STUDIES IN THE DISEASES OF MANGIFERA INDICA LINN.

I. Preliminary Observations on the Necrosis of the Mango Fruit with Special Reference to the External Symptoms of the Disease

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Introduction

The mango (Mangifera indica Linn., Fam. Anacardiaceae) is an important fruit tree of India which is cultivated in most of the provinces of the country. Until recently very little interest was taken either by the Government or by the growers to raise improved varieties or to improve the mango cultivation. In recent years thanks to the enterprise of the Imperial Council of Agricultural Research and of the agriculture departments, the mango cultivation is receiving a very strong impetus particularly in Bihar and in the United Provinces. Considering the importance of the fruit, however, the investigations carried out in India on the diseases of mango are extremely meagre. In this and subsequent papers of this series it is intended to deal with the diseases to which the mango tree and the mango fruit are susceptible.

This paper which is the first of the series deals exclusively with our preliminary observations on the necrosis of the mango fruit with particular reference to the external symptoms of the disease. The work is only in its initial phase but the authors venture to publish the results with the hope that the disease will attract the attention of other scientific workers who might be in a position to collect information regarding the disease in their respective provinces and localities. Co-operation of scientists all over India is required to get a correct estimate of the incidence and extent of the disease and the financial loss involved.

The necrosis of the mango fruit is definitely known in two of the most important mango-growing provinces of India, namely, Bihar and the United Provinces. It most probably occurs in Bombay and Bengal, and we venture to think that proper investigation will prove the existence of the disease in other mango-growing provinces as well.

The occurrence of the necrosis must have been observed long before it was actually recorded. So far as the writers are aware the first record of
the disease is from Bihar; it was made in the year 1908 by Woodhouse* (1909), the then Economic Botanist to the Bihar Government. He writes, "Round Bhagalpur mangoes do not seem to be much affected by disease, but this year much fruit is said to have been spoiled at the Sabour Farm by the smoke from the brick-kilns which apparently blacken the apex of the mango and interferes with its development." (The italics are ours.) The disease has also been referred to by Naik (1934) in a Hindi agricultural journal, by Allan (1936) and by Pal and his colleagues (1937).

In the United Provinces the disease was first observed in the year 1923 when reference was made to Mr. P. K. Dey, the Plant Pathologist to the U.P. Government. Since then the disease is apparently increasing at a tremendous rate, as judged from the enquiries and complaints received from orchard owners every year.

The occurrence of the necrosis of the mango fruit and the extent of financial loss caused by the disease can be ascertained by means of an intensive and extensive survey of the mango-growing areas in different provinces by men thoroughly acquainted with the symptoms of the disease. It is a task that can be carried out only with the active co-operation of the agricultural departments and botanical institutions of different provinces. No such attempt has yet been made in any province even where the disease is quite prevalent.

In the United Provinces the disease goes by the popular name of Koeli. But the term includes two different diseases altogether. One is the necrosis in which the blackening and the disintegration of the tissue invariably starts from the apex of the fruit, and from nowhere else, long before the mango is ripe; the other in which the dark spots appear in any part of the skin of the fruit, including the apex. The two diseases are entirely different in character, still they are confused by the villagers from whom information regarding the prevalence of the disease in preceding years, and the first incidence of the disease in the locality, are usually taken. While surveying, therefore, it is necessary to exercise the utmost caution in accepting the opinions of the villagers. They are better left out of consideration altogether unless their descriptions are substantiated by facts.

The authors carried out a detailed survey of the disease in a number of orchards in the neighbourhood of Lucknow situated on Kursi Road, Barabanki Road, Sitapur Road, Malihabad Road and Malihabad proper during the mango season of 1937. The number of orchards kept under

* The authors' thanks are due to Dr. T. C. N. Singh, D.Sc. (Luck.), Assistant Economic Botanist to the Bihar Government, for the reference.
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observation was twelve, and of these three were utilised for special work regarding the necrosis. All these orchards contained the most superior qualities of mangoes that are grown in the United Provinces. For example, Dasehri, Safeda, Gola-Mohanbhog, Fazli and others. All these are "graft" mangoes. In the Kapurthala garden, however, there are a number of Tukhmi† mango trees which were also included in our observation. These orchards are well kept and well cared for. Although as many as twelve orchards were kept under observation the number is insignificant in comparison with the total number of orchards in Lucknow and other important mango-growing centres in the United Provinces, namely, Unao, Cawnpore, Hardoi, Farrukhabad, Bareilly, Rampur, Moradabad, Saharanpur, Dehra Dun, Bulandshahar, Gorakhpur and Benares, etc. Nevertheless the results obtained from the survey cannot be ignored and the further information that we expect to get in the mango season of 1938 will supplement and not supplant the result obtained last year.

The following are the three orchards kept under special observation.

<table>
<thead>
<tr>
<th>Name by which orchard is referred in the text</th>
<th>Location</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kapurthala</td>
<td>2nd mile, Kursi Road, Aliganj, Lucknow</td>
<td>Kapurthala State</td>
</tr>
<tr>
<td>2. Bahadurpur</td>
<td>Off 4½ miles Kursi Road, Village Bahadurpur, Lucknow</td>
<td>Sheikh Abdur Rahman</td>
</tr>
<tr>
<td>3. Zahirpur</td>
<td>5 miles Kursi Road, Village Zahirpur, Lucknow</td>
<td>Mr. Devi Shanker Shukla</td>
</tr>
</tbody>
</table>

The Bahadurpur orchard was utilised for most intensive work and was normally visited twice every week and more often when necessity demanded.

Some difficulty was experienced with regard to the identification of the variety of mango in the orchard. Owing to the fact that in some cases no proper record was available reliance had to be placed on the names given by the gardener in charge of the orchard.

† Tukhmi [Tukhm=Seed (Persian)]. Growing from seed as opposed to graft. Fruit mostly fibrous.
Damage.—An attempt was made to ascertain the total percentage of mango crop damaged annually by necrosis in all the mango-growing provinces in India and in the United Provinces in particular by inviting figures from the agricultural and marketing departments. But no figures were available. This is due to the fact that there has been no organised survey in the affected provinces to collect information on the point.

The following few facts relate to the damage done in the orchards kept under our observation. It was seen that the necrosis occurred in all the orchards excepting those in Malihabad proper. The extent of damage in the affected orchards varied. Of the three special orchards mentioned the damage was most heavy in the Bahadurpur orchard where the entire crop was heavily infected. Dasehri suffered most, the damage being 100 per cent. The other varieties showed relatively less infection. The crop in the Kapurthala garden too, was heavily infected. Here again Dasehri showed cent. per cent. infection. Two varieties in this garden proved to be resistant. The damage was least in the Zahirpur orchard. It will be apparent from the above that the extent of damage in an orchard depends on the varieties grown. Orchards having the resistant varieties suffer the least. But the best varieties of mangoes are most susceptible. The question of varietal resistance is discussed elsewhere.

Financial Loss.—An attempt was also made to ascertain the financial loss due to the necrosis in the U.P. or elsewhere in India. But as in the case of the damage no figures were available. The authors had naturally to take resort to the reported financial loss sustained by the owners of the orchards under observation. The financial loss, it should be remembered, does not depend solely upon the amount of crop damaged but is dependent upon various other factors, namely, the total production, demand, etc., of the mango for the year under consideration.

The following figures as obtained from the orchard owners give only an approximate idea of the financial loss sustained by them.

Before the incidence of the disease the mango crop of Zahirpur orchard used to be sold for Rs. 700–Rs. 1,000 per year according to the amount of yield. Since the advent of the disease there was a marked drop in the income. The condition grew so bad that the orchard was abandoned. The condition of the orchard has improved lately. The disease is comparatively less severe and the crop last year was sold for Rs. 500.

The mango crop of Bahadurpur orchard used to be worth about Rs. 800–Rs. 1,000. Since the incidence of the disease the income has substantially decreased. Last year (1937) the crop was sold for Rs. 113 only. The crop
of the Kapurthala garden was sold for only Rs. 50 last year (1937). Its yield was relatively less than in other gardens.

Symptoms of the Necrosis

Altogether twenty-two varieties of mangoes, fifteen grafts and seven *Tukhmi*, from the Bahadurpur orchard and the Kapurthala orchard were kept under close watch to keep a complete record of the external symptoms of the disease from its very inception to the final stage. The symptoms are more or less the same for all the varieties that are affected with necrosis. The differences that exist are differences of degree only rather than anything of fundamental nature. The following is a description of the symptoms of the disease as found in Dasehri mangoes (Plate II, Figs. 2–12).

The first external symptom that heralds the incidence of the necrosis is the appearance of a small aetiolated area at the distal end of the mango fruit against the general green colour of the skin. The aetiolated area gradually increases in size and intensity and covers the entire tip. Generally, however, before complete aetiolation has taken place isolated greyish spots of indefinite outline make their appearance. The tip at that period assumes a dirty green colour—a mixture of yellow and green. As the disease progresses the spots become dark-brown, increase in size and finally coalesce to form a continuous necrotic area. This is the advanced stage of necrosis. Due to the decay of the tissue the necrotic portion collapses. At this stage the diseased mango fruit shows three distinct regions externally (Plate II, Figs. 6–9).

1. The healthy green part which constitutes the major portion of the fruit, towards the stalk end.
2. The necrotic part, a much smaller area than the former, at the distal end.
3. A narrow zone between the two major areas, which consists of the aetiolated skin.

The next stage in the development of the disease is complete disintegration of the pericarp and the mesocarp of the necrotic area exposing the flesh which shows a dark-brown colour. As more and more of the pericarp and mesocarp tissues disintegrate, the stone of the fruit emerges and remains protruding beyond the flesh. The protruding stone has a layer of collapsed tissue over it, the thickness of the layer depending upon the degree of disintegration the mesocarp tissue has undergone. The sequence of symptoms will be at once apparent from Plate II, Figs. 2–12.

The symptoms described above for the Dasehri variety are also shown by the Safeda and certain *Tukhmi* varieties. In the Gola-Mohanbhog, however, where the attack is less severe, the disease does not proceed beyond
the earlier stage (Plate II, Figs. 14–19). In this variety etiolation first makes its appearance at the distal end and is followed by brown spots which coalesce. There is no further advance of necrosis, and the disintegration of the tissue and the consequent emergence of the stone is not known to occur.

So far as our observations go the necrosis in Dasehri usually extends up to a sixth of the length of the fruit. In Safeda and the Tukhmi varieties usually a quarter of the fruit becomes necrotic. In other varieties such as Gola-Mohanbhog, etc., the disease is restricted to a very small area at the apex of the fruit. The authors have not yet come across any fruit of any variety where the necrosis claims the whole of the mango. This is likely to occur in specially favourable condition to the disease. The extent of damage in a given fruit must be directly proportional to the intensity of the disease. Although the whole mango may not become necrotic the apparently healthy portion—the portion which is not directly affected, loses the taste and becomes unfit for human consumption.

In many cases the disease is accompanied by Gummosis, that is, the exudation of drops of gums from the necrotic region. The amount of exudation varies not only with the varieties but also within a given variety. Gummosis is most copious in the Gola-Mohanbhog variety.

**Varietal Resistance to the Necrosis.**

In the Bahadurpur orchard and in the Kapurthala orchard altogether twenty-two varieties of mangoes, fifteen grafted and seven Tukhmi, were kept under observation. It was found that all the varieties were not affected to the same extent as judged from the percentage of fruit damaged. In the following table the grafted varieties are arranged in order of their susceptibility as found for the Bahadurpur orchard. It will be seen that in certain cases the same variety has been entered separately in Table II. This is done only in those cases where the apparently same variety growing in different orchards shows great difference in the extent of damage.

It will be seen from Table II that the Dasehri variety is most susceptible to the disease (100 per cent.). The fact has been repeatedly confirmed from our inspection of other orchards. If any variety is likely to be affected in a given orchard it is Dasehri. Of the other varieties in the Bahadurpur orchard Gola-Mohanbhog, Fazli and Langara come next in order, with an estimated loss of 90 per cent. Khajuri shows a loss of 75 per cent. and Amin, Safeda (Lucknow) and a certain Bombay variety about 50 per cent. Loss in the Malda variety is only 10 per cent. There is no completely immune variety in this orchard.
**TABLE II**

*Susceptibility of the Graft Varieties to Necrosis. Arranged in order of their susceptibility as found in Bahadurpur Orchard*

<table>
<thead>
<tr>
<th>Variety</th>
<th>Loss in percentage (approximate)</th>
<th>Bahadurpur orchard</th>
<th>Kapurthala orchard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dasehri</td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Langara</td>
<td></td>
<td>90</td>
<td>75</td>
</tr>
<tr>
<td>Fazli</td>
<td></td>
<td>90</td>
<td>.</td>
</tr>
<tr>
<td>Fazli</td>
<td></td>
<td>.</td>
<td>50</td>
</tr>
<tr>
<td>Gola-Mohanbhog</td>
<td></td>
<td>90</td>
<td>.</td>
</tr>
<tr>
<td>Khajuri</td>
<td></td>
<td>75</td>
<td>.</td>
</tr>
<tr>
<td>Khajuri (Bombay)</td>
<td></td>
<td>.</td>
<td>75</td>
</tr>
<tr>
<td>Khajuri</td>
<td></td>
<td>.</td>
<td>10</td>
</tr>
<tr>
<td>Amin</td>
<td></td>
<td>50</td>
<td>.</td>
</tr>
<tr>
<td>Sundari</td>
<td></td>
<td>50</td>
<td>.</td>
</tr>
<tr>
<td>Bombay</td>
<td></td>
<td>50</td>
<td>.</td>
</tr>
<tr>
<td>Bombay</td>
<td></td>
<td>.</td>
<td>10</td>
</tr>
<tr>
<td>Safeda (Lucknow)</td>
<td></td>
<td>50</td>
<td>.</td>
</tr>
<tr>
<td>Safeda (Malihabad)</td>
<td></td>
<td>.</td>
<td>10</td>
</tr>
<tr>
<td>Safeda (Narma)</td>
<td></td>
<td>.</td>
<td>nil</td>
</tr>
<tr>
<td>Malda</td>
<td></td>
<td>10</td>
<td>.</td>
</tr>
<tr>
<td>Kesari</td>
<td></td>
<td>.</td>
<td>20</td>
</tr>
<tr>
<td>Kalapahar</td>
<td></td>
<td>.</td>
<td>20</td>
</tr>
<tr>
<td>Tamburia</td>
<td></td>
<td>.</td>
<td>nil</td>
</tr>
</tbody>
</table>
The results obtained in the Kapurthala garden are somewhat different. The amount of damage on the whole is slightly less. The order in which the different varieties would be arranged according to the incidence of disease is also slightly different. There are two completely immune varieties, namely, *Safeda* (Narma) and *Tamburia*.

One more interesting point to be remembered in this connection is that not only is there a varietal difference in the resistance, but there is a sub-varietal difference as well. For example, in the Safeda different sub-varieties are susceptible to different degrees. Thus the Safeda (Lucknow) shows about 50 per cent. loss due to the disease, the Safeda (Malihabad) shows 10 per cent. loss while the Safeda (Narma) is completely resistant. Similarly among the three sub-varieties of the Khajuri, the loss is 75 per cent. in two sub-varieties and 10 per cent. in another.

The difference might be due to the fact that the conditions in the two orchards are not strictly comparable. Hence the same variety shows different degrees of damage in the Bahadurpur and Kapurthala orchards. It is not improbable, however, that different varieties are passing under the same varietal name. Or perhaps, there is a real difference in the susceptibility within the variety or again it might be an example of individual resistance.

There is a varietal difference in the resistance of the *Tukhmi* mangoes as will be evident from Table III.

**Table III**

*The Tukhmi Varieties arranged in order of their Susceptibility to the Necrosis (Kapurthala Orchard)*

<table>
<thead>
<tr>
<th><em>Name of Variety</em></th>
<th>Per cent. loss (a rough estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pautahia</td>
<td>75</td>
</tr>
<tr>
<td>Lambauri</td>
<td>75</td>
</tr>
<tr>
<td>Baheli</td>
<td></td>
</tr>
<tr>
<td>Sahtnia</td>
<td></td>
</tr>
<tr>
<td>Basaindha</td>
<td></td>
</tr>
<tr>
<td>Paharia</td>
<td></td>
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</table>

* The names were obtained from the gardener. Their correctness therefore cannot be vouchsafed.
It will be seen from Table III that among the Tukhmi mangoes Pautahia and Lambauri are susceptible and four other varieties are almost completely free from the disease.

An interesting fact was observed in this connection. The Tukhmi trees in the Kapurthala garden grow in pairs and the two members of each pair belong to a different variety, viz., Pautahia variety grows with Basaindha variety and Lambauri variety grows with Baheli variety. The first mentioned member of the pair is in each case susceptible. It is a conclusive proof of the varietal resistance to the necrosis, since in both the cases the members are growing in the identical edaphic and climatic conditions.

Probable Cause of the Disease

1. Parasitic Organism.—As the necrosis may well be caused by some parasitic organism like bacteria and fungi, attempts were made to isolate any organism that might be responsible for the disease. For this purpose portions of diseased tissue were taken and put into slants of various nutritive media and were kept at room temperature. Periodic isolations were attempted from diseased tissues of fruits of different varieties showing different degrees of rotting. More than 50 cultures were attempted each time but always with the identical result that no organism appeared in the culture. The disease does not seem to be due to a fungus or to a bacterium.

2. Virus.—Attempts were made to ascertain if the disease was due to virus by inoculating the diseased tissue into the healthy mango fruit growing on the tree, using the system utilized by Murphy and M'Kay (1926) for infecting the potato tubers with virus. By means of a cork-borer (diameter 6 mm.) a small plug of healthy tissue about 10 mm. in length and 6 mm. in diameter, was taken out from a healthy mango fruit and was replaced by a plug of the same length taken out from the diseased portion of a fruit by the next higher size cork-borer (diameter 7 mm.). The part was sealed with paraffin and vaseline mixed in a requisite proportion. All the operations were carried out in an aseptic condition. For the control, similar operations were made excepting that instead of the plug of the diseased tissue a plug of healthy tissue was inserted. The experiment was carried out only with the Safeda (Lucknow) since a sufficient number of healthy fruits was not available for the purpose of inoculation in any other variety. Altogether fifty fruits were inoculated and about the same number kept as control. The inoculation was carried on in the orchard and the fruits were allowed to remain on the tree. It was thought that any causal organism present in the diseased tissue would produce necrosis in the healthy part it was placed in contact with. No necrosis appeared. At a later stage, however, rotting due to a species of Mucor set in, both in the inoculated fruits and in the
controls. The organism must have come in as a contamination. More elaborate work on this aspect of the problem involving injection of healthy mango fruits with extracts from diseased tissue is in progress.

3. **Soil Condition.**—It seems unlikely that the soil condition should be responsible for the incidence of the disease. The disease is recorded in diverse localities where the soil conditions are different. And in the same orchards where the soil has been specially prepared and manured for the mango tree and has thus claim to a fair degree of uniformity, different varieties behave differently towards the disease. Further, it has already been pointed out that in the Kapurthala garden there are four *Tukhmi* trees, *viz.*, Pautahia, Lambauri, Basaindha and Baheli. Of these Pautahia and Basaindha grow in a pair whereas Lambauri and Baheli form another pair. Although growing in the identical soil conditions one of each pair is very susceptible to the necrosis, the other is not at all susceptible. Thus Pautahia and Lambauri are resistant and Basaindha and Baheli are susceptible. It is possible, however, that the soil condition plays a secondary rôle in the incidence of the disease.

4. **Vigour of the Tree.**—That the necrosis of the mango fruit is not due to the lack of vitality of the trees is quite apparent from our survey. Almost all the trees in the orchards under observation which showed necrosis were perfectly healthy. It was found, however, that the lack of vitality of the tree may be a contributory cause of the necrosis. For example, an unhealthy tree (tree no. 24, Bahadurpur garden, Lucknow) showed cent. per cent. infection where the healthy tree of the same variety nearby had a less heavily infected crop. A similar observation was made on a variety of Safeda (Narma) where a withering tree (tree no. 6A, Bahadurpur garden) had a very poor crop of mangoes all of which were affected with the necrosis, while the mangoes on vigorous and healthy trees of the same variety nearby remained unaffected. In Zahirpur garden too an unhealthy Safeda tree showed relatively greater infection.

5. **Brick-Kiln Fumes.**—It is a popular belief that the necrosis of the mango fruit is caused by brick-kiln fumes. Almost all the villagers and the gardeners in charge of the orchards attribute the disease to the fumes emitted by the brick-kilns. There seems to be some justification for holding this view, since according to them the disease follows the brick-kiln. This view is also held by many prominent persons who have sometime or other concerned themselves with the problem. For example, Woodhouse (1909) as already referred to, stated that, “The round Bhagalpur mangoes do not seem to be much affected by disease, but this year much fruit is said to have been spoilt at the Sabour Farm, by the smoke from the brick-kilns which apparently blackens the apex of the mango and interferes with its development.” Also Naik (1934).
Allan (1936) is more emphatic on the effect of brick-kiln fumes on the mango fruit. He writes: "There is no doubt whatsoever that the modern coal burning brick-kiln is a definite menace to a garden. Whether this damage arises as some think, from the heating effect of the kiln on the soil nearby or, as the writer believes, from the fumes emitted may not be a settled matter; but undoubtedly such a kiln specially if to the windward, i.e., to the west or south-west (between March and June) of an orchard seriously endangers the fruit which in consequence is apt to develop a blackening of the skin and a rotting tendency long before it is ripe. The presence of a kiln does not seem to affect the young tree or its growth, but comes into play when fruiting develops. The damage is in inverse rates to the distance of the kiln from the orchard boundary. To establish a garden within 400 yards to windward of modern brick-kiln is to court trouble later. To allow such a kiln to develop near a valuable garden without serious protest is again admitting trouble. If the kiln is on the leeward or side away from that of the prevalent wind, usually between March and June this means to the east of the garden, damage is much less likely and even at 100 to 200 yards but little direct harm may arise." Mr. P. K. Dey, the Plant Pathologist to the Government of U.P., conducted a rough and ready experiment on the effect of SO$_2$ on the mango fruit by burning sulphur under a tree bearing healthy Tukhmi mangoes. At the time of the fumigation the fruits were about an inch in length and quite healthy without any sign of necrosis. The plant was fumigated twice a day for 7 days. On each occasion sulphur was burnt for half-an-hour in such a manner that the tree became covered with the SO$_2$ fumes. The exposure of the mangoes to the SO$_2$ fumes must have lasted much longer than half-an-hour. On the fifth day yellowish colour appeared at the tip and blackening appeared on the seventh day. Soon the diseased tissue collapsed exposing the stone and within a fortnight necrosis had claimed the distal half of the fruit. All the mangoes in the tree were affected.*

As stated, the experiment was a rough and ready one. It was limited to only one tree. No control was kept nor was the experiment carried out under controlled conditions. Nevertheless as the disease seemed to be identical to the necrosis of the mango produced by the brick-kiln fumes, investigations have been started in this laboratory to ascertain the effect of SO$_2$ fumes and brick-kiln fumes on the mango plant and mango fruit, particularly on the latter, under controlled experimental conditions.

During the mango season of 1937 a survey of a limited number of mango orchards in the neighbourhood of Lucknow situated by the side of Kursi

* In a private conversation with the senior author.
Road, Barabanki Road, Sitapur Road, Malihabad Road and in Malihabad proper was undertaken. The limitation was imposed by the lack of financial resources and properly qualified surveyors at the disposal of the authors.

It appears from the above survey that the necrosis of the fruit is quite common in the immediate vicinity of the brick-kilns. It was also found in Bahadurpur orchard, which is situated at a distance of about 500 yards in a bee line from the operating brick-kiln. The Zahirpur orchard which is said to be affected by the same brick-kiln is situated at a distance of no less than 800 yards. There is no other brick-kiln nearer to Zahirpur orchards than the one mentioned above. It seems, therefore, that if brick-kiln fumes are responsible for the disease they are able to affect even at a distance of half-a-mile. A distance of 400 yards only from the brick-kiln to the orchard as suggested by Allan (1936) and Naik (1934) is clearly not enough for the protection of the orchards.

As stated, necrosis is common in the immediate vicinity of brick-kilns. But there are exceptions. In Malihabad proper Nazir Hasan Khan has a brick-kiln situated within the compound of his own orchard which has been operating for the last five years, but according to the owner none of his mangoes, which are exclusively Safeda (Malihabad), are affected by necrosis. As will be seen from Table II, Safeda (Malihabad) is susceptible to necrosis to some extent. In Kapurthala orchard only 10 per cent. of the fruits proved to be diseased. If the necrosis were entirely due to the fumes one would have expected at least a few fruits in Khan’s garden to be necrotic, the kiln being in such close vicinity. About two furlongs from this brick-kiln there is a very big orchard belonging to Isaq Ali Khan which has all the superior varieties of mangoes, namely, Dasehri, Safeda, etc., etc. But necrosis is unknown there. Further, there is another very big brick-kiln about 800 yards away from Nazir Hasan’s orchard and separated from it by a Nullah. This also does not seem to have any effect on these orchards.

These observations are interesting inasmuch as they tend to preclude the possibility of the fumes being the factor producing necrosis. Even if fumes are found to be the cause of necrosis there must be other factors operating to account for the observed facts. These orchards are under further observations.

The question of the direction of the wind is closely associated with that of the fumes. If the disease is due to the fumes the importance of the direction of wind must be admitted. In the course of our survey, however, not much relation could be established between the extent of the disease and the direction of the wind. It was found that not only is there a periodic change
in the direction of the wind, but there is also a diurnal change. The wind keeps on changing its direction, so that an observer looking at a chimney top emitting fumes will see fumes being blown off in one direction at one time and in another direction sometime later. A definite direction for a prolonged period is sometimes maintained and can be seen on a still day. Alteration in the direction of the wind both at the ground level and at a height of 30 feet (chimney-top level) requires to be studied before any authoritative data can be supplied.

The three orchards affected with necrosis do not bear the same relation to the nearest brick-kiln so far as the direction is concerned. It is seen that the Bahadurpur orchard is to the east, Zahirpur orchard to the north-east and the Kapurthala orchard to the south of the nearest brick-kiln. They are all affected by necrosis.

The direction of the wind and the direction and proximity of the orchard in relation to brick-kilns are of importance inasmuch as they determine the concentrations of the fume constituents reaching the orchards. An analysis of the $SO_2$ content of the air at different distances from brick-kilns is in progress in the laboratory.

"Taper Tip" Disease

In the course of our investigation we came across a large number of mangoes of Dasehri variety that showed a peculiar tapering of the distal end of the fruit. On further examination it became clear that the condition could not be regarded as normal and perforce we had to come to the conclusion that it indicated a kind of disease hitherto unrecorded. The name 'taper tip' is proposed for this disease in view of the characteristic appearance presented by the affected fruit.

The external symptoms of this disease were carefully noted. It was found that the fruit of all shows an intensification of the normal green colour at the distal end. The portion thus affected apparently ceases to take part in the further development or takes part only to a very limited extent, with the result that in the mature fruit the distal end is more or less abruptly tapering (Pl. II, Fig. 20) and is often curved. The fruits affected by the disease fail to attain the normal size, remain relatively small and are easily detachable from the stalk. As has been already stated the taper tip disease is most abundant in the Dasehri variety. Almost cent. per cent. are affected in Bahadurpur orchard and a large number in orchards elsewhere. It is also found in a Bombay variety. Gola-Mohanbhog, Safeda and other varieties investigated, have so far proved to be peculiarly free from this disease.
The necrosis may occur in fruits already affected with the taper tip disease. The symptoms in such cases are identical to those described elsewhere. The aetiology of the skin associated with the necrosis makes its appearance at the distal end already affected with taper tip, which is followed by the formation of brown patches and the ultimate disintegration of the tissues.

In Bahadurpur orchard the two diseases, the taper tip and the necrosis, were so associated together that the taper tip seemed to be the earliest symptom of the incidence of necrosis even prior to aetiology. But most probably the taper tip bears no relation to the necrosis since the disease is found to occur in the Dasehri variety in certain orchards of Malihabad and Lucknow where the necrosis is unknown. It is possible, however, that in these orchards the disease does not proceed beyond the initial stage in which case, it is to be assumed that the initial symptom of necrosis varies between varieties, for example between Dasehri and Gola-Mohanbhog.

Summary

The paper deals primarily with the external symptoms exhibited by a hitherto undescribed disease of the mango fruit. The disease has been termed necrosis and the popular name by which it is referred to is "Black tip" since the necrosis invariably starts at the distal end of the fruit and the necrotic area is distinctly dark-brown in colour.

The earliest external symptom of the disease is the aetiology of the distal end of the fruit. Later on grey spots of indefinite outline make their appearance in the aetiolated area, turn brown in colour and coalesce. In the cases of more severe attack, the entire tissue thus affected collapses, exposing the stone of the fruit having a more or less thin layer of collapsed tissue over it. This is particularly prominent in Safeda, Dasehri and certain Tukhmi varieties. The necrotic area remains restricted usually to about a quarter of the size of the fruit. The rest is not directly affected.

At an early stage of the disease, the necrotic area shows gummosis. The extent of exudation of the gum depends upon the variety.

Twelve orchards in the neighbourhood of Lucknow were kept under observation in the mango season of 1937. Three of these were utilised for special work relating to the disease. The result of our limited survey showed that the disease is common in orchards situated in the vicinity of brick-kilns, but not without exception.

Susceptibility to the disease varies with the variety, Dasehri being the most susceptible.

There is also a real difference in the susceptibility within a variety.
Lack of vigour of the tree seems to be a contributory cause of the incidence of the disease.

It has not so far been possible to isolate any fungus or bacterium from the diseased part, neither has it been possible to induce the disease in healthy fruit by inoculating diseased tissues. Apparently the disease is not due to fungus or bacterium. The possibility of its being due to virus is still an open question.

A disease called Taper tip is recognised. The symptoms of the disease are that the distal end of the fruit shows an intensification of the normal green colour, tapers abruptly and is often curved, causing the affected fruit to remain smaller than the average ones.

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LITERATURE CITED


DESCRIPTION OF PLATE FIGURES

FIGS. 1–12. Dasehri variety

FIG. 1.—A normal, healthy mango of Dasehri variety.

FIG. 2.—Earliest symptom: aetiolation of the skin of the apical region.

FIG. 3.—Intensification of aetiolation.

FIG. 4.—Appearance of brownish spots in the aetiolated area.

FIG. 5.—Spots larger and dark-brown; earlier stage of coalescence.

FIG. 6.—Formation of continuous necrotic area due to the coalescence of the dark-brown spots.
Figs. 7–9.—Necrosis more advanced. An etiolated zone round the dark-brown necrotic area.

Figs. 10–12.—Stages in the emergence of seed owing to the collapse of healthy tissue due to necrosis. The zone of etiolation round the necrotic area is still persistent.

Fig. 13.—Safeda variety. A mango showing advanced stage of necrosis. Seed protruding and a faint etiolated zone round the necrotic area is visible.

Figs. 14–19.—Gola-Mohanbhog variety

Fig. 14.—Earliest symptom: etiolation of the skin of apical region.

Fig. 15.—Appearance of small brown spots in the etiolated area.

Fig. 16.—Spots larger and in the earlier stages of coalescence.

Fig. 17.—Formation of continuous necrotic area due to coalescence.

Fig. 18.—More advanced stage.

Fig. 19.—The most advanced stage so far found in Gola-Mohanbhog.

Fig. 20.—A mango of Dasehri variety showing the Taper tip disease,