CHAPTER VIII
INVESTIGATIONS ON THE RED LEAF DISEASE IN AMERICAN COTTONS

(a) General

The reddening of leaves and the bad opening of bolls are the common symptoms of physiological disorder that are exhibited by the American cotton plants. Investigations conducted on these two physiological diseases have revealed that the same two symptoms can develop on account of quite different and distinct causes. It has been demonstrated (Jasur, 1943) that the bad opening of bolls or 'Jink' occurred in the Punjab and Sind on account of two different causes viz., deficiency of nitrogen and water starvation. These two conditions generally prevailed on soils of different chemical and physical composition. Similarly, the yellowing and subsequent reddening of leaves in the American cottons in the Punjab occurred as a result of depletion of nitrogen from the leaves at the time of maturity (Jasur, 1940 and Jasur and Kewar Singh, 1947). On nitrogen deficient soils this was a common symptom exhibited by the American cotton crop. The development of yellowing and reddening of leaves on light sandy land could either be prevented or delayed by the application of nitrogen in any form. It is the object of this investigation to show that the cases that produced leaf reddening in American Upland cottons grown under rainfed conditions in American cotton growing tracts of India are
entirely different from those that mentioned for the Punjab and Sind. The causes that bring about reddening in the Malwa tract are also different from the causes that produce leaf reddening in the Deccan Karnataka.

The reddening of leaves in Kanpur American cottons was reported by Burt/Haider (1919) from the United Provinces and by Kottur (1920) from Dharwar and by Prayag (1927-28) from Khandesh. It was found to be present by Sawinay (1932) in the Deccan Hyderabad and by Rao and Jad (1936) in the Central India. Thus it was a disease appearing in many parts of India where American cottons were grown.

The red pigment in the leaves of American Uplands is also found to develop as a result of injury caused by Jassids. The injury caused death of leaf tissues and the red pigment developed subsequently. The physiological reddening and the reddening caused by Jassids are invariably mixed up. This investigation was undertaken to determine the causes of the leaf reddening that occurs in the absence of Jassid injury.

At Indore, the leaf reddening occurred at the time of boll formation while at Gadag it appeared at the stage of bud formation. It, therefore, appeared at an earlier stage at Gadag than at Indore. At Indore, the reddening persisted up to the end of the season while at Gadag it declined as the newly formed leaves did not turn red and the older leaves were shed.
Thus there appeared to be fundamental differences between the nature and the causes that give rise to leaf reddening in the two tracts.

The investigation was conducted at Indore in Malwa and the cotton crop was sown with rains in June-July.

(b) The effect of manuring on leaf reddening.

Some important observations regarding the appearance of the red leaf in American Upland cottons grown in different sowing date-manual experiments from 1945 to 1947 threw light on the causes of the red leaf blight that appeared at Indore. The reddening generally occurred in this tract at the fruiting stage i.e., in October-November. It is the stage at which the demand for elaborated food materials is greatest and the leaves rapidly began to be depleted of food bringing about their senescence. It was invariably observed that the plots that had received a dressing of sulphate of ammonia were the first to show the leaf reddening. The reddening in the ammonium sulphate plots appeared two to three weeks earlier than the control plots. Thus application of sulphate of ammonia unlike Punjab and Sind hastened reddening.

The early reddening of the crop in the manured plots was also found to be associated with an early maturity. The plots that received the sulphate of ammonia matured earlier by 10 to 15 days than the plants in the unmanured plots. This fact of early maturity in the manured plots was verified by
determining the index of earliness by using Bartlett's formula in a factorial experiment comprising of 4 levels of nitrogen, 3 levels of potash and 3 levels of phosphoric acid. The index of earliness for each level of nitrogen is given below; the higher value of index indicates comparatively early maturity.

Table XXXIX

<table>
<thead>
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<tbody>
<tr>
<td>Percentage of 1st picking to total</td>
<td>49.4</td>
<td>68.8</td>
<td>61.1</td>
<td>60.8</td>
<td>±0.73</td>
</tr>
</tbody>
</table>

The crop matured earlier in the manured plots (by about 10 percent in the first picking) and higher doses of nitrogen did not further make the crop early.

In the same experiments NP plots turned red earlier than nitrogen plots while the reverse was the case with NK plots.

It is clear that early maturity brought about early senescence of the leaves on account of early depletion of food materials from the leaves and consequently the reddening appeared early in the manured plots. Thus both the facts viz., appearance of the red leaf at the crop maturation stage and hastening of maturity and consequently of reddening by manuring suggested depletion of food materials from the leaves which became senescent and turned red.
It is at this stage that the temperatures drop in Malwa below 70°F and this is supposed to be a temperature favourable for the formation of anthocyanin pigments.

The application of sulphate of ammonia was also found to hasten maturity in the case of arboreum cottons grown at Indore and herbaceum cottons at Surat but the leaves of these cottons did not show reddening as in the case of hirsutum types.

(c) The effect of debudding the plants on leaf reddening.

In order to confirm experimentally that the reddening of leaves was related to maturation of the crop in the black cotton soils under rainfed conditions, it was undertaken to study the effect of preventing the crop from reaching normal maturity by artificial means on leaf reddening. This object was attained by weekly removal of buds and flowers from the time of their appearance. The crop was thus maintained in the vegetative stage. Ten plants were debudded in an experiment where sulphate of ammonia and ammonium phosphate were kept as treatments in 1947 season. The debudding was started from 20th August in the control as well as in plots treated with sulphate of ammonia and ammonium phosphate while ten plants were allowed to fruit normally in the same three treatments. Indore I was the variety used. The plants in which fruiting was allowed to occur, leaf reddening started in November. Manured plants began to show reddening a fortnight
earlier. Leaf reddening did not occur (except in the case of very old leaves) in the debudded plants until the end of the season in all treatments. The tops remained green in colour as the bolls were not produced and consequently the leaves did not get depleted of food materials.

This experiment was repeated in 1948 on a larger scale. Four plots measuring 12' x 40' were set apart for this investigation. The crop of Indore I was sown on 21st June. Two plots were kept as controls and two plots were debudded from 18th August. The leaf reddening appeared as usual in the control plots in the last week of October. The reddening did not appear in the debudded plots except in isolated patches on the older leaves.

(d) The behaviour of different strains of American Uplands.

It will be shown later that when Indore cottons were grown at Gadag they showed Gadag type of leaf reddening which appeared early at the stage of bud formation and which became less and less as the crop matured. Similarly, when Gadag cottons were grown at Indore, they showed Indore type of leaf reddening.

So far the results obtained were qualitative. In the meanwhile, a quantitative method of measuring the red blight index was worked out and all the conclusions discussed above were tested.
(e) Method of measuring red leaf index.

Leaf reddening is a general term which does not signify the extent of leaf reddening. It was necessary to find out a method by which a rough idea in quantitative terms of the degree of leaf reddening could be obtained for scientific study. The basis of this method is the number of leaves showing signs of reddening at a given date. A leaf turned red partly or wholly is taken as the one that suffered from this disease. The plants were divided into five categories or grades. When all leaves were green or less than three leaves showed signs of reddening it was taken as zero grade. Grade 1 was taken when three leaves showed reddening. Grade 2 was taken when more than three leaves were attacked by the red leaf but young leaves were green. Grade 3 was taken when all the leaves showed reddening in patches. When the whole plant turned red it was taken as grade 4.

The plants were selected at random and graded as shown above from each subplot of an experiment. Ten plants were taken in each case and if there was one plant of grade 1 amongst ten plants, the red leaf index was taken as 0.1. If there were two plants one of grade 1 and the other of grade 2, the mean red leaf index for ten plants would be 0.3. These values are given in the following pages and they can be expressed in percentage by shifting the decimal point.
Quantitative determination of red leaf index in a complex experiment.

An experiment comprising of all combinations of three varieties (Indore I, Laxmi and Gadag I), two levels of nitrogen (0, 50 lb., N) and two treatments (control and defruiting) was laid out in the cotton season of 1950-51 at Indore. The crop was planted on 10th July. Gadag I was so severely damaged by jassids that the plants remained small and stunted and consequently the red leaf blight index of this variety came out to be very low.

The following Table gives the red leaf blight index at weekly intervals in the three varieties, the mean of three varieties in the control and manured plots and the average of the control and defruited plants.

**Table XL**
The red leaf blight index at weekly interval

<table>
<thead>
<tr>
<th></th>
<th>Indore I</th>
<th>Laxmi</th>
<th>Gadag I</th>
<th>Control</th>
<th>Manured</th>
<th>Control</th>
<th>Defruited</th>
</tr>
</thead>
<tbody>
<tr>
<td>17th Oct.</td>
<td>0.04</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.02</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>24th Oct.</td>
<td>0.09</td>
<td>0.05</td>
<td>0.05</td>
<td>0.10</td>
<td>0.07</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>21st Nov.</td>
<td>0.45</td>
<td>0.37</td>
<td>0.37</td>
<td>0.56</td>
<td>0.37</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>28th Nov.</td>
<td>0.59</td>
<td>0.38</td>
<td>0.39</td>
<td>0.56</td>
<td>0.45</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>5th Dec.</td>
<td>0.74</td>
<td>0.44</td>
<td>0.45</td>
<td>0.62</td>
<td>0.56</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>12th Dec.</td>
<td>0.81</td>
<td>0.49</td>
<td>0.48</td>
<td>0.74</td>
<td>0.61</td>
<td>0.31</td>
<td></td>
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<tr>
<td>19th Dec.</td>
<td>0.87</td>
<td>0.53</td>
<td>0.52</td>
<td>0.82</td>
<td>0.65</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>26th Dec.</td>
<td>0.91</td>
<td>0.54</td>
<td>0.54</td>
<td>0.91</td>
<td>0.69</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>2nd Jan.</td>
<td>0.95</td>
<td>0.57</td>
<td>0.57</td>
<td>0.95</td>
<td>0.73</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>9th Jan.</td>
<td>0.99</td>
<td>0.59</td>
<td>0.59</td>
<td>0.99</td>
<td>0.77</td>
<td>0.36</td>
<td></td>
</tr>
</tbody>
</table>

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S.S. | 0.101 | 0.123 | 0.123
The following are the main conclusions confirming the previous findings.

The red leaf blight appeared towards the end of October in all varieties i.e., at the fruiting stage. Thus Gadag cottons also showed Indore I type of red leaf. Laxmi suffered significantly less from the red leaf than Indore I. Laxmi is known to be a red leaf resistant variety. The red leaf blight increased as the season advanced in the case of all varieties.

Manuring with sulphate of ammonia significantly increased the reddening of leaves in all varieties. The manured plants showed leaf reddening a fortnight earlier than the unmanured plants.

The red leaf index was significantly less in the defruited plants than in the control plants.

(g) Causes of red leaf in Malwa.

When the fruiting season sets in there is a rapid depletion of food materials from the leaves and this is accompanied by the death of the tissues of the leaves. Even in a normal leaf some cells scattered over the entire area are non-functioning. This is more so at the tips and marginal region than in the central regions. The first stage that precedes the death of cells is the decomposition of the green pigments which provide the basic material for the formation
of anthocyanin substances. These products are not, however, converted into anthocyanin until there is a drop in temperature below 70°F. As soon as the night temperatures begin to fall in the month of October the anthocyanin substances begin to be formed and the red patches first appear in the older leaves. As the cell sap of the epidermal cells is acidic the anthocyanin substances turn red. These patches increase in area as the season advances. The same phenomenon later appears in the young leaves, which rapidly become senescent on account of the rapid depletion of food material. When the cotton plants are debudded the upper leaves remain functioning for a longer time and the decomposition of green pigments does not occur. Consequently, the substances that go to form anthocyanin are not produced even though the temperature conditions become favourable for production of pigment.

The application of ammonium sulphate is found to hasten maturity bringing about earlier senescence in the leaves, and consequently the reddening occurs as soon as the temperature drops.

The internal factors and the external factors of temperature operate together in producing reddening at Indore. If decomposition of green pigments does not occur the fall of temperature would not produce reddening and vice versa. This is why some leaves or some parts of leaves are green or red as the case may be.

It may be mentioned here that this was not the only
combination of factors that produced the red leaf. It may be produced by any other combination of factors in other tracts or in different plants. The above combination only holds good for the development of the red leaf in hirsutum cottons grown under Malwa conditions.