Varietal and physico-morphological resistance of okra cultivars against *Amrasca biguttula biguttula* (Homoptera: Cicadellidae)

Khadija Javed, Muhammad Aamir Rashid, Adeela Munawar, Kashif Hussain and Humayun Javed

**Abstract**

Effect of jassid population on different okra varieties was observed on the time frame at different life stages of the plant and effect of physio-morphic characters. Linear mixed models and growth curves were used by keeping plants effect random to account repeated measures data and cubic trend interaction with varieties was found to be significant using AIC, BIC and deviance criteria of model selection. Nested designs were used for the area within each plant. Results revealed Arka Anamika (6.96 insects/plant) to be the most resistant cultivar among all the five tested cultivars followed by Super Green (8.11 insects/plant). Ambika (13.3 insects/plant) was least resistant cultivar among all the five tested cultivars. Host plant resistance was enhanced by the hair density on plant leaves of okra cultivars; cultivars having high density of trichomes showed high resistance towards the jassid infestation. Leaf area differences drive the insect population was also calculated.

**Keywords:** Leaf area, jassid population, okra varieties, varietal resistance

**Introduction**

Okra (*Abelmoschus esculentus*) is cultivated worldwide and belongs to Malvaceae family. Okra is herbaceous annual plant of the old world tropics [14]. Its hairy leaves are lobbed and up to 11 inches in length and cultivars vary in pod color, shape and plant height and also vary in tolerance to rainfall [15]. Okra production is affected by number of bacteria, viruses, nematodes and insects and these losses upto 25% resulting income loss to growers. Okra jassid, *Amrasca biguttula biguttula* (Homoptera: Cicadellidae) has become a serious pest of agronomic crops, vegetables and ornamental plants. It is the most destructive amongst sucking insect pests attacking the ‘okra’ crop [20]. Okra is the most suitable host for survival and feeding to its nymph [19]. The damage caused by *Amrasca. biguttula biguttula* starts from young seedling to the mature crop resulting in 50% yield loss [5]. Jassid’s attack causes the reduction in plant height and number of leaves up-to 49.8% and 45.1%, respectively [17]. *Amrasca. biguttula biguttula* is the most serious pest well distributed in Pakistan [10], India [7], Bangladesh, Thailand [9] and other Southeast Asian countries [2]. Excessive feeding damage the phloem tubes and causes disease, hopper burn (phytotoxemia) the main symptom of jassid attack [21]. Damage leaves develop brown and curl at the edges, stunted growth and unable to produce flowers and fruits and fall off leaves. Oviposition preference and subsequent population build-up on variety of host plants are tools for damage potential. Host plant resistance is a major part of IPM program and is helpful when used with other control methods [13]. Resistant cultivars were less affected by jassid with respect to susceptible cultivars [11]. Density of trichomes on vein, subvein, and lamina have influenced on oviposition behavior [22]. Present studies were conducted to explore the role of host plant resistance and physico-morphic characters to *Amrasca biguttula biguttula* population.

**Materials and Methods**

The study was conducted on Physico-morphic resistance of different okra cultivars against *Amrasca biguttula biguttula* at University Farm, Koont of Pir Mehr Ali Shah Arid Agriculture University, and Rawalpindi during 2015. Five okra cultivars (Ambika, Arka Anamika, Rama Karishna, Sabaz Pari and Super Green) were selected.
Experimental layout

Experiment was laid out according to CRD with three replications. The plot size was maintained up to 35 ft x 15 ft. The row to row and plant to plant distance was 2.5 ft and 2 ft, respectively. The seed was sown on parallel ridges. No plant protection measures were applied and material was screened under natural insect pressure. Normal agronomical practices were adopted to manage the crop. The data were recorded weekly basis early in the morning, starting three weeks after the sowing of crop. The data regarding nymph and adult population of *Amrasca biguttula biguttula* /leaf basis. Ten plants were selected randomly from each replication of each treatment and was examine in such a way that upper, middle and lower leaf of ten plants were observed with the help of magnifying glass and remaining examining of leaf was continued in the similar way to record the population of jassid. The population were calculated by applying the following formula

\[
\text{Population (per leaf)} = \frac{\text{Total number of insects}}{\text{Number of leaves observed}}
\]

To determine the physico-morphic characters of okra, following parameters were studied: Hair density/cm² on lamina, midrib and veins of the leaf was determine under microscope from three randomly selected leaves in each treatment. Five upper, middle and lower leaves were taken from each treatment. Leaf area was measured by using digital leaf area meter.

Statistical analysis

For Statistical analysis, growth curve models in lme4\textsuperscript{3} package in R were used as it might possible to have a nonlinear pattern in time course data and different model selection criteria as AIC, BIC, log likelihood and deviance were employed \textsuperscript{15}. So, higher order polynomials were used to account interaction of Okra varieties with higher ordered polynomials of time. For visualization of repeated measures data ggplot2 \textsuperscript{23} package and for pairwise comparison of Okra varieties lsmeans function in lsmeans package in R was applied. To detect the significantly different areas of hair density among Okra varieties Turkeys test \textsuperscript{1} was applied.

Results and Discussion

Five different varieties on the time frame against the jassid population were assessed for the insect damage. Varieties used in the experiment include Ambika, Arka Anamika, Rama Karishna, Sabz Pari, and Super Green. Figure 1 depict cubic trend among all five okra varieties over 18 weeks and showed an increasing trend in Jassid population. It also denote the continuous changes in the population of jassid throughout the data collection period. Population of jassid was varying in different varieties based on many factors responsible for preference or non-preference of the insect. Maximum population was recorded in Ambika variety during 17\textsuperscript{th} week of data collection followed by the jassid population in Rama Karishna and Sabz Pari; both were at par. Minimum jassid population was recorded in Arka Anamika as shown in the figure 1.

![Figure 1: Facet plot of Varieties over weeks of Jassid population](image)

Three different model were tested to check the integrity and effect of time frame and varietal differences on the jassid population. Models were as follow;

**Model 1**

\[
\text{jassid population} = \text{week} + \text{variety} + \text{week} \times \text{variety} + (\text{week|plants})
\]

**Model 2**

\[
\text{jassid population} = \text{week}^2 + \text{week}^3 + \text{variety} + \text{week}^2 \times \text{variety} + (\text{week|plants})
\]

**Model 3**

\[
\text{jassid population} = \text{week}^3 + \text{variety} + \text{week} \times \text{variety} + (\text{week|plants})
\]

AIC and BIC criteria was used to check goodness of model fit among 3 models. Model with minimum AIC and BIC was considered best. Also the p-value (<0.05) for Model2 shows significant impact of effects.
Table 1: Goodness of fit criteria for models

<table>
<thead>
<tr>
<th>Model</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>Log Lik</th>
<th>deviance</th>
<th>Chisq</th>
<th>Chi Df</th>
<th>Pr (&gt;Chisq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model1</td>
<td>14</td>
<td>1055.923</td>
<td>1106.301</td>
<td>-513.962</td>
<td>1027.923</td>
<td>2</td>
<td>0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Model2</td>
<td>16</td>
<td>484.7821</td>
<td>542.3568</td>
<td>-226.391</td>
<td>452.7821</td>
<td>575.1411</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Model3</td>
<td>16</td>
<td>565.0111</td>
<td>622.5859</td>
<td>-266.506</td>
<td>533.0111</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

ANOVA was calculated for model 2 which is the best suited model of varieties against the jassid population over time frame and displayed below;

Table 2: ANOVA for Model 2

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Df</th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week</td>
<td>1</td>
<td>1913.687</td>
<td>1913.687</td>
<td>5841.845</td>
</tr>
<tr>
<td>Week²</td>
<td>1</td>
<td>580.5868</td>
<td>580.5868</td>
<td>1772.337</td>
</tr>
<tr>
<td>Week³</td>
<td>1</td>
<td>17.29662</td>
<td>17.29662</td>
<td>52.8008</td>
</tr>
<tr>
<td>Variety</td>
<td>4</td>
<td>86.27717</td>
<td>21.56929</td>
<td>65.84384</td>
</tr>
<tr>
<td>Week³*Variety</td>
<td>4</td>
<td>105.8997</td>
<td>26.47494</td>
<td>80.81912</td>
</tr>
</tbody>
</table>

Plot of observed (points) and fitted values (lines) of model 2 were shown in fig. 2 showing a cubic trend over time. Maximum jassid population in Ambika variety followed by Rama Karishna trailed by Sabz Pari. Jassid population in Arka Anamika variety calculated as minimum population of the jassid.

Table 3: Pairwise contrast analysis of Okra Varieties

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Estimate</th>
<th>SE</th>
<th>Df</th>
<th>t.ratio</th>
<th>p.value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ambika, Arka Anamika</td>
<td>0.876336</td>
<td>0.121926</td>
<td>10.46731</td>
<td>7.187462</td>
</tr>
<tr>
<td>2</td>
<td>Ambika, Rama Karishna</td>
<td>0.339799</td>
<td>0.121926</td>
<td>10.46731</td>
<td>2.786933</td>
</tr>
<tr>
<td>3</td>
<td>Ambika, Sabz Pari</td>
<td>0.485866</td>
<td>0.121926</td>
<td>10.46731</td>
<td>3.984933</td>
</tr>
<tr>
<td>4</td>
<td>Ambika, Super Green</td>
<td>0.707866</td>
<td>0.121926</td>
<td>10.46731</td>
<td>5.805715</td>
</tr>
<tr>
<td>5</td>
<td>Arka Anamika, Rama Karishna</td>
<td>-0.53654</td>
<td>0.121926</td>
<td>10.46731</td>
<td>-4.40053</td>
</tr>
<tr>
<td>6</td>
<td>Arka Anamika, Sabz Pari</td>
<td>-0.39047</td>
<td>0.121926</td>
<td>10.46731</td>
<td>-3.20253</td>
</tr>
<tr>
<td>7</td>
<td>Arka Anamika, Super Green</td>
<td>-0.16847</td>
<td>0.121926</td>
<td>10.46731</td>
<td>-1.38175</td>
</tr>
<tr>
<td>8</td>
<td>Rama Karishna, Sabz Pari</td>
<td>0.146067</td>
<td>0.121926</td>
<td>10.46731</td>
<td>1.197999</td>
</tr>
<tr>
<td>9</td>
<td>Rama Karishna, Super Green</td>
<td>0.368067</td>
<td>0.121926</td>
<td>10.46731</td>
<td>3.018781</td>
</tr>
<tr>
<td>10</td>
<td>Sabz Pari, Super Green</td>
<td>0.222</td>
<td>0.121926</td>
<td>10.46731</td>
<td>1.820782</td>
</tr>
</tbody>
</table>

Pairwise contrast of different varieties with each other was done to check out the effect on each other and result revealed that contrast of [Ambika, Rama Karishna], [Arka Anamika, Super Green], [Rama Karishna, Sabz Pari] and [Sabz Pari, Super Green] were non-significant. Iqbal et al. [6] also found Arka Anamika to be the most resistant cultivar. Results of the present study were in accordance with the results of Shakeel et al. [18] who found Super Green to be moderately resistant cultivar among the tested okra cultivars.
Hair Density

Table 4: ANOVA for Hair Density in Different Varieties

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Df</th>
<th>SS</th>
<th>MS</th>
<th>F-value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>4</td>
<td>458</td>
<td>114.5</td>
<td>10.55</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Area (Variety)</td>
<td>10</td>
<td>1064</td>
<td>106.4</td>
<td>9.80</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Leaf Position (Area(Variety))</td>
<td>30</td>
<td>10530</td>
<td>351.0</td>
<td>32.32</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Residuals</td>
<td>90</td>
<td>977</td>
<td>10.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 2: Hair Density Mean with error bars in Different Okra Varieties

Nested design is used for hair density data set as upper, middle and lower area is nested within a variety and leaf positions (Lemina, midrib, vein) is nested within area and then in each variety of okra. All the three sources of variation shows significant results towards the effect of hair density. The results of the hair density showed that jassid has less preference to cultivars which had a higher hair density ratio and more preference towards the less dense leave hairs as Ambika is highly susceptible cultivar because of lowest hair density. Super green variety was the less resistive cultivar but has the highest hair density among other cultivars. Most resistant varieties based on hair density was Arka Anamika. But the comparison of cultivar Sabz Pari and Super Green against Arka Anamika cannot be done because jassid population was more in the first two varieties but unlikely have more hairs. So the results of the current study cannot be compared to the results of Mahal et al. [9] and Uthamasamy [22] who reported that hair density of the cultivar results in more host plant resistance towards the sucking insect pest of okra.

Leaf area difference among different varieties were calculated. Varieties having significant different among leaf area among different varieties have been shown in Table 4. Many non-significant response have been received. But only significant result are shown in the table.

Table 5: Area within each variety of Okra

<table>
<thead>
<tr>
<th>Difference</th>
<th>Lower</th>
<th>Upper</th>
<th>p adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super Green: Middle-Ambika: Lower</td>
<td>6.556</td>
<td>11.973</td>
<td>0.0049</td>
</tr>
<tr>
<td>Ambika: Upper-Ambika: Lower</td>
<td>5.667</td>
<td>11.084</td>
<td>0.0313</td>
</tr>
<tr>
<td>Sabz Pari: Upper-Ambika: Lower</td>
<td>9.444</td>
<td>14.862</td>
<td>0.0000</td>
</tr>
<tr>
<td>Super Green: Upper-Ambika: Lower</td>
<td>10.667</td>
<td>16.084</td>
<td>0.0000</td>
</tr>
<tr>
<td>Rama Karishna: Lower-Arka Anamika:Lower</td>
<td>-5.556</td>
<td>-0.138</td>
<td>0.0387</td>
</tr>
<tr>
<td>Sabz Pari: Upper-Arka Anamika: Lower</td>
<td>6.111</td>
<td>11.529</td>
<td>0.0128</td>
</tr>
<tr>
<td>Super Green: Upper-Arka Anamika: Lower</td>
<td>7.333</td>
<td>12.751</td>
<td>0.0008</td>
</tr>
<tr>
<td>Sabz Pari: Lower-Rama Karishna: Lower</td>
<td>5.778</td>
<td>11.195</td>
<td>0.0252</td>
</tr>
<tr>
<td>Rama Karishna: Middle-Rama Karishna: Lower</td>
<td>5.778</td>
<td>11.195</td>
<td>0.0252</td>
</tr>
<tr>
<td>Sabz Pari: Middle-Rama Karishna: Lower</td>
<td>6.444</td>
<td>11.862</td>
<td>0.0063</td>
</tr>
<tr>
<td>Super Green: Middle-Rama Karishna: Lower</td>
<td>8.778</td>
<td>14.195</td>
<td>0.0000</td>
</tr>
<tr>
<td>Ambika: Upper-Rama Karishna: Lower</td>
<td>7.889</td>
<td>13.307</td>
<td>0.0002</td>
</tr>
<tr>
<td>Arka Anamika: Upper-Rama Karishna: Lower</td>
<td>5.889</td>
<td>11.307</td>
<td>0.0202</td>
</tr>
<tr>
<td>Rama Karishna: Upper-Rama Karishna: Lower</td>
<td>7.444</td>
<td>12.862</td>
<td>0.0006</td>
</tr>
</tbody>
</table>
The results of the infested and uninfested leaves were in accordance with the results of Mandal et al. [12] and Bhat et al. [13] who also found that the infested leaves had low vigor with respect to the non-infested leaves.

### Conclusion

It is evident from the current study that variety Arka Amika was most resistant varieties and variety Ambika was most susceptible one based on the *Amrasca biguttula biguttula* population. Interaction of the pest population with hair density was negative and leaf area interaction to the population of jassid calculated positive.

### References