Genetic analysis of fruit and shoot borer (Earias vittella Fab.) resistance in okra (Abelmoschus spp.)

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ABSTRACT: Four okra varieties viz., Arka Anamika, Salkeerthy, Sel 2 and KL 9 of cultivated species Abelmoschus esculentus, and two varieties viz., Susthira and AC5 of semi-domesticated species Abelmoschus caillei were crossed in all possible combinations. The parents and hybrids were evaluated for resistance against fruit and shoot borer, Earias vittella Fab. Differential response to fruit and shoot borer infestation was observed in all genotypes. The study revealed that the parents AC 5 and KL 9 are the potential donors of shoot and fruit borer resistance. Selection of genotypes with short growth habit, short flowering period and short fruit length will help to minimize the shoot and fruit borer infestation. Arka Anamika was identified as a good donor parent in breeding for fruit number, fruit weight and fruit length. The hybrid obtained by Sel 2 x AC5 cross was identified with high marketable fruit yield and resistance to fruit and shoot borer, and field tolerance to Yellow Vein Mosaic Virus.

Keywords: Abelmoschus esculentus, Earias vitella, okra, host plant resistance

INTRODUCTION
Shoot and fruit borer, Earias vittella is a major pest of okra which causes severe damage affecting both quantity and quality of yield. As okra is grown in an area of three lakh ha with an annual production of 32 lakh tonnes in India (NHB, 2005), it is of a prime importance to reduce the damage caused by this pest. Resistant varieties are preferred, because the use of pesticides will cause the residual problems as it is harvested and consumed as tender pods. The regular and indiscriminate pesticide usage will results in the development of resistance in insects, resurgence and environmental pollution (Suneetha et al., 2007). Because of these factors an emphasis is always being given to develop insect resistant varieties. The improvement of the varieties is an effective way to reduce the losses in the crop. For a successful breeding programme, screening the available germplasm for resistance source and to combine the identified resistance to the existing high yielding varieties is necessary. Therefore, the present study was undertaken to introgress the resistance contributing traits with high yield and also to study the genetics behind fruit and shoot borer resistance attributes.

MATERIALS AND METHODS
The present research work was conducted at the Department of Plant Breeding and Genetics, College of Horticulture, Kerala Agricultural University, Vellanikkara. The experimental materials included three high yielding varieties (Arka Anamika, Salkeerthy and Susthira) and three resistant genotypes (KL 9, Sel 2 and AC 5) which were previously evaluated (Karuppaiyan, 2006) and were crossed in all possible combinations. The whole research work was conducted to effect crosses between resistant and high yielding parent to develop advanced generations like F1, F2, BC1 and BC2. Six generation materials (Parents, F1, F2, BC1 and BC2) selected F1 lines of other crosses were evaluated against shoot and fruit borer and other yield attributes along with check variety. The parents and F1 s were raised in green houses and the selfing and backcrossing of the F1 s were done with corresponding parents. F2 s and six generations of two selected crosses (Sel 2 x AC5 and KL9 x Salkeerthy) were raised in open field condition in randomized block design (RBD) with four replications. Recommended package of practices of KAU was followed to grow a successful crop of okra. The crop was left open for natural infestation by fruit and shoot borer and no pesticides were sprayed. Fruit borer susceptible variety Salkeerthy was raised in border rows.

Observations were recorded from five randomly selected plants from each replication and they were evaluated for yield attributes and resistance to fruit and shoot borer when there was maximum damage observed in the susceptible check variety. Biochemical and statistical analysis were employed to understand the genetics of various characters. The relative degree of resistance to shoot and fruit borer infestation was judged on the basis of percentage shoot and fruit infestation in each genotype. The genotypes were grouped into five resistance classes based on their shoot and fruit
infestation *i.e.*, i) immune (0 per cent infestation), ii) highly resistant (1-10 per cent shoot or fruit infestation), iii) moderately resistant (11-20 per cent infestation), iv) susceptible (21-30 per cent infestation) and v) highly susceptible (>31 per cent infestation) (Kumbhar *et al*., 1991) and it was adopted in the present study.

**RESULTS AND DISCUSSION**

The donor parents used in the study were previously reported to have fruit and shoot borer resistance by Karuppaiyan (2006). Considering the cross compatibility of cultivated high yielding varieties, the resistant donor are preferably selected over wild resistant genotypes. The performances of genotypes were assessed in the open field condition, comparing the percentage of shoot infestation, fruit infestation, days to first flowering, plant height, internode length, fruit number per plant, fruit weight, fruit length, fruit yield per plant and marketable fruit yield (Tables 1). High variability was observed for shoot infestation and fruit infestation in F$_2$ generation of intervarietal crosses. High genetic advance, genetic gain and heritability were recorded for shoot infestation and fruit infestation indicated that selection can be resorted for the improvement of these characters. Positive association of fruit yield with number of fruits, number of internodes, fruit weight and fruit length leads to the conclusion that selection of these traits along with short growth habit, short flowering period and short fruit length will minimize the economic damage.

Generation mean analysis of Sel 2 x AC5 indicated the presence of complementary epistasis for fruit infestation. As these traits with high dominance variance are non fixable, selection for this traits is ineffective. Therefore heterosis breeding programme will be useful for improving these traits. In the inter varietal cross KL9 x Salkeerthy it was observed that duplicate epistasis govern the fruit borer resistance and digenic non-allelic interaction model was inadequate to explain shoot borer infestation. These results are in agreement with those of Akhtar *et al*. (2010) and Sogalad *et al*., (2012). The selected F$_1$'s and genotypes of generation mean analysis of Sel 2 x AC 5 and KL9 x Salkeerthy were screened for pest infestation in open field conditions with susceptible variety in border rows to raise the pest population for better screening. The mean infestation data was used for the classification. Based on the rating scale given by Kumbhar *et al*. (1991) the genotypes were classified for degree of resistance. Twenty seven genotypes of different crosses and different generations are screened in the present study. The study revealed that F$_1$'s of Susthira x Sel 2, Susthira x AC 5, Sel 2 x Arka Anamika, Arka Anamika x Sel 2, Arka Anamika x Sal and Arka Anamika x KL9 were found immune to shoot borer but none of them were immune to fruit borer (Table 2). AC5 and KL9 x AC5 were highly resistant to shoot borer and F$_1$ of Sel 2 x AC5 was highly resistant to fruit borer.

The F$_1$, F$_2$ and BC$_1$ generation of Sel2 x AC 5 were also moderately resistant to shoot borer. No genotype was immune to fruit borer. AC5 has shown minimum shoot infestation among the parents. In case of fruit infestation F$_1$ of Sel 2 x AC 5, F2 s of KL9 x Sel 2 and Susthira x Sel 2 shown high resistance or low infestation. KL 9 x Sel 2 (11.76 per cent), Susthira x Sel 2 (14.2 per cent) and KL 9 x Susthira (20 per cent) showed less than 20 per cent fruit infestation hence treated as moderately resistant to fruit borer. Among the F$_2$ s of Arka Anamika x KL9, Arka Anamika x Sel 2, Sel 2 x Arka Anamika, Susthira x AC5 and Salkeerthy was found highly susceptible for both shoot borer and fruit borer infestation. Susthira x Sel 2. In case of marketable fruit yield KL9 x Susthira secured the highest. The susceptibility of many cultivated varieties to fruit borer was previously reported by Vyas and Patel (1991), Srinivasa and Sugeetha (2001), and Neeraja *et al*. (2004).

It is evident from the result that the progenies of resistant parents have shown preferable traits for further selection. These results are consistent with the findings of workers like Bairwa *et al*. (2005) and Karuppaiyan (2006). It was observed that there is a differential response to fruit and shoot borer infestation in all genotypes while the pest causing the damage was same. It may be because of some morphological and biochemical variation between the fruit and shoot of the same genotype and due to variation in insect preference and their interactions. The F$_1$ of Sel 2 x AC 5 was found having high resistance to both fruit borer (highly resistant) and shoot borer (moderately resistant) compared to all other genotypes under study. This genotype scored comparatively high fruit yield (163.11 g) and marketable fruit yield (152.41g) (Table 3) and its F$_2$ has shown field resistant to yellow vein mosaic virus also. Therefore this cross was identified as an elite genotype with both high yield and pest resistance and advanced to further generations. Even the fruit yield was highest in *A. esculentus* genotypes but the yield loss was minimum in *A. caillei* due to less susceptibility to pest and diseases. The F$_2$ generations of interspecific crosses of *A. caillei* and *A. esculentus* have shown less coefficient of infection for Yellow Vein Mosaic Virus and Salkeerthy and its progenies were highly susceptible to
Table 1. Mean performance of F₂ progenies and the parents in natural field condition

<table>
<thead>
<tr>
<th>F²</th>
<th>Pht</th>
<th>FN</th>
<th>Nr</th>
<th>FW</th>
<th>FY</th>
<th>FL</th>
<th>SI</th>
<th>FI</th>
<th>FG</th>
<th>Flp</th>
<th>MFY</th>
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<td>5.00</td>
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<td>203.00</td>
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<td>18.18</td>
<td>27.50</td>
<td>8.50</td>
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<td>5.00</td>
<td>42.50</td>
<td>238.00</td>
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<td>18.18</td>
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<td>30.00</td>
<td>144.00</td>
<td>20.00</td>
<td>16.66</td>
<td>20.80</td>
<td>6.00</td>
<td>29.85</td>
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<td>50.00</td>
<td>170.00</td>
<td>21.90</td>
<td>20.00</td>
<td>11.76</td>
<td>7.50</td>
<td>26.27</td>
<td>150.08</td>
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<td>8.00</td>
<td>60.00</td>
<td>228.00</td>
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<td>144.04</td>
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<td>5.00</td>
<td>47.50</td>
<td>237.50</td>
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<td>20.00</td>
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<td>25.96</td>
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<td>P1 x P2</td>
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<td>5.00</td>
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<td>6.00</td>
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<td>5.00</td>
<td>40.00</td>
<td>152.00</td>
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<td>7.50</td>
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<td>6.50</td>
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<td>5.00</td>
<td>50.00</td>
<td>190.00</td>
<td>15.60</td>
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<td>80.00</td>
<td>7.50</td>
<td>32.33</td>
<td>38.00</td>
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**MEAN**

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<tr>
<th></th>
<th>Pht</th>
<th>FN</th>
<th>Nr</th>
<th>FW</th>
<th>FY</th>
<th>FL</th>
<th>SI</th>
<th>FI</th>
<th>FG</th>
<th>Flp</th>
<th>MFY</th>
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<td></td>
<td>52.74</td>
<td>4.48</td>
<td>5.46</td>
<td>42.50</td>
<td>191.80</td>
<td>17.21</td>
<td>11.72</td>
<td>30.87</td>
<td>7.01</td>
<td>28.91</td>
<td>130.38</td>
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</table>

**SD**

|         | 14.85 | 1.15 | 0.91 | 8.39 | 54.35 | 4.59 | 11.36 | 16.12 | 0.83 | 1.93 | 45.63 |

**VARIANCE**

|         | 220.76 | 1.33 | 0.83 | 70.53 | 2953.95 | 21.14 | 129.07 | 259.94 | 0.70 | 3.74 | 2082.78 |

**CD at 5 %**

|         | 21.49 | 1.67 | 1.32 | 12.15 | 78.63 | 6.65 | 16.43 | 23.32 | 1.21 | 2.79 | 66.02 |

**CD at 1 %**

|         | 16.81 | 1.30 | 1.04 | 9.50 | 61.49 | 5.20 | 12.85 | 18.24 | 0.94 | 2.18 | 51.63 |

**Notes:**
- **P1** - Arka Anamika (A.A)
- **P2** - KL9
- **P3** - Salkeerthy (Sal)
- **P4** - Sel 2
- **P5** - Susthira (Sus)
- **P6** - AC5
- Dff - Days to first flowering
- Pht - Plant height (cm)
- FN - Fruit number / plant
- FW - Average fruit weight (g)
- FL - Fruit length (cm)
- FG - Fruit girth (mm)
- FY - Fruit yield (g) / plant
- MFY - Marketable fruit yield (g)
- Nr - Number of ridges per fruit
- SI - Shoot infestation (%)
- FI - Fruit infestation (%)
- Flp - Flowering period (days)

Values in bold and underlined refer to the minimum and maximum respectively.
<table>
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<th>Category</th>
<th>In terms of shoot damage</th>
<th>In terms of fruit damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immune (0% infestation)</td>
<td>Susthira x Sel 2, Susthira x AC 5, Sel2 x Arka Anamika,</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>Arka Anamika x Sel2, Arka AnamikaxSal, Arka AnamikaxKL9</td>
<td></td>
</tr>
<tr>
<td>Highly resistant (1-10%)</td>
<td>AC5, KL9xAC5</td>
<td>Sel 2xAC5 (F₁)</td>
</tr>
<tr>
<td>Moderately resistant (11-20%)</td>
<td>Sel 2xSal, KL9xSel 2, SalxKL9, SalxArka Anamika,</td>
<td>KL 9 x Sel 2, Sal x Susthira,</td>
</tr>
<tr>
<td></td>
<td>SalxSusthira, Sel 2xAC5 (F₁, F₂, BC₁), KL 9 x Sal (F₁, BC₂)</td>
<td>KL 9 x Sal (F₁, BC₂)</td>
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<tr>
<td>Susceptible (21-30%)</td>
<td>KL 9 x Susthira, KL 9, KL 9 x Sal (BC₁), Sel 2 x AC 5 (BC₂)</td>
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<tr>
<td></td>
<td></td>
<td>xKL9, Arka Anamika x Sal,</td>
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<td></td>
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<td>Susthira x AC5, Sel 2xAC5(BC₂),</td>
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<td>KL 9 x Sal (F₁, F₂, BC₂)</td>
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<td>Highly susceptible (&gt;30%)</td>
<td>Salkeerthy</td>
<td>Salkeerthy, SalxArka Anamika,</td>
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<td>KL9xAC5, Arka Anamika x Susthira,</td>
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<td>Arka AnamikaxSel 2, Sel 2xSal, Sel</td>
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<td>2xAC5, BC₂)</td>
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Table 3. The resistance and yield related traits of genotypes

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<th>Genotype</th>
<th>%SI</th>
<th>%FI</th>
<th>FY</th>
<th>MFY</th>
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<td>147.17</td>
<td>Sel2 x AC5</td>
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<td>26.80</td>
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<td>31.50</td>
<td>238.00</td>
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<td>20.80</td>
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<td>114.04</td>
<td>P2</td>
<td>14.75</td>
<td>18.88</td>
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<td>170.00</td>
<td>150.08</td>
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<td>12.78</td>
<td>4.25</td>
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<td>BC2</td>
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<td>80.00</td>
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</table>

Per cent shoot infestation (%SI), Per cent fruit infestation (%FI), Marketable fruit yield (MFY), fruit yield (FY)
YVMV. These were previously observed by and Karuppaiyan (2006) and Kousalya et al. (2006) and they reported that A. caillei was highly resistant to YVMV. Presence of biochemical factors like high phenol and tannin content in the fruits and shoots of resistant genotypes compared to susceptible genotypes indicated that the biochemical constituents play a role in fruit and shoot borer resistance. The study revealed that The F₁ hybrid of Sel 2 x AC5 identified as the best hybrid for both high marketable fruit yield and resistance to fruit and shoot borer, and it also showed field tolerance to Yellow Vein Mosaic Virus. The present research work reveals that the parents AC 5 and KL 9 are the potential donors of shoot and fruit borer resistance. But many of the crosses using parent AC 5 (Abelmoschus caillei) genotype were not successful. Crossing barriers like cross incompatibility and hybrid sterility was found in the generation of F₁ plants of interspecific crosses involving A. caillei and A. esculentus genotypes. Embryo culture and genetic engineering methods are suggested in future to minimize the constrains in the gene transfer between these species and this will open new avenues for further research. Secondly promising F₁s like Sel 2 x AC 5, KL 9 x Salkeerthy (resistant high yielding genotypes) and other outstanding genotypes from the breeding lines can be further advanced to obtain elite varieties with desirable economical characters.

REFERENCES


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