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Biochemical factors associated with mango mealy bug (*Drosicha mangiferae* G.) infestation in different mango cultivars at Malda, West Bengal (India)

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Abstract

Five different popular mango cultivars (Fazli, Guti, Lakhanbhog, Gopalbhog and Langra) of Malda, West Bengal, India were screened for the mango mealy bug (*Drosicha mangiferae* G.) population in panicle and trunk throughout the pest infestation period during 2018 and 2019. The average pest number at peak time (13 Standard Meteorological Week or SMW) of infestation indicated that maximum pest number of 132.57 and 28.05 was noted in the 30 cm branch of inflorescence and 10 cm^2 area of the trunk in Fazli cultivar. Whereas, minimum number of 20.27/ 30 cm branch of inflorescence and 6.36 in the same area of trunk was found in Langra. Study of various biological parameters of mealy bugs also indicated the the order of infestation of the five cultivars as Fazli>Guti>Lakhanbhog>Gopalbhog>Langra. Analysis of various biochemical parameters revealed that there was a significant positive correlation between pest density phagostimulants like sugar, protein, moisture and nitrogen. Significant negative correlation was observed between pest number and alkaloid, flavonoid, phenol, tannin, ascorbic acid as well as crude fibre suggesting their pivotal role in low pest incidence. By considering the adjusted R^2 in stepwise multiple regression model, it was noticed that tannin was the most significant factor (39.2 %) followed by nitrogen (15.5 %), flavonoid (11.4 %), phenol (7.7 %), ascorbic acid (6.9 %) and protein (6.2 %) to influence pest number. Factors like moisture (1.0 %), sugar (2.7 %), antioxidant (1.0 %) had minor contributions. Therefore, it can be concluded that a combination of factors influence pest density and a single factor is not adequate to affect the pest population. The study is helpful in understanding the host preference of mealy bug.

Key words: Mango mealy bug, cultivar preference, oviposition preference, biochemical estimation, phagostimulants, phagodeterrents.

Introduction

Mango (*Mangifera indica*) is a popular fruit worldwide for its palatability, rich aroma and nutritive value (Litz, 1997). The state of West Bengal has 70-80 thousand hectares of mango cultivation field covering 44 % of the total fruit crop cultivation area (Bhattacharya, 2014). Among all the districts, Malda district occupies the top position with a production of about 196 metric tons (Chakraborty *et al.*, 2015). Mango mealy bug, *Drosicha mangiferae*, is one of the most important mango pest which can cause huge amount of fruit loss (Atwal, 1976). In the extent of injury, mealy bug ranks second after hopper and the loss can reach up to 50 % (Karar *et al.*, 2013). Mango mealy bug causes fruit drop by its non-stop sap sucking ability from the twigs and due to the honey dew secretion it facilitates black sooty mould development making the fruit inconsumable (Bhagat, 2004).

There are reports about the inefficiency of mealy bug control by chemical pesticide spray (Tandon and Lal, 1980; Yousuf and Ashraf, 1987). But still application of chemical pesticide is the method of choice to achieve effective control of this notorious pest (Latif and Ismail, 1957; Karar *et al.,* 2010). Indiscriminate and repeated use of the pesticide not only leads to pest resistance but also increases the cost of crop-production. In this scenario, it becomes imperative to look for an effective alternative like planting and propagating less preferred commercially popular cultivar for future use to reduce pest incidence.

It is very well established that a wide array of different chemicals like primary, intermediary and secondary metabolites are responsible for causing the non-preference of a pest so deficiency of nutrients can lead to non-preference to certain host plants; similarly presence of certain compounds make a host plant unsuitable. These compounds act as feeding and oviposition deterrent (Jayaraj and Uthyaswamy, 1990).

Cassava mealy bug cultivar preference have been recorded in many studies (Dreyer and Jones, 1981; Le Rü and Tertuliano, 1993;). Dreyer and Molyneux (1985) have also reported that biochemical factors play key roles in influencing wheat and pea plant cultivar non-preference for aphids like *Schizaphis graminum, Myzus persicae* and *Acyrthosiphon pisum*. Reports of biochemical factors imparting cotton cultivar non-preference for sucking pest are available (Harijan *et al.*, 2017). Sandhi *et al.* (2017) working with okra germplasm varieties also documented significant contribution of biochemical factors to determine cultivar non-preference for sucking pest like a jassid pest, *Amrasca biguttula biguttula* (Ishida). But there is only a single report on factors affecting mango cultivar preference of mango mealy bug *D. mangiferae* where correlation of different phagostimulants and phagodeterrents with mango mealy bug density was reported by Karar *et al.* (2015) in Pakistan.

Over 30 cultivars of mango are commercially cultivated in India (Tharanathan *et al.*, 2006). These cultivars differ from each other in morphological characters, aroma and taste (Mukherjee, 1948; Naik and Gangolly, 1950). Therefore, it is expected that the intensity of mealy bug infestation will vary in the cultivars and biochemical factors play key roles in influencing the pest population intensity.

Therefore, the present study was undertaken to count the number, screen biological parameters and perform morphometry of mango mealy bug in five different commercial mango cultivars of Malda district of West Bengal both in field and laboratory conditions. The amount of various important biochemical factors was also measured. Correlation and multiple linear regression analysis of biochemical factors with pest number was also carried out to establish the role of these biochemical factors to influence mango mealy bug occurrence in five commercial mango cultivars of Malda.

Materials and methods

Field screening for cultivar preference: The cultivar choice was thoroughly studied for two consecutive years by counting population of mango mealy bug in the inflorescence/panicle and trunk of various mango cultivars strictly in field conditions. The experimental orchards were kept free from all insecticide sprays.

Population study of mango mealy bug in different cultivars: Three mango orchards with an average 15-20 years old trees and with a history of mango mealy bug infestation were selected. These orchards were located at Kaligram (25.38^0 N-88.04^0 E) and Chanchal (25.38^0N-88.01^0E) in Malda district and were 3-4 km apart. At least two trees of each popular commercial cultivars (Fazli, Guti, Lakhanbhog, Gopalbhog and Langra) were selected and tagged for counting mango mealy bug. Trees of different cultivars were selected on the basis of having similar layered-crown type canopy, similar age and location at the same agro climatic zone. Ten inflorescence of each trees from the four directions were tagged by binding colored thread, and the mealy bugs were counted from 30 cm branch at weekly interval in the year 2018 and 2019 during the pest infestation period. Therefore, total 20 inflorescence of each cultivar were taken into account and each inflorescence was considered as a replicate. Similarly, the population of mango mealy bug nymphs or adults in the 10 cm^2 of the trunk were also counted by using a metal square piece. Peak infestation time was noted carefully in both years of study. The numbers were compiled and analyzed through complete randomized block design using SigmaPlot software. The data regarding mealy bug nymphal population were subjected to analysis of variance (ANOVA) and means were compared by using Duncan's Multiple Range Test (DMRT) at 0.05 level of significance.

Biological parameters of mango mealy bug feeding on different mango cultivars: In the month of May, five egg carrying descending females having more or less similar size were collected from these selected cultivars. These gravid females from each variety were placed separately in a 100 mL beaker and then covered with cotton cloth. Fresh leaves of the cultivars from the orchards were supplied as food after wrapping the petioles with water soaked cotton. This was done to keep moisture intact for a considerable amount of time. Then egg laying behavior was noticed. After 7 days of rearing, these females from each cultivar were weighed and their length and width were measured with scale. Lastly, the egg sacs of the female were dissected with the help of tweezers and the number of eggs were counted from mealy bugs in each cultivars. Oviposition preference was analyzed by counting the mean number of eggs. Various other biological parameters like weight, length and width of adult female feeding on different cultivars were also measured. ANOVA of mean fecundity (the number of eggs/female), weight, length and width were calculated using SigmaPlot software. Means were compared by DMRT using the same software.

Biochemical analysis of panicle: Panicles from different mango cultivars were plucked at random from all directions during the peak time of mango mealy bug infestation and marked. Thereafter, these panicles were brought to the Entomology Laboratory of Zoology Department at Gour Banga University, Malda, West Bengal. Soon after that, panicles were cleaned in tap water, weighed and kept in the shade for drying. After drying, they were at first ground in an iron mortar and pestle and later on in a grinder. The fine powder was obtained by sieving the ground material through a 1 mm mesh and analyzed for 13 different biochemical parameters *viz.,* sugar, protein, alkaloid, flavonoid, phenol, tannin, ascorbic acid, moisture, lipid, antioxidant, crude fibre, mineral and nitrogen. Biochemical parameter was studied in four replicates. Means and standard deviations were calculated. The data were subjected to ANOVA and post hoc DMRT using SigmaPlot.

Total sugar was determined according to the method adopted by Dubois *et al.* (1956) with slight modifications. Total protein was estimated following Lowry *et al.* (1951). The method of Obadoni and Ochuho (2001) and Harborne (1983) was followed with slight modifications in order to determine alkaloid. For quantifying flavonoids, the method of Boham and Kocipai (1994) was followed with slight modifications. The method of Ainsworth *et al.* (2007) was used with little modifications to quantify total phenol. Tannin was estimated according to Van-Burden *et al.* (1981). The assay of total ascorbic acid was done following Barakat *et al.* (1993) method with slight modifications. Muslin cloth was rubbed against the freshly picked panicles to remove the dirt and weighed. Then they were at first kept in shade and later on oven dried after 2-3 days. After drying, the panicles were again weighed and moisture percentage was measured as-

$$\text{Moisture (\%)}= \frac{A-B}{A} \times 100$$

Where, A=weight of the fresh panicles, and B=weight of the dried panicles.

For lipid extraction and measurement, AOAC (1975) method was adopted with some modifications.

The total antioxidant activity was measured by quantifying free radical scavenging ability of the sample following Wong *et al.* (2006) with slight modifications. Crude fibre was estimated using AOAC (1975) method with some modifications. Total mineral assay was performed according to AOAC (2000) with slight modifications. Nitrogen was estimated following Kjeldahl digestion method and then percentage was measured by the formula of Winkleman *et al.* (1986).

Correlation and multiple linear regression analysis: Pairwise correlation between the peak time pest number per panicle of various cultivars and different biochemical factors were worked out. In order to deduce the role of individual biochemical factor in determining the pest number, a stepwise linear regression model was generated considering average pest number/panicle at peak time of infestation as dependent variable (Y) and various biochemical factors as independent variables and named as X_1, X_2,…..X_N. IBM SPSS 20 statistical software was used to create this model. During this model generation independent variables having gradually higher correlation coefficient were entered one by one and a regression equation was ultimately generated as follows:

$Y=a+b_1x_1+b_2x_2+b_3x_3$…………..b_nx_n.

Where, a=intercept, b=regression coefficient, Y=number of pests/panicle, X_1 to X_N were various independent variables.

Individual contribution of variables was calculated through stepwise multiple regression analysis.

Results

Population of mango mealy bug in the panicle: Population dynamics of mango mealy bug clearly depicted that the population peaked up at 13 SMW in both years of study (Fig. 1, 2). Number of pest also varied greatly in different cultivars as evident from Table 1. When average of two years are considered, Fazli was found to harbor the most number of the pest with an average of 132.57 whereas pest count on Langra was 26.67. ANOVA of means of both years as well as average of both years clearly revealed that means differ from each other significantly. When cumulative numbers of two years were considered, Gopalbhog and Langra had almost similar numbers (20.27 and 26.67) as measured by DMRT test at 0.05 level of significance. All the other cultivars differed significantly from each other (Table 1). The order of infestation of mango cultivars due to the preference of mealy bug was Fazli> Guti> Lakhanbhog> Gopal Bhog> Langra.

Table 1. Mean population of mango mealy bug on different cultivars of mango per 30-cm branch during peak time (13 SMW) of 2018 and 2019

Cultivars	Year		Mean
	2018	2019	
Fazli	83.00 a	183.15a	132.57a
Guti	39.50 b	153.7b	96.6b
Lakhan bhog	30.05 b	134.0b	82.02c
Langra	11.00 c	29.55c	20.27d
Gopalbhog	13.75 c	39.5d	26.67d

*ANOVA of means of mango mealy bug number in both 2018 and 2019 (in mango panicle) shows significant differences among the means. The post hoc DMRT (Duncan Multiple Range Test) showed that means sharing similar letters in 2018 and 2019 did not differ significantly from each other at P=0.05.

Population of mango mealy bugs on the tree trunk: The population trend of mango mealy bug on trunk revealed that the number gradually peaked at 13 SMW similar to the panicle (Fig. 3, 4). At the peak time of infestation in 2018, Fazli cultivar had the maximum number (23/unit area) whereas minimum number (4.06/unit area) was encountered in Langra. ANOVA of means differed significantly as revealed by the greater calculated F-value (32.49) than the critical value (2.75). In DMRT, other than Guti vs Lakhanbhog and Gopalbhog vs Langra, all the other cultivars depicted significant difference of means. Similar trends were also noticed in 2019, with Fazli having the highest number of mealy bugs/unit area (33.16) compared to a meager 8.66/unit area in

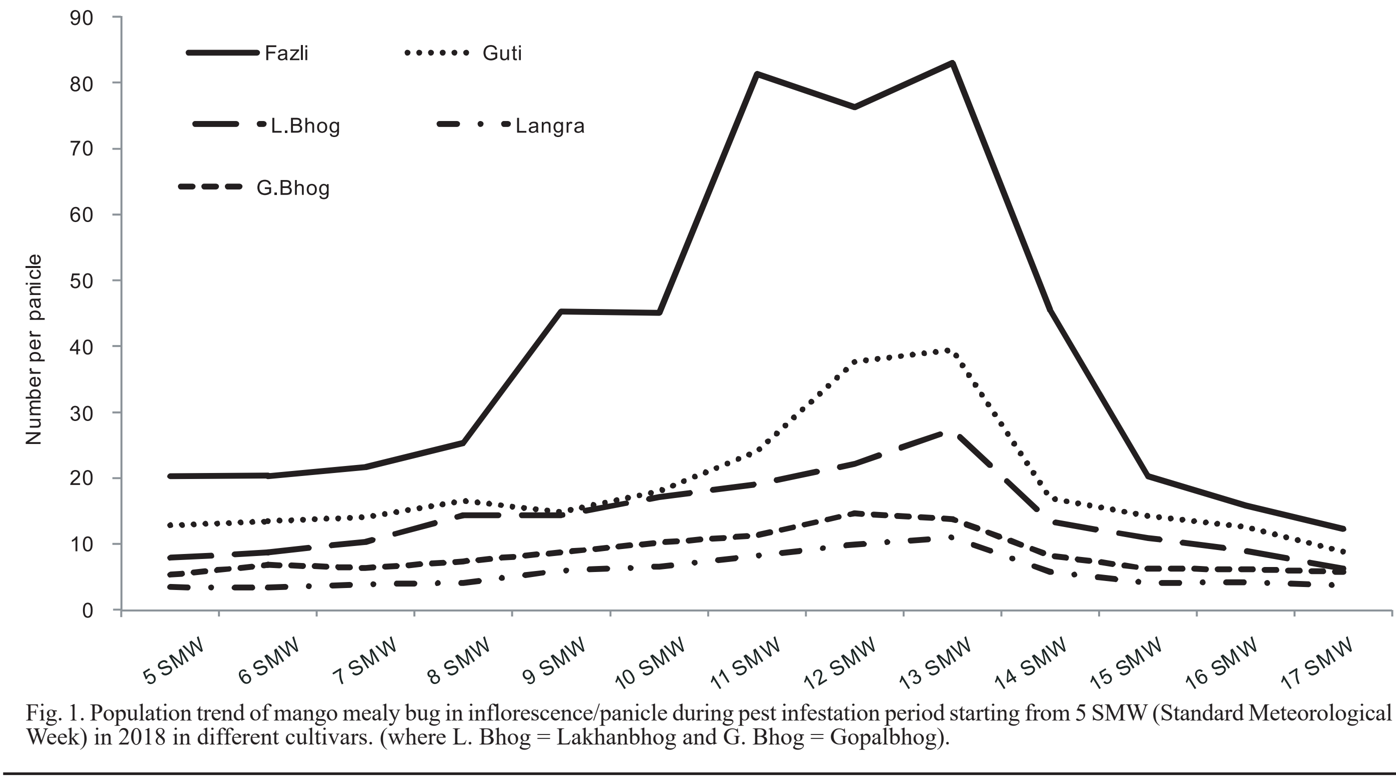

Fig. 1. Population trend of mango mealy bug in inflorescence/panicle during pest infestation period starting from 5 SMW (Standard Meteorological Week) in 2018 in different cultivars. (where L. Bhog = Lakhanbhog and G. Bhog = Gopalbhog).

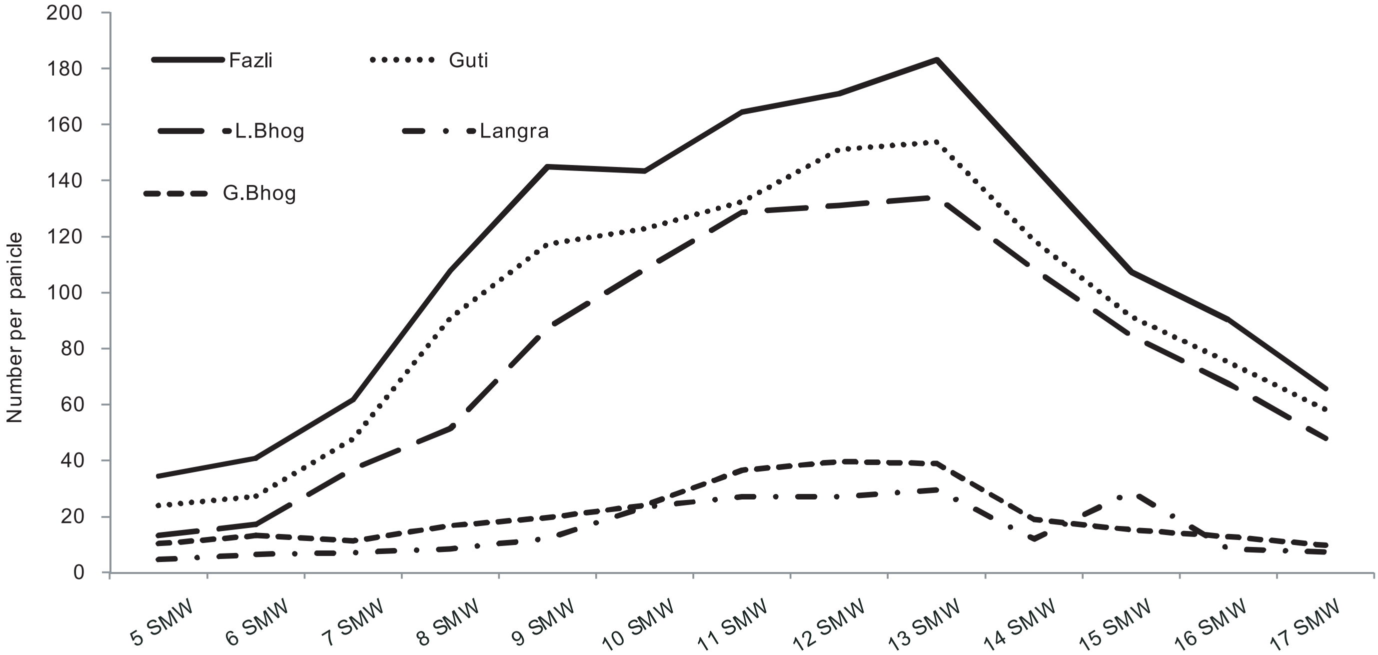

Fig. 2. Population trend of mango mealy bug in inflorescence/panicle during pest infestation period starting from 5 SMW (Standard Meteorological Week) in 2019 in different cultivars. (where L. Bhog = Lakhanbhog and G. Bhog = Gopalbhog).

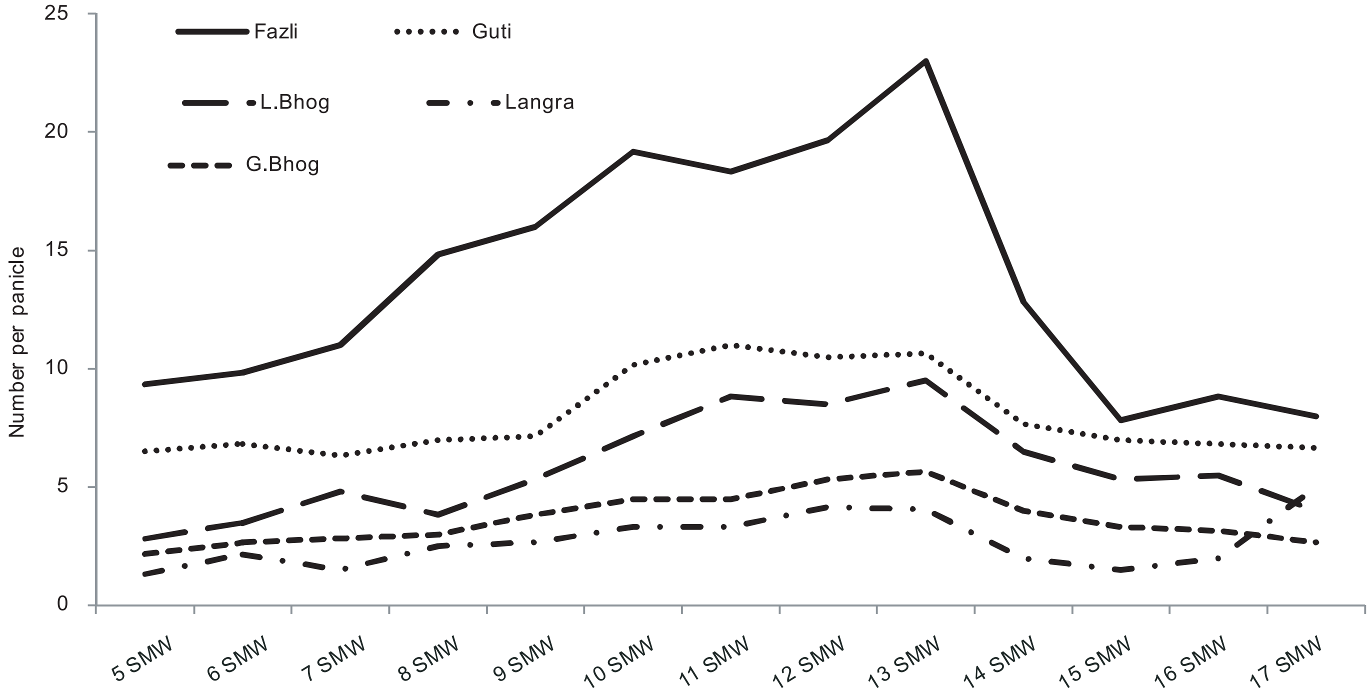

Fig. 3. Population trend of mango mealy bug at 10 cm^2 of trunk during pest infestation period starting from 5 SMW (Standard Meteorological week) in 2018 in different cultivars. (where L. Bhog = Lakhanbhog and G. Bhog = Gopalbhog).

Langra. When cumulative number of both years were considered, our results clearly show that the average number of mango mealy bug differed significantly (F-value 10.33 and critical value 2.53) and means of Guti vs Gopalbhog and Langra vs Gopalbhog did not differ from each other significantly. All the other pairs significantly differed from one another (Table 2). So, the above findings were found to corroborate with panicle data.

Oviposition preference and morphometry of mango mealy bug feeding on different cultivars: The various biological parameters of a gravid female reared on different mango cultivars is presented in Table 3. This study clearly revealed that mango mealy bug growing on various cultivars differed significantly in length, width and weight. Gravid female mealy bug gained the highest weight on Fazli cultivar (0.256 g) whereas mealy bugs infecting Langra had the minimum weight (0.18 g). Females grew up to 0.234 cm on Fazli, on the contrary it achieved only 0.142 cm on Langra. Similarly maximum width of mealy bug was found on Fazli (0.174 cm) whereas lowest width was noticed on Langra (0.106 cm). Moreover, gravid female laid more eggs on Fazli (109.4) compared to all the other cultivars. The number of eggs/female gradually diminished from Fazli (109.4) followed by Guti (84.6), Lakhanbhog (76.4), Gopalbhog (62.2) and Langra (42.2). Mean number of eggs produced by females in different cultivars also varied significantly as observed by ANOVA.

Table 2. Mean population of mango mealy bug on different cultivars of mango per 10 cm^2 of trunk during peak time (13 SMW) of 2018 and 2019.

Cultivars	Year 2018	Year 2019	Mean
Fazli	23.0 a	33.16a	28.05a
Guti	10.66 b	26.0a	18.33b
Lakhan bhog	9.5 b	21.83a	15.66b
Langra	4.06c	8.66b	6.36c
Gopalbhog	5.66c	11.83c	8.74c

Means sharing similar letters in 2018 and 2019 did not differ significantly from each other at P=0.05.

Table 3. Biological parameters of gravid female mango mealy bug grown on different mango cultivars

Cultivar	Number of eggs / female*	Gravid female weight(g)*	Female length (cm)*	Female width (cm)*
Fazli	109.4 a	0.256 a	0.234 a	0.174 a
Guti	84.6 b	0.242 b	0.220 a	0.164 a
Lakhanbhog	76.4 b	0.222 c	0.228 a	0.162a
Langra	42.2 c	0.18 d	0.142 b	0.106 b
Gopalbhog	62.4 d	0.20 d	0.178 c	0.126 c

*Means sharing the similar letters did not differ from each other significantly in DMR test at P=0.05.

On the basis of statistical analysis of cumulative data of two years of mealy bug number present in panicle and trunk as well as oviposition preference and morphometry study data, cultivars were categorized as the most preferred (Fazli), moderately preferred (Guti and Lakhanbhog), and less preferred (Gopalbhog and Langra).

Chemical factors in panicle of different mango cultivars at the peak time of mango mealy bug infestation

Sugar: Regarding the results of sugar content, significant variation was observed among the cultivars (Table 4A). Fazli had significantly higher content of sugar (11.87 mg/g) compared to the other varieties. Apart from Gopalbhog and Langra, rest of the cultivars demonstrated significant difference of means.

Protein: Significant variation in protein content was noticed among the various cultivars of mango (Table 4A) with the highest quantity observed in Fazli (8.39 mg/g). The mean protein content found in Lakhanbhog, Gopalbhog and Langra did not differ from each other significantly.

Alkaloids: The amount of alkaloid varied significantly in the cultivars as shown in Table 4A. In Lakhanbhog variety, lowest quantity of alkaloid (5.62 mg/g) was detected, whereas the Langra variety had the highest amount (8.4 mg/g). As per DMRT, the mean amounts of alkaloid of Fazli, Guti and Lakhanbhog were similar.

Flavonoids: The flavonoid content in various cultivars differed significantly from each other (Table 4A). The difference of means were non-significant between two pairs of cultivars (Fazli and Guti, Gopalbhog and Langra) as revealed by DMRT.

Phenol: The results depicted in Table 4A show that the means of the phenol content had non-significant differences.

Tannin: Tannin quantity varied significantly in the cultivars (Table 4A). As per the results obtained in DMRT, Guti and Lakhanbhog varieties did not have significant difference.

Ascorbic acid: The cultivars differed significantly in respect to ascorbic acid amount (Table 4B). Ascorbic acid was found in the range of 1.66-4.34 mg/g in all the cultivars.

Moisture: Highest amount of moisture was found in Fazli (59.11 %) which differed significantly from the other cultivars (Table 4B). DMRT showed that Guti, Gopalbhog and and Lakhanbhog cultivars did not differ significantly from each other in the amount of moisture.

Lipid: Significant differences in lipid amount was observed in the various cultivars studied (Table 4B). Both Guti and Langra had significantly lower amount (1.62 %) of lipid whereas relatively higher amount were found in Lakhanbhog (3.50 mg/g) and Gopalbhog (4.10 mg/g).

Antioxidant activity: The measured antioxidant activity differed

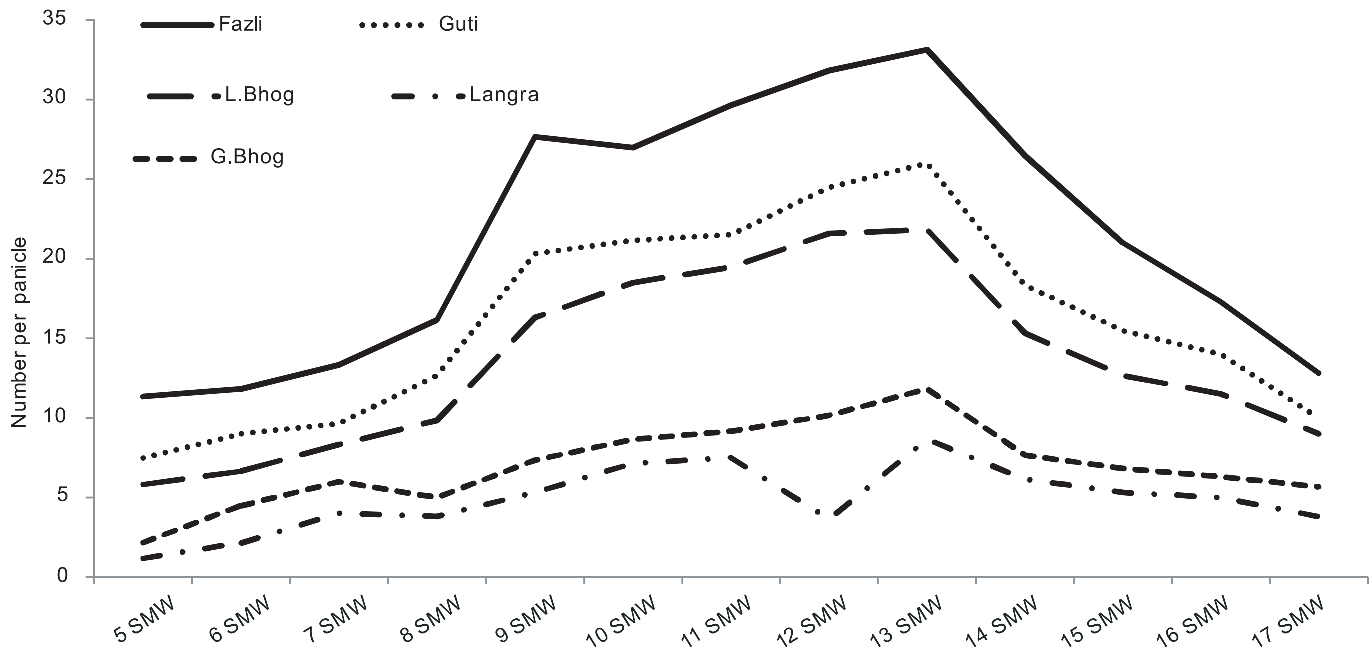

Fig. 4. Population trend of mango mealy bug at 10cm^2 of trunk during pest infestation period starting from 5 SMW (Standard Meteorological Week) in 2019 in different cultivars. (where L. Bhog = Lakhanbhog and G. Bhog= Gopalbhog).

Table 4A. Comparison of biochemical constituents of panicle in different cultivars at peak time of mango mealy bug infestation

Cultivar	Sugar (mg/g)*	Protein (mg/g)*	Alkaloid (mg/g)*	Flavonoid (mg/g)*	Phenol (mg/g)	Tannin (mg/g)*
Fazli	11.87 a	8.39a	5.85 a	7.27a	1.14a	11.26a
Guti	9.43b	6.16b	6.10 a	7.45a	1.18a	31.82b
Lakhanbhog	8.05c	6.09 c	5.62 a	8.85b	1.22a	34.75b
Langra	6.23d	5.21 c	8.4b	14.57c	1.41a	67.49c
Gopalbhog	7.12d	5.55 c	7.15c	10.1c	1.33a	52.97d

Means in the column ending with similar letters do not differ significantly by DMRT (Duncan's Multiple Range) test P=0.05.

significantly in various cultivars (Table 4B) with the maximum activity being noted in Langra (84.75 %). DMRT of antioxidant activity yielded significant difference in all the cultivars.

Crude fibre: The crude fibre percentage found in various cultivars also differed significantly (Table 4B). Comparatively higher amount was observed in Langra (54.59 %) compared to the rest of the cultivars.

Mineral: Significant differences were found in mineral contents of various cultivars (Table 4B).

Nitrogen: The nitrogen content within the various cultivars differed significantly (Table 4B) with Fazli showing relatively higher amount of nitrogen (1.20 %).

Correlation of biochemical parameters with the pest population: The correlations between various biochemical factors and number of pests/panicle at peak time (13 SMW) was worked out and is presented in Table 5. There was a significant positive correlation between pest number and sugar, protein, moisture and nitrogen content at $P \leq 0.05$. Maximum positive correlation existed between pest number and nitrogen (r= 0.841) followed by protein (r= 0.795), sugar (r= 0.755) and moisture (r= 0.713). On the contrary, significant negative correlation was observed between pest number and alkaloid, flavonoid, phenol, tannin, ascorbic acid, antioxidant or crude fibre amount. Highest negative correlation was found between pest number and flavonoid (r= -0.883) followed by alkaloid (r= -0.860), phenol (r= -0.825), ascorbic acid (r= -0.732), crude fibre (r= -0.701), tannin (r= -0.677) and antioxidant (r= -0.012). Lipid and mineral had a non-significant correlation.

Multiple linear regression analysis: Stepwise multiple linear regression model was generated for elucidating the role of various biochemical parameters on mango mealy bug pest number fluctuation, and the results are depicted in Table 6. It was clear from the model that mineral content had no role in influencing the pest number/panicle as the adjusted R^2 value was -0.055. Even with the addition of lipid percentage in the model as the second variable, the adjusted R^2 did not increase beyond -0.081 indicating zero contribution of lipid. Maximum increase of adjusted R^2 value was noted when the tannin content was also considered along with the first two parameters. The adjusted R^2 value reached from -0.081 to 0.392 expressing individual 39.2 % role in controlling the dependent variable Y which is pest number/panicle. Therefore, it may be inferred that tannin was the most potent factor. Nitrogen, flavonoid and phenol were the next three major contributors in regulating the pest number and they had 15.5, 11.4 and 7.7 % role according to the current analysis. Similarly, ascorbic acid was responsible for 6.9 % fluctuation in pest number. Protein accounted for 6.2 % population fluctuation of mealy bug. Crude fibre had also contributed for 5.3 % pest population fluctuation. All the other factors made minor contributions. Surprisingly, alkaloid was found to have no role in controlling pest population as the calculated adjusted R^2 value was observed to be reduced from the earlier variable.

Discussion

The data pertaining to the number of mealy bug at peak time of infestation (13 SMW) clearly revealed that there is a cultivar preference of mango mealy bug. Fazli is highly preferred whereas Langra is least preferred. Furthermore, our results also indicated that gravid females laid more eggs, gained more weight, and also attained greater size on the most preferred Fazli variety compared to the other less preferred varieties emphasizing cultivar preference.

In our present study nutritional factors like sugars, moisture,

Table 4B. Comparison of biochemical constituents of panicle in different cultivars at peak time of mango mealy bug infestation

Cultivar	Ascorbate (mg/gm)*	Moisture (%)*	Lipid (%) *	Antioxidant (% activity)*	Crude fiber (%)*	Mineral (%) *	Nitrogen (%)*
Fazli	1.66a	59.11a	1.75a	61.25a	39.24a	5.72a	1.20a
Guti	2.04b	55.26 b	1.62b	66.00b	47.34b	9.07b	1.11a
Lakhanbhog	2.41c	54.62b	3.50c	70.50c	50.16c	8.32b	1.12a
Langra	4.40d	42.51c	1.62b	84.75d	54.59d	6.57c	1.03b
Gopalbhog	4.34d	52.65b	4.10d	79.00e	51.18c	6.47d	1.07b

Means in the column ending with similar letters do not differ significantly by DMR (Duncan's Multiple Range) test at P=0.05.(*) means of these biochemical constituents differ significantly at $P \leq 0.05$.

Table 5. Simple correlation between populations of mealy bug on mango inflorescence with biochemical factors

Constituents	Correlation coefficient (r)
Sugar	0.755*
Protein	0.795*
Alkaloid	-0.860*
Flavonoid	-0.883*
Phenol	- 0.825*
Tannin	-0.677*
Ascorbic acid	-0.732*
Moisture	0.713*
Lipid	-0.180*
Antioxidant	-0.012*
Crude fiber	-0.701*
Mineral	-0.012*
Nitrogen	0.841*

(*) significant at $P \leq 0.05$.

Table 6. Stepwise multiple regression to elucidate the roles of individual biochemical factors to influence pest density

Regression equation	DF	F-value	P-value	Adjusted R^2	Individual variable's role (%).
Y= -1.682-0.066 $X1$	1	0.003	>0.05	-0.055	0.00
Y=1.802-0.037 $X1$-0.40 $X2$	2	0.284	>0.05	-0.081	0.00
Y=2.504+0.955 $X1$+0.020 $X2$-1.113 $X3$	3	5.085	<0.05	0.392	39.20
Y=16.093+1.596 $X1$+0.117 $X2$+0.638 $X3$-10.010 $X4$	4	4.816	<0.05	0.445	5.30
Y=-1.043+0.385 $X1$-0.460 $X2$-0.343 $X3$-3.512 $X4$+4.587 $X5$	5	4.174	<0.05	0.455	1.00
Y=6.805-2.449 $X1$-0.038 $X2$+2.748 $X3$-6.312 $X4$-2.834 $X5$-3.481 $X6$	6	4.485	<0.05	0.524	6.90
Y=-2.708-3.466$X1$-0.032$X2$+3.202$X3$-2.267$X4$-2.899$X5$-03.536 $X6$+3.307 $X7$	7	4.334	<0.05	0.551	2.70
Y=22.74-4.669 $X1$-0.084 $X2$+3.636 $X3$-0.183 $X4$+0.156 $X5$-2.322 $X6$+1.983 $X7$-12.966 $X8$	8	4.034	<0.05	0.561	1.00
Y=34.565-3.501 $X1$+0.469 $X2$+4.050 $X3$—2.966 $X4$_4.095 $X5$-1.410 $X6$+1.456 $X7$-14.62 $X8$-2.846 $X9$	9	4.483	<0.05	0.623	6.20
Y=32.644-3.057 $X1$+0.515 $X2$+3.046 $X3$-1.672 $X4$-4.372 $X5$-1.207 $X6$+0.815 $X7$-13.044 $X8$-1.773 $X9$-2.955 $X10$.	10	5.642	<0.05	0.710	7.70
Y=31.9021-3.018 $X1$+0.554 $X2$+0.731 $X3$-2.518 $X4$-5.603 $X5$-1.981 $X6$+0.065 $X7$-11.198 $X8$+1.983 $X9$-1.689 $X10$+11.455 $X11$	11	12.05	<0.05	0.865	15.50
Y=34.04-3.093 $X1$+0.613 $X2$+3.897 $X3$-2.833 $X4$-5.910 $X5$-2.046 $X6$-0.099 $X7$-11.944 $X8$+2.085 $X9$-1.742 $X10$+12.03 $X11$+0.213 $X12$	12	9.69	<0.05	0.846	0.00
Y=4.836-1.639 $X1$+0.008 $X2$+1.131 $X3$+4.650 $X4$-4.918$X5$-0.205$X6$+1.597$X7$-2.467 $X8$+3.066 $X9$+0.140 $X10$+6.465 $X11$-0.215 $X12$-2.272 $X13$.	13	36.36	<0.05	0.960	11.40

Where, Y (Dependent Variable)= pest no/panicle at the peak time of infestation.
($X1$ to $X9$ = Independent Variables). $X1$= Mineral content, $X2$= Lipid content, $X3$= Tannin content, $X4$= Crude fiber %. $X5$= Moisture, $X6$= Ascorbate content, $X7$= Sugar content, $X8$= Antioxidant activity, $X9$= Protein content, $X10$= phenol content, $X11$= Nitrogen %, $X12$= Alkaloid content, $X13$= Flavonoid content.

protein, mineral, lipid, nitrogen which are phagostimulants varied in different cultivars. Similarly, significant variations were also recorded among the various cultivars regarding content of physiological inhibitors like alkaloid, flavonoid, tannin, ascorbic acid, antioxidant and crude fibre. These results of our current study are perfectly in sync with the findings of others (Jayaraj and Uthyaswamy, 1990; Fraenkel, 1969; Kogan, 1977) where it has been observed that insect behavior and adaptation are prejudiced by the chemical constituents of the host plant. These chemicals can either act as physiological inhibitors or cause nutritional deficiencies which play key role in varietal non-preference and antibiosis. Schoonhoven *et al.* (1998) have also shown that it is the balance of attractant and deterrent compounds within a plant which determine antixenosis or non preference of insect.

The positive correlation detected between sugar and pest number in our current study are in line with other studies (Albert *et al.*, 1982; Bartlet *et al.*, 1994) where they reported that sugar like sucrose acts as a phagostimulant in variety of insects. Similarly, Jumal *et al.* (2013) have reported that sugars contribute positively in host selection and acceptance of *Busseola fusca*, a lepidopteran pest.

In our current study, protein was found more in preferred cultivars compared to the less preferred ones. This is similar to the findings reported elsewhere (Febvay *et al.*, 1988; Prosser *et al.*, 1992; Abisgold *et al.*, 1994; Girousse and Bournoville, 1994; Sarmah *et al.*, 2011) where insect growth, reproduction, food choice or weight have been found to be influenced positively by nitrogen and protein.

According to our present study, there was positive correlation of mealy bug density and moisture content which is in conformity with Parvez *et al.* (2000) who observed that moisture contributes for cultivar selection and low moisture was responsible for less-preference of certain maize cultivars by *Chilo partellus* (S.). Our results are also supported by findings of Shah *et al.* (2016) who noted that lower moisture content in less preferred cultivar of maize was responsible for lower insect pest incidence. But our data of presence of higher moisture level in preferred cultivars is not corroborating with the study of Karar *et al.* (2015) who have reported insignificant correlation between mango mealy bug number and moisture.

It was also very much evident from the current study that the estimated nitrogen quantity was highest in the most preferred variety and it gradually diminished in the less preferred varieties. These results are in conformity with other findings (Singh and Taneja, 1989; Zhong-xian *et al.*, 2007) where positive correlation between various insect pests and nitrogen content were observed. Our finding regarding nitrogen content is in contradiction with Karar *et al.* (2015) who noted highest quantity of nitrogen in inflorescence of Tukmi cultivar which is the least preferred mango cultivar in the agro climatic region of Multan of Pakistan.

Results of our current study have pointed out that higher alkaloid and flavonoid content is responsible for reduced pest number which is very much similar to the other studies and deterrent roles of alkaloid and flavonoid had been clearly demonstrated in a sucking bug, aphid (Smith, 1966; Todd *et al.,* 1971; Dreyer & Jones, 1981; Dreyer and Molyneux, 1985). These reports also indicated that localization of secondary metabolites like alkaloid, flavonoid or phenolic acids determines insect abundance and if they are located within the mesophyll tissue, the stylet penetration will be deterred. Therefore, it can be inferred that in our findings higher presence of secondary metabolites in the panicle mesophyll tissue of less preferred cultivars had acted as repellent to mango mealy bug. It is also an established fact that phenol is antifeedant of herbivores (Matern and Kneusal, 1988; Kumar *et al.*, 2014). Negative and significant correlation of phenol and pest number in this study is in agreement with the above findings.

Tannin content varied significantly among the mango cultivars and the less preferred cultivars had relatively higher tannin content, is in line with the findings reported by Fenny *et al.* (1968), Bernays *et al.* (1981) and Grayer *et al.* (1992). In all these reports feeding- deterrent activity of tannin were clearly observed against various insects. The feeding deterrence of tannin can also be elucidated by findings of Chakravorty and Sahni (1972) and Bhat *et al.* (1981) against a sucking cotton jassid pest. Tannin acquires antifeedant property from its binding ability to precipitate protein like digestive enzymes, interference ability with nutrient absorption in gut and astringent action (Sharma and Agarwal, 1983; Sharma *et al.*, 2009; Barbehenn *et al.*, 2011).

The results related to ascorbic acid content also indicated greater presence in less preferred variety which is in line with the findings of Ahamed *et al.* (2013) who reported antioxidant and pest control activity of selected medicinal plants against insect pests and ascorbic acid as a potent antioxidant (Quintus *et al.*, 2005). Even in host plant-nematode interaction, more ascorbic acid is synthesized in the non preferred plant cultivars suggesting its role in plant defense (Arrigoni *et al.,* 1979). The insect deterrent or insecticidal properties of antioxidants is a well-established phenomenon (Miles *et al.*, 1993; Mohamed and Adelgaleil, 2008; Kumar *et al.*, 2014). Presence of higher amount of antioxidant in less preferred cultivars compared to moderately preferred and most preferred cultivars in the study is further emphasizing the pest deterrent role of antioxidants. The lipid content also varied significantly in different cultivars and the pest number and lipid amount correlated negatively in our study. Yang *et al.* (1995) also reported that wild peanut cultivars having higher percentage of dietary lipid affected the growth and development of fall armyworm (*Spodoptera frugiperda*) feeding on groundnut (*Arachis* sp). Negative but significant correlation was observed between pest number and mineral content in different cultivars which is very much in line with findings of Silva *et al.* (2005) who reported similar negative correlation between mineral content and aphid population in alfalfa cultivars.

Moreover, it is a well-established fact that secondary metabolites like alkaloid, phenols, terpenoids not only act as antifeedants of insects but they also have insect growth and oviposition deterrent roles (Isman, 2006; Diaz, 2016; Soujanya *et al.*, 2016; Zust and Agrawal, 2016). Similar kind of ovipostion deterrence was also noticed in the current study where gravid female laid more eggs in most preferred Fazli or moderately preferred Guti containing more of oviposition deterrents like tannin, flavonoid, phenol, ascorbic acid, antioxidants, compared to all the other lesser preferred cultivars .

The roles of individual biochemical factors to influence pest population were elucidated by adjusted R^2 value in the stepwise multiple regression analysis. Maximum effect was imparted by tannin followed by nitrogen, flavonoid, phenol, ascorbic acid, protein and crude fiber. Factors like sugar, antioxidant, and moisture made moderate contributions in influencing pest number. No effect of mineral lipid and alkaloid were noticed. Therefore, from these findings it can be inferred that the insect deterrents (tannin, flavonoid, phenol, ascorbic acid, crude fibre) played more significant roles than the phagostimulants (nitrogen, sugar, moisture, protein) to control the pest density. This current finding is in conformity with Jermy (2011) who reported that insect has greater sensitivity of chemoreceptors towards feeding inhibitors and this sensitivity is of greater significance to choose the host than the adapting ability to some phagostimulants. Adjusted R^2 value reached 0.96 when all factors were included *i.e.*, 96 % influence on pest population. It can be assumed that even if all individual factors made some contributions for determining pest number in regression analysis but the combination of factors is more important as also reported elsewhere (Karar *et al.*, 2015; Harijan *et al.*, 2017; Sandhi *et al.*, 2017).

Counting of mango mealy bug number at peak time of infestation in panicle and trunk, oviposition preference and morphometry study have indicated that Langra and Gopalbhog varieties are the less preferred, Lakhanbhog and Guti are moderately preferred whereas Fazli is most preferred among all the cultivars. Less preferred cultivars contain more of the insect feeding and oviposition deterrents like tannin, antioxidants, alkaloid, flavonoids, phenol and relatively less nutrients like nitrogen, sugar, protein and moisture. On the contrary, more preferred varieties contain more of the nutrients which act as phago stimulants. This study is helpful to understand the biochemical basis of varietal preference of mango mealy bug.

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