	0.611 ^{NS}	-0.495 ^{NS}	-0.673 ^{NS}	-0.611 ^{NS}
BD 269	0.367 ^{NS}	-0.596 ^{NS}	-0.757 ^{NS}	-0.349 ^{NS}
BD 274	0.550 ^{NS}	-0.896 ^{NS}	-0.957 ^{NS}	-0.861 ^{NS}
BD 275	0.312 ^{NS}	-0.431 ^{NS}	-0.763 ^{NS}	-0.817 ^{NS}
BD 277	0.624 ^{NS}	-0.866 ^{NS}	-0.985 ^{NS}	-0.626 ^{NS}
BARI Mistikumra 1	0.319 ^{NS}	-0.756 ^{NS}	-0.792 ^{NS}	-0.932 ^{NS}
BARI Mistikumra 2	0.559 ^{NS}	-0.297 ^{NS}	-0.977 ^{NS}	-0.951 ^{NS}
Gazipur local line	0.524 ^{NS}	-0.861 ^{NS}	-0.580 ^{NS}	-0.846 ^{NS}
China line	0.815 ^{NS}	-0.795 ^{NS}	-0.571 ^{NS}	0.721 ^{NS}

NS, Non-significant ($p \geq 0.05$); * Significant ($p < 0.05$)

The abundance of epilachna beetle on the germplasms had positive correlation with moisture content, total chlorophyll, reducing sugar, and ash content of leaf, but there was negative association between the protein content of leaf and the abundance of *Epilachna* spp. (Table 2). Only BD 269, the most infested germplasm showed statistically significant positive correlation of adult epilachna beetle with the moisture and ash content of leaf ($r = 0.998$ and 0.997 , respectively).

Table 2. Correlation coefficients (r values) between biochemical contents of leaf and the abundance of adult epilachna beetle on 12 germplasms of sweet gourd

Germplasms	Biochemical contents (%)				
	Moisture	Total Chlorophyll	Reducing sugar	Protein	Ash
BD 264	0.439 ^{NS}	0.866 ^{NS}	0.512 ^{NS}	-0.383 ^{NS}	0.591 ^{NS}
BD 265	0.734 ^{NS}	0.929 ^{NS}	0.866 ^{NS}	-0.958 ^{NS}	0.711 ^{NS}
BD 266	0.201 ^{NS}	0.327 ^{NS}	0.764 ^{NS}	-0.858 ^{NS}	0.909 ^{NS}
BD 268	0.885 ^{NS}	0.763 ^{NS}	0.763 ^{NS}	-0.862 ^{NS}	0.558 ^{NS}
BD 269	0.998*	0.619 ^{NS}	0.371 ^{NS}	-0.728 ^{NS}	0.997*
BD 274	0.973 ^{NS}	0.982 ^{NS}	0.500 ^{NS}	-0.692 ^{NS}	0.968 ^{NS}
BD 275	0.749 ^{NS}	0.756 ^{NS}	0.971 ^{NS}	-0.932 ^{NS}	0.756 ^{NS}
BD 277	0.813 ^{NS}	0.973 ^{NS}	0.771 ^{NS}	-0.695 ^{NS}	0.756 ^{NS}
BARI Mistikumra 1	0.773 ^{NS}	0.756 ^{NS}	0.908 ^{NS}	-0.429 ^{NS}	0.718 ^{NS}
BARI Mistikumra 2	0.680 ^{NS}	0.655 ^{NS}	0.756 ^{NS}	-0.500 ^{NS}	0.814 ^{NS}
Gazipur local line	0.953 ^{NS}	0.908 ^{NS}	0.619 ^{NS}	-0.513 ^{NS}	0.923 ^{NS}
China line	0.326 ^{NS}	0.319 ^{NS}	0.931 ^{NS}	-0.911 ^{NS}	0.645 ^{NS}

NS, Non-significant ($P \geq 0.05$); * Significant ($P < 0.05$)

DISCUSSION

According to our findings, the average number of grubs among the varieties varied from 3.1 to 7.2/ plant, which is in accordance with the findings of Uikey et al. (2016) who found a peak of 8.4 grubs/ plant on bottle gourd. Barik et al. (2020) found a range of 2.3 to 11.1 adults/ plant in different genotypes of brinjal. The findings of current study showed more or less close conformity to this result. However, the variation of host plant, geographic location, and cultivating season is the major factor that influences the abundance of any insect.

Asafuddaullah et al. (2015) reported a range of 6.8% to 14.1% leaf infestation by *Epilachna* spp. on different cultivars of sweet gourd. The infestation level of a host plant by an insect is an indication of the suitability of that host to the insect. The less the infestation by an insect is, the lower the plant is susceptible to the insect. In our study, BD 275 and BARI Mistikumra 1 were the least susceptible varieties faced only 6.2% leaf infestation.

The morphological characteristics of plants can manipulate insect abundance through antixenosis. This term includes the non-preference of the host plant to insect pests for food, shelter, or reproduction (Padmaja & Aruna 2019). Therefore, in the current study, we made efforts to find out the effect of leaf trichomes, number of leaf per plant and leaf area of host plant on insect abundance. The leaf trichomes and leaf area are the factors having negative impact on the abundance of *Epilachna* spp., whereas the number of leaf per plant had positive influence. The findings are in agreement with the results of Ali et al. (2017) who reported negative relationship of the abundance of *Epilachna* spp. with the leaf hair density and leaf area of brinjal. Amin et al. (2011) reported that the presence of trichomes on leaf affects the growth and development of insect as they create a barrier in its free movement, ease of feeding, and oviposition. On the other hand, presence of higher number of leaves increases the bushiness of plants, and thus can make the plant as a suitable shelter for any insect. This might be the probable reason of how the number of leaf per plant affects insect abundance positively.

Browne and Raubenheimer (2003) reported that the availability of essential nutrients in host plant controls the growth, development, and infestation levels of the pests. The biochemical contents in host plant determine its nutritional status for associated herbivores, which ultimately affect the suitability of the host to them (Amin et al. 2015). Among the biochemical properties of host plant, protein and carbohydrate affect the body mass gain and development of juveniles of the phytophagous insects (Gall & Behmer 2014). The present findings showed partial conformity with that of Sarkar et al. (2017) who found that higher amount of carbohydrates, proteins, lipids, nitrogen and moisture content of bitter gourd leaves positively influenced the growth rate and fecundity of *E. dodecastigma*. Therefore, the findings of current study revealed that the germplasms containing lower amount of leaf moisture, chlorophyll, reducing sugar and ash were less susceptible to the attack of *Epilachna* beetle.

CONCLUSION

In conclusion, the abundance of both grub and adult of *Epilachna* spp. showed significant variation among the tested germplasms. Considering the correlation of adult epilachna beetle with the physico-chemical characteristics of sweet gourd leaf, the presence of higher number of leaf trichome, larger leaf area, and lower amount of leaf moisture, chlorophyll, reducing sugar and ash may impart resistance to plants against the infestation of *Epilachna* spp.

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