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THE ROLE OF PHYSICO-MORPHIC AND CHEMICAL PLANT CHARACTERS OF DIFFERENT GENOTYPES OF BT-COTTON (*GOSSYPIUM HIRSUTUM* L.) IN THE POPULATION FLUCTUATION OF JASSID (*AMRASCA BIGUTTULA BIGUTTULA*) (ISHIDA) (HOMOPTERA: CICADELLIDAE) IN PUNJAB PAKISTAN

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ABSTRACT

Cotton is one of mostly attacked crop by sucking insect pests, out of which Jassid *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae) has become one of the serious pest of this crop. The present study was conducted on different selected genotypes of the Bt-cotton to find out the role of the physico-morphic and chemical plant characters on the population fluctuation of jassid. The effects of physico-morphic and chemical plant characters of Bt-cotton were correlated with the jassid population and their role was calculated by processing the data into simple and multiple linear regression equation. The maximum variations were observed among the resistance and susceptible genotypes of Bt-cotton due to plant height, hair density, thickness of leaf lamina, leaf area, length of hair, moisture percentage and total minerals. The results revealed that hair density on midrib, vein and lamina had negative and significant correlation, length of hair on midrib and vein had non significant correlation while Thickness of leaf lamina exerted positive and significant correlation with the Jassid population per leaf. Gossypol glands on midrib and vein showed positive and significant correlation while on lamina had negative and significant effect. Total minerals exerted positive and significant effect whereas reducing sugar, calcium and manganese showed negative and significant correlation with the Jassid density. Multiple linear regression models revealed that hair density on midrib and total minerals in the leaves were the most important characters.

Key words: Bt-cotton, Genotypes, Resistance, Jassid, Physico-Morphic, Chemical characters.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important cash crops of Pakistan and provides raw materials for cotton industry. It contributes 7.1 % of the value added in the agriculture, 1.5 % to the gross domestic products and export valuing of 10.22 billion dollars (Anonymous, 2014-15). This crop is providing employment to millions of peoples in ginning factories and textile mills. It was grown on an area of 2961 million hectares in 2014-15 showing an increase of 5.5% over last year area of 2806 million hectares with an average yield of 802 kg/hectare (Anonymous, 2014-15).

Growing of transgenic cotton is a new technology in Pakistan Agriculture. The area under Bt-cotton increased up to 3,238 ha during 2005 (Rao, 2006). In 2006, Bt-cotton was grown on 0.20 million ha. in Pakistan (Rao, 2007). Bt cotton has provided a specific, safe and effective tool for the control of Lepidopterous pests (Shelton *et al.*, 2002; Mendelsohn *et al.*, 2003; Wu and Guo, 2005). But it is highly susceptible to sucking insect pests and of which Jassid (*Amrasca bigutulla bigutulla* (Ishida)((Homoptera: Cicadellidae) is the most important and very serious pest reported to cause retardation in plant growth, deterioration of lint quality resulted in loss of cotton yield (Afzal and Ghani, 1953). A study in Pakistan revealed 37.6% loss in yield of seed cotton by combined attack of Jassid (4.6 per leaf) and thrips (14.6 per leaf) (Attique and Ahmad, 1990). Bhat *et al.* (1986) estimated 19.45% reduction of cotton yield in non-hairy susceptible cotton varieties due to Jassid (*Amrasca bigutulla bigutulla* (Ishida) alone. The jassid (nymphs + adults) both are involved in the crop damage by sucking the cell sap, turning the leaf pale yellow and curling downward. Jassid (*Amrasca biguttula biguttula*) injects toxic material into the leaf veins which can cause necrosis of the leaves around edges and at least falling of the leaves. *Amrasca biguttula biguttula* lays its eggs in the midrib of the leaves. The eggs require a week to hatch and the nymphs require another two weeks to become adult. The adults life is 5-7 weeks, which continuously sucks sap from the leaf. The use of the resistance genotype is the familiar tool for the bio-intensive pest management. The physico-morphic plant characters of plants are associated with attraction, feeding and egg laying of the insect pests. Development of the resistant varieties to insect pests is an important strategy of the pest management (Bhatti *et al.*, 1976).The physical and morphological characters of the resistance varieties may lead to the introduction of resistance character to favord genotypes. The resistance mechanisms related to morphological or structural plant features that impair normal feeding or oviposition by insects or contribute to the action of other mortality factors are together called phonetic resistance (Kogan, 1994). The morphological characteristics of the host plant may also influence the nutrition of the insect by limiting the amount feeding due to shape, colour or texture of the nutritive material and influence the digestibility and utilization of food by the insect. The present study was carried out to find out the correlation of different physico-morphic and chemical plant characters of the different genotypes of Bt-cotton having different degrees of resistance and susceptibility with the population of Jassid (*Amrasca bigutulla bigutulla* (Ishida).

MATERIALS AND METHODS

The six selected genotypes of Bt-cotton having different responses to the jassid population as its shown in the table.

Table 1. Status of the Different Genotypes of the Bt-Cotton and Their response against Jassid (*Amrasca biguttula biguttula*) (Ishida)

Sr. No.	Bt-Cotton Genotypes	Response against Jassid
1	AA-703	***
2	MG-06	***
3	BT-121	**
4	CA-12	**
5	AURIGA-101	*
6	MNH-886	*

*= Susceptible, **= Intermediate, ***= Resistant

These genotypes were sown on May 13, 2010 in the field of Progressive Farmer Chak No. 38/J.B. Dagora, District, Faisalabad using Randomized Completed Block Design (RCBD) with three replications. The plot size was kept at 7.64 m × 9.17 m and row to row distance 0.76 m. Data regarding Jassid (nymphs + Adults) population were recorded at weekly interval by randomly selecting 10 seedlings from each plot and by selecting 15 leaves from randomly selected five plants in such a way that one leaf from top portion of 1st plant, second leaf from middle portion of 2nd plant and third leaf from bottom portion of 3rd plant and so on. The average populations of the Jassid (nymph + adult) on each genotype of Bt-Cotton were calculated by simple arithmetic means. The different physico-morphic and chemical plant characters were recorded at the crop maturity. One leaf each from top, middle and bottom portion of three plants were plucked and brought to the laboratories of Entomology Department, University of Agriculture, Faisalabad, 2010 for the analysis. The various physico-morphic and chemical plant characters noted are given as below.

Physico-morphic Plant Characters

Hair Density: The number of hair was counted under a stereo binocular microscope. An half cm^2 sample was taken with the help of an iron made dye. The number of hair was counted from midrib, vein and lamina from three different places of each leaf. The unit of measurement for midrib and vein was cm and for lamina was cm^2.

Length of Hair: Length of hair was measured by an ocular micrometer from midrib, vein and lamina by counting six hairs from each site using stereo scope binocular microscope from the samples used for counting hair density.

Thickness of Leaf Lamina: A cross section was made with the help of a fine sharp razor and the thickness of leaf lamina was measured from three different places of each leaf under a stereo scope binocular microscope with the help of an ocular micrometer. One leaf each from top, middle and bottom portion of three plants was taken into consideration. The unit of the measurement was µm.

Gossypol Glands: One leaf each from top, middle and bottom portion of three plants was plucked and the numbers of gossypol glands were counted under a stereo binocular microscope. A 0.5 cm^2 sample was taken with the help of an iron made dye. The number of gossypol glands were counted from midrib, vein and lamina from three different places of each leaf. The unit of measurement for midrib and vein was cm and for lamina was cm^2.

Chemical Plant Characters

Moisture Percentage in Leaves: Three leaf samples each of 10 g, from the top, middle and lower parts of various plants were plucked from every plot. All leaves, were cleaned with a muslin cloth, weighed, classified and kept into a drying oven, run at 100 $\pm$ 5ºC for 12 hours. The dry matter of leaves was weighed and put back into the oven at the same temperature for another six hours. After the weight of the dry material, became constant, the moisture percentage was calculated, according to the following formula:

$$\text{Moisture \%age} = \frac{\text{Wt. of fresh leaves} - \text{Wt. of the dry leaves}}{\text{Wt. of fresh leaves}} \times 100$$

Total Minerals: Weighed 2 g of dry leaf tissue powder from each sample and put into a boron-free fused silica crucible. The samples were burnt to ash in Muffle furnace at 600ºC for five hours. The dry matter after combustion was weight and again put at the same temperature till it was completely burnt to white/grayish ashes to a constant weight. The experiment was repeated three times. The total minerals were calculated as follows (Ranganna, 1977).

$$\text{Total Minerals (\%)} = \frac{A}{B} \times 100$$

A= Weight of the ash & B= Weight of dried leaves

Nitrogen: 0.5 g of dry leaf tissue powder from each sample was taken to determine the total nitrogen percentage in leaf tissues by the Kjeldahl Method (Winkleman *et al*. (1986).

$$\text{Nitrogen (\%)} = \frac{(V\text{-}B) \times AA\ (14.01) \times R}{W \times 1000} \times 100$$

Where V= Sample titration volume (ml)
B= Digestion blank titration volume (ml)
A= Acid mortality
R= Ratio of total digest volume to distillation volume
W= Dry plant weight (g)

Protein: Protein contents were determined from each sample by the following formula;

Protein (%) = Nitrogen contents in the leaf × 6.25

Reducing Sugars: The sugar solution should be neutral. The concentration of the sugar solution should be such that the titre value ranges between 15 ml and 50 ml. Adjusted the sugar concentration in the solution taken for titration so as to contain 0.1 to 0.3 g of sugar per 100 ml, when 10 ml of mixed Fehling's solution was used. Initially titrated by the incremental method. When the correct dilutions are established, perform subsequent titration by the standard method.

Pipetted 10 ml of the mixed Fehling's solution into a 250 ml flask. Added 50 ml water. Filled the burette with the clarified sugar solution. Added from the burette, sugar solution sufficient to reduce almost completely the Fehling's solution used. Mixed and heated to boiling on hot plate or burner covered with clean asbestos-filled wire gauze. Boil for 15 seconds, if the colour remained blue (indicating that the Fehling's solution was not completely reduced), added further 2-3 ml of the sugar solution. Boiled the solution for a few seconds. Added drops of methylene blue solution and completed the titration by adding the sugar solution drop-wise until the indicator was completely decolourized. Recorded the volume of solution required. The accuracy of the incremental method was increased by attaining the end point as rapidly as possible and by maintaining a total boiling period of 3 minutes.

Pipetted 10 ml of mixed Fehling's solution into each of two 250 ml conical flasks. Filled the 50 ml burette with the solution to be titrated. Run into the flask almost the whole volume of sugar solution required to reduce the Fehling's solution, so that 0.5 ml to 1.0 ml was required later to complete the titration. Mixed the contents of the flask and boiled moderately for 2 minutes. Then added 3 drops of the methylene blue solution, took care not to allow it to touch the side of the flask. Completed the titration within 1 minute by adding 2 to 3 drops of sugar solution at 5 to 10 second intervals, until the indicator was completely decolourized. At the end point, the boiling liquid assumed the brick-red colour of precipitated cuprous oxide, which it had before the indicator was added. Noted the volume of the solution required (Ranganna, 1977).

$$\text{Reducing sugars (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{Titre} \times \text{wt. or volume of the sample} \times 100}$$

Macro and Micro Nutrients Determination: Macro and micro nutrient determination were made from nitric-perchloric acid digest of plant tissues. The essential features of the method were as follows:

Plant material (1 g oven dry basis) was predigested in Taylor digestion tubes at room temperature in 100 ml. of a 2.1 mixture of $HN0_2$-$HCL0_4$ overnight or until the vigorous reaction phase was past. Small short stemmed funnels were placed in the mouth of the tubes to reflex acid. After the preliminary digestion, tubes were placed in a cold aluminum block digester and the temperature raised to 150ºC for 1 hour after which U-shaped glass rods were placed under each funnel to permit exist of volatile vapours. Temperature was slowly increased until all traces of HNO_3 had disappeared, after which the U-shaped glass rods were removed and the temperature rose to 235ºC. Time was noted when dense white fumes of $HC10_4$ appeared in the tubes and digestion was continued for 30 minutes more. Samples were removed from the digester, allowed to cool for few minutes and a few drops of distilled water was added carefully through the funnel. After vapours had condensed, water was added in small increments washing down walls of tubes and funnels. Appropriate dilutions were made with distilled water. The solution of each tube was mixed and then left undisturbed for a few hours. Supernatant liquid was then decanted and Ca, Mg, Zn, Fe, Cu and Mn in the aliquots were analyzed by atomic absorption spectro-photometry (Wright and Stuczynski, 1996) Potassium in the plant digests was determined by flame photometry (Sparks, 1996) and Phosphorus was determined colorimetrically by the vanadomolyhydro-phosphorus acid colour method (Jackson, 1958).

Statistical Analysis: The data regarding population of Jassid (*Amrasca bigutulla bigutulla* (Ishida) obtained from host plant resistance section, bio-intensive management, physico-morphic and chemical plant characters studies were analyzed statistically using RCBD Design with the objective to find the significance among genotypes/treatments. The means were separated by DMR Test at P = 0.05. The data regarding population of Jassid (*Amrasca bigutulla bigutulla* (Ishida) were also processed into simple correlation and multiple linear regression analysis of variance along with coefficient of determination values with the weather factors for 2009 and 2010 individually and on cumulative basis. The data regarding population in selected genotypes of Bt-cotton were also processed for simple correlation with the physico-morphic and chemical plant characters and the characters which showed significant correlations were processed for multiple regression analysis with the physico-morphic and chemical plant characters with the objective to find their role/impact toward population fluctuation of the pest. The data were transformed in to square root transformation before calculation correlation and multiple regression analysis of variance.

RESULTS

Various physico-morphic (hair density, length of hair, gossypol glands on midrib, vein and lamina and thickness of leaf lamina) and chemical plant characters (moisture percentage, total minerals, nitrogen, protein, lipids, reducing sugar, calcium, magnesium, phosphorus, potassium, copper, zinc, manganese and ferrous were determined from plant leaves of various selected genotypes of Bt-cotton with the objective to determine the variation in genotypes. These factors were processed for simple correlation and the factors which showed significant correlation with the pest population were computed for multiple linear regression analysis of variance with the objective to find the impact of these factors individually as well as in their possible combinations through steps. The different physico-morphic characters are mentioned in the table 2. The results showed that hair density on the midrib, vein and leaf lamina with (r) values of 0.949, 0.956 and 0.581 of all the genotypes of the Bt-Cotton leaves which showed negative and significant correlation with Bt-Cotton Jassid. The length of the hair on the midrib, vein and lamina with (r) values 0.260, 0.193 and 0.405 showed negative and non significant relation with the jassid population. The thickness of the leaf lamina with (r) values 0.941 showed positive and highly significant correlation with the population fluctuation of the Jassid per leaf. On the other hand Gossypol glands on the midrib and vein with (r) values 0.595 and 0.631 showed positive and highly significant correlation with the population fluctuation of Jassid population while gossypol glands on the leaf lamina with (r) values 0.460 showed negative and significant correlation with Jassid population per leaf.

From these results it is concluded that MG-06 had maximum hair density i.e 30.46 cm^{-1}whereas MNH-886 showed minimum hair density i.e. 15.39 cm^{-1} on midrib. While as far as the hair density on vein is concerned MG-06 had maximum number of hair i.e. 36.85 cm^{-1} whereas Auriga-101 showed the minimum number of hair i.e. 18.34 cm^{-1} on their leaf veins. On the leaf lamina the maximum number of the hair were observed on MG-06 i.e. 172.58 cm^{-2} while the minimum number of hair were observed on CA-12 i.e. 76.89 cm^{-2} . In the present study, length of hair was not important as it showed non significant correlation with the Jassid population. Thickness of leaf lamina showed significant and highly significant correlation with population fluctuation of Jassid per leaf. Gossypol glands on midrib ($P<0.01$) and vein ($P < 0.01$) showed positive and significant correlation with the population density of Jassid per leaf while on lamina had negative and significant ($P < 0.05$) effect.

Table 2. Effect of Physio-morphic Plant Characters in Population Fluctuation of the Jassid (*Amrasca bigutulla bigutulla* (Ishida) in various Selected Conventional Genotypes of Cotton.

Plant Characters		r-value
Hair Density	Midrib	-0.949**
	Vein	-0.956**
	Lamina	-0.581**
Length of Hair	Midrib	-0.260ns
	Vein	-0.193ns
	Lamina	-0.405ns
Thickness of Leaf Lamina		0.941**
Gossypol Glands	Midrib	0.595**
	Vein	0.631**
	Lamina	-0.460*

*Significant at $p \leq 0.05$; ** Significant at $p \leq 0.01$; ns, Non-significant

Varietal Variation in Chemical Plant Characters

i) **Moisture Contents:** It is evident from the results that the maximum moisture content was recorded to be 82.94 % in the leaves of CA-12 and did not differ significantly from those of recorded on MG-06 and AA-703 with 82.62 and 82.61 % moisture contents in their leaves, respectively. The minimum moisture content was recorded to be 81.05 % in the leaves of Auriga-101 and did not differ significantly from those of recorded in the leaves of MNH-886 and BT-121 showing 81.61 and 81.80 %, respectively. From these results it is concluded that the genotype CA-12 had maximum moisture percentage in the leaves whereas the genotype Auriga-101 showed minimum moisture percentage.

The chemical plant characters are shown in the Table 3. The results revealed that total minerals showed positive and significant correlation ($r=0.907^{**}$) while reducing sugar, calcium and manganese had negative and significant correlation with the pest population having r-values of 0.605^{**}, 0.803^{**} and 0.453^{*}, respectively. Moisture percentage, nitrogen, protein, lipids, magnesium, phosphorus, potassium, copper, zinc and ferrous were not so important as they showed non significant correlation with the Jassid population.

Table 3. Effect of Chemical Plant Characters in Population Fluctuation of the Jassid (*Amrasca biguttula biguttula*) (Ishida) in various Selected Conventional Genotypes of Cotton.

Plant Characters	r-value
Moisture Contents	-0.210 ns
Total Minerals	0.907**
Nitrogen	0.169 ns
Protein	0.030 ns
Lipids	-0.441ns
Reducing Sugar	-0.605**
Calcium	-0.803**
Magnesium	0.307ns
Phosphorous	-0.250ns
Potassium	-0.239ns
Copper	0.261ns
Zinc	0.203ns
Manganese	-0.453*
Ferrous	-0.322ns

* = significant at $P < 0.05$, ** = Significant at $P < 0.01$, Ns = Non-significant

Linear Regression Models

a) Impact of Physico-Morphic Plant Characters on the Jassid Population: It is evident from Table 4 the results that hair density on midrib showed negative and significant effect and exerted maximum impact i.e. 90 % in per unit change of the pest density followed by hair density on vein and lamina which exerted 5.3 and 1.3 % impact in population fluctuation of the Jassid. The other factors like thickness of leaf lamina, gossypol glands on midrib, vein and lamina had minor impact in per unit change of the pest density which ranged from 0 to 0.9 %. Furthermore the regression analysis of variance reveals that all the models were good fitted. The 100-R^2 value was calculated to be 97.9 when the effects of all the factors were computed together.

b) Impact of Chemical Plant Characters on the Jassid Population: It is evident from table 5 results that total minerals showed maximum impact i.e. 82.3 % in per unit change of the pest followed by calcium, manganese and reducing sugar with 4.3, 0.6 and 0.1 % role in population fluctuation of the Jassid per leaf. The overall impact of these factors when computed together was calculated to be 86.7 %. All the regression equations were found to be fitted the best.

Table 4. Multiple Linear Regression Models regarding Population of Jassid per Leaf and Various Physico-morphic Plant Characters in Bt-Cotton.

	Regression Equation	R^2	100-R^2	Impact (%)	S.E.	F. value
**Y =	2.738 – 0.273X1**	0.900	90.0	90.0	0.057	144.72
**Y=	2.767 – 0.135X1**-0.131X2**	0.953	95.3	5.3	0.040	152.21
**Y=	2.752-0.158X1**-0.138X2** + 0.014X3*	0.966	96.6	1.3	0.036	131.40
**Y=	2.113-0.132X1**-0.114X2**+0.009X3+0.008X4	0.968	96.8	0.2	0.036	97.02
**Y=	1.596-0.132X1**-0.086X2*+0.0004X3+0.007X4+0.125X5*	0.977	97.7	0.9	0.032	101.41
**Y=	1.449-0.127X1**-0.089X2*+0.002X3+0.007X4 + 0.068X5 + 0.0778X6	0.979	97.9	0.2	0.032	83.79
**Y=	1.433-0.126X1**-0.088X2*+0.002X3+ 0.007X4+0.067X5+0.087X6-0.0028X7	0.979	97.9	0.0	0.033	65.32

Where

X1=Hair density on midrib cm-1, X2=Hair density on vein cm-1, X3=Hair density on lamina cm-2
X4=Thickness of leaf lamina µ X5=Gossypol glands on midrib cm-1 X6=Gossypol glands on vein cm-1
X7=Gossypol glands on lamina cm-2

Table 5. Multiple Linear Regression Models regarding Population of Jassid per Leaf and Various Chemical Plant Characters in Genotypes of Bt-Cotton.

	Regression Equation	R^2	100-R^2	Impact (%)	S.E.	F. value
**Y=	-0.728 + 0.565X1**	0.823	82.3	82.3	0.076	74.17
**Y=	-0.505 + 0.5544X1**-0.062X2	0.824	82.4	0.1	0.078	35.19
**Y=	2.870+0.441X1** + 0.064X2 -0.235X3	0.861	86.1	4.3	0.072	29.00
**Y=	-0.272+ 0.445**X1+0.027X2-0.257X3* + 0.066X4	0.867	86.7	0.6	0.073	21.17

X1=Total minerals X2=Reducing sugar X3=Calcium X4=Manganese

DISCUSSION

Various physico-morphic and chemical plant characters were co-related with the population density of Jassid (nymph + adult) with the objective to determine the effect of these characters in population fluctuation of the pest on various selective genotypes of Bt-Cotton In the present study, hair density on midrib, vein and lamina showed significant ($P < 0.01$) and negative correlation with the pest population having r-values of 0.949, 0.956 and 0.581, respectively. The present findings are in conformity with those of Riaz *et al*. (1987), Ali *et al*. (1995a), Ali *et al.* (1999), Hassan *et al*. (1999), Raza (2000), Bashir *et al*. (2001) and Aslam *et al*. (2004) who also reported negative correlation between population of jassid and hair density. But according to Ashfaq *et al*. (2010) that hair density on midrib, vein and lamina had non-significant effect on the population of Jassid. Similarly the findings of Naveed *et al*. (2011) also contradicted with the present findings who reported higher population of Jassid on variety showing higher hair density and vise versa. Length of hair was not important as it showed non-significant correlation with the population of Jassid. However, the effect was found to be negative. The present findings are contradicted with those of Raza (2000), who reported that length of hair on leaf midrib showed negative correlation with Jassid nymph. The present findings are also not in conformity with hose of Aslam *et al*. (2004) and Sikka *et al*. (1966) who reported that length of hair was important physico-morphic character contributing some resistance against jassid. Thickness of leaf lamina exerted positive and significant correlation with the Jassid density per leaf with r-value of 0.941. The present findings are in conformity with those of Ali *et al.* (1995a) who also reported positive and highly significant correlation between Jassid population and thickness of leaf lamina. Gossypol glands on midrib ($P<0.01$) and vein ($P < 0.01$) showed positive and significant correlation with the population density of Jassid per leaf while on lamina had negative and significant ($P < 0.05$) effect. The present findings are partially in conformity with those of Ali *et al*. (1995a) who reported that gossypol glands on midrib and lamina were not important for Jassid population but gossypol glands on vein exerted highly significant and positive correlation with the pest population. In the present study, length of hair was not important as it showed non significant correlation with the Jassid population. The present findings are in conformity with those of Ali *et al*. (1995a).

Total minerals showed positive and significant correlation ($r=0.907^{**}$) while reducing sugar, calcium and manganese had negative and significant correlation with the pest population having r- values of 0.605^{**}, 0.803^{**} and 0.453^{*}, respectively. Moisture percentage, nitrogen, protein, lipids, magnesium, phosphorus, potassium, copper, zinc and ferrous were not so important as they showed non significant correlation with the Jassid population. The present findings are in agreement with those of Ali *et al*. (1995a) who reported that moisture contents were not important for Jassid. The present findings can partially be compared with those of Ali *et al*. (1995b) who reported that total lipids, reducing sugar, magnesium and calcium in middle and bottom leaves showed significant and negative correlation with Jassid population while total minerals had positive and significant effect on the Jassid population. But in the present study total lipids and magnesium showed non-significant correlation with the pest density. The present findings are contradicted with those of Ali *et al*. (1995c) who stated that reducing sugar had positive and significant correlation with the Jassid density.

Multiple linear regression analysis of variance revealed that hair density on midrib was the most important character which contributed maximum in per unit change of pest density i.e. 90% followed by hair density on vein and lamina showing 5.3 % and 1.3 % impact in variation of the pest, respectively.

Amongst chemical plant characters, total minerals were found to be the most important characters resulted in 82.3 % impact in population variation of Jassid per leaf. The impact of reducing sugar, calcium and magnesium was calculated to be 0.1, 3.7 and 0.6 %, respectively in per unit change of the pest density.

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