Fruit Infestation and Larval Density of Melon Fly, *Bactrocera cucurbitae* (Coq.) as Influenced by Morphological Traits of Bitter Gourd (*Momordica charantia* L.)

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Abstract

Melon fly, *Bactrocera cucurbitae* (Coq.) (Diptera: Tephritidae) is one of the most important biotic constraints for reaping optimum yield potentiality of cucurbitaceous crops. Due to its peculiar life history and mode of damage it is very much difficult to manage the pest by implementing conventional tactics. Thus, it is important to search for plant characteristics that are associated with survivability and development of the pest. Ten bitter gourd cultivars including open pollinated, hybrids and local accessions were taken to study the effect of morphological traits on fruit infestation and larval density of melon fly. There exist significant variation in percent fruit infestation and larval density per infested fruit in different test cultivars and were correlated positively (r=0.48). Positive correlation of percent fruit infestation and larval density per fruit were derived with fruit weight (r=0.76 and 0.75), length (r=0.71 and 0.72) and diameter (r=0.68 and 0.60). On the contrary, negative correlation were observed with ribs density (r=-0.78 and -0.73), ribs depth (r=-0.24 and -0.18) and skin toughness (r=-0.80 and -0.84) of fruits. Multiple correlations on the impact of morphological traits of fruits on percent fruit infestation and larval density fruit^{-1} were also derived.

1. Introduction

Bitter gourd (*Momordica charantia* L.) is one of the most important nutritious cucurbitaceous vegetables grown throughout the tropical and sub-tropical tracts of Asia, particularly India, Pakistan, Sri Lanka and China. Among several biotic stresses, insect pests are a major bottleneck for increasing the production and productivity of these vegetables. Amongst the insect pest, melon fly [*Bactrocera cucurbitae* (Coq.) (Diptera :Tephritidae)] is an important threat (Shah et al., 1948) that infest ultimate economic part, i.e. fruits of the crop. The pest has been found to infest about 81 host plants (Dhillon et al., 2005c), but bitter gourd is one of the most preferred hosts and has been a major limiting factor in realizing optimum yield potentiality (Srinivasan, 1959; Lall and Singh, 1969; Rabindranath and Pillai, 1986). The extent of losses caused by the pest varies from 30-100% depending upon cucurbit species and the season (Dhillon et al., 2005b). It is very much difficult to manage the pest simply through the application of chemical pesticides due to their peculiar biological features and concealed feeding habit. Development or identification of cultivar(s) resistant to the pest is an important component for IPM as suggested by Panda and Khush (1995). Different varieties of bitter gourd exhibit variation in the extent of fruit fly infestation (Yadav et al., 2003; Dhillon et al., 2005a). However, information regarding the morphological factors such as depth of ribs, flesh thickness, fruit diameter and fruit length, and fruit toughness (Dhillon et al., 2005c) and chemical factors such as in moisture level; ascorbic acid, reducing, non-reducing and total sugars, nitrogen, protein, phosphorus and potassium contents (Tewatia et al., 1998), etc. responsible for this variation in different levels of infestations is vital for initiating crop improvement program to develop resistant lines. In the present study an initiative was undertaken to find out the impact of different morphological traits of bitter gourd fruits on the extent of infestation and larval density fruit^{-1}.

2. Materials and Methods

The study was conducted at the Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India (situated at 26°19' N latitude and 89°23' E longitude and at an altitude of 43 masl). Ten cultivars of bitter gourd including open pollinated, hybrids and local accessions were taken for the study. The test materials were planted on raised beds of 1.5 m width with a plant-to-plant spacing of 1 m in

June (rainy season) and February (summer season) of 2007 and 2008. The experiment was replicated thrice arranged by following randomized block design (RBD). In each bed five plants were tagged randomly for recording observation. The rainy season crop fruited in August-September and the summer season crop during April-May. Recommended agronomic practices were adopted to raise the crop except chemical control of insect pests.

Marketable sized fruits were picked at three days intervals and brought to the laboratory for recording observation regarding larval density fruit^{-1} and percent fruit infestation. Percent fruit infestation was calculated on number basis as follows:

$$\% \text{ fruit infestation} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits observed}} \times 100$$

The infested fruits were cut open to count the number of maggots of melon fly fruit^{-1}. Healthy fruits were used to observe morphological traits in the test cultivars. Observation on morphological traits of fruit was recorded from three randomly selected fruits from all the replicates. Vernier calipers was used to measure length and diameter of the fruits, depth of ribs by scale and intensity of ribs (number of ribs cm^{-2}) was determined by counting number of ribs cm^{-2} area of fruit surface. Toughness of fruits was determined by using texture analyzer (Make: Stable Micro Systems, UK; Model: TA-XT plus).

The data, thus obtained were analyzed statistically using INDOSTAT and Microsoft Excel package of statistical analysis. The percentage data were transformed using angular transformation. The significance of differences between the cultivars was judged by F-test, and the treatment means were compared by the LSD (least significant difference) at p=0.05. The data on percentage fruit infestation and larval density fruit^{-1} were also subjected to correlation, multiple linear regression analysis to see the impact and association of morphological traits on resistance/susceptibility reaction to the pest and its density.

3. Results and Discussion

Significant differences in percent fruit infestation and larval density fruit^{-1} were observed among the test cultivars in both the seasons of study (Table 1). Percent fruits infested by the melon fly during summer seasons of 2007 and 2008 (February sown crop) varied from 8.83 to 20.08 being lowest in 'Kalimpong local' and highest in 'Sasya' F_1, while during rainy season of 2007 and 2008 (June sown crop) the infestation varied from 35.53 (Kalimpong local) to 71.13% ('Vivek' F_1). Number of maggots (larval density) infested fruit^{-1} during summer season (2007 and 2008) ranged from 6.60 ('Pundibari local') to 11.97 ('Green long') and during rainy season (2007 and 2008) it varied from 20.82 to 40.43 being highest in Vivek F_1 and lowest in Pundibari local. Percent fruit infestation and larval density infested fruit^{-1} varied over season and significantly higher infestation and larval density observed in the rainy season crop as compared to that of summer season. This variation in infestation and larval density might be due to prevailing environmental conditions that affect population dynamics and biology of the pest. Mean percent infestation and larval density during summer season was recorded as 12.01% and 9.55 (number of larva infested fruit^{-1}), respectively, whereas, during rainy season it was 50.91% and 29.34.

3.1. *Association of morphological traits with percent fruit infestation and larval density*

3.1.1. *Fruit weight*

Significant variation in fruit weight was observed in different cultivars of bitter gourd evaluated (Table 2). Fruit weight varied from 25.20 to 100.87 g. being lowest in Pundibari local and highest in Sasya F_1. Percent fruit fly infestation and larval density/ infested fruit in different cultivars was positively and significantly (p=0.05) correlated (r=+0.77 and+0.75, respectively) with the fruit weight (Table 2 and 3). This could be attributed to the availability of sufficient edible material in large sized fruit, affording opportunities for adequate feeding and survival of the maggots as noted by Singh and Vashishtha (2002).

3.1.2. *Fruit length and diameter*

Fruit length and diameter varied from 4.93 to 15.23 cm and 3.20 to 5.10 cm, respectively in different cultivars evaluated. Fruit length and diameter was minimum in Pundibari local and maximum in Vivek F_1. Both length and diameter of fruit that determine the size of the fruit were correlated positively (r=+0.71 and+0.68, respectively) and significantly (p=0.05) with percent fruit infestation. Larval density/infested fruit when correlated with length and diameter of fruits, significant and positive association (r=0.71 and 0.59) was also observed. Earlier, Lakra and Singh (1983) also found that bigger fruits carried more eggs than smaller ones while working on the preference of *C. vesuviana* on Indian jujube fruits.

3.1.3. *Ribs density and depth*

Ribs density (number of ribs cm^{-2} fruit surface) ranged from 7.17 to 12.97 being significantly (p=0.05) lower in 'Pusa Do Mousumi' and higher in the local cultivar Pundibari local. Depth of ribs in different test cultivars also varied significantly from 4.48 to 7.06 mm. Higher depth was recorded in 'Rakkhuse' whereas lower was in Vivek F_1. There exists a significantly negative correlation (r=-0.78) of percent fruit infested with the ribs density. However, depth of ribs correlated negatively (r=-0.25) but not significantly. Dhillon et al. (2005c) also observed this trend of observation and opined that in general, the number of ridges was greater in resistant and lower in the susceptible one. Larval density infested fruit^{-1} also showed

Table 1: Impact of morphological features of bitter gourd fruits on melon fly infestation

Cultivars	Larval density fruit^{-1}	Percent fruit infestation	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Ribs density cm^{-2}	Depth of ribs (mm)	Skin toughness (kg cm^{-2})
Green long	20.65(25.12)	39.87(37.89)	58.50^{bc}	10.27^{bc}	4.27^{cd}	8.23^{cd}	5.81^{abc}	6.55^{cd}
Vivek F1	25.81(28.46)	44.10(40.93)	95.53^{a}	15.23^{a}	5.10^{a}	7.13^{d}	4.48^{d}	6.17^{d}
Sasya F1	23.85(27.89)	44.76(41.52)	100.87^{a}	13.97^{a}	4.80^{ab}	8.67b^{cd}	5.17^{bcd}	6.30^{d}
Pusa Do Mausumi	21.05(25.46)	40.51(38.62)	54.40^{bc}	8.13^{c}	4.73^{ab}	7.17^{d}	4.92^{bcd}	6.73^{bcd}
Arka harit	18.79(24.47)	29.62(31.31)	57.07^{bc}	10.67^{b}	3.84^{de}	6.47^{d}	6.12^{ab}	7.06^{abcd}
Bolder	19.38(24.79)	25.02(28.42)	62.67^{b}	9.23^{bc}	4.70^{ab}	10.53^{abc}	7.07^{ab}	8.47^{a}
Rakkhuse	17.29(23.31)	25.90(29.38)	63.63^{b}	11.33^{b}	4.51^{abcd}	10.60^{abc}	6.03^{ab}	8.20^{abc}
Peyarafuli local	16.35(22.56)	23.73(27.86)	49.87^{bcd}	9.33^{bc}	4.27^{cd}	10.77^{ab}	5.34^{bc}	8.40^{a}
Pundibari local	13.71(20.34)	18.90(24.51)	25.20^{e}	4.93^{d}	3.20e	12.97^{a}	4.73^{cd}	8.27^{ab}
Kalimpong local	17.56(22.95)	22.18(26.80)	51.60^{bcd}	7.90^{c}	4.17^{cd}	10.8^{ab}	4.87^{bcd}	6.73^{bcd}
SEm±	1.698 2.369	2.2639	4.8156	1.1417	0.3513	1.1972	0.6004	0.7867
CD (p=0.05)	9.325	4.5831	10.1171	2.3986	0.7380	2.5153	1.2615	1.6528

*Figures in the parenthesis are arc-sine (angular) transformed values **Values following same letters are not statistically different

Table 2: Individual regression equations of morphological traits associated with percent fruit infestation

Morphological traits	Correlation coefficient (r)	Regression equations	R^2 value
Fruit weight	0.76758	Y=1.7161x+7.9473	0.5892
Fruit length	0.71687	Y=0.2175x+3.2569	0.5139
Fruit diameter	0.67837	Y=0.0377x+3.1727	0.4602
Ribs density	-0.78132	Y=-0.167x+14.60	0.6105
Ribs depth	-0.24669	Y=-0.02x+6.083	0.0609
Skin toughness	-0.80453	Y=-0.0766x+9.6978	0.6473

Table 3: Individual regression equations of morphological traits associated with larval density fruit-1 (infested)

Morphological traits	Correlation coefficient (r)	Regression equations	R2 value
Fruit weight	0.75123	Y=4.997x+34.456	0.5643
Fruit length	0.71927	Y=0.6493x+2.425	0.5173
Fruit diameter	0.59931	Y=0.0991x+2.447	0.3592
Ribs density	-0.72938	Y=-0.4649x+18.302	0.532
Ribs depth	-0.17760	Y=-0.0428x+6.2801	0.0351
Skin toughness	-0.83711	Y=-0.2371x+11.862	0.7008

negative correlation with ribs density (r=-0.73) and ribs depth (r=-0.18). It can be inferred that more number of deep ribs unit area^{-1} fruit surface^{-1}; less preferred the cultivar for infestation by the fly and vice-versa.

3.1.4. Skin toughness of fruits

Significant variation in skin toughness of fruits of different cultivars was also recorded. Tougher skin of fruits were observed in cultivars 'Bolder' and 'Peyarafuli local' (8.47 and 8.40 kg cm^{-2}, respectively), whereas the fruits of Vivek F_1 and Sasya F_1 were comparatively softer (6.17 and 6.30 kg cm^{-2}, respectively). Fruit toughness was associated negatively and significantly both with percent fruit infestation (r=-0.80) and larval density fruit^{-1} (r=-0.83), i.e. tougher the fruit less was the infestation and larval density.

The interaction between plant and herbivore is influenced by several morphological traits that interfere with feeding and oviposition by the insects (De Ponti, 1977). Identification of physico-chemical factors involved in host plant selection by insects is an important step in selecting resistant genotype (Maxwell and Jennings, 1980). Chelliah and Sambandam (1971) observed that egg laying by the melon fly was 17.77% in fruits having tough rind in *Cucumis callosus* when compared with 87.33% of the fruits of susceptible variety. Thick and tough rind fruits of genotypes resistant to melon fly were earlier reported by Pal et al. (1984). Percentage fruit infestation increases with an increase in fruit length and diameter as reported by Jaiswal et al. (1990) and Tewatia et al. (1997). In the present investigation, positive association of percent fruit infestation and larval density fruit^{-1} was derived with fruit weight, length and diameter. On the contrary, negative correlation were observed with ribs density, ribs depth and skin toughness of fruits. Thus the results are in corroboration with the findings of earlier studies conducted by several workers. Multiple regression equation of larval density fruit^{-1} and morphological traits of fruit was determined as follows:

$Y=2.30+0.17x_1+0.31x_2+0.09x_3-0.41x_4-0.22x_5-0.74x_6$ (R^2=71.25%)

Where, Y=Larval density infested fruit^{-1}
x_1=Fruit weight, x_2=Fruit length
x_3=Fruit diameter, x_4=Ribs density
x_5=Ribs depth and x_6=Skin toughness

It also appeared from the analysis that 71.25% variation in fruit infestation was influenced by the morphological traits of fruits.

Multiple linear regression analysis indicated that the morphological traits explained 79.8% of the total variation in percentage of fruit infestation by the pest. The multiple regression equation was determined as under:

$Y=-2.90+8.21x_1+0.76x_2+5.57x_3-1.57x_4-0.36x_5-11.25x_6$ (R^2=79.8%)

Where, Y=Percent fruit infested by melon fly
x_1=Fruit weight, x_2=Fruit length
x_3=Fruit diameter, x_4=Ribs density
x_5=Ribs depth and x_6=Skin toughness

4. Conclusion

Infestation of bitter gourd by melon fly has been found to influence much by the morphological traits of fruit. The cultivars having higher ribs density, ribs depth and tough skin of fruits to be selected so as to lessen melon fly infestation. The traits can also be utilized for developing melon fly resistant cultivars in future.

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