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# Role of Different Physico-Chemical Characters of Okra as a Host Plant for Preference of *Earias* spp.

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**Abstract.-** Spotted bollworms are very important pests of okra and host plant resistance is one of the most important components of IPM for minimizing the losses caused by these insects. In the current studies, a diverse genetic pool of okra genotypes was evaluated to identify physico-morphic and chemical plant factors conferring resistance against *Earias* spp. Susceptibility of okra to this pest was associated with more dense hairs on leaf midrib and high amount of crude protein, reducing and non reducing sugars. While ten fruit weight and fruit yield per plant were negatively correlated with pest infestation. Mineral contents like Ca, Mn and Zn showed negative correlation but their contribution towards fruit infestation was very nominal. Multiple linear regression models indicated that biochemical factors explained more (99.0 %) variation in fruit infestation than the physico-morphic factors (91.0%). Present studies reflect that genotypes Diksha, Sapz pari and Super star can be used as a source of resistance in okra and hair density on midrib, high amount of crude protein, reducing and non-reducing sugars can be used as marker traits to select for resistance against *Earias* spp.

**Keywords.** Okra, *Earias***,** physico chemical characters, host plant resistance, spotted bollworms.

## INTRODUCTION

Okra, *Abelmoschus esculentus* (L.) is an important vegetable crop of the tropical and subtropical region. Because of high consumer's demand and better price, it is widely grown by the farmers throughout Pakistan. Okra plants are attacked by a number of insect pests during their different growth stages, which are major constraints in getting higher yields (Kumar *et al*., 2002; Gulati, 2004). The spotted bollworms are the most dreaded pests causing serious turn down of the produce in terms of quality as well as quantity (Suman *et al.*, 1984). *Earias* spp. is distinguished from other pests of okra by its marked tendency for stem boring. The larvae enter the terminal bud of the vegetable shoot and channel down from the growing point. Severe attack, results in wilting of top leaves and collapsing of main stem (Atwal and Dhaliwal, 2005). The larvae also bore into the flower buds, flowers and fruits of the crop. Serious decline in production of okra due to fruit and shoot borer has been reported; 8.4 to 73.2% variations in fruit infestation (Kumar and Urs, 1988), 32.06 to 40.84% loss in yield (Singh and Brar, 1994) and 20 to 51% reduction in yield (Krishnikumar and Srinivasan, 1987).

Exclusive reliance on insecticides as a control strategy against this pest has resulted in several undesirable effects like pesticide pollution, resurgence of secondary pests, insecticide resistance, elimination of beneficial fauna and different human health problems. Varietal resistance is considered to be a cornerstone for ecological approach to pest control in IPM. Plant characteristics have been recognized important resistance factors by both plant breeders and entomologists. Each plant species has a distinctive set of defense traits ranging from morphological to phyto-chemical factors that have behavioral and physiological effect for a potential herbivore consumer (Slansky, 1990). The first plant organs contacted during the preliminary stages of host acceptance are surface hairs or trichomes. Pubescence as a resistance factor interferes with insect oviposition, attachment to the plant, feeding, colonization and ingestion. Conversely, glabrous character of leaves may also result in reduction of population in certain cases (Lukefahr *et al*., 1965) and pubescent accessions may support more eggs than having glabrous leaves (Murugesan, 1982). In

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addition, increased leaf fiber, silica content (Bergvinson *et al*., 1997; Rojanaridpiched *et al*., 1984), surface wax and high hemicellulose (Hedin *et al*., 1993) have been identified as resistance mechanisms in different crops.

Several chemical constituents of plants act as olfactory and gustatory stimuli for insect pests. These chemicals may be nutritive (*i.e*., sugars, amino acids and phospholipids etc.) or non nutritive (Schoonhoven, 1982). The absence of essential nutrients may also act as a barrier for plants to serve as a host for insects (Febvay *et al*., 1988). High concentrations of digestibility reducing substances such as lignin and silica also act as detrimental factors (Ukwungwu and Obebiyi, 1985).

The present study was conducted with the objective to determine the physico-morphic and chemical plant factors in the selected genotypes of okra towards resistance/susceptibility against the pest.

## MATERIALS AND METHODS

The diverse genetic pool of 30 okra genotypes comprising 8 hybrids, 6 breeding lines, 4 local varieties and 12 exotic varieties were evaluated. The experiment was conducted at the research area of Post Graduate Agriculture Research Station, University of Agriculture, Faisalabad, during 2006 and 2007. During 2006, preliminary screening was done based on fruit infestation of *Earias* spp. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The plot size was kept at 8.5×8.5 m, with row-to-row spacing of 0.60 m and plant-to-plant 0.30 m. Based on fruit and shoot infestation observations, 9 entries of okra (3 susceptible, 3 moderately resistant and 3 resistant) were selected for final screening trial against spotted bollworms. The selected genotypes of okra were again sown in the same experimental area during 2007-08. Fruit infestations were recorded by counting damaged and undamaged fruit percents, from randomly selected five plants in each genotype at 7±1 days interval. Shoot infestation was recorded by counting percent damaged and undamaged shoots from randomly selected twenty-five plants in each genotype at 7±1 days interval.

*Characterization of okra genotypes*

*Physico-morphic traits*

Plant height (cm) was measured by selecting ten plants randomly in centimeters from the ground level to the plant canopy with the help of ordinary meter rod in each test entry. The primary branches arising from the basal node were counted from randomly selected ten plants in each test entry. Ten fruit weight (g) was determined by taking three samples of ten fruits from each plot were weighed using an electric balance. Fruit yield per plant (g) was obtained by weighing the total quantity of fruits obtained from five selected plants per plot and converting into per plant basis. Moisture (%) in leaves was determined by taking three samples each of 10g leaves from top portions of different plants from each plot. All the leaves were cleaned with muslin cloth, weighed and kept into drying oven at 100±5˚C for 12 hours. The dry matter of leaves were weighed and kept back into oven at the same temperature for another six hours. After the weight of the dry material became constant, the moisture percentage was calculated. Hair density from leaf midrib, vein and lamina was counted under stereoscopic microscope by taking three top leaves each from randomly selected five plants from each plot.

Thickness of leaf lamina was determined with the help of an ocular micrometer under binocular microscope by taking cross section of three top leaves each from randomly selected five plants per plot. Hair density on fruits was calculated under stereo microscope by taking three fruits from five randomly selected plants of each entry. Leaf area (cm) was measured by laser leaf area measuring meter, Model CI 203 (USA) by taking three leaves from top, bottom and lower portion of randomly selected five plants from each plot. Fruit length and width was determined by taking three full-grown edible fruits from five randomly selected plants of each test entry with meter scale and average was worked out.

*Biochemical characters of fruits*

Healthy, ripped fruits of nine selected genotypes of okra were collected from the field, washed and dried into the oven. These fruits were pulverized which was used for the estimation of crude protein (%), fat contents (%), reducing and non reducing sugar contents (%), The ash (%), cellulose (%), hemicellulose (%), lignin (%), acid detergent fiber (ADF) (%) , neutral detergent fiber (NDF) (%) were determined by the standard AOAC methods (AOAC. 1990). Phosphorus was determined colorimetrically by the vanadomolyhdo-phosphoric acid colour method (Jackson, 1958). Potassium and sodium were determined on Gallen Kamp Flame Photometer (Sparks, 1996). The concentrations of Ca, Mg, Zn, Mn and Cu were analyzed by atomic absorption spectrophotometry (Wright and Stuezynski, 1996).

*Statistical analysis*

Data were subjected to the analysis of variance using MSTATC package. The means were compared by using Duncan's Multiple Range Test (DMRT) at P = 0.05. (Steel *et al.*, 1990). Data of various physio-morphic and biochemical plant factors were also processed for simple correlation and multiple linear regression analysis to determine their impact on the fruit infestation caused by *Earias* spp.

## RESULTS

*Relative susceptibility of okra genotypes to* Earias *spp.*

There were significant differences for fruit infestation percents ($F_{29,\ 418}$ = 77.46, P≤ 0.01) and shoot infestation ($F_{29,\ 418}$ = 33.52, P≤ 0.01) in all okra genotypes tested during 2006. Genotypes Parbani Kranti, Pusa sawani and Ikra-1 had maximum fruit and shoot infestation where as the Super star, Sabz pari and Diksha had minimum fruit and shoot infestation (Table I).

Based on the data of fruit infestation 9 genotypes of okra *viz.*, Parbani kranti, Pusa sawani and Ikra-1 (showing susceptible response with maximum fruit infestation), Ikra anamika, Lakshami-24 and P-1999-31 (having intermediate response) and Super star, Sabz pari and Diksha (showing resistant response with minimum fruit infestation) were selected for final screening trials during 2007.

**Table I.- Comparison of infestation (%) of fruit and shoot of various genotypes of 'okra' (*Abelmoschus esculentus* L.) by *Earias vittella* (Fab.) and *E. insulana* (Boisd.) during 2006.**

| Genotypes | Fruit infestation (%) | Shoot infestation (%) |
|---|---|---|
| Parbani Kranti | 18.93[a] | 26.29[a] |
| Pusa sawani | 17.89[b] | 25.71[a] |
| Ikra-1 | 17.32[bc] | 25.52[a] |
| Clean Spineless | 16.73[cd] | 22.86[bcdef] |
| Ikra-24 | 16.46[de] | 22.86[bcdef] |
| Zeenat | 15.73[ef] | 20.95[ijk] |
| Namdahari | 15.57[fg] | 21.33[ghij] |
| Ikra-2 | 15.10[fgh] | 21.33[ghij] |
| Green Star | 14.95[fghi] | 22.48[cdefg] |
| Dera local | 14.80[ghi] | 23.62[bc] |
| Sanam | 14.32[hi] | 21.14[hijk] |
| Pusa green | 14.19[i] | 24.00[b] |
| PMS-beauty | 13.16[j] | 22.29[defgh] |
| Ikra anamika | 13.10[j] | 22.10[efghi] |
| Lakshami-24 | 12.77[jk] | 22.10[efghi] |
| P-1999-31 | 12.77[jkl] | 20.95[ijk] |
| Cok-1418 | 12.64[jkl] | 23.43[bcd] |
| Okra-3 | 12.42[jklm] | 21.33[ghij] |
| Cok-1396 | 12.38[jklmn] | 21.33[ghij] |
| Ikra-3 | 12.18[klmn] | 21.71[fghi] |
| Karam-5 | 12.13[klmno] | 20.38[jkl] |
| SPA-2001 | 12.00[klmno] | 23.05[bcde] |
| Makhmali | 11.82[lmno] | 24.00[b] |
| Punjab Selection | 11.63[mno] | 24.00[b] |
| PMS-55 | 11.56[nop] | 20.00[kl] |
| Green Wonder | 11.35[op] | 21.52[ghij] |
| Arka anamika | 11.78[p] | 20.38[jkl] |
| Super star | 9.82[q] | 19.62[l] |
| Sabz pari | 8.36[r] | 14.86[m] |
| Diksha | 8.17[r] | 14.67[m] |

Means sharing similar letters are not significantly different by DMRT at P = 0.05.

The analysis of variance showed significant differences of fruit ($F_{8,\ 124}$ = 242.91, P≤ 0.01) and shoot infestation ($F_{8,\ 124}$ = 216.29, P≤ 0.01) of selected genotypes of okra during 2007. Again the genotypes Super star, Sabz pari and Diksha lower fruit and shoot (%) infestation, Lakshami-24, P-1999-31 and Ikra anamika showed intermediate response whereas Parbani Kranti, Pusa Sawani and Ikra-1 showed highest infestation (Table II).

*Physico-morphic characters of okra genotypes*

There was a significant variation in plant height ($F_{8,\ 16}$ = 89.07, P ≤ 0.01), number of primary branches per plant ($F_{8,\ 16}$ = 14.87, P ≤ 0.01), ten

**Table II.- Comparison of infestation (%) of fruit and shoot of selected genotypes of 'okra' (*Abelmoschus esculentus* L.) by *Earias vittella* (Fab.) and *E. insulana* (Boisd.) during 2007.**

| Genotypes | Fruit infestation (%) | Shoot infestation (%) |
|---|---|---|
| Parbani Kranti | $19.73^{a}$ | $35.43^{a}$ a |
| Pusa sawani | $18.45^{b}$ | $33.24^{b}$ |
| Ikra-1 | $18.49^{b}$ | $33.33^{b}$ |
| Ikra anamika | $14.65^{c}$ | $20.57^{d}$ |
| Lakshami-24 | $14.49^{c}$ | $23.62^{c}$ |
| P-1999-31 | $13.69^{d}$ | $20.57^{d}$ |
| Super star | $11.92^{e}$ | $15.24^{e}$ |
| Sabz pari | $11.26^{f}$ | $14.10^{f}$ |
| Diksha | $10.46^{g}$ | $12.74^{ef}$ |

Means sharing similar letters are not significantly different by DMRT at P = 0.05.

fruit weight ($F_{8,16} = 398.91$, $P \leq 0.01$), fruit yield per plant ($F_{8,16} = 27.73$, $P \leq 0.01$), leaf moisture contents ($F_{8,16} = 6.97$, $P \leq 0.01$), hair density on midrib ($F_{8,16} = 59.51$, $P \leq 0.01$), hair length on midrib ($F_{8,16} = 6.80$, $P \leq 0.01$), hair density on vein ($F_{8,16} = 37.99$, $P \leq 0.01$), hair length on vein ($F_{8,16} = 10.36$, $P \leq 0.01$), hair density on lamina ($F_{8,16} = 45.99$, $P \leq 0.01$), hair length on lamina ($F_{8,16} = 3.48$, $P \leq 0.05$), hair density on fruits ($F_{8,16} = 6202.55$, $P \leq 0.01$), hair length on fruits ($F_{8,16} = 7.48$, $P \leq 0.01$), leaf area ($F_{8,16} = 2.72$, $P \leq 0.05$), thickness of leaf lamina ($F_{8,16} = 6.30$, $P \leq 0.01$), fruit length ($F_{8,16} = 10.75$, $P \leq 0.01$) and non significant variation in fruit width ($F_{8,16} = 1.17$, $P \leq 0.31$). Comparison (by LSD Test at P=0.05) of means of different physico-morphic characters of selected genotypes of okra is shown is given in Table III.

The results revealed that hair density on midrib, hair length on vein, hair density on lamina and thickness of leaf lamina showed a positively significant correlation with the fruit infestation by *Earias* pp. on okra with r-values of 0.94, 0.73, 0.86 and 0.48, respectively, whereas ten fruit weight, fruit yield per plant, and fruit length showed a negative correlation with the fruit infestation with r-values of 0.56, 0.64 and 0.71, respectively. Plant height, number of primary branches, leaf moisture, hair length on midrib, hair density on vein, hair length on lamina, hair density on fruits, hair length on fruit, leaf area and fruit weight showed non

**Table III.- Means comparison of different physico-morphic plant characters of selected genotypes of Okra (*Abelmoshus esculentus* L.)**

| | P-1999-31 | Sabz pari | Diksha | Lakshami-24 | Pusa sawani | Ikra-1 | Super Star | Parbani kranti | Ikra anamika | LSD at 5% |
|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) | 113.8d | 125.1b | 132.7a | 113.2d | 118.8c | 107.4ef | 101.0g | 104.6f | 108.4e | 3.24 |
| Primary branches/plant | 1.40a | 1.43a | 1.37ab | 1.07c | 1.47a | 1.43a | 1.23b | 0.93c | 1.23b | 0.15 |
| Ten fruits weight (gm) | 87.53g | 112.1b | 121.8a | 85.67g | 98.47e | 87.25g | 109.0c | 95.58f | 102.6d | 1.88 |
| Fruit yield/plant (gm) | 128.2d | 139.6a | 141.7a | 135.9b | 131.9c | 127.2d | 139.1ab | 129.0cd | 123.3e | 3.68 |
| Leaf moisture contents (%) | 81.03bc | 81.70ab | 80.97bc | 80.37c | 79.17d | 80.30c | 81.37abc | 82.40a | 81.53ab | 1.07 |
| Hair density on midrib (cm) | 69.78c | 48.11d | 43.56de | 74.23bc | 94.23a | 94.23a | 40.90e | 99.11a | 76.44b | 6.25 |
| Hair length on midrib (µm) | 30.78a | 27.44c | 29.44ab | 23.78de | 22.22e | 29.44ab | 28.44bc | 28.44bc | 24.78d | 1.97 |
| Hair density on vein (cm) | 24.97c | 31.78b | 24.45c | 16.89e | 39.55a | 19.55d | 15.55e | 26.45c | 19.78d | 2.56 |
| Hair length on vein (µm) | 24.11cd | 22.56de | 21.44e | 21.44e | 31.22a | 26.56b | 20.89e | 25.56bc | 24.22bcd | 2.425 |
| Hair density on lamina ($cm^2$) | 67.11c | 59.11d | 44.90f | 52.11e | 101.4a | 99.11a | 45.45f | 87.90b | 56.23de | 4.55 |
| Hair length on lamina (µm) | 23.78a | 19.45bc | 19.56bc | 22.45a | 23.78a | 23.23a | 23.11a | 21.78ab | 17.78c | 2.78 |
| Hair density on fruit ($cm^2$) | 477.9a | 366.1f | 349.3g | 397.2d | 457.5b | 307.0i | 328.5h | 372.0e | 400.0c | 2.14 |
| Hair length on fruit (µm) | 16.70de | 18.03abc | 16.66de | 17.55bc | 16.63e | 18.22ab | 17.40cd | 18.36a | 17.96abc | 0.76 |
| Leaf area ($cm^2$) | 30.84abcd | 35.14abc | 40.96ab | 32.09abcd | 25.40cd | 42.68a | 23.04d | 36.11abc | 30.36bcd | 11.85 |
| Thickness of leaf lamina (µm) | 9.17bcd | 9.33bc | 8.67cd | 10.33a | 9.27bcd | 9.72ab | 8.44cd | 10.39a | 8.39d | 0.922 |
| Fruit Length(cm) | 10.97bc | 12.13ab | 12.70a | 9.167d | 8.900d | 10.97bc | 12.00abc | 9.333d | 10.87c | 1.27 |
| Fruit width (cm) | 1.53ab | 1.67ab | 1.70ab | 1.55ab | 1.43b | 1.60ab | 1.75a | 1.77a | 1.70ab | 0.31 |

**Table IV.- Means comparison of different bio-chemical characters of selected genotypes of okra (*Abelmoschus esculentus* L.)**

| | P-1999-31 | Sabz pari | Diksha | Lakshami-24 | Pusa sawani | Ikra-1 | Super Star | Parbani kranti | Ikra anamika | LSD at 5% |
|---|---|---|---|---|---|---|---|---|---|---|
| Protein (%) | 17.77b | 17.06c | 17.10c | 17.81b | 18.15a | 18.31a | 17.25c | 18.29a | 18.15a | 0.33 |
| Nitrogen (%) | 2.84b | 2.73c | 2.74c | 2.85b | 2.90a | 2.93a | 2.76c | 2.93a | 2.90a | 0.05 |
| Total lipids (%) | 2.17b | 1.71d | 1.86c | 1.88c | 2.18b | 2.26a | 1.78d | 2.19ab | 2.17b | 0.08 |
| Cellulose (%) | 44.44abc | 41.51e | 43.58cd | 43.82bc | 44.98a | 44.47abc | 42.62d | 44.72ab | 45.24a | 1.03 |
| Lignin (%) | 11.42c | 12.81a | 12.67a | 12.08b | 10.24d | 10.50d | 12.77a | 11.52c | 11.55c | 0.49 |
| NDF (%) | 72.00b | 70.04f | 71.88bc | 71.51d | 71.64cd | 72.10b | 71.02e | 73.15a | 72.00b | 0.33 |
| AD F (%) | 55.85bc | 54.31f | 56.59a | 55.57cd | 55.22de | 54.97e | 55.39d | 56.23ab | 55.46cd | 0.42 |
| Reducing sugars (%) | 3.29c | 2.72e | 2.63f | 3.34bc | 4.18a | 4.23a | 2.92d | 4.18a | 3.39b | 0.08 |
| Non reducing sugars (%) | 6.92e | 6.42g | 6.38g | 7.01d | 7.33b | 7.35b | 6.63f | 7.72a | 7.22c | 0.06 |
| Total Ash (%) | 6.65e | 5.83g | 6.30f | 7.09b | 7.28a | 7.26a | 6.86d | 7.23a | 6.94c | 0.05 |
| Potash (ppm) | 2.70d | 2.35f | 2.19g | 2.78c | 3.08b | 3.25a | 2.39f | 3.20a | 2.56e | 0.06 |
| Calcium (ppm) | 0.85d | 0.94ab | 0.98a | 0.90bc | 0.75e | 0.81d | 0.90bc | 0.85d | 0.86cd | 0.06 |
| Phosphorus (ppm) | 0.54cd | 0.49d | 0.54cd | 0.56c | 0.63a | 0.63a | 0.54cd | 0.61ab | 0.57bc | 0.05 |
| Magnesium (ppm) | 0.44bc | 0.33c | 0.35d | 0.39cd | 0.52a | 0.55a | 0.45b | 0.56a | 0.56a | 0.06 |
| Copper (ppm) | 13.50d | 8.47g | 9.77f | 15.87c | 16.90c | 16.07c | 12.17e | 20.17a | 18.73b | 1.21 |
| Zinc (ppm) | 18.57c | 24.03a | 23.40ab | 17.90a | 11.97e | 12.97e | 22.90b | 11.17e | 18.17c | 0.94 |
| Menganese (ppm) | 34.70d | 52.90a | 52.50a | 36.80c | 25.27g | 26.13f | 48.77b | 28.53e | 36.60c | 0.72 |

significant correlation with the fruit infestation. The results showed that hair density on leaf lamina in okra showed positive effect with the fruit infestation. The results regarding multiple linear regression models along with coefficients of determination between fruit infestation and various physico-morphic plant factors indicated that hair density on midrib exerted maximum impact (42.7%) with a negative trend on the fruit infestation caused by *Earias* spp. on okra followed by 10 fruit weight and fruit yield per plant with 31.4 and 15.5 % contribution in the fluctuation of fruit infestation, respectively. The 100 $R^2$ value was calculated to be 91.0 when the effect of all the physico-morphic plant factors were computed together (Table V).

*Biochemical factors of okra genotypes*

There was a significant variation in protein ($F_{8, 16}$ = 20.29, P $\leq$ 0.01), nitrogen ($F_{8, 16}$ = 20.28, P $\leq$ 0.01), total lipids ($F_{8, 16}$ = 78.32, P $\leq$ 0.01), cellulose ($F_{8, 16}$ = 12.43, P $\leq$ 0.01), hemi-cellulose ($F_{8, 16}$ = 27.14, P $\leq$ 0.01), lignin ($F_{8, 16}$ = 32.65, P $\leq$ 0.01), neutral detergent fiber ($F_{8, 16}$= 58.38, P $\leq$ 0.01), acid detergent fiber ($F_{8, 16}$ = 23.36, P $\leq$ 0.01), reducing sugars ($F_{8, 16}$ = 668.72, P $\leq$ 0.01), non reducing sugars ($F_{8, 16}$ = 926.13, P $\leq$ 0.01), total ash ($F_{8, 16}$ = 1041.80, P $\leq$ 0.01), potash ($F_{8, 16}$ = 307.70, P $\leq$ 0.01), calcium ($F_{8, 16}$ = 14.95, P $\leq$ 0.01), phosphorus ($F_{8, 16}$ = 9.94, P $\leq$ 0.01), magnesium ($F_{8, 16}$ = 32.10, P $\leq$ 0.01), copper ($F_{8, 16}$ = 95.71, P $\leq$ 0.01), zinc ($F_{8, 16}$ = 252.90, P $\leq$ 0.01), and manganese ($F_{8, 16}$ = 2077.85, P $\leq$ 0.01). Comparison (by LSD Test at P=0.05) of means of different bio-chemical characters of selected genotypes of okra is shown in Table IV.

The results pertaining to correlation coefficients (r-values) between fruit infestation and chemical characters of okra revealed that crude protein, nitrogen, total lipids, reducing sugars, non reducing sugars, cellulose, lignin, NDF, total minerals, potassium, phosphorus, magnesium and copper showed a positive correlation with the fruit infestation. Calcium, magnesium and zinc contents had a negative correlation on the fruit infestation caused by *Earias* spp. on okra with r-values of 0.645, 0.778 and 0.969, respectively. Hemicellulose and ADF showed non significant correlation with the fruit infestation (Table V).

**Table V.- Correlation between fruit infestation (%) caused by *Earias* spp. and physico-morphic and chemical plant characters of various selected genotypes of Okra (*Abelmoschus esculentus* L.).**

| Physical plant characters | Fruit infestation (%) | Chemical plant factors | Fruit infestation (%) |
|---|---|---|---|
| Plant height (cm) | -0.364 ns | Crude protein (%) | 0.894 ** |
| Number of primary branches | -0.260 ns | Nitrogen (%) | 0.888 ** |
| Ten fruit weight (gm) | - 0.561 ** | Total Lipids (%) | 0.821 ** |
| Fruit yield per plant (gm) | -0.639 ** | Reducing sugars (%) | 0.956 ** |
| Leaf moisture contents (%) | -0.246 ns | Non reducing sugars (%) | 0.952 ** |
| Hair density on midrib (cm) | 0.942 ** | Cellulose (%) | 0.690 ** |
| Midrib hair length (μm) | -0.250 ns | Hemi-cellulose ( %) | 0.216 ns |
| Hair density on vein (cm) | 0.187 ns | Lignin (%) | 0.835 ** |
| Vein hair length (μm) | 0.725 ** | Neutral detergent fiber (%) | 0.650 ** |
| Lamina hair density ($cm^2$) | 0.863 ** | Acid detergent fiber (%) | 0.090 ns |
| Lamina hair length (μm) | 0.361 ns | Total minerals (%) | 0.798 ** |
| Fruit hair density ($cm^2$) | 0.129 ns | Potassium (ppm) | 0.449 * |
| Fruit hair length (μm) | 0.160 ns | Calcium (ppm) | -0.645 ** |
| Leaf area ($cm^2$) | 0.061 ns | Phosphorus (ppm) | 0.834 ** |
| Thickness of leaf Lamina (μm) | 0.483 * | Magnesium (ppm) | 0.822 ** |
| Fruit length (cm) | -0.707 ** | Copper (ppm) | 0.849 ** |
| Fruit weight (cm) | -0.121 ns | Manganese (ppm) | -0.778 ** |
| | | Zinc (ppm) | -0.969 ** |

**Multiple Linear Regression Models along with Coefficients of determination ($R^2$) between fruit infestation and various morpho-physical plant factors.**

| Regression Equation | $R^2$ | 100 $R^2$ | Role of individual factor (%) |
|---|---|---|---|
| **Y= 7.37 – ** 0.34 $X_1$ | 0.314 | 31.4 | 31.4 |
| ** Y= 13.89 – 0.18 $X_1$ – ** 0.70 $X_2$ | 0.469 | 46.9 | 15.5 |
| ** Y= –1.28 + 0.03 $X_1$ + 0.18 $X_2$ + **0.33 $X_3$ | 0.896 | 89.6 | 42.7 |
| ** Y= -1.66 + 0.01 $X_1$ + 0.19 $X_2$ + **0.30 $X_3$ – 0.13 $X_4$ | 0.901 | 90.1 | 0.5 |
| ** Y= -0.46 + 0.02 $X_1$ + 0.12 $X_2$ + **0.26 $X_3$ – 0.001 $X_4$ + 0.71 $X_5$ | 0.909 | 90.9 | 0.8 |
| ** Y=-0.461 + 0.019 $X_1$ + 0.12 $X_2$ + ** 0.26 $X_3$ – 0.0036 $X_4$ + 0.07 $X_5$ – 0.02 $X_6$ | 0.909 | 90.9 | 0.0 |
| ** Y= 0.393 + 0.026 $X_1$ + 0.0926 $X_2$ + **0.246 $X_3$ – 0.0333 $X_4$ + 0.083 $X_5$ – 0.042 $X_6$ – 0.084 $X_7$ | 0.910 | 91.0 | 0.1 |

*, Significant at $P \leq 0.05$
**, Significant at $P \leq 0.01$
Y, Fruit infestation (%); $X_1$, Ten fruit weight (g); $X_2$, Fruit yield per plant (g); $X_3$, Midrib hair density (cm); $X_4$, Vein hair length (μm); $X_5$, Lamina hair density (cm); $X_6$, Thickness of leaf lamina (μm); $X_7$, Fruit length (cm).

**Multiple Linear Regression Models along with Coefficients of determination ($R^2$) between fruit infestation and various bio-chemical plant factors.**

| Regression Equation | $R^2$ | 100 $R^2$ | Role of individual factor (%) |
|---|---|---|---|
| ** Y= – 23.270 + **6.354 X1 | 0.799 | 79.9 | 79.9 |
| ** Y= – 24.231 + 4.076 $X_1$ + 5.84 $X_2$ | 0.804 | 80.4 | 0.5 |
| ** Y= – 21.336 + 3.75 $X_1$ – 4.153 $X_2$ + 1.005$X_3$ | 0.810 | 81.0 | 0.6 |
| ** Y= – 9.636 – 0.32 $X_1$ – 6.70 $X_2$ - 0.722$X_3$ +**1.940 $X_4$ | 0.936 | 93.6 | 12.6 |
| ** Y= – 8.424 + 0.010$X_1$ + 2.726 $X_2$ – 0.497 $X_3$ – **1.343 $X_4$ – * 1.983 $X_5$ | 0.953 | 95.3 | 1.7 |
| ** Y= –7.684 + 0.107 $X_1$ + 2.351 $X_2$ – 0.316 $X_3$ + **1.300 $X_4$ + * 2.108 $X_5$ –1.523 $X_6$ | 0.953 | 95.3 | 0.0 |
| ** Y= – 4.89 – 0.537 $X_1$ + 3.383 $X_2$ – 0.548 $X_3$ +*0.997 $X_4$ + **2.50$X_5$ – 0.234$X_6$ – 0.431 $X_7$ | 0.956 | 95.6 | 0.3 |
| ** Y= – 2.343 – 1.459 $X_1$ + 6.33 $X_2$ + – 1.278 $X_3$ + *1.012 $X_4$ +*2.01 $X_5$ – 0.46 $X_6$ – 0.782 $X_7$ + 1.32 $X_8$ | 0.962 | 96.2 | 0.6 |
| ** Y= –11.317 –1.689 $X_1$ + 6.79 $X_2$ – 1.16 $X_3$ +*1.05 $X_4$ + 1.81 $X_5$ – 0.495 $X_6$ – 0.71 $X_7$ + 1.17 $X_8$ + 2.42 | 0.963 | 96.3 | 0.1 |

| | | | |
|---|---|---|---|
| $X_9$ | | | |
| ** $Y = -8.99 - 1.825 X_1 + 7.099 X_2 - 1.018 X_3 + {}^{*}0.996 X_4 + 1.646 X_5 - 0.440 X_6 - 0.737 X_7 + 0.869 X_8 + 0.33 X_9 + 0.043808 X_{10}$ | 0.965 | 96.5 | 0.2 |
| ** $Y = -8.107 - 2.98 X_1 + 9.62 X_2 - 0.804 X_3 + 1.00 X_4 + 1.53 X_5 - 0.408 X_6 - 0.923 X_7 + 0.689 X_8 + 0.399 X_9 + 0.054 X_{10} + 0.996 X_{11}$ | 0.966 | 96.6 | 0.1 |
| ** $Y = -8.500 - 0.855 X_1 + 4.432 X_2 - 0.536 X_3 + {}^{*}1.028 X_4 + 1.448 X_5 - 0.349 X_6 - 0.035 X_7 + 0.202 X_8 + 0.298 X_9 + 0.058 X_{10} - 0.667 X_{11} + 3.294 X_{12}$ | 0.972 | 97.2 | 0.6 |
| ** $Y = -8.248337 - 1.006 X_1 + 4.78 X_2 - 0.439 X_3 + 9.85 X_4 + 1.631 X_5 - 0.364 X_6 - 0.053 X_7 - 0.150 X_8 + 0.299 X_9 + 0.059 X_{10} - 0.632 X_{11} + 3.37 X_{12} - 0.353 X_{13}$ | 0.973 | 97.3 | 0.1 |
| ** $Y = -16.183 - 0.310 X_1 + 5.33 X_2 - 0.072 X_3 + 0.866 X_4 + 2.612 X_5 - 0.218 X_6 + 0.189 X_7 + 0.29 X_8 + 0.507 X_9 + 0.043 X_{10} - 1.160 X_{11} + 3.134 X_{12} - 0.291 X_{13} + 0.218 X_{14}$ | 0.976 | 97.6 | 0.3 |
| ** $Y = -14.548 + 2.923 X_1 - 4.165 X_2 - 0.996 X_3 + 2.223 X_4 - 0.060 X_5 + 0.218 X_6 + 0.869 X_7 - 0.949 X_8 - 0.394 X_9 + 0.008 X_{10} - 0.407 X_{11} + 7.023 X_{12} + 0.3136 X_{13} - 0.039 X_{14} - 0.165 X_{15}$ | 0.990 | 99.0 | 0.0 |
| ** $Y = -13.374199 + 2.66 X_1 + -3.54 X_2 - 1.014 X_3 + 2.033 X_4 - 0.0340 X_5 - 0.210 X_6 - 0.806 X_7 - 0.886 X_8 - 0.400 X_9 + 0.006 X_{10} - 0.405 X_{11} + 0.761 X_{12} + 0.31 X_{13} - 0.030 X_{14} - 0.153 X_{15} - 0.050 X_{16}$ | 0.990 | 99.0 | 0.0 |

*, Significant at $P \leq 0.05$
**, Significant at $P \leq 0.01$
Y, Fruit infestation (%); $X_1$, Crude Protein (%); $X_2$, Nitrogen (%); $X_3$, Total lipids (%); $X_4$, Reducing sugars (%); $X_5$, Non Reducing sugars (%); $X_6$, Cellulose (%); $X_7$, Lignin (%); $X_8$, Neutral detergent fiber (%); $X_9$, Total minerals (%); $X_{10}$, Potassium (ppm); $X_{11}$, Calcium (ppm); $X_{12}$, Phosphorus (ppm); $X_{13}$, Magnesium (ppm); $X_{14}$, Copper (ppm); $X_{15}$, Manganese (ppm); $X_{16}$, Zinc (ppm)

The results on impact of various chemical characters of okra on the fruit infestation by *Earias* spp. is shown in Table V. Crude protein was found to be the most important plant character which contributed the maximum (79.9%) in the fluctuation of fruit infestation followed by reducing and non reducing sugar with 12.6 and 1.7 % contribution, respectively. Total lipids, neutral detergent fiber, phosphorus, nitrogen, lignin, copper, potassium, total minerals, calcium and magnesium showed nominal contribution in the fluctuation of fruit infestation of okra by *Earias* spp.

## DISCUSSION

The plant resistance against herbivore insects involves the contribution of various morphological, nutritional and allelochemical attributes (Slansky, 1990). The insects show a natural tendency to select those plants for oviposition which can provide protection to more eggs and easy access to nutritional sites to neonate larvae. In this regard morphological plant characters are of great important because they are the first ones to interact with the invading insects. In the present study an attempt was made to explore the role of various physico-morphic and chemical plant traits towards preference of *Earias* spp. on okra. For this purpose the fruit infestation can be used as a standard to check the susceptibility of different okra genotypes as described by Sundararaj and David (1987).

Agarwal and Ktiyar (1974) observed that the cotton genotypes with intermediate or high pubescence were more preferred for oviposition and damage by *Earias fabae* as compared to glabrous ones. Sharma and Agarwal (1983) further found that leaf hairiness may exert positive and significant effect on the number of eggs laid by *E. vittella* (F.) both in the laboratory and field experiments. Moreover intercrossing hairs on leaf surface of okra and cotton were also observed to increase the suitability for oviposition of *E. vittella* (F.) as mentioned by Mehta and Saxena (1970). In the present study, strong positive correlation of hair density on midrib and lamina and hair length of veins was found with infestation of different okra genotypes by *Earias* spp. Teli and Dalaya (1981) also reported more suitability of densely haired okra genotypes to spotted bollworms. Whereas Saini and Singh (1999) found a significant and positive correlation of *E. insulana* (Boisd.) with trichome density of different host plants, which indicates that regardless of host plant these pests tend to select pubescent places for oviposition probably due to better protection of eggs and newly emerged larvae. Therefore the selection of genotypes with less pubescence on leaves may give better results in breeding programme against *Eairas* spp. In the present study, hair density on fruit showed non significant correlation with the fruit infestation.

Conversely, Kumbher *et al*. (1991) found a positive correlation of increased fruit hair density of okra towards resistance to *E. vittella*. Rao and Panwar (2002) reported low moisture contents in the resistant genotypes of maize against *Chilo partellus* Swinhoe. However, there was no apparent association between leaf moisture contents and fruit infestation among the tested genotypes in the current study. Fruit weight, fruit yield per plant and fruit length had a negative correlation and 31.4, 15.5 and 0.1% contribution, respectively. Thickness of leaf lamina may offer resistance for feeding but in the current studies no contribution of leaf lamina thickness was observed with fruit infestation.

Biochemical constituents resulting from primary and secondary plant metabolism products provide chemical cues which mediate host plant selection by *Earias* spp. by affecting the growth, development and survival of insects. In this regards the role of primary metabolic products like proteins, carbohydrates, sugars and lipids is very important as stated by Slansky (1990). In the present study, crude proteins, total lipids, reducing and non reducing sugars had positive association with fruit infestation. Crude protein and reducing sugars were the most important factors contributing the maximum role for fruit infestation by *Earias* spp. These findings are inconformity with those of Singh (1987) who reported positive correlation with proteins, reducing sugars and non reducing sugars of okra fruit blocks, seeds and pericarps on post embryonic development of *Earias* spp. Similarly Sundraraj and David (1987) also reported the association of high fecundity, survival and quicker development of *E. vittella* with high level of proteins, free amino acids and reducing sugars. These nutrients may act as feeding stimulants for this insect; therefore the selection for reduced amount of such chemicals may be useful as reported by Smith (1986) because the deficiency of such nutrients may also act as a barrier for plants to serve as a host for insects as confirmed by Febvay *et al*. (1988).

Increased amount of fibers in association with chemical and physical factors may interact with plant feeding (Slansky, 1990). Acid detergent fibers and hemi-cellulose showed non significant association, while neutral detergent fiber, cellulose and lignin showed a positive correlation with nominal impact on fruit infestation. Among minerals, although Zn. Mn and Ca had a negative association but their contribution towards resistance was negligible. The contribution of biochemical factors was more as compared to the physico-morphic factors towards plant preference.

## CONCLUSIONS

The most important traits linked with host plant susceptibility were midrib hair density, crude protein, reducing and non reducing sugars. Whereas as yield components like ten fruit weight and fruit yield per plant were negatively correlated with pest infestation. This comparison of factors from okra genotypes of diverse genetic pool may be useful to pin point those plant characters which may be used as markers during screening for resistance in breeding programs. The genotypes Diksha, Sapz pari and Super star possessed those characters which made them comparatively non preferred for the *Earias* spp. These genotypes are supposed to perform better in the field and can also be used as a source of resistance in the breeding program of okra against *Earias* spp.

## REFERENCES

A.O.A.C., 1990. In: *Official methods of analysis*, 15th ed., Sec. 959.08. AOAC. Inc., Suite 400, 220 Wilson Boulevard, Arlington, Virginia, 22201, USA.

ATWAL, A.S. AND DHALIWAL, G.S., 2005. *Agricultural pests of South Asia and their management*. Kalyani Publishers, New Dehli, India. pp.280.

AGARWAL, R.A. AND KATIYAR, K.N., 1974. Ovipositional preference and damage by spotted bollworm (*Earias fabia*) in cotton. *Cotton Dev*., **4**: 28-30.

BERGVINSON, D.J. ARNASON, J.T. AND HAMILTON, R.I., 1997. Phytochemical changes during recurrent selection for resistance to the European corn borer. *Crop Sci.,* **37**:1567-1572.

FEBVAY, G., BONNIN, J., RHABE, Y., BOURNOVILLE, R. DELROT, S. AND BONNEMAIN, J.L., 1988. Resistance to different Lucerne cultivrs to the pea aphid Acyrthosiphon pisum: influence of phloem composition on aphid fecundity. *Ent. Exp. Appl.,* **48**: 127-134.

GULATI, R., 2004. Incidence of *Tetranychus cinnabarinus* infestation in different varieties of *Abelmoschus esculentus. Ann. Pl. Prot. Sci.,* **10**: 239-242.

HEDIN, P., DAVIS, F.M. AND WILLIAM, E.P., 1993. 2,4-dihydroxy-7-methoxy-(2H)-1-,4-benzin-3(4H)-one (N-

O-ME-DIMBOA), a possible toxic factor in corn to the southwestern corn borer. *J. chem. Ecol.,* **19**: 531-542.

JACKSON, M.L., 1958. *Soil chemical analysis*. Constable and Co. Ltd., London, pp. 141-151.

KRISHNIKUMAR, N.K. AND SRINIVASAN, K., 1987. Efficacy ad economics of pest control of okra with conventional and synthetic pyrethroid insecticides. *Indian J. Pl. Prot.,* **15**: 81-83.

KUMAR, K.K. AND URS, K.C.D., 1988. Population fluctuation of *Earias vittella* (Fab.) on okra in relation to abiotic factors. *Indian. J. Pl. Prot.,* **16**: 137-142.

KUMAR, S., PRASAD, S. AND SINGH, R.N., 2002. Resurgenco of two spotted mite due to acaricides and botanicals on okra. *Ann. Pl. Prot. Sci.,* **10**: 51-54.

KUMBHER, T.T., DUMBER, A. AND KOKATE, A.S., 1991. Studies on the varietal resistance in okra, Abelmoschus *esculentus* L. (Moench) to shoot and fruit borer, *Earias* spp. *Maharashtra J. Hort*., **5**: 78-82.

LUKEFAHR, M.J., MARIN, D.F. AND MEYER, J.R., 1965. Plant resistance to five Lepidoptera attacking cotton. *J. econ. Ent.,* **58**: 516-518.

MEHTA, R.C. AND SAXENA, K.N., 1970. Ovipositional responses of the cotton spotted bollworm, *Earias fabia* (Lepidoptera, Noctuidae) in relation to its establishment on various plants. *Ent. Exp. Appl.,* **13**: 10-20.

MURUGESAN, S., 1982. *The Spotted Bollworm,* Earias vittella *(Fab), Ecology and host resistance.* Ph. D. thesis, Tamil Nadu Agriculture University, Coimbatore, India.

RAO, M.N. AND PANWAR, V.P.S., 2002. Biochemical factors affecting resistance to *Chilo partellus* (Swinhoe) in maize. *Ann. Pl. Prot. Sci.,* **10**: 28-30.

ROJANARIDPICHED, C., GRACEN, V.E., EVERETT, H.L., COORS, J.C., PUGH, B.F. AND BOUTHYETTE, P., 1984. Multiple resistance factor in maize to European corn borer. *Maydica,* **29**: 305-315.

SAINI, R.K. AND SINGH, R., 1999. Host plant preference for oviposition by the spiny bollworm, *Earias insulant* Boisd. (Lep. Noctuida). *J. appl. Ent.,* **123**: 241-245.

SCHOONHOVEN, L.M., 1982. Biological aspects of antifeedants. *Ent. Exp. Appl.,* **31**: 57-69.

SHARMA, H.C. AND AGARWAL, R.A., 1983. Ovipositional behaviour of spotted bollworm *Earias vittella* (Fab.) on some cotton genotypes. *Insect Sci. Applic.,* **4**: 373-376.

SINGH, G. AND BRAR, K.S., 1994. Effects of dates of sowing on the incidence of *Amrasca biguttula* (Ishida) and *Earias* spp. On okra. *Indian J. Ecol.,* **21**: 140-144.

SINGH, R., 1987. Effect of okra fruit blocks, seeds and pericarp on pest embryonic development of *Earias vittella* (Fab.) in relation to some phytochemicals of selected okra genotypes. *Proc. Indian Acad. Sci. (Anim. Sci).,* **96**: 361-367.

SLANSKY, F. JR., 1990. Insect nutritional ecology as a basis for studying host plant resistance. *Fl. Entomol.,* **73**: 359-378.

SMITH, C.M., 1986. Trends affecting research strategies in plant resistance to insects. *Agric. Ecosyst. Environ*., **18**: 1-7.

SPARKS, D. L. (ed.), 1996. *Methods of soil analysis*, part 3: *Chemical methods*, Soil Science Society of America. Madison, Wisconsin.

STEEL, R.G.D., TORRIE, J.H. AND DICKEY, D.A., 1990. *Principles and procedures of statistics. A biometric approach*, 3rd edition. WCB Mc Graw Hill Companies, inc., USA.

SUMAN, C.L., WAHI, S.D. AND JAGAN MOHAN, N., 1984. Distribution pattern of okra shoot and fruit borer (*Earias vittella* Fab.) under natural conditions. *Indian L. Ent.,* **45**: 362-364.

SUNDARARAJ, R. AND DAVID, B.V., 1987. Influence of biochemical parameters of different hosts on the biology of *Earias vittella* (Fab.) (Noctuidae: Lepidoptera). *Proc. Indian Acad. Sci. (Anim. Sci).,* **96**: 329-332.

TELI, V.S. AND DALAYA, V.P., 1981. Studies on varietal resistance in okra (*Abelmoschus esculentus* (Linn.) Moench) to the shoot and fruit borer, *Earias vittella* Fabricius. *South Ind. Hort.,* **29**: 54-60.

UKWUNGWU, M.N. AND ODEBIYI, J.A., 1985. Incidence of *Chilo zacconius* Blesznski on some rice varieties in relation to plant characters. *Insect Sci. Appl.,* **6**: 653-665.

WRIGHT, R.T. AND STUCZYNSKI, T., 1996. Atomic absorption spectro photometry. In: *Methods of soil analysis, part 3: Chemical methods* (ed. D. L. Sparks). Soil Science Society of America. Madison, Wisconsin. pp. 69-90.

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**Table III.-** **Means comparison of different physico-morphic plant characters of selected genotypes of Okra (*Abelmoshus esculentus* L.)**

| | P-1999-31 | Sabz pari | Diksha | Lakshami-24 | Pusa sawani | Ikra-1 | Super Star | Parbani kranti | Ikra anamika | LSD at 5% |
|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) | 113.8d | 125.1b | 132.7a | 113.2d | 118.8c | 107.4ef | 101.0g | 104.6f | 108.4e | 3.24 |
| Primary branches/plant | 1.40a | 1.43a | 1.37ab | 1.07c | 1.47a | 1.43a | 1.23b | 0.93c | 1.23b | 0.15 |
| Ten fruits weight (gm) | 87.53g | 112.1b | 121.8a | 85.67g | 98.47e | 87.25g | 109.0c | 95.58f | 102.6d | 1.88 |
| Fruit yield/plant (gm) | 128.2d | 139.6a | 141.7a | 135.9b | 131.9c | 127.2d | 139.1ab | 129.0cd | 123.3e | 3.68 |
| Leaf moisture contents (%) | 81.03bc | 81.70ab | 80.97bc | 80.37c | 79.17d | 80.30c | 81.37abc | 82.40a | 81.53ab | 1.07 |
| Hair density on midrib (cm) | 69.78c | 48.11d | 43.56de | 74.23bc | 94.23a | 94.23a | 40.90e | 99.11a | 76.44b | 6.25 |
| Hair length on midrib (µm) | 30.78a | 27.44c | 29.44ab | 23.78de | 22.22e | 29.44ab | 28.44bc | 28.44bc | 24.78d | 1.97 |
| Hair density on vein (cm) | 24.97c | 31.78b | 24.45c | 16.89e | 39.55a | 19.55d | 15.55e | 26.45c | 19.78d | 2.56 |
| Hair length on vein (µm) | 24.11cd | 22.56de | 21.44e | 21.44e | 31.22a | 26.56b | 20.89e | 25.56bc | 24.22bcd | 2.425 |
| Hair density on lamina ($cm^2$) | 67.11c | 59.11d | 44.90f | 52.11e | 101.4a | 99.11a | 45.45f | 87.90b | 56.23de | 4.55 |
| Hair length on lamina (µm) | 23.78a | 19.45bc | 19.56bc | 22.45a | 23.78a | 23.23a | 23.11a | 21.78ab | 17.78c | 2.78 |
| Hair density on fruit ($cm^2$) | 477.9a | 366.1f | 349.3g | 397.2d | 457.5b | 307.0i | 328.5h | 372.0e | 400.0c | 2.14 |
| Hair length on fruit (µm) | 16.70de | 18.03abc | 16.66de | 17.55bc | 16.63e | 18.22ab | 17.40cd | 18.36a | 17.96abc | 0.76 |
| Leaf area ($cm^2$) | 30.84abcd | 35.14abc | 40.96ab | 32.09abcd | 25.40cd | 42.68a | 23.04d | 36.11abc | 30.36bcd | 11.85 |
| Thickness of leaf lamina (µm) | 9.17bcd | 9.33bc | 8.67cd | 10.33a | 9.27bcd | 9.72ab | 8.44cd | 10.39a | 8.39d | 0.922 |
| Fruit Length(cm) | 10.97bc | 12.13ab | 12.70a | 9.167d | 8.900d | 10.97bc | 12.00abc | 9.333d | 10.87c | 1.27 |
| Fruit width (cm) | 1.53ab | 1.67ab | 1.70ab | 1.55ab | 1.43b | 1.60ab | 1.75a | 1.77a | 1.70ab | 0.31 |

**Table IV.-** **Means comparison of different bio-chemical characters of selected genotypes of okra (*Abelmoschus esculentus* L.)**

| | P-1999-31 | Sabz pari | Diksha | Lakshami-24 | Pusa sawani | Ikra-1 | Super Star | Parbani kranti | Ikra anamika | LSD at 5% |
|---|---|---|---|---|---|---|---|---|---|---|
| Protein (%) | 17.77b | 17.06c | 17.10c | 17.81b | 18.15a | 18.31a | 17.25c | 18.29a | 18.15a | 0.33 |
| Nitrogen (%) | 2.84b | 2.73c | 2.74c | 2.85b | 2.90a | 2.93a | 2.76c | 2.93a | 2.90a | 0.05 |
| Total lipids (%) | 2.17b | 1.71d | 1.86c | 1.88c | 2.18b | 2.26a | 1.78d | 2.19ab | 2.17b | 0.08 |
| Cellulose (%) | 44.44abc | 41.51e | 43.58cd | 43.82bc | 44.98a | 44.47abc | 42.62d | 44.72ab | 45.24a | 1.03 |
| Lignin (%) | 11.42c | 12.81a | 12.67a | 12.08b | 10.24d | 10.50d | 12.77a | 11.52c | 11.55c | 0.49 |
| NDF (%) | 72.00b | 70.04f | 71.88bc | 71.51d | 71.64cd | 72.10b | 71.02e | 73.15a | 72.00b | 0.33 |
| AD F (%) | 55.85bc | 54.31f | 56.59a | 55.57cd | 55.22de | 54.97e | 55.39d | 56.23ab | 55.46cd | 0.42 |
| Reducing sugars (%) | 3.29c | 2.72e | 2.63f | 3.34bc | 4.18a | 4.23a | 2.92d | 4.18a | 3.39b | 0.08 |
| Non reducing sugars (%) | 6.92e | 6.42g | 6.38g | 7.01d | 7.33b | 7.35b | 6.63f | 7.72a | 7.22c | 0.06 |
| Total Ash (%) | 6.65e | 5.83g | 6.30f | 7.09b | 7.28a | 7.26a | 6.86d | 7.23a | 6.94c | 0.05 |
| Potash (ppm) | 2.70d | 2.35f | 2.19g | 2.78c | 3.08b | 3.25a | 2.39f | 3.20a | 2.56e | 0.06 |
| Calcium (ppm) | 0.85d | 0.94ab | 0.98a | 0.90bc | 0.75e | 0.81d | 0.90bc | 0.85d | 0.86cd | 0.06 |
| Phosphorus (ppm) | 0.54cd | 0.49d | 0.54cd | 0.56c | 0.63a | 0.63a | 0.54cd | 0.61ab | 0.57bc | 0.05 |
| Magnesium (ppm) | 0.44bc | 0.33c | 0.35d | 0.39cd | 0.52a | 0.55a | 0.45b | 0.56a | 0.56a | 0.06 |
| Copper (ppm) | 13.50d | 8.47g | 9.77f | 15.87c | 16.90c | 16.07c | 12.17e | 20.17a | 18.73b | 1.21 |
| Zinc (ppm) | 18.57c | 24.03a | 23.40ab | 17.90a | 11.97e | 12.97e | 22.90b | 11.17e | 18.17c | 0.94 |
| Menganese (ppm) | 34.70d | 52.90a | 52.50a | 36.80c | 25.27g | 26.13f | 48.77b | 28.53e | 36.60c | 0.72 |