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Assessment of Yield Losses and Impact of Morphological Markers of Various Mango (*Mangiferae indica*) Genotypes on Mango Mealybug (*Drosicha mangiferae* Green) (Homoptera: Margarodidae)

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Abstract.- A field experiment was conducted during 2006-2007 in a private orchard, in Multan, to assess the fruit loss in different genotypes of mango (*Mangiferae indica***)** due to mango mealybug **(***Drosicha mangiferae* Green**)** infestation and to determine relation of mango varieties morphological characters to abundance, preference and non preference of mango mealybugs. Results revealed that pest population was highest in varieties which were regular bearer, possessed light green leaf color, larger leaf size, round to medium beak, medium lenticels, light pink inflorescence, high exopericarp thickness and oblong fruit shape while population was minimum in varieties which possessed medium erect branches, alternate fruits bearer, light green leaf color, smaller leaf size, weak to absent fruit beak, medium lenticels, green inflorescence high exopericarp thickness and ovate fruit shape. Flesh color and mid rib vein curvature seemed to have no significant role with pest abundance. Pest observations for loss assessment revealed that the fruits obtained in pests managed genotypes were statistically more than untreated *i.e.* 10.82 percent in cultivar Anwar Retual followed by 10.81, 10.23, 9.53, 9.41, 9.21, 8.42 and 7.75 percent on Retaul-12, Chaunsa, Black Chaunsa, Sindhri, Tukhmi, Dusehri and Fajri, respectively. Maximum population of mango mealybug was recorded on Chaunsa *i.e.* 17.52 individuals/ inflorescence and minimum on Anwar Retaul *i.e.* 9.67 /inflorescence.

Keywords: IPM, mango genotypes, *Drosicha mangiferae*, population; fruit loss.

INTRODUCTION

Mangiferae indica is known as king of fruits**.** It is attacked by a number of insect pests among which mealybugs are the important pest of mango. Mango mealybug has about 20 species of which *Drosicha mangiferae* (G.), *Drosicha stebbingi* (G.) and *Rastrococcus iceryoides* (G.) are considered to be key destructive mealybugs species of mangoes in subcontinent South East Asia. *D. mangiferae* is the serious, dilapidating, polyphagus, dimorphic and notorious pest of mango orchards in Pakistan (Karar *et al.*, 2006). The nymphs and females of this bug suck sap from inflorescence, tender leaves, shoots and fruit peduncles. Affected panicles shrivel and become died. Infested plants are affected by the sooty mould (Tandon and Lal, 1978). Due to the growth of sooty mould on the leaves, photosynthetic activity is affected (Pruthi and Batra, 1960). Sooty mould fungus growth on the honeydew (Smith *et al.*, 1997) renders the fruit unmarketable, reduce the photosynthetic efficiency of leaves and causes leaf drop (CAB International, 2005). Severe infestation affects the fruit set and causes fruit drop. It cause immense damage and deprive the trees from its nutrients, ultimately quality and quantity of the fruit is severely reduced (Herren, 1981). Mango mealybug became a serious pest of mango and citrus in West Africa which reduced mango fruit 50-90% and pest caused social and cultural problems (Moore, 2004).

In Indo Pakistan the pest is reported to cause loss from 1907 (Green, 1908). Since that time farmers in Indo Pak had used various practices to combat with pest population including cultural, mechanical and chemicals, however after introduction and invasion of the pest in any orchard it is very difficult to eradicate the pest numbers. *D. mangiferae* made the growers decrepitude through

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setting of no fruits at all (Sen, 1955). Farmers in Pakistan due to persistence of pest have uprooted their orchards to cascade pest invasion (Karar *et al.*, 2006).

Estimation of yield losses in all genotypes of mango is a major dilemma in economic production of high quality and quantity mangoes over the entire region. It is estimated that about 50% losses occur in mango crop due to mango mealybugs. Keeping in view the severity of the problem and facts mentioned above, the present study was conducted to broaden mealybug preferred and non preferred scion genotypes spectrum from indigenous germplasm at Punjab which is at verge due to domestication and assessment of fruit loss in different genotypes of mangoes on the basis initial fruit set to final fruits obtained per inflorescence both from integrated pest managed and non-integrated pest managed plants separately.

MATERIALS AND METHODS

The experiment was conducted to determine morphological markers affecting mango mealybug resistance in scion genotypes and to evaluate ultimate losses of mango fruits caused by mango mealybug in different genotypes of mango due to pest invasion. For this purpose eleven locally grafted mango genotypes *i.e.* Chaunsa, Fajri, Langra, Black Chaunsa, Sufaid Chaunsa, Sindhri, Malda, Anwar Retaul, Dusehri, Retaul-12, Sensation and one seed born cultivar Tukhmi were selected in an garden during 2006-07 in district Multan, Pakistan. Three full grown orchards of age 15-18 years were selected. The distance between orchards was about two km.

For estimating fruit losses in different genotypes six plants of each genotype were selected from each garden (3 plants each from IPM and non-IPM orchards i.e. neighbor farmers). On IPM the pest population were kept at zero level by development of mounds, pasting grease band on plastic sheet and spraying insecticides below the band through adopting measures as described below) Mounds of 1.5 feet high were developed around the trunk of trees on April 5, 2006 and were spread on soil on June 28, 2006 for the destruction of eggs 2) Plastic sheet of 9 inch in width was wrapped around the trunk of trees. After installing the band 1 inch layer of grease was pasted in the middle of plastic sheet on December 10, 2006. The practices were done to stop crawling of first instar nymphs upwards on the tree 3) Profenophos @ 30 ml/100 liter water was applied on February 3, 2007. It was sprayed to kill the congregated nymphs below the band.

Data collection and statistical analysis

Morphological parameters *viz.*, tree, leaf, fruit and inflorescence morphological characters *i.e.* growth habit, length, fruit bearing habit, leaf color, leaf shape, veins mid rib curvature, length, width, petiole, new leaves color, inflorescence type, inflorescence color, fruit size, fruit color, fruit shape, thickness of exo-pericarp, beak and flesh color were determined through examining 15 plants randomly selected from each orchard.

Pest observations were recorded from uniform sized twenty inflorescence at East, West and South (having maximum population of mango mealybug) for each cultivar at a height of 4 to 6 feet above ground level. Selected inflorescence were randomly, tagged and the number of fruits developed were counted during 1st week of April, 2007. The data regarding population of mealybugs and number of fruits per tagged and inflorescence were recorded.

The data regarding the number of fruits obtained in treated and untreated trees were counted at maturity. The percent loss in fruits for each cultivar was calculated under the following formula (Tiongson, 2011).

$$\text{Loss in Fruit (\%)} = \frac{\text{No. of fruits in treated trees (IPM)} - \text{Number of fruits in untreated trees (Non-IPM)}}{\text{Number of fruits in treated trees (IPM)}} \times 100$$

The data on initial developed fruits and final obtained fruits were analyzed through MSTAT-C using ANOVA II (Anonymous, 1989). Means were separated by DMRT (Duncan Multiple Range test method) at 5% level of significance.

RESULTS

Morpholocal characters of mango trees, leaves, inflorescence and fruits

Mango varieties were screened for their morphological characters and their relation to pest abundance. Varieties Anwar Retaul, Sufaid chaunsa, Sindhri, Dusehri and Tukhmi had minimum pest population they possessed semi erect to medium branching of tree, alternate Fruit bearing habbit, medium green leaf color, smaller leaf size, high thickness of exopericarp, medium lax density of lenticels, light pink to peach red color of inflorescence while varieties Chaunsa, Kala Chaunsa, Malda, Retual 12, Fajri, Langra and Sensation were with dense population of mango mealybug and possessed heavy branches, regular bearer, light green leaf color, larger leaf size, round to medium beak, medium lenticels, light pink inflorescence, low exo-pericarp thickness and oblong fruit shape (Tables II and III).

Population of mango mealybug recorded per inflorescence in treated and untreated trees

Significant variation was observed among population of *D. mangiferae* per inflorescence on different genotypes of mango (F= 22.25; df = 11, 22; p=0.05 Table I) recorded from untreated and treated trees (Table II). The higher population of *D. mangiferae* was recorded to be 18, 18, 16, 16, 15, 15 and 15 per inflorescence on 'Chaunsa', 'Black Chaunsa', 'Fajri', 'Malda', 'Retaul-12', 'Langra', and 'Sensation', respectively. The statistically similar population of mango mealybug was recorded on 'Sindhri' and 'Tukhmi' at 12 and 12 per inflorescence followed by 'Dusehri' (11) and 'Sufaid Chaunsa' (11) whereas, minimum population was recorded on 'Anwar Retaul' with population of 10/ inflorescence. (Table I, Fig. 1)

Initial mango fruits

Significant variation was observed regarding number of fruits per inflorescence in different genotypes of mango (F=24.32 df=2,22 p= 0.05 Table I) in untreated and Treated plants (Table II). The results revealed significant difference among genotypes and between treated and non treated trees. In general untreated trees of all the genotypes showed less mango fruits as compared to IPM trees of the same genotypes. The maximum loss of

Table I.- Average population of mango mealybug recorded per inflorescence, fruit present at initial stage and fruits obtained at final stage in non IPM trees.

Genotypes	Av. population / Inflorescence (**)	Condition of fruits	
		Fruit loss at initial Stage (**)	Fruits loss at final stage (**)
Chaunsa	17.52 a	10.23 ab	80.58 a
Fajri	15.65 b	7.75 abcd	69.18 b
Langra	15.08 b	3.47 d	71.59 bc
Black chaunsa	17.52 a	9.53 ab	22.71 hi
Sufaid chaunsa	10.72 cd	4.61 cd	52.0 d
Sindri	11.75 c	9.41 abc	24.43 gh
Malda	15.63 b	5.82 bcd	45.85 e
Dusehri	11.10 cd	8.42 abc	28.80 g
Anwar ratul	9.67 d	10.82 a	18.43 i
Ratul-12	15.18 b	10.81 ab	64.07 c
Tukhmi	11.65 c	9.21 d	21.52 hi
Sensation	14.78 b	3.49 d	34.71 f
LSD @5%	1.6933	36.51	2.52
F-Value	22.25	2.81	157.45
P-Value	0.05	0.018	0.000

Table II.- Average population of mango mealybug recorded per inflorescence, fruit present at initial stage and fruits obtained at final stage in IPM trees.

Genotypes	Av. population/ Inflorescence (**)	Condition of fruits	
		Fruit loss at initial Stage (**)	Fruits loss at final stage (**)
Chaunsa	0.03d	1.20 bc	19.00 ab
Fajri	1.33 bc	1.80 a	10.10 bcdef
Langra	1.46 abc	0.80 cde	17.53 abc
Black chaunsa	1.81 ab	1.80 a	2.90 f
Sufaid chaunsa	1.90 a	0.99 cd	22.00 a
Sindri	1.83 ab	1.73 ab	2.06 f
Malda	1.41abc	0.50 de	11.00 bcdef
Dusehri	0.45 d	1.20 bc	7.00 ef
Anwar Ratul	0.22d	0.79 cde	4.00 ef
Ratul-12	1.00 c	1.20 bc	13.00 abcde
Tukhmi	0.37 d	0.48 de	9.00 cdef
Sensation	1.23 c	0.32 e	13.33 abcd
LSD @5%	0.5142	0.54	9.29
F-Value	14.38	7.82	4.09
P-Value	0.000	0.000	0.0024

Means sharing similar letters are not significantly different by LSD Test at 0.05% level of significance.

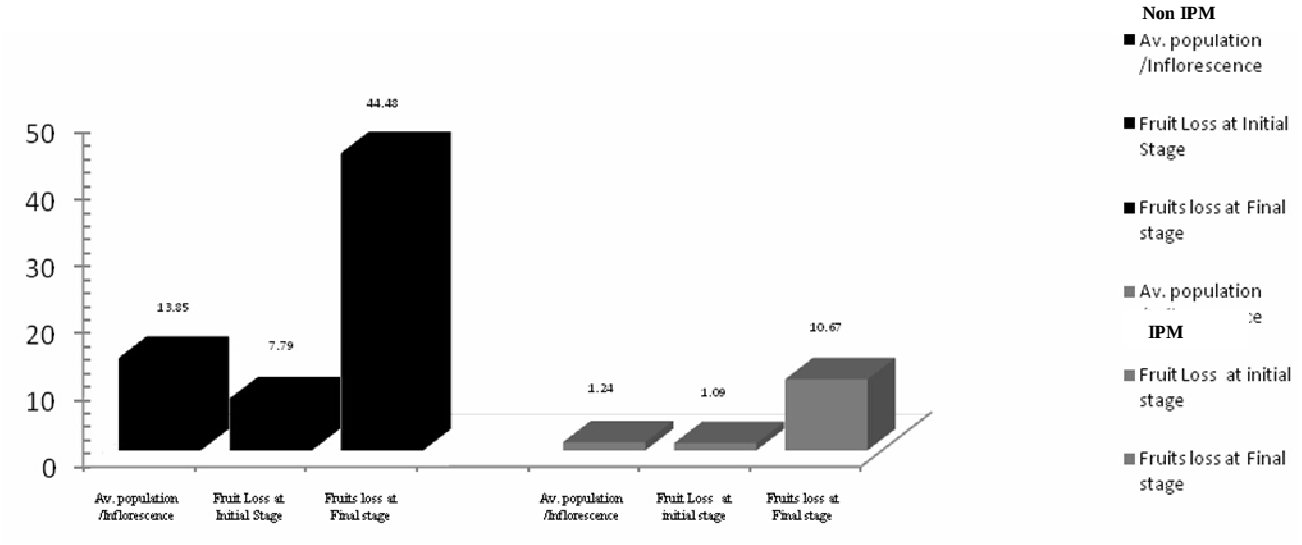

Fig. 1. Comparison of IPM vs non IPM trees regarding population, initial and final fruit loss.

10.82% mango fruit was recorded on Anwar Retaul followed by 10.81, 10.23, 9.53, 9.21, 8.42 and 7.75% on Retaul-12, Chaunsa, Black Chaunsa, Tukhmi, Dusheri and Fajri, respectively. The minimum fruit number of fruits was obtained in cultivar Langra (3.47%) and Sensation (3.49%), respectively.

On overall basis it was observed that treated trees showed 5.34 % increase in fruits over untreated trees.

Mango fruits obtained at maturity

The data regarding number of fruits obtained at maturity in untreated and treated trees of different genotypes revealed significant variation among genotypes (F=135.12 df=2, 22 p= 0.05 Table I), both treated and untreated trees (Table II). The fruits obtained in untreated trees of all the genotypes showed significantly lower number of fruits as compared to treated trees of all the genotypes of mango. On overall basis the decrease in fruit in untreated trees was 41.34% as compared to treated trees (Table I, Fig. 1).

On individual basis the maximum fruit decrease was found to be 80.58 percent on Chaunsa cultivar followed by Langra, Fajri, Retaul-12, Sufaid Chaunsa, Malda and Sensation with 71.59, 69.18, 64.07, 52.00, 45.85 and 34.71 percent fruit decrease, respectively (Table I). The decrease in fruit in untreated trees over treated trees was 18.43, 21.52, 22.71, 24.43 and 28.80 on Anwar Retaul, Tukhmi, Black Chaunsa, Sindhri and Dusheri, respectively (Table II). Among twelve genotypes tested for losses of mango fruits caused by *D. mangiferae* under field condition during 2006-2007 at Multan. No significant differences were found to exist among genotypes regarding number of fruits per inflorescence at initial stage of the experiment. The maximum loss in fruit was observed to be 11 percent in cultivar 'Anwar Retaul' at initial stage of the experiment followed by 11, 10, 10, 9, 9, 8 and 8 percent fruit losses on 'Retaul-12', 'Chaunsa', 'Black Chaunsa', 'Sindhri', 'Tukhmi', 'Dusehri' and 'Fajri', respectively. The genotypes 'Malda', 'Sufaid Chaunsa', 'Sensation' and 'Langra' showed 6, 5, 5 and 3 percent fruit losses, respectively at initial stage of the experiment. At final stage of the experiment 'Chaunsa' cultivar suffered the maximum fruit loss showing 81 percent fruit losses followed by 72, 69, 64, 52, 46, 35, 29, 24, 23, 22 and 18 percent fruit losses on 'Langra', 'Fajri', 'Retaul-12', 'Sufaid Chaunsa', 'Malda', 'Sensation', 'Dusehri', 'Sindhri', 'Black Chaunsa', 'Tukhmi' and 'Anwar Retaul', respectively. It was observed

Table III.- Morphological characters of tree and leaf of various mango genotypes.

Varieties characteristics	Tree Characters		Characters of foliage						
	Growth habit & branching pattern	Fruit bearing habit	Leaf color	Leaf shape	Veins mid rib curvature	Length (cm)	Width (cm)	Petiole (cm)	New leaves color
Chaunsa	Vigorous semi spreading	Regular bearer	Light green	Elliptical	Medium	27-30	8-10	1.50-2.0	Light pink
Fajri	Moderately vigorous, spreading	Alternate bearing absent	Light green	Elliptical	Medium	18-20	4-6	3-4	Light yellowish green
Langra	Moderately vigorous, spreading round	Alternate bearing tendency high	Light green	Elliptical	Medium	18-20	5-7	3-4	Light pink
Black Chaunsa	vigorous, medium branched, spreading	Alternate bearing tendency high	medium green	leaf elliptical	Medium	18-22	4-7	3-4	Light pink
Sufaid Chaunsa	Medium branched spreading is medium	Alternate bearing tendency is high	dark green	leaf elliptical	Medium	27-30	7-10	3-4	Light pink
Sindri	Large growing, medium branched	Tendency for alternate bearing is low	Green	Leaf elliptical	Medium	16-20`	4-7	3-4	Medium pink
Malda	Moderately vigorous, semi spreading to spreading	Regular bearer	Medium green	Elliptical	Medium	16-18	3-5	4-5	Light pink
Dusehri	Moderately vigorous, spreading	Regular bearer	Medium green	Elliptical	Medium	18-22	4-7	3-4	Light yellowish green
Anwar Ratul	Vigorous, medium branched	alternate bearing high	Medium dense, medium green	elliptical	Weak	20-30	4-7	3-6	Light pink to mid rib dark pink
Ratul-12	Vigorous, semi erect to spreading	Alternate bearing tendency is low	Dark green	Elliptical	Weak	22-27	5-7	3-5	Light pink
Tukhmi	Vigorous semi spreading	Alternate bearing is high	Dark green	Elliptical	Medium	20-21	7-8	2.6	Purple green
Sensation	Moderately vigorous, spreading round	Regular bearer	Medium green	Elliptical	Strong	25-30	5-8	5-6	Light pink

Table IV.- Morphological lineaments of Inflorescence and mature fruit of various mango genotypes.

Mango varieties	Inflorescence			Mature fruit									
	Type	Color	Growth habit	Color	Size	Shape	Lenticels	Beak	Fruit length (cm)	Fruit breadth (cm)	Skin thickness (µm)	Weight	Flesh color
Chaunsa	Medium, compact	Light greenish	Well branched	Light greenish yellow	Medium to large	Ovate to obliquely oblong	Density medium	Rounded	10-12	6-8	6-7	300-400	Whitish
Fajri	Medium, compact	Light pink	Medium branched	Light green	Large	Oblong to obliquely oval	Medium dense	Medium	12-15	7-10	7-9	350-700	Pale yellow
Langra	Medium compact	Light pink	Well branched	Light green	Medium	Ovate	Medium	Absent	9-11	6-8	6-7	250-350	Lemon yellow
Black Chaunsa	Medium compact	Greenish white	Medium long	Dark green	Medium	ovate to oval oblong	Medium	Weak	12-15	5-8	7-9	250-350	lemon yellow
Sufaid Chaunsa	Long	Light greenish white	Medium branched	Light greenish	Medium	Ovate to oval	Medium	Short	10-14	5-8	5-7	400-550	Whitish
Sindri	Medium long	Light green	Well branched	Light green	Large	Ovalish oblong	Medium dense	Absent	15-17	7-9	7-8	330-450	Pale yellow
Malda	Medium long, compact	Light pink	Medium branched	Medium green	Medium	Broad oblongish	Medium	Short	9-11	6-8	6-7	250-350	Light yellowish
Dusehri	Medium long, medium compact	Light greenish	Medium branched	Light green	Small to medium	Oblong to oblong oblique	Medium	Absent	8-10	6-8	4-7	150-200	Lemon yellow
Anwar Ratul	Short to medium, compact	Light pink	Well branched	Light green	Medium	Ovate	Medium lax	Absent	8-10	6-8	6-7	150-350	Reddish yellow
Ratul-12	Vigorous, semi erect to spreading	Light green	Well branched	Dark green	Small	Ovate	Medium lax	Weak to absent	6-8	6-7	6-7	150-350	Light pink
Tukhmi	Compact, Medium	Light yellowish Green	Well branched	Light yellowish green	Medium	Ovate	Medium lax	Absent	8-9	4-5	6-7	150-200	Yellow
Sensation	Medium long, medium compact	Peach red	Medium branched	Purple red	Medium	Oval oblique	Dense	Short	9-11	5-8	5-8	250-350	Light pink

that at later season, control is more critical to reduce the fruit loss. It is also important to note that control measures provide a bigger benefit in genotypes that are highly susceptible to the mango mealybug. These results indicate that host plant resistance is a most important to develop.

DISCUSSION

In the present work regarding morphological characters of mango genotypes and their relation to pest abundance, ultimate loss to plant in the form of deterioration of quality and quantity of fruits revealed that population of pest was highest in Chaunsa cultivar and lowest in Anwar Retaul may be due to semi erect branching system in Anwar Retaul which allows less inhabitation of mango mealybug.

Insects are more attractive to dense canopy structure in mango orchards. Chaunsa, Kala Chaunsa, Malda, Langra, Fajri, Retaul 12 and sensation were medium to heavily branched with round spreading structure while Anwar Retaul, Dusehri, Sufaid Chaunsa were less heavily branched while Anwar Retaul had semi erect branching which provides optimum sunshine, less shade, more aeration, which ultimately provide less favorable habitat for mealybug to invade. Najib (2011) also reported that mealybug were infrequent in cassava variety "Mandioca" which possess erect branching system and this characters must be transmitted to other cassava commercial varieties to get rid of Cassava mealybug populations. Kerns *et al.* (2011) also claimed that less dense canopy allows pesticides to particulate hence mealybugs population is reduced.

Regular bearing and alternate bearing ability is ability of fruit bearing deciduous plants to bear fruits. Some fruit plants are naturally alternate fruit bearer such phenomenon can be controlled by application of *paclobutrazol* in soil by drenching method. Most of tree orchards are regular bearer, however a few cultivars in mango are alternate fruit bearer for example Anwar Retaul, Langra, Black Chaunsa and Sufaid Chaunsa are alternate Fruit bearer while varities such as sensation, Chaunsa, Sindhri, Malda and Retaul 12 are regular bearer. Alternate bearing allows much time to growers to reduce the pest occurrence. Also farmers in alternate bearing apply *Paclobutrazol* which is applied through drenching which ultimately kill mango mealybug female eggs near soil through cultural operations and hence more attention to tillage ultimately reduce next batch to invade in the pest. Regular bearer varieties do not require more tillage operations hence mango mealybugs grow rapidly hence population is unchecked grows at enormous rate.

Leaf color plays a very important role in attraction and prevalence of pest population. Mealybugs were abundant in Chaunsa, Kala Chaunsa, Langra, Fajri, Malda, Retaul 12 and Sensation while mealybugs were less in Tukhumi, Dusehri, Sindhri, Sufaid Chaunsa and Anwar Retaul. Many authors across the world reported that mealybugs are more attractive to dark green color varieties and are less attractive to light green to peach red colored leaf varieties (Karageorgou, 2007). Chaunsa, Kala Chaunsa, Langra, Fajri, Malda, Retaul-12 and Sensation had light green color while varieties Tukhumi, Dusehri, Sindhri, Sufaid Chaunsa and Anwar Retaul had medium green leaf color to dark green leaf color so the present results showed that mealybugs were numerous on light green colored varieties and were less abundant in dark green. Results of present studies were in contradiction to Najib (2011) described that cassava Mandioca is grey colored variety and has resistance to mealybugs.

Leaves display an enormous array of sizes and shapes. Although these attributes appear to have evolved primarily in response to abiotic conditions in the plant's habitat, the importance of insect herbivores as additional selective agents is still poorly understood (Rivero-Lynch *et al.*, 1996). A necessary requirement for leaf size and shape to evolve in response to attack by insects is that insects must respond to leaf morphology. Leaf size extremely affects invasion of sucking insects on host crops. In many crops narrow shaped leaves *viz.*, in cotton okra and super okra are used as morphological markers for reducing tolerance or resistance of cultivars to pests. When the situation was analyzed in mango crop, varieties Fajri, Sindhri, Malda, Dusehri and Anwar Retaul were narrow shaped with reduced leaf width which ultimately

resulted in low mealybug abundance in these crops than other genotypes. Nawab (2010) reported that in okra shaped leaves (leaves with reduced width) provide less favorable site for insects to reside for which crops.

Mealybugs after reaching the tree in month of February pass through various moults and reaches to second instar at this time they are abundant in twigs and suck the cell sap then they shift to new inflorescence. Present studies significantly revealed that mango mealybugs were abundant in varieties with medium compact, light green inflorescence while were scarce in inflorescence with short compact, peach red to light pink colored, medium branched inflorescence.

Again after destruction of inflorescence, the mealybugs move to mature fruits which are formed. Present studies revealed that mature fruit serves as morphological marker for deterrence or attraction of pest population. Varieties *viz.*, Black Chaunsa, which harbored maximum population of D. *magniferae* had dark green mature fruit as compared to varieties which harbored less D. *magniferae* population and had light green color. However, present studies also conclude that qualitative and enzymatic activities of these clones genotypes must be carried out to find out the exact enzymes involved. Use of morphological traits is not always the best way to evaluate genetic distance, since the degree of divergence between genotypes at the phenotypic level is not necessarily correlated with a similar degree of genetic difference

D. *magniferae* population was higher in varieties with oblong shape and were scarce in varieties with ovate shape of mature fruits.

Lenticels are airy aggregation of cells within the structural surfaces of stems, roots and other parts of vascular plants. They function as pore providing medium for direct exchange of gases between internal tissues and atmosphere thereby passing the periderm which would other wise prevent exchange of gases. Here in the present studies varieties in which lenticels were medium lax were harboring minimum population of mango mealybug than varieties in which the lenticels were medium. However lenticels role in exaggeration of pest population must be explored. A possible explanation may be that lenticels play a role for exchange of gases so Co_2 density plays direct role in competition for obtaining oxygen for both fruits and mealybugs so that mealybug density is not where lenticels are in medium lax, however further studies must be directed to explore the role between lenticels and mealybugs.

Mid rib curvature seems to play no significant role with pest abundance. All the varieties in thickness of exopericarp play a very vital role in abundance, preference or non preference of mango varieties to D. *magniferae* (G.) The present studies revealed that mango mealybug population was highest in varieties where thickness of pericarp was highest and lowest in varieties which possessed low thickness of exopericarp. Results clearly showed that exo-pericarp thickness showed significant role in abundance and spread of mango mealybug.

Host plants resistance plays a very vital role in desirable trait tree production. Tolerance or moderate resistance can be enhanced by incorporation of these valuable traits in varieties. Few authors have described that biochemical constituents like glycoalkaloid (solasodine), phenols, phenolic oxidase enzymes namely poly phenol oxidase and peroxidase are available in plants and these biochemical constituents possess insect resistance properties (Kalloo, 1988). Work in such regards must be conducted to elaborate in concise biochemical enzymes involved in conferring resistance to such notorious insects.

Comparative loss assessment concludes that maximum loss was observed in varieties Chaunsa, Langra, Fajri and Retaul 12 while moderate level of loss was observed in Malda and Sufaid Chaunsa. Low level of loss in Sindhri, Dusehri, Anwar Retaul and Tukhami. Major fruit loss took place at final stage. Larger fruits were fallen, destroyed and wilted. Smaller sized fruit cultivars bear low to moderate fruit loss. Present studies conclude that varieties with host plant resistance must be prevailed to prevent abundance of mealybugs in mango orchards. From these results it was observed that mango mealybug caused maximum loss up to 80 percent and these findings are inconformity with those of Hiepko (1983), Wodageneh (1985), and Sen (1955). Similarly Moore (2004) reported that mango mealybug reduced mango fruit to 50-90 percent. Karar *et al.* (2007) also reported mango

mealybug caused a loss of 70-100% in mango.

CONCLUSIONS AND RECOMMENDATIONS

Present work concludes that varieties Anwar Retaul, Tukhami, Sindhri, Dusehri, and Sufaid Chaunsa bear moderate level of resistance to mango mealybug abundance. Efforts on biochemical studies regarding molecular factors involved in those varieties must be carried out to enhance production of mangoes in Pakistan and to avoid ultimate loss caused by mealybugs.

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Table III.- Morphological characters of tree and leaf of various mango genotypes.

Varieties characteristics	Tree Characters		Characters of foliage						
	Growth habit & branching pattern	Fruit bearing habit	Leaf color	Leaf shape	Veins mid rib curvature	Length (cm)	Width (cm)	Petiole (cm)	New leaves color
Chaunsa	Vigorous semi spreading	Regular bearer	Light green	Elliptical	Medium	27-30	8-10	1.50-2.0	Light pink
Fajri	Moderately vigorous, spreading	Alternate bearing absent	Light green	Elliptical	Medium	18-20	4-6	3-4	Light yellowish green
Langra	Moderately vigorous, spreading round	Alternate bearing tendency high	Light green	Elliptical	Medium	18-20	5-7	3-4	Light pink
Black Chaunsa	vigorous, medium branched, spreading	Alternate bearing tendency high	medium green	leaf elliptical	Medium	18-22	4-7	3-4	Light pink
Sufaid Chaunsa	Medium branched spreading is medium	Alternate bearing tendency is high	dark green	leaf elliptical	Medium	27-30	7-10	3-4	Light pink
Sindri	Large growing, medium branched	Tendency for alternate bearing is low	Green	Leaf elliptical	Medium	16-20`	4-7	3-4	Medium pink
Malda	Moderately vigorous, semi spreading to spreading	Regular bearer	Medium green	Elliptical	Medium	16-18	3-5	4-5	Light pink
Dusehri	Moderately vigorous, spreading	Regular bearer	Medium green	Elliptical	Medium	18-22	4-7	3-4	Light yellowish green
Anwar Ratul	Vigorous, medium branched	alternate bearing high	Medium dense, medium green	elliptical	Weak	20-30	4-7	3-6	Light pink to mid rib dark pink
Ratul-12	Vigorous, semi erect to spreading	Alternate bearing tendency is low	Dark green	Elliptical	Weak	22-27	5-7	3-5	Light pink
Tukhmi	Vigorous semi spreading	Alternate bearing is high	Dark green	Elliptical	Medium	20-21	7-8	2.6	Purple green
Sensation	Moderately vigorous, spreading round	Regular bearer	Medium green	Elliptical	Strong	25-30	5-8	5-6	Light pink

Table IV.- Morphological lineaments of Inflorescence and mature fruit of various mango genotypes.

Mango varieties	Inflorescence			Mature fruit									
	Type	Color	Growth habit	Color	Size	Shape	Lenticels	Beak	Fruit length (cm)	Fruit breadth (cm)	Skin thickness (µm)	Weight	Flesh color
Chaunsa	Medium, compact	Light greenish	Well branched	Light greenish yellow	Medium to large	Ovate to obliquely oblong	Density medium	Rounded	10-12	6-8	6-7	300-400	Whitish
Fajri	Medium, compact	Light pink	Medium branched	Light green	Large	Oblong to obliquely oval	Medium dense	Medium	12-15	7-10	7-9	350-700	Pale yellow
Langra	Medium compact	Light pink	Well branched	Light green	Medium	Ovate	Medium	Absent	9-11	6-8	6-7	250-350	Lemon yellow
Black Chaunsa	Medium compact	Greenish white	Medium long	Dark green	Medium	ovate to oval oblong	Medium	Weak	12-15	5-8	7-9	250-350	lemon yellow
Sufaid Chaunsa	Long	Light greenish white	Medium branched	Light greenish	Medium	Ovate to oval	Medium	Short	10-14	5-8	5-7	400-550	Whitish
Sindri	Medium long	Light green	Well branched	Light green	Large	Ovalish oblong	Medium dense	Absent	15-17	7-9	7-8	330-450	Pale yellow
Malda	Medium long, compact	Light pink	Medium branched	Medium green	Medium	Broad oblongish	Medium	Short	9-11	6-8	6-7	250-350	Light yellowish
Dusehri	Medium long, medium compact	Light greenish	Medium branched	Light green	Small to medium	Oblong to oblong oblique	Medium	Absent	8-10	6-8	4-7	150-200	Lemon yellow
Anwar Ratul	Short to medium, compact	Light pink	Well branched	Light green	Medium	Ovate	Medium lax	Absent	8-10	6-8	6-7	150-350	Reddish yellow
Ratul-12	Vigorous, semi erect to spreading	Light green	Well branched	Dark green	Small	Ovate	Medium lax	Weak to absent	6-8	6-7	6-7	150-350	Light pink
Tukhmi	Compact, Medium	Light yellowish Green	Well branched	Light yellowish green	Medium	Ovate	Medium lax	Absent	8-9	4-5	6-7	150-200	Yellow
Sensation	Medium long, medium compact	Peach red	Medium branched	Purple red	Medium	Oval oblique	Dense	Short	9-11	5-8	5-8	250-350	Light pink