# DISEASES OF PAN (*PIPER BETLE*) IN THE CENTRAL PROVINCES.

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Pan (*Piper betle*) is cultivated in many parts of the Central Provinces and Berar. It is a very valuable money crop. Wherever it is successfully grown it yields large profits. Since the last few years in many pan growing parts of the Province there have been outbreaks of diseases which have completely destroyed the affected gardens and so pan cultivation in these areas has been perforce abandoned at Ramtek, Drug, Nagpur and other places; and so the prosperity of the villages or tahsils where pan cultivation was once a flourishing industry has become adversely affected. Where there were formerly flourishing pan gardens are now dilapidated remnants of the old "chick-houses" completely overrun with weed.

All over the Province two varieties of pan, *viz.*, *Bangla* and *Kapoori*, are chiefly grown; but the methods of cultivation considerably vary from place to place. A brief account of some of these methods followed in various parts of the Province is given below.

As pan plants grow best under temperate and moist conditions and as the texture of pan leaves is affected by exposure to sunlight, they are therefore invariably grown in enclosed shady places. The pan gardens are of two types. In one type of the garden pan plants are grown in "chick-houses" and in the other type living plants are used as supports, shade and wind-breaks for the pan vines.

The "chick-house" type of a garden, locally known as "tanda" or "berja", is common in most parts of the Central Provinces, whereas the other type is to be found in Berar and Nimar. As the initial expenditure of making a "tanda" and of maintaining it is very high it is generally run on a co-operative basis, several "baris" or pan growers forming a combine for the construction and maintenance of a "tanda".

A "tanda" is usually five to six feet high and about 170 feet in length, the area being 0·6 acre or more; it is an enclosed structure the four sides of which are made up of "tattis" or split bamboo frames covered with dry grass or dry sticks. They are supported against wooden or bamboo posts;

the roof is made up of light thatching material, such as grass. On one side of the "tanda" there are openings with doors which are made of the same material as the sides of the "tanda"; the number of the openings depend on the length of the side; exactly in front of the opening on the inner side of the tanda, there is a screen made of thatching to prevent wind blowing directly on the plants when the door is opened.

The pan vines are supported on a framework made of split bamboo sticks.

In Berar and Nimar pan is not grown in "chick-houses"; the necessary moisture, shade, protection from wind and support for the vines is ensured by growing pan in a plantation of *Sesbania aculeata* (*savari*), *Sesbania grandiflora* (*agasi*), *Erythrina Indica* (*pangara*) and *Moringa pterygosperma* (*sheoga*).

To prevent the inroads of stray cattle and animals the garden is surrounded by walls, about 6 feet high, made of thatching or dried stalks of cotton or "tur" (*Cajanus indicus*). These walls serve also as wind-breaks.

*Soil.*—As a rule the type of soil preferred is that which is well-drained, such as alluvial soil, sandy loam or loamy soil of a light colour; soil that can hold water without becoming clayey, is suitable; clay loams, heavy clays or calcarum soils are not suitable.

*Cultivation.*—In Berar* the land reserved for pan planting is ploughed either with a wooden or iron plough about the middle of April, and manured with Farm Yard Manure at the rate of about 50 carts per acre. To get the soil well pulverised "bakharing" is done after ploughing. After the break of the monsoon, beds, locally called "bare", are laid out. They are usually 9 feet square. On their four sides, are ridges one foot broad and six inches high; on one side of the "bare" there is an irrigation water channel, one foot wide, running through the middle of the "bare", and at right angle to the water channel there is another similar ridge dividing the "bare" into two compartments, each known as "wafa". There is an inlet for the irrigation water from the main water channel in one of the two "wafas", and from this "wafa" the water passes into the second "wafa" through an opening in the middle of the central ridge dividing the "bare" into two "wafas". (*Vide* sketch No. I.)

About the first week of June seeds of *savari* (*Sesbania aculeata*), *sheoga* (*Moringa pterygosperma*) and *ambadi* (*Hibiscus subdariffa*) are sown; two pounds (by measure) of *savari* seeds and half a pound of *ambadi* are used per 100 beds. *Savari* is sown thickly on both the margins of a ridge; two *sheoga* seeds are sown on each ridge which run parallel to the length of a "wafa". A

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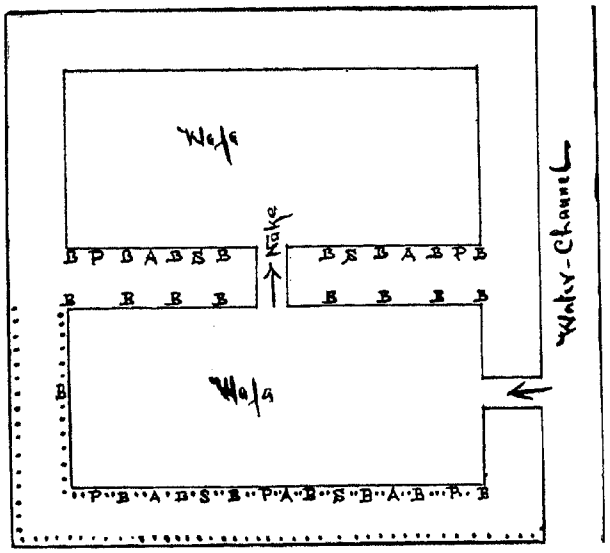
SKETCH NO. I.




A.—Ambadi.
B.—Betel vines.
P.—Pangara.
S.—Sheoga.
.....—Savari.

*pangara* cutting, about two to three inches thick in diameter, is planted at each end of the ridge; another *pangara* cutting, about five to six inches in diameter, is planted in the centre of each alternate ridge which forms the unbroken long side of a "wafa". Irrigation is given as required.

Pan cuttings are planted from the middle of August to the end of September. Usually 17 cuttings are planted in each "wafa", but at times as many as 25 cuttings are planted. Invariably an odd number of cuttings are planted, the same number of pan cuttings on each ridge on the long side of the "wafa" and one cutting in the middle of the small ridge farther away from the water channel. A pan cutting has usually four to six nodes; half the length of the cutting is underground. Before cuttings are planted, seedlings of *savari* and other plants are thinned out, the seedlings of *savari* being left one to two inches apart; at the same time the water channel is repaired if necessary.

After the pan cuttings are planted, the "wafas" are irrigated daily for one week. About a week after the planting new earth is added to the ridges and furrows of the bed at the rate of four baskets per bed. From the second week irrigation is given every alternate day for about a fortnight; a month after planting the cuttings Farm Yard Manure at the rate of five carts per 100 beds is given, and the beds are irrigated as required every third or fourth day.

*Savari* is thinned about four times ; at the end of the year *savari* plants are about one foot apart. Precautions are taken to prevent the pan leaves being crushed or squashed by the pressure of *savari* branches and leaves and at the same time to keep the pan leaves well shaded from the sun.

The pan vines are supported against *savari* plants and every two months the tops of the vines are tied to them with plantain fibre.

A second application of manure is given in December or January at the rate of five carts per 100 "wafas".

*Ambadi*, when mature, is harvested ; the stalks are utilised for extracting fibre.

In January the temporary "tattis" are removed and replaced by new permanent "tattis", 10 to 12 feet high made of bamboos, cotton stalks and similar other material.

About the end of March a second dose of new earth is applied.

In the month of June of the second year the operation of lowering of the vines is done. The whole of the vine, except its lower part upto about a height of 18 inches from the ground surface, is removed from its supports to which it has got attached, is rolled into a bundle and buried underground. The second year about 13 plants per "wafa" are allowed to stand, the rest being removed. As the vines grow their tops are tied to their supports once every fortnight.

After the vines are lowered bamboos are fixed on the ridges ; about 1,000 bamboos are required for 100 "wafas" ; about 10 vines per "wafa" are supported on the bamboos, and the rest of the vines are supported on *pangara* or *sheoga* plants. Irrigation is given as found necessary, in summer every day, in winter every alternate day.

Leaf picking begins about the end of October and is continued for about a month and a half.

In February the tops of *savari* plants are pruned if they have grown very high. The vines are at the same time lowered, rolled into bundles and tied to the lower parts of the support. These lowered vines are not buried underground. Before the vines are lowered the "wafas" are manured at the rate of five carts of Farm Yard Manure per 100 "wafas".

In March new earth is applied both to the furrow and ridge. A second dose of earth is given in June and July.

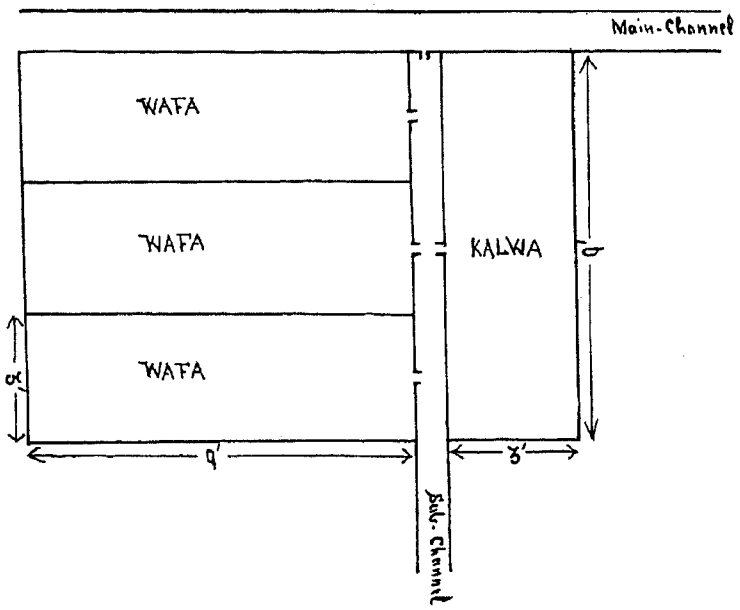
In the third and following years, lowering of vines once a year, in February, is done ; manure is given twice a year, in June or July and December or January ; fresh earth is applied in February or March and June, and the water channels are repaired and strengthened twice a year.

The pan gardens in Berar are kept for 4 to 6 years; sometimes a garden is as many as 12 years old.

The varieties usually grown are Local Jalgaon, Deshi (*Nagwelichi pan*) and *Bangla*; *Bangla*, however, is not much favoured in Berar.

In Morsi Taluq (Berar) the land reserved for pan garden is ploughed once and "bakhared" four times before the rains break. Farm Yard Manure at the rate of 20 to 25 cart-loads per acre is applied and at times sheep is allowed to fold on the land before the final bakharing is given; the beds are prepared by the end of June after the commencement of the rains. Each bed is nine feet long and three feet broad; ridges six inches high and twelve inches broad are made on all the sides of the bed; the beds are of two kinds and are laid out as per sketch No. II.

SKETCH No. II.




Well rotted and well ground Farm Yard Manure at the rate of two to three baskets per bed is applied, only three of the ridges of a "wafa" are manured, the one nearest the feeder water channel being left unmanured; but all the four ridges of a "kalva" are manured. Seeds of *savari*, at the rate of 50 lbs. per acre, are thickly sown on the manured ridges of a bed. At times plantain (*Musa indica*) and papaya (*Carica papaya*) trees are planted in the beds as secondary crops. About a month after *savari* seeds have been sown pan cuttings usually at the rate of 15 to 20 per bed, are planted on the ridges where the *savari* plants are growing.

The pan vines are supported against *savari* plants and when they reach the top of their supports they are then trained down the supports; this

operation of climbing up to the top of the *savari* plants and then running down them takes about a year ; the vines are then removed from their supports rolled into rings and buried underground leaving the growing upper parts of the plants above ground supported against *savari* plants. This operation is repeated once every year for the next two or three years. As a rule a pan garden is maintained for four years when a new garden is started on another piece of land ; the old pan garden land is rotated for three or four years with other crops before it is replanted with pan.

The pan garden is fenced on all sides with *pangara* trees, cotton or *tur* stalks covering the interspaces between the trees.

In Basim (Berar) an acre of a suitable piece of land is divided into two halves ; one half is planted with pan and the other half with garden crops like turmeric (*Curcuma longa*), chillies (*Capsicum* spp.), tobacco (*Nicotiana tobacum*) etc. Pan is grown on one half of the land for about five years at the end of which the neighbouring half is brought under pan cultivation and on the old pan land san hemp (*Crotolaria juncea*) is grown the first year followed by turmeric, chillies, tobacco and such other crops for about three years before pan is again replanted on this land.

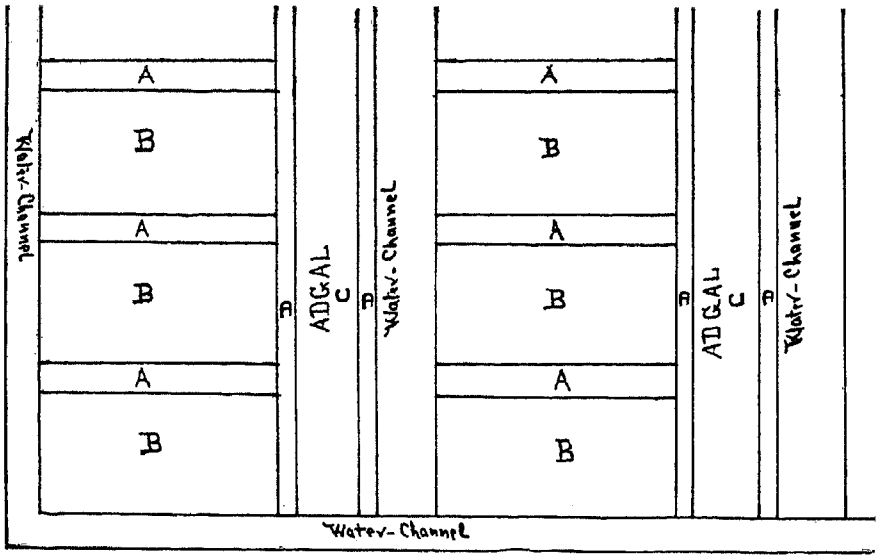
To make an enclosure for the garden living stumps of *pangara* (*Erythrina indica*) are planted two feet apart all round the garden area ; seeds of *savari* (*Sesbania aculeata*) and *agasi* (*S. grandiflora*) are sown between the *pangara* stumps. A good live fencing is thus made when the *pangara* stumps strike roots and *savari* and *agasi* plants have grown high. If there are any openings between the plants they are closed with cotton stalks. The beds are laid out as in sketch III.

In all parts of the Central Provinces, except Nimar where pan cultivation in general is similar to that in Berar, pan is grown in "chick-houses". The many operations pertaining to the making and maintaining of a pan garden are not precisely the same in all parts of the Province. There are various modifications of these operations which are peculiar to particular localities, *e.g.*, in some places only a single internode of a pan vine is sown as "seed", in other places the length of the cutting may be as much as 12 to 15 inches ; in some places watering is done by hand, in others by means of irrigation channels.

A detailed account of the mode of pan cultivation in Timarni (Hoshangabad District) is given below :—

*Soil.*—The soil preferred by the pan grower is what is known as "Mitta Jamean" ; it is well drained and is found very suitable for *Bangla* variety of pan ; the second best type of soil is "Sahra"; it is of a yellow type.

SKETCH No. III.




A. Ridge on which Savari plants and Betel vines are planted.
B. Space between ridges (8 ft. × 4 ft.) for holding water.
C. Space known as Adgal for holding water and planting plantain trees.
D. Ridge, 1 ft. wide and 6 in. high.

"Gangari" variety of pan and *Pipri* (*Piper longum*) grow best on this soil. The site selected for a pan garden is always near a tank or where wells can be readily and cheaply sunk and water available at a depth of not more than 10 or 12 feet below ground level.

*Construction of a Pan Garden.*—The site selected for the garden is thoroughly weeded. It is then divided into parallel lines, the distance between two lines being about 30 inches; these lines indicate the position of the ridges to be made for the planting of pan cuttings; on each of these lines wooden posts are fixed about 5 feet apart; and each post is about six feet high from the ground. These posts are joined together at the top by bamboos, split into halves; which are in turn linked together by a trellis work of thin split bamboos—bamboos split into four parts; these thin bamboo sticks are about five inches apart. On this bamboo foundation of the roof of the "chick-house" is spread dried grass which is tied to the split bamboos.

The soil is dug about six inches deep by a pick-axe; the clods are broken and the ground is levelled; new earth is then heaped on the lines plotted for making ridges; the whole area is well soaked with water. The following day ridges are made, about 6 to 7 inches broad and about 9 inches high. The making of the "chick-house" is completed by enclosing the whole area with tattis made of bamboos, *ambadi* stalks and grass.

The "chick-house" is constructed in January or February and pan is planted from the middle of February to April.

There are two methods of planting pan. One is locally called "*pindi-boni*" and the other "*keechad-boni*".

*Pindi-boni.*—For this method of pan planting the pan vine is cut into pieces, each piece having a single internode with one leaf and one "eye" or leaf bud. Two such pieces are placed lengthwise side by side, along one edge of the ridge. Similarly other pairs are placed in a line, three pairs covering a length of about eight inches; on the opposite edge of the ridge, there is a similar row of pairs of pan cuttings; the cuttings, but not the leaves, are covered with wet soil, which is well pressed down with a mallet made of mud. As soon as a ridge is planted, water is sprinkled over it and then completely covered with grass. Water is sprinkled twice a day for about three months by which time the leaf bud has developed into a shoot, about nine inches long. In about a month's time the cutting strikes roots; the grass covering is then thinned out and liquid manure made of fermented crushed linseed seed or linseed or *til* oil cake mixed with water is applied. About a fortnight later, the original pan leaf attached to the pan internode or cutting has regained its normal turgidity and stands erect above the ground surface, the grass covering is then completely removed. Bamboo sticks are now fixed to the ridges as supports for the growing pan vines.

About three months after planting the cuttings the original leaves on the cuttings are removed and the new shoots which are about nine inches long are tied to the bamboo supports. The ridges are now irrigated not by sprinkling water on the plants but by pouring water directly on the ridges through a bamboo funnel. Water is carried in an earthen pot on the left shoulder of a cooly who walks on the furrow between the ridges and pours water on the ridge through a bamboo funnel about four feet long. Linseed or *til* oil cake is applied to the ridges.

In about five months after planting—in July or August—the vines bear six or seven leaves each; the lowermost one or two leaves are then picked; and thereafter leaf picking is continued once a week. By October or November the vines have reached their maximum growth.

The following January or February the vines are detached from their bamboo supports; the vines are uprooted leaving six vines between two posts—the distance between the posts being about five to six feet. Before the vines are uprooted their leaves are picked. The bamboo sticks which serve as supports for the vines are removed; the soil on the ridges is raked up and well watered so as to turn the soil into a paste; each of the vines

—six in number between two posts—left rooted in the ground is then laid on the ridge on which it is growing ; the stem is covered with earth but not the leaves. The same operations which were done the previous year when the cuttings were planted are carried out the second year except that the ridges are not now covered with grass. In October the vines are lowered, *i.e.*, the vines are detached from their supports and rolled into coils which are tied to the supports.

The second method of planting known as "*keechad-boni*" is done as follows :—

The "seed" is a pan cutting having three or four internodes. The preliminary operations are the same as in "*pindi-boni*". At the time of planting the ridge is soaked with water so that the soil forms a sort of a paste ; the "seed" which, in this case, is a cutting having three to four internodes is placed lengthwise on either side of the ridge and is buried into the moist earth so that the stem is wholly covered with soil but not the leaves. The various operations of cultivation are the same as in "*pindi-boni*" except that the cutting is not covered with grass and the plants are renewed every three years.

It is uneconomical to maintain a garden of old plants as the yield of leaves is much reduced as the plant ages. Therefore the vines of one planting are allowed to grow for about four to six years. The garden is then replanted with a fresh supply of "seed" and the "chick-house" repaired or rebuilt as required ; but the same ground is used for replanting the garden ; thus the garden may be renewed and replanted every 5 or 6 years ; but the ground remains the same ; some gardens are reported to be a hundred years old.

Rotation is not practised in Timarni.

At Timarni along with pan *pipri* (*Piper longum*) is also cultivated as a mixed crop. Generally one *pipri* plant alternates with seven pan plants.

The varieties of pan grown at Timarni are *bangla*, *kapuri* and *gangeri*, the first two are more commonly grown than the third variety.

In most parts of the Central Provinces pan is grown in "chick-houses" and the plants supported on a framework of split bamboo sticks and not on living plants as in Berar and Nimar but there are many variations in the methods of cultivation. In places like Ramtek, Bhandak, Bhandara, Saugor, Jubbulpore the "seed" is a pan cutting having 3 to 5 internodes or about 12 to 15 inches in length ; usually the top shoots are preferred for planting. The whole cutting is not buried underground but only the lower half, the leaves from this part of the cuttings are removed before planting. The cuttings are planted a foot apart.

In some places cuttings are not planted on ready-made ridges. The land after it has been dug up, levelled and manured is divided into a number of parallel strips; each of the strips is about twelve inches wide and eighteen inches apart from its neighbours. The whole land is heavily irrigated the evening previous to planting; the following morning cuttings are planted in parallel lines nine inches apart in the already plotted out twelve inches wide strips; the distance between two cuttings in the same line is nine to twelve inches. Two or three days later the eighteen inch space between the planted strips is well trampelled under foot; a furrow, which serves as an irrigation channel, is thereby formed, and the planted strip is converted into a ridge. The watering of the garden in Ramtek, Bhandara, Bhandak and other places is done by means of irrigation channels leading from the source of water supply which may be a tank or a well near the gardens. The main irrigation channel may pass and water several gardens. At Damoh, Saugor and Jubbulpore watering is done by hand as at Timarni but the water is poured in the furrows or water channels and not directly on the ridges as at Timarni.

In places like Ramtek, Nagpur, Bhandara, Drug, Bhandak and Jubbulpore the same land is generally used repeatedly for pan planting but it is allowed to lie fallow two or three years after the garden is broken up when it is four or five years old. But in Timarni, Damoh and Saugor the land is never rested but new "seed" is replanted once every five or six years on the same land with the result that several gardens are reported to be over a hundred years old.

*Diseases.*

The most important fungus diseases of pan in this Province are foot-rot (caused by *Phytophthora parasitica* var. *piperina* n. var. and *Pythium piperinum* n. sp.), leaf-rot (caused by *P. parasitica* var. *piperina*), and anthracnose (caused by *Glœosporium* sp. and *Colletotrichum* spp.); from foot-rot affected plants in some places, *Sclerotium Rolfsii* Sacc., *Rhizoctonia bataticola* (Taub.) Butl. and *R. Solani* Kühn have also been isolated. The damage done by these sclerotial fungi has not so far been known to be serious and it is not improbable that these fungi may not be the primary causes of foot-rot, *Phytophthora* or *Pythium* being the primary cause; or they may be infecting the plants when weakened by an attack of anthracnose.

Foot-rot caused by *Phytophthora parasitica* var. *piperina* is of very general occurrence in a majority of the pan growing parts of the Province. Wherever it is found, the pan garden is completely wiped out and that too very rapidly. *Pythium piperinum* has so far been isolated only from diseased plants from Timarni (Hoshangabad District) but the damage it causes is as much as that caused by *Phytophthora parasitica* var. *piperina*.

*Phytophthora parasitica* var. *piperina* has been known to occur in an epidemic form at Ramtek, Nagpur, Bhandara, Bhandak (Warora District), Saugor, Damoh, Jubbulpore, Sohagpur and Udaipura, Timarni and Seoni Malwa (Hoshangabad District) and Malkhed (Amraoti District).

Foot-rot caused by *Sclerotium Rolfsii* has been so far known only in Udaipura, Timarni and Seoni Malwa (Hoshangabad District), *Rhizoctonia bataticola* and *R. Solani* have been isolated in a few cases from foot-rot affected plants from Timarni and Seoni Malwa.

Anthracnose disease, like the *Phytophthora* and *Pythium* diseases, completely destroys the gardens where it occurs. It has been known to be in an epidemic form in Timarni, Seoni Malwa and Mandla, but it is not improbable that it may be of a much wider distribution in the Province, its presence having been overlooked; and this may be the reason for the reported failure of soil treatment in some places, like Saugor and Piparia, where some gardens attacked by the *Phytophthora* root-rot were treated with Bordeaux Mixture. In the case of a plant attacked by anthracnose the parts of the plant above the diseased area at first show signs of pallor and wilting; the leaves and branches below the infected parts are green and normal. However the infection spreads rapidly downwards as well and it is not long before the whole plant turns brown and dry as in the case of the foot-rot affected plant.

*General Symptoms of the Diseases.*

The general outward symptoms of plants attacked by foot-rot and anthracnose are very similar.

The very first symptom shown by a diseased plant is the loss of what the "bari" or pan grower calls "zamak" or luster. This symptom though invariably shown by a diseased plant is not readily noticeable except by an experienced eye, like that of a "bari", because the plant at this stage does not look conspicuously different from a healthy plant, as there is no sign of drooping or wilting of leaves or loss of green colour. Another characteristic symptom of the plant which shows this loss of luster is that from the topmost one or two nodes there is no development of adventitious rootlets; the root eyes remain dormant whereas in the case of a healthy plant either the root eyes are perceptibly swollen or rootlets have begun to sprout. Soon after the plant shows these primary symptoms of infection another conspicuous symptom develops; the lamina of the leaf of a healthy plant stands at a right angle to its petiole but the lamina of the plant showing the primary symptoms has a slight droop where its base is joined to the petiole, and later the droop of the lamina becomes very pronounced, the petiole however remains erect. Even the feel of a slightly drooping leaf blade is different

from that of the healthy leaf. The diseased plant now begins to show a general pallor of the leaves; in the upper leaves especially there is a distinct loss of green colour and a tendency to yellowing. This pallor rapidly spreads all over the leaves and the upper tender parts of the plant are found to wilt as if suffering from drought. In the case of a plant attacked by foot-rot the whole plant rapidly turns yellow and then dries up; the succulent stem is now brown, brittle and dry as stick. The conspicuous wilting and yellowing follow within a day or two after the primary symptoms of the infection have been noticed.

*Control Measures.*

In a previous publication (Dastur, 1931) it has been shown that at Ramtek irrigating the soil with Bordeaux Mixture has proved beneficial for the control of foot-rot caused by *Phytophthora.*

During the rains of 1933 several pan gardens at Seoni Malwa and Timarni (Hoshangabad District) were reported to be badly diseased; the disease in Seoni Malwa was said to have been observed since the last 3 or 4 years but at Timarni the pan gardens were reported to have been diseased for the first time. Control measures on an extensive scale were tried at Timarni.

In a garden, named Rajashahi Berja, five pan growers owned varying number of lines, the total number being 70. Of these 70 lines the first 20 lines commencing from the east of the garden were the most diseased, especially the first 11 lines in which a very large number of plants were dead or dying and the remaining had practically ceased to grow. Stems showed anthracnose lesions and leaves were badly spotted by leaf-rot. There were very few cases of foot-rot. The neighbouring plot of 10 lines (Nos. 21-30) showed a much better growth and there were very few plants wilting, and hardly any case of leaf-rot. The next group of 10 lines (Nos. 31-40) were the best in the garden, diseased plants were very few and far between. The remaining lines (Nos. 41-70) were much more diseased than lines 31-40 and as much diseased as lines 21-30.

In this garden foot-rot was not much in evidence. The chief diseases were anthracnose on the stem and branches caused by *Glœosporium* sp. and leaf-rot of leaves caused by *Phytophthora parasitica* var. *piperina.*

This garden was under pan cultivation for the last 50 years. The 70 lines of pan in it were of varying ages. Lines Nos. 7-11 were one year old, Nos. 41-45 were three years old, Nos. 52-70 were four years old, and Nos. 12-30 and 46 to 51 were five years old. Since the disease was reported to have occurred for the first time, and since the intensity of infection varied from place to place in the garden, it was decided to try control measures in this

garden, if the owners gave permission. Four owners were anxious to get their plants treated as their lines were more or less infected, but the fifth owner, who owned the lines, Nos. 31-40, in the central part of the garden, and these lines were the best in the whole garden, refused to get his lines treated. So his block of lines served as a "control".

The garden was therefore divided in five blocks. The first block contained the first 20 lines commencing from the east, the second, third and fourth blocks had 10 lines each, *viz.*, lines Nos. 21 to 30, 31 to 40, and 41 to 50 respectively. The last block on the west had the remaining 20 lines, *viz.*, lines Nos. 51-70. Of the five blocks the third block having lines Nos. 31-40 which were the healthiest in the garden was the "control" block. The remaining 60 lines in blocks I, II, IV and V were first irrigated with Bordeaux Mixture (2–2–50), at the rate of 25 gallons of the mixture for a ridge of 150 ft. length. In block I having lines Nos. 1 to 20 which was the most affected the plants were sprayed with Bordeaux Mixture (2–2–50); blocks II and IV, having lines 21 to 30 and 41-50 respectively, were sprayed with Bouisol ($3\frac{1}{2}$ lbs. in 100 gallons of water); and block V, having lines 51-70, was sprayed with Sulsol (5 lbs. in 100 gallons of water); about two gallons of the spray fluids were required for spraying plants in a ridge of 150 ft. length.

Before treating the blocks all the diseased leaves were picked from the plants; all the diseased plants, whether affected by foot-rot or anthracnose, were uprooted and destroyed, except in block I which was the most diseased. In this block the plants were chiefly attacked by anthracnose; therefore those which had their upper parts diseased were pruned off a few inches below the seat of infection and those plants which had their stems and branches attacked by anthracnose near about the ground surface were cut flush to the soil level; dead or dying plants were uprooted.

As far as possible all the dead and dying plants and cuttings were removed from the garden and destroyed.

For irrigating the ridges with Bordeaux Mixture the fungicide was poured on the ridge from its either side, half the quantity was poured from one side of the ridge and the remaining half from the other side.

The first treatment was given on the 28th of August, 1933, the second treatment was given on the 4th of October and the third treatment was given on the 4th of December.

At the time of the second treatment there was a distinct change in the general appearance of the garden. Block I, having 1 to 20 lines, which was sprayed with Bordeaux Mixture and which was the worst affected when the treatment was first given had not a single leaf attacked by leaf-rot nor

was there any case of anthracnose infection. The plants had recovered remarkably and put forth a fresh growth of leaves and branches; they had also increased in size considerably. In six weeks the vines were double their previous size when the first treatment was given. The ridges which before treatment looked sparsely planted and had dull yellow coloured plants were now very full and thickly planted and full of green shining leaves. The anthracnose infected plants which had their diseased parts pruned off developed new shoots and a new flush of leaves; the plants which had been cut at the soil level developed new shoots from the eyes on the underground stems. The leaves were distinctly greener than normal healthy leaves of untreated plants. It was reported that these treated leaves fetched a higher price in the market than the untreated leaves because the former were much greener in colour.

The Bouisol sprayed lines in block II which were before treatment superior to the lines sprayed with Bordeaux Mixture and only slightly inferior to the control lines in block III were also quite free from disease and looked the best in the garden at the time of the second treatment. Sulsol sprayed lines which were before treatment as good as the lines in block II were found to be not so good as the Bordeaux Mixture and Bouisol sprayed blocks. The plants were not quite free from anthracnose. The control block which originally was the best when treatment in the other blocks was first given was now the poorest; all the 10 lines were badly diseased; the general colour of the plants was pale yellow; the plants were dying in large numbers due to foot-rot and anthracnose.

After the diseased plants had been removed or pruned both in the control block and the blocks to be treated counts were made of the number of healthy plants in one ridge in each of the Bordeaux Mixture sprayed and Bouisol sprayed blocks and in the control block. The results are given in Table I.

TABLE I.

| Line Number | Treatment | No. of plants on 26-8-33 | No. of plants on 5-10-33 | Difference | Percentage of loss |
|---|---|---|---|---|---|
| 1st | Ridge treated with Bordeaux Mixture and plants sprayed with Bordeaux Mixture. | 524 | 757 | + 232 | .. |
| 41st | Ridge treated with Bordeaux Mixture and plants sprayed with Bouisol. | 1575 | 1516 | — 59 | 3 |
| 31st | No treatment .. .. | 1601 | 926 | — 675 | 42 |

The increase in the number of plants in Bordeaux Mixture sprayed lines is due to new shoots developing from the underground parts of plants which were cut at the soil line. Similar counts were made at the time of the second and third treatments ; the results are given in Table II.

TABLE II.

| Line Number | Treatment | No. of plants on 5-10-33 | No. of plants on 5-12-33 | Difference | Percentage of death |
|---|---|---|---|---|---|
| 1st | Ridge treated with Bordeaux Mixture and plants sprayed with Bordeaux Mixture. | 757 | 757 | .. | .. |
| 31st | No treatment .. .. | 926 | 401 | — 525 | 56 |
| 34th | No treatment .. .. | 759 | 351 | — 408 | 53 |
| 41st | Ridge treated with Bordeaux Mixture and plants sprayed with Bouisol. | 1516 | 1456 | — 60 | 3 |
| 53rd | Ridge treated with Bordeaux Mixture and plants sprayed with Sulsol. | 801 | 634 | — 167 | 20 |
| 60th | Do. | 719 | 614 | — 105 | 14 |

In this garden Bordeaux Mixture and Bouisol sprayed blocks were the best ; Sulsol treated block was inferior to these two blocks but much superior to the untreated block. Though there were a number of plants in the control block they were more or less all infected ; they showed a general pallor and looked sickly, but the treated blocks, especially the Bordeaux Mixture and Bouisol sprayed blocks, were very leafy and dark green in colour.

In another garden, named Kabeethwalla Berja, having about 50 lines, 30 lines were treated. This was entirely a newly made garden, the planting having been done for the first time in the beginning of 1933 ; at the time of treatment the plants were very small being only 7 months old ; there were many deaths due to foot-rot (*Pythium*) and anthracnose. A central block of 30 lines was ear-marked for treatment leaving as "control" 10 untreated lines on its either side. All the 30 lines were first irrigated with Bordeaux Mixture, 2–2–50 ; out of these 30 lines 20 lines were sprayed with Bouisol and 10 with Sulsol. The method of treatment was the same as already described above. The results are given in Table III.

TABLE III.

| No. of blocks | Treatment | No. of lines treated | Loss between 1st and 2nd treatment | Loss between 2nd and 3rd treatment | Total loss between 1st & 3rd treatment |
|---|---|---|---|---|---|
| 1. | Ridges treated with Bordeaux Mixture and plants sprayed with Bouisol. | 20 | 3% | 4% | 7% |
| 2. | Ridges treated with Bordeaux Mixture and sprayed with Sulsol. | 10 | 3% | 3% | 6% |
| 3. | No treatment .. .. | 20 | 50% | almost completely destroyed | almost 100% |

In 1933 when the first reports of damage done by disease were received from Timarni only a few gardens were infected; some of these were more or less completely destroyed and in the others the infection had not much advanced; therefore the latter were treated as an experimental measure. As the disease spread to other healthy gardens there was a panic amongst the "baris", and since in the early treated gardens the plants had a better stand and the further spread of the disease was considerably checked many more garden owners offered their shares of the affected gardens for treatment. Ultimately out of the 19 gardens at Timarni 13 were treated. Of the remaining six gardens four had been more or less completely destroyed by disease before the treatment could be given, and the owners of the other two gardens would not let them be treated though they were infected. In the 13 gardens over 800 lines were treated in each of them some lines were left untreated as "controls".

Wherever the ridges were irrigated with Bordeaux Mixture and the plants were sprayed with Bordeaux Mixture or Bouisol the plants reacted very favourably to treatment. The death rate decreased considerably and the plants had become very leafy and dark green in colour. Sulsol was not found to be as efficacious in controlling anthracnose and leaf-rot as Bouisol or Bordeaux Mixture, but Sulsol treated lines were much better than the untreated lines.

The best method of control is treating the ridges with Bordeaux Mixture, 2–2–50, and spraying the vines with Bordeaux Mixture, 2–2–50, or with Bouisol once every two months.

It is essential to repeat these treatments about every two months because foot-rot (caused by *Phytophthora parasitica* var. *piperina* and *Pythium*

*piperinum*) and anthracnose are found more or less all the year round though the greatest damage is during the rains and the first part of winter. Another advantage of spraying with Bordeaux Mixture or Bouisol has been that the sprayed leaves are much greener than the unsprayed leaves of even healthy plants, and therefore the leaves are reported to fetch a higher market value.

At Timarni the cost of spraying with Bordeaux Mixture a line of 150 feet having well grown plants in full flush is about three pies and the cost of treating a ridge 150 ft. in length is about two and a half annas. The cost depends on the local price of copper sulphate and lime for making the fungicide. There is no extra cost for labour because of the method of irrigation practised at Timarni. The water is contained in an earthen pot which is carried on the shoulder of a cooly and the water is poured on the ridges through a bamboo funnel. Therefore the ridge can be treated when it is to be irrigated, water being replaced by Bordeaux Mixture. With a little practice the cooly is easily capable of applying the right quantity of the liquid, *viz.*, one gallon per 6 ft. of the ridge.

When ridges are irrigated by sprinkling water with hand, as at Jubbulpore, there would not be any extra cost of labour but where irrigation is by means of irrigation channels and where ridges are not irrigated but furrows, as at Ramtek and in Berar, there may be an extra cost of labour, as water has to be carried to the garden from its common source of supply which may be far away from the garden.

The extra cost of labour involved in spraying would be negligible as not more than 2½ gallons of the spray fluid is required for treating a line of 150 ft. length.

The cost of spraying with Bouisol (3½ lbs. per 100 gallons of water) or Sulsol (5 lbs. per 100 gallons of water) instead of with Bordeaux Mixture is one anna and one and a half anna respectively. On account of the excessive cost of Bouisol compared to that of Bordeaux Mixture the former cannot be recommended for soil treatment. There is no particular advantage in treating the ridge with Bordeaux Mixture and leaves with Bouisol. It is therefore preferable to have the same fungicide both for soil treatment and spraying. Bordeaux Mixture leaves a blue stain on the leaves but since the leaves before they are marketed are invariably washed in water, staining of the leaves with the fungicide is of no consequence and the "baris" of Timarni do not object to the use of Bordeaux Mixture as a spray.

Removal and destruction of diseased plants is essential because it has been found that in those treated gardens where the owners have neglected

the removal and destruction of dead or dying plants there have been more cases of fresh infection than in those gardens where the diseased plants have been systematically removed. In the case of anthracnose infected plants pruning the vines a couple of inches below the lowest lesion is essential before spraying. It is not necessary to completely uproot the plants which are attacked only by anthracnose.

Where pan is to be planted in soil known to be diseased it is advisable to treat the soil with Bordeaux Mixture before planting the "seed".

The new earth that is applied in pan gardens, about twice every year, should preferably be treated with Bordeaux Mixture before it is applied; but if it is not convenient to do so the application of new earth on the ridges should immediately precede the bi-monthly irrigation with the fungicide so that the new earth does not remain long untreated in the garden and thus become a focus of fresh infection.

When irrigation is by means of a funnel or by hand on the ridge itself the fungicide need only be applied on the ridge and its sides; but if the irrigation is by means of water channels it is necessary to treat both ridges and furrows which serve as irrigation channels.

In the gardens where "pipri" (*Piper longum*) is planted along with pan it should be also treated with Bordeaux Mixture, as it is as equally susceptible to foot-rot and anthracnose as pan.

If a foot-rot infected garden is not treated with the fungicide, it is essential that it should not be replanted with pan, because the crop is sure to be completely wiped out by disease before it is a year or two old. The soil sould be rotated with crops which are not susceptible to the foot-rot fungi. It is not possible to say how long the soil should be rested or rotated with other crops. In Ramtek the pan garden soil is allowed to fallow for two or three years after the garden has been three or four years old; but when the foot-rot infected soil (the cause of the foot-rot being *Phytophthora parasitica* var. *piperina*) is replanted even after it has been rested for three years the crop is again as much diseased as the previous crop of three years back. Either the fungus has remained dormant during this period, or susceptible weeds like *Vinca* spp. and *Martynia diandra* ("Baghnakh" or "Vincher akara") which overrun fallow land during the rains become diseased and thus keep on infecting the soil from time to time.

In those parts, like Timarni and Saugor, where the fallowing of the pan garden soil is not practised and where the garden is continuously under pan for decades after decades the choice is between treating the garden or abandoning it when it becomes diseased, because not only will the standing crop be

destroyed by the disease but the replanted crop will share the same fate, if the soil is not treated with the fungicide.

*A detailed account of the diseases.*

*Foot-Rot.*

*Phytophthora* and *Pythium* rots. The above ground parts of a foot-rot affected plant show a general pallor and drooping of tender shoots and leaves but there are no other signs of infection on the leaves or stems, such as lesions or rotting of any of the ærial parts. But if a plant showing marked yellowing and drooping is pulled out it will generally give way at the collar and its underground parts will be found to be in various stages of decay and rot. If a plant showing early signs of infection is carefully removed from the soil its fine roots and rootlets will be found to be dead or dying and discoloured black or brown. If the root or rootlet which is dead or dying is cut open longitudinally narrow black or brown coloured streaks will be seen in the region of its vascular bundles, even if the root may appear externally to be healthy. These discoloured streaks in the root can be traced back to the diseased rootlets. If the root be cut transversely the central core will be found to be black or brown or some of the vascular bundles will be prominent as brown or black coloured dots. In the tissues of the underground node the infection can be readily traced by the presence of discoloured xylem tissues. If the node be cut transversely the basal parts of the roots can be easily recognised by the presence of black streaks which extend into the tissues of the node; it will be readily seen that the infection spreads from the roots to the nodes. In the very early stage of infection it is invariably seen that the blackening is confined wholly or partly to the tissues of a root or rootlet. In a slightly more advanced stage the blackening from the rootlet extends to the tissues of the node and the discolouration of the nodal tissues is at first confined to the tissues adjacent to the place from where the rootlet has developed. When the infection travels to the nodal tissues further spread in the underground stem can be traced by the presence of discoloured vascular bundles. Where the infection is very slight only one such discoloured vascular bundle in the node or the internode may be present. At this stage the plant may not show any outward sign of infection. The wilting depends on the extent of the infection in the tissues and the rapidity with which the plant wilts depends also on the internode which has become first infected. If the disease is confined to the internode just below the ground surface the aerial parts of the plant are more or less completely cut off from food supply from the soil and therefore the plant wilts very rapidly. Whereas if the infection starts from an internode farther away from the soil surface, the underground

parts of the plant above this diseased internode still continue to function till they become infected and therefore the diseased plant appears to remain normal and healthy for a much longer period after it has become diseased.

As the underground part of the stem of an old plant contains four or five internodes on account of the addition of fresh earth, about twice a year, it often happens that there are some healthy internodes between or below the infected internodes; from these healthy internodes new healthy shoots may develop, so that a diseased plant may have its main stem wilting and drying but its side shoots arising from the underground parts may be healthy and green; these side shoots also later become diseased. The disease may spread from one underground internode to another, or one or more internodes may catch the infection directly from the soil. From the condition of the roots it is possible to say if the fungus has extended into a particular internode from its diseased neighbour or whether it is a case of direct infection. In the case of direct infection the roots are dead or are dying from tip upwards; they are more or less in a decayed state, especially the rootlets; in the case of the spread of the disease from an infected internode, the roots may look healthy and may not show any signs of infection; the presence of the disease in the internode can be detected by the presence of discoloured tissues when the internode is cut open. Direct infection of the internodes above soil surface has not been observed though a thorough search has been made in various parts of the Provinces. The spread of the disease from the underground parts to the aerial parts does not extend usually to more than one or two internodes at the most because the plants are killed before the disease can spread further. A badly diseased internode distinctly shows a wet rot; the tissues have completely rotted, the soft parts are destroyed and the fibrous parts are in shreds.

The disease always appears to develop suddenly but it is doubtful if this is really so in all cases. Under moist conditions of high atmospheric humidity and low temperature the development of the disease may be rapid but it becomes inactive and the progress is slow when the season is dry and warm. When once the tender leaves and shoots show signs of wilting the death of the plant is very sudden; but this wilting, the outward symptom of the disease, does not necessarily follow rapidly in the wake of the infection; this wilting is the direct result of the death of the tissues of the internode nearest the soil surface.

*Microscopic Study of the Diseased Tissues.*

In transverse or longitudinal sections the necrotic tissues are readily visible, even with the naked eye, because of their prominent black or brown colour. A microscopic study of a section through a badly diseased stem or

root shows in the necrotic area a general collapse of the cortical cells, cell walls coloured brown or black, and cell lumen filled with a black or brown substance, which is either granular or gummy in appearance, especially in the xylem region. In the xylem tissues there is also a disintegration of the vascular bundles, a lysigenous cavity being produced which is filled with a granular or gummy substance and fragments of the thickened walls of the vessels (Plate LXXVI, Fig. 12). In newly diseased cells the protoplasm at first becomes granular and later plasmolysed ; the middle lamella of the cell wall appears to be dissolved, as the suspect cells become separated. The diseased tissues begin to turn brown and later black ; in the cortical region they ultimately collapse, and in the vascular region the walls of the cells and vessels may give way. Judging from the presence of the necrotic area it appears that the disease advances up the stem through the vascular region. Beyond the badly diseased area the number of vascular bundles which are necrotic becomes reduced and the cortical tissues are found to be firmer and more healthy looking till ultimately only a single vascular bundle may be found to be diseased and discoloured ; the stem beyond this point may be entirely healthy. Similar is the case with the progress of the disease in the roots.

In hand and microtomic sections the hyphæ are not readily visible especially in the discoloured tissues. In the necrotic areas which are turned brown or black the hyphæ if present are usually empty and their walls are similarly discoloured as the host tissues, and therefore their presence is usually obscured by the general discolouration prevalent in that area. In some cases the hyphæ can be with difficulty traced but in some parts of the diseased tissues it is evident that they have not been invaded by the fungus, since the cell walls are not swollen ; whereas in other parts the hyphæ cannot be traced but the cell walls are distinctly swollen and separated ; the hyphæ seem to have disintegrated in these parts. In the discoloured region where the hyphæ are dead and also discoloured they do not take the Cotton Blue or Rosazurin dye ; but in the diseased tissues which have not become discoloured the hyphæ can be readily stained with either of these dyes. Hyphæ, neither in the newly diseased tissues nor in the discoloured areas are found in great quantities and when present long strands of the hyphæ have not been seen (Text-Fig. 14). The hyphæ are generally inter-cellular but sometimes they may be also intra-cellular, especially, in the discoloured tissues. Haustoria have not been observed. The cell walls between which the hyphæ run become swollen, at times considerably ; these swollen cell walls may become striated.

The following methods for staining hand and microtomic sections were

employed to detect the presence of hyphæ: (1) Sections were first cleared in a lacto-phenol solution and stained with Cotton Blue and Saffranin as recommended by Lepik (1928); (2) Hand sections were first boiled in lactic acid and then stained with Cotton Blue; (3) Sections or small pieces of the infected tissues were first boiled in a three per cent. solution of caustic potash and washed in water and then stained with Rosazurin; (4) Hand sections were stained with Cotton Blue in Amman's Solution (Linder, 1929).

Since the hyphæ are so few in quantity in the necrotic areas and since continuous long strands of hyphæ have not been traced in the invaded tissues, therefore it is probable that the destruction of the tissues over such large areas may be the result of some toxins that may be produced by the fungus. Another reason for the hyphæ being found in such small numbers is that there may be a disintegration of the hyphæ as they become old. In sections of the discoloured tissues, small lengths of hyphæ are found though the cell walls have become swollen and the adjoining cells separated from each other over a large area (Text-Fig. 14), it seems that in the empty spaces the hyphæ have disintegrated after having killed the cells.

The infection is always soil borne; no cases have been observed where the disease spreads from the above ground stem to the collar and the underground parts. It is doubtful if the healthy underground stem is directly infected by the pathogene in the soil. An examination of numerous specimens and inoculation experiments lead to the conclusion that the parasite penetrates the stem either through a root or rootlet. Invariably it is the root or rootlet that is first found to be diseased. The fungus first infects either an adventitious rootlet, arising from an underground stem or infects a secondary rootlet; or the main root may become directly infected through a wound. The infection then travels up to the node of the underground stem from which the diseased root or rootlet arises.

If the node bearing a diseased root or rootlet be so cut transversely that the infected root or rootlet is cut longitudinally the necrotic parts of the root or rootlet will be found to be in continuation of the discoloured black cortical and vascular tissues of the node.

The necrotic tissues have invariably been found to extend from a node to the internode above and below it. No case so far has been observed where an internode between two healthy nodes has discoloured tissues.

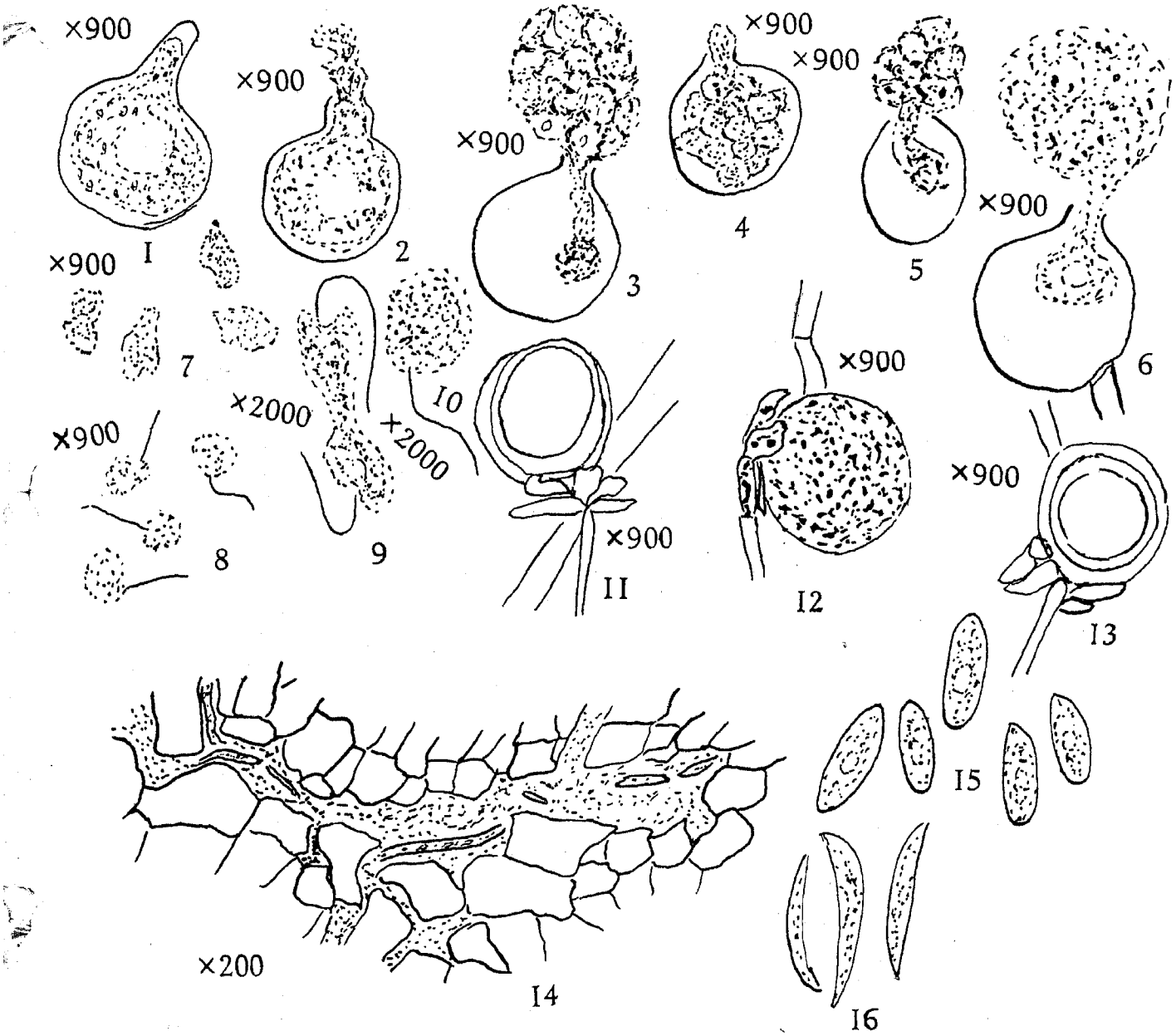
*Pythium piperina* nov. sp.

*Morphology.*

The fungus makes a luxurious ærial cottony growth when grown on rice meal agar, Quaker Oats agar and French bean agar. The growth is similar to that of *Phytophthora parasitica* on these media.

The hyphæ are 2·2 to 5·75 $\mu$ thick; they branch freely. They may form knotted masses or coils, but they do not develop clavate or sickle-shaped bodies similar to those observed by Braun (1925) in cultures of *Pythium de Baryanum* Hesse and by Carpenter (1921) in cultures of *P. Butleri* Subrm.

The fungus when grown on agar media or on ants or flies develops sporangia very rarely; but when sterilized moist soil in a Petridish or in a test tube is inoculated with this fungus, though there is not much of ærial mycelial growth, sporangia are freely developed on the mycelium of the inoculum. The sporangia are generally globular and without a distinct papila. At times they may be ovoid or pear-shaped when they may have a distinct papila. They are terminal, lateral or intercalary. The protoplasm in the mature sporangium is highly granular and contains one large vacuole. Before the contents of the sporangium are discharged they may become divided into zoospore units (Plate LXXV, Figs. 1(*a*) and 2 and Text-Figs. 3 to 5) or they may remain as a homogeneous and highly granular mass of protoplasm (Plate LXXV, Figs. 1 *a* and 4 and Text-Figs. 1, 2 and 6). The contents of the sporangium are expelled *en masse* either directly through an opening in some part of the wall (Plate LXXV, Figs. 1, 2 and 4 and Text-Figs. 3–6) or through a thin walled transient discharge tube which protrudes through the wall (Plate LXXV, Figs. 5 and 6 and Text-Figs. 1 and 2); this tube often has a hayline plug at the apex but which soon gives way under pressure of the discharging contents; the discharge tube does not swell into a vesicle; even if the sporangium has a papila (the ovoid or pear-shaped sporangium being usually papilate), the discharge of the contents do not necessarily take place through the papila. Whether the discharge of the contents is through a tube or directly through an aperture in the sporangial wall, and whether the protoplasm is or is not differentiated into zoospore units before it is expelled out of the sporangium, the contents are discharged in a continuous stream and collect near the opening of the sporangium or near the mouth of the discharge tube, as the case may be, generally in a globular mass (Plate LXXV, Figs. 1–4); the discharged sporangial contents have not been observed to be enclosed in a vesicle. Soon after the contents have passed out through the discharge tube, there is no trace of the tube, it having either become disintegrated or dissolved. If the zoospores have not been already demarcated in the sporangium the protoplasm outside the sporangium is soon differentiated into zoospore units. The zoospores in the globular mass outside the empty sporangium are polygonal in shape (Plate LXXV, Fig. 2 and Text-Fig. 7) and vary in number according to the size of the sporangium but not more than 12 have been observed. The individual zoospores break away from the mass collected round the empty




mother sporangium. The zoospore that is swimming in a film of water is found when fixed with iodine to be more or less round (Text-Figs. 8 and 10 and Plate LXXV, Fig. 7) having generally one cilium but sometimes, though not often, two or three cilia have been observed ; when more than one cilium are present one cilium is as long as that of an uni-ciliate zoospore and the other cilia are usually much smaller ; these cilia do not necessarily arise from the same place. The single cilium and the longer cilium, when more than one cilium are present, seem to arise from a slight depression in the zoospore. What looks like a multi-ciliate zoospore may not be really a

single zoospore with more than one cilium but may be a body consisting of two or three still undifferentiated zoospore units which may or may not later get separated into individual zoospores. This would account for the cilia being of different sizes and the cilia not arising from the same point when more than one are found on a globular naked protoplasmic body. Again at times, though very rarely, a naked protoplasmic body with a constriction in the middle and two long cilia, one at either end, has been observed (Text-Fig. 9). This body looks as if the two zoospores which have remained united together are now separating at the place of the constriction. But in some few cases the zoospore has appeared to be distinctly two ciliate, the two cilia being of equal length and arising from a common point. The sporangia measure 12·5—20·4 $\mu$, usually they measure 15·3—20·3 $\mu$ the average being 16·3 $\mu$. The zoospores measure 3·4 to 5·1 $\mu$, and the cilia measure 4·6 to 10·1 $\mu$.

The motile zoospores were first fixed on a glass slide with a drop of iodine solution and the solution was allowed to dry up almost completely; the yellow stained almost dry spot was then covered with a small drop of Amman's mounting medium (Linder, 1929) containing Cotton Blue, and a cover slip was then placed on the drop; by this method zoospores and their cilia were preserved in their original state and clearly stained blue, the body of the zoospore staining deeper blue than the cilium. Permanent mounts were made of these slides by ringing the cover slip with Canada Balsam after the water from the medium had evaporated.

Oogonia are developed in large numbers on rice meal agar, or French Bean agar or Quaker Oats agar. Oogonia are globoid or spherical, lateral, terminal or intercalary; they are smooth, thin walled and hyaline; they measure 15·3—25·5 $\mu$ in diameter, the average being 19·30 $\mu$. They resemble sporangia in shape and more or less in size.

Antheridia may be single or many per oogonium (Plates LXXV and LXXVI, Figs. 8–10 and Text-Figs. 11–13); they arise from neighbouring hyphæ or they may be a branch of the oogonial stalk or they may develop from the main hypha bearing the oogonium. The antheridial hyphæ may have a number of swellings, the swellings being not separated by septa; each swelling may apply itself to the oogonium; it is not possible to say if each of these swellings has pierced the oogonial wall, but it looks as if the antheridial hypha has fused with the oogonial wall at more than one place. When more than one antheridium are present all have not necessarily discharged their contents in the oogonium, though as a rule they have; all are not always found to be empty at maturity (Plate LXXVI, Fig. 9). The contents of all the antheridia do not necessarily enter the oosphere; after the oosphere has been

fertilized and the oospore wall developed the remaining antheridia may extrude their contents in the space between the oospore wall and the oogonial wall (Plate LXXVI, Fig. 10). Though the number of antheridium per oogonium may be greater than one still only a single oospore is invariably developed within the oogonium. The oospore generally lies free within the oogonium but at times it more or less completely fills the oogonial cavity or a large area of the oospore wall is in close contact with the inner oogonial wall. The oospore is smooth and thick walled ; in colour it is usually hyaline but sometimes may be slightly yellow coloured.

The oospore may also develop parthogenetically (Plate LXXVI, Fig. 11). Such an oospore is in no way different from one formed as the result of fertilization.

The oospores measure 12·75—20·4 $\mu$, the average being 16·6 $\mu$.

*Pythium piperinum* nov. sp.

Mycelium intercellular ; in culture exhibiting strong ærial cottony growth ; composed of hyphæ 2·2—5·75 $\mu$ in diameter. Sporangia globular, without a papila, measuring 12·5—20·4 $\mu$ (average 16·4 $\mu$) ; zoospores formed within the sporangium before discharge of the contents or formed outside the sporangium after the discharge of the contents ; discharge of the contents through an opening in the sporangial wall or through a discharge tube ; the contents not emptied into a vesicle ; zoospores collect outside the sporangium in a globular mass ; zoospores at the most 12 in number spherical, generally uni-ciliate but sometimes two-ciliate ; measuring 3·4—5·1 $\mu$, cilia measuring 4·6—10·1 $\mu$. Oogonia spherical or sub-spherical, terminal, lateral or intercalary ; smooth, thin walled and hyaline ; measuring 15·3—25·5 $\mu$ in diameter (average 19·3 $\mu$). Antheridia one to many per oogonium borne terminally or laterally on a separate hypha or on the hypha bearing the oogonium. Oospores one per oogonium, smooth, thick walled, hyaline or slightly coloured yellow, spherical, almost filling the oogonial cavity ; formed after fertilization or parthogenetically, measuring 12·75—20·4 $\mu$ in diameter (average 16·6 $\mu$).

Parasitic on the underground stem and roots of *Piper betle* and on the roots of *Piper longum*.

*Inoculations.*

The parasitism of *Pythium piperinum* has been established by successful inoculations ; they take more readily during the rains than in winter or summer. The infection takes through the underground rootlets or through old wounds on roots and stems ; when the inoculum is placed on the freshly cut surface, the infection does not take, especially in the case of the freshly

cut surface of a stem; this is very probably due to the toxic effect of the "bleeding" that results from a freshly cut surface on the inoculum.

Seedlings of cotton, wheat, water melon, rice, *Taphrosia candida* and chillies (*Capsicum* spp.) which are susceptible to infection by Pythiums in this Province and seedlings of castor and cress (*Lepidium satiyum*) failed to take the infection when inoculated with the pan *Pythium*.

*Phytophthora parasitica* var. *Piperina* n. var.

Sporangia are pear-shaped. They vary considerably in size but not in shape; the papila is very prominent; it is raised and forms an arc of a circle; the sporangia are very much similar to those of *P. parasitica* Dast. (Dastur, 1913). In size they vary from 30·0—65·3 ⩒ 20·4—40·8, though usually they measure 35·7—56·1 ⩒ 30·6—35·7. Conidia or chlamydospores are also similar to those of *P. parasitica*.

This fungus has been isolated from specimens received from Ramtek, Paraseoni, Nagpur, Bhandara, Bhandak, Jubbulpore, Sohagpur, Saugor, Damoh, Piparia, Timarni and Seoni Malwa, but oospores have been found only in some of the cultures of the fungus isolated from specimens received from Paraseoni and Bhandara.

The development of the sexual organs is of the "infestans" type, antheridia being amphigynous.

The oogonium is at first hyaline, smooth and thin walled, but with the development of the oospore the oogonium becomes yellow or yellow brown or orange yellow coloured and the wall is distinctly thickened. The oogonium may remain smooth walled but generally it becomes thick crusted on the outside due to secondary thickening, which makes the outline of the wall indistinct and rough; a similar condition has been observed in *P. parasitica* (Dastur, 1913), *P. Colocasiæ* Rac. (Butler and Kulkarni, 1913), *P. infestans* (Mont.) de Bary (Clinton, 1910). The oogonium is generally embedded in the medium and is entangled in a mat of nodular and budded hyphæ. The size of the oogonia varies according to the nature of the medium on which they are developing. In diameter they vary from 20·4—40·8 $\mu$, the average measurement being 33·4 $\mu$.

Antheridia are hyaline, thin walled and persistent.

Oospores usually completely fill the oogonial cavity. They are round, smooth and thick walled, hyaline in colour but at times they may be slightly tinged yellow. They measure 17·8—33·1 $\mu$, the average being 26·1 $\mu$.

According to Thompson (1929) Mr. S. F. Ashby, Mycologist, Imperial Institute, has identified the *Phytophthora* on pan in the Malaya States to be *P. Colocasiæ*. The sporangia of the *Phytophthora* under study are much

broader than those of *P. Colocasiæ* and do not separate by a slender pedicel as do the sporangia of the Malayan *Phytophthora*. The oospores of these two *Phytophthoras* do not much differ in size; Thompson's measurements for the oospores of the Malayan fungus being 19·5—31·5 $\mu$ but he has found the oospores to be "coloured brownish yellow when mature", whereas the oospores of the *Phytophthora* under study are generally hyaline and rarely tinged yellow. Therefore the *Phytophthora parasitica* on pan in the Central Provinces is not considered to be the same as the Malayan pan *Phytophthora*.

Judging from the general characteristics the fungus has certain resemblances to *P. parasitica* on *Ricinus communis* and *Vinca rosea* (Dastur, 1913). The sporangia of the pan *Phytophthora* are very much similar to those of *P. parasitica*; the oogonia of the fungus are bigger than those of *P. parasitica* but it has already been shown that the size of the oogonium is not constant and is influenced by the nature of the medium on which the oogonia are developed. The oospores are bigger than those of *P. parasitica*. In recent isolations of *P. parasitica* from *Ricinus communis* and *Vinca rosea* oogonia and oospores have been larger than those already recorded (Dastur, 1913); the oogonia measure 25·5—30·6 $\mu$ in diameter and the oospores measure 20·4—28·0 $\mu$.

The pan fungus is capable of readily infecting seedlings of *Ricinus communis*, *Vinca rosea* and *Martinya diandra* but not *Colocasia antiquorum*; on the few occasions when the leaves have shown signs of infection, lesions have remained very small and localised and have not been typical of those produced by *P. Colocasiæ*; the petiole and the corm have not taken the inoculation.

The pan *Phytophthora* is considered to be a variety of *P. parasitica* Dast. and therefore it is named *P. parasitica* var. *piperinum* n. var.

*Phytophthora parasitica* var. *piperina* n. var.

Hyphæ generally inter-cellular, sometimes intra-cellular; haustoria absent; sporangia pear-shaped or broadly ovate with a prominent papila; measuring 30·0—63·3 $\vee$ 20·4—40·8 $\mu$; motile zoospores bean-shaped and biciliate; resting zoospores spherical measuring 2·2—5·7 $\mu$; chlamydospores similar to those of *P. parasitica* Dast.; oogonia at first hyaline, smooth and thin walled and spheroidal; after fertilization thick and smooth or rough walled, yellow or yellow brown coloured; measuring 20·4—40·8 $\mu$, average 33·4 $\mu$; antheridia hyaline, thin walled, persistent and amphigynous; one antheridium per oogonium; oospores spherical, almost filling the oogonium, smooth and thick walled hyaline, or very pale yellow coloured; measuring 17·8—53·1 $\mu$, average 20·1 $\mu$.

Parasitic on roots, underground stems and leaves of *Piper betle* and on roots of *Piper longum*.

*Isolation of Phytophthora.*

This fungus is not always readily isolated from root-rot infected plants. Numerous attempts have been made to isolate the pathogen from specimens collected from various parts of the Province, but very often the results have been unsatisfactory. The isolations of pure cultures of *Phytophthora* have been very few compared to the isolations of other fungi, bacteria and nematodes. This difficulty may be due to the exudate produced by the tissues of the pan plant, which may have a toxic effect on the parasite. An externally sterilized piece of pan stem planted on rice agar or glucose agar darkens or blackens the medium near about the place where the piece lies. The pathogen has not been isolated from all parts of the diseased area. When the infected tissues, which have either completely rotted and are in shreds, are incubated in culture media after sterilizing the tissues with corrosive sublimate (1 in 1,000) and washing them in sterilized water, *Phytophthora* makes no growth whatsoever; when the infected tissues show signs of soft rot and are similarly treated and incubated even then *Phytophthora* is not always obtained, and if obtained it is more often than not mixed with other fungi or bacteria. The organisms usually obtained from the wholly or partly decayed tissues are nematodes, *Fusarium* spp., *Glœosporium* sp. and bacteria, in some cases, *Sclerotia Rolfsii* and in a few cases, *Rhizoctonia bataticola* and *R. Solani.* In the tissues of decaying infected parts the hyphæ of *Phytophthora* seem to be dead or to have lost their vitality; but however when a piece of the infected tissues, which is firm and at the cuts ends of which are visible at the most two or three brown or black dots in the vascular area is incubated, cultures of *Phytophthora* are readily obtained; in many cases the cultures are pure but there is the probability of *Glœosporium* sp. being also simultaneously isolated; this probability is considerably reduced if the green bark round the infected piece is removed or scraped before it is incubated. There is a greater possibility of obtaining a pure culture of *Phytophthora* if for the incubation is used the central woody part of a node the tissues of which are firm and not badly discoloured.

*Inoculations.*

Successful inoculations with the *Phytophthora* isolated from diseased pan plants have been obtained. When the inoculations were done on the aerial parts, wounded or unwounded, they were usually not successful. In some cases there was a slight water soaked discolouration round the place of the inoculum, but this discolouration did not extend further. When the inoculum was well mixed with soil the plant took the inoculation. The infection was more readily taken when the inoculum was in contact with old roots which were dead or dying. When the inoculum was placed in direct contact

with a freshly cut part of a root or underground stem the infection very often did not take; it is probable that the "bleeding" from the newly cut surface of the root or the stem has a toxic effect on the fungus and so acts as an antiseptic layer between the exposed tissues of the plant and the fungus. Not only was this the case with the *Phytophthora* isolated from pan but similar results were obtained when for the inoculations *Phytophthora* isolated from *Ricinus communis, Vinca rosea, Peperomia artifolia, Martinia diandra* and *Chrysaidocarpus lutescens* was used.

The pan *Phytophthora* produces the typical wet rot of leaves, petioles and stems of *Peperomia artifolia*, similar to that developed on a naturally infected plant in the rains.

The pan fungus is capable of infecting seedlings of *Ricinus communis*, and of *Vinca rosea*, and leaves of *Martinia diandra, Euryclis amboinensis, Iris.* sp. and *Chrysaidocarpus lutescens.*

*Foot-rot—Sclerotial fungi.*

(*a*) *Sclerotia Rolfsii.*—The infected underground stem of the plant in the early stages of the disease shows a distinct wet-rot; the underground stem is of a sickly pale yellow colour and its bark is slimy, which easily peels off from the wood. In a transverse section the presence of the vascular bundles is not necessarily marked off by a black discolouration as in the case of foot-rot caused by *Phytophthora* and *Pythium.* The infection does not seem to spread necessarily from the rootlets to their nodes. In advanced cases, even when diseased plants are killed and have become dry, the presence of the fungus can be readily recognised by the clear white feathery strands of hyphæ which spread out fan-like on the outside of the underground stem.

This fungus isolated from diseased pan plants does not produce in cultures sclerotia in such large numbers as does *S. Rolfsii* isolated from diseased wheat, cotton, potato and tomato plants. In sub-cultures of the fungus which has been grown in culture media for several generations, there is a very good growth of hyphæ but sclerotia are very sparingly developed or none at all. The mycelial growth is white and feathery. The first symptoms of the sclerotial formation is the appearance of globular white fluffy soft bodies generally superficial on the ærial mycelium. These bodies soon change their consistency and colour; they become very hard and woody and the colour changes from snowy white through different shades of brown to tobacco brown or raw amber or brownish drab. The surface of the sclerotium is smooth and not pitted. In diameter an individual sclerotium is about one or one and a half millimetres, but in sub-cultures kept going

for several generations the sclerotia may lose their individuality and several may fuse together forming a hard shapeless mass of the same colour as the single round sclerotium. The surface of this sclerotial mass is also smooth and not pitted.

(*b*) *Rhizoctonia bataticola* and *R. Solani*.—In the early stages of infection by these sclerotial fungi there do not seem to be any external symptoms by which an infected plant can be differentiated from one attacked by *Phytophthora* or *Pythium*. In advanced cases of infection the underground parts are dry ; the rot is distinctly dry and not wet as in the case of *Phytophthora* and *Pythium* infections. The soft parts of the tissues are more or less completely destroyed and the underground stem is in shreds. At this stage if the disease is caused by *R. bataticola* its minute black sclerotia may be distinctly visible. Sclerotia of *R. Solani* have not been found on infected plants.

*Rhizoctonia Solani.*

In cultures the mycelium is at first white in colour and does not grow much above the surface of the medium. The mycelium that creeps along the glass sides of the culture tube soon develops scattered conglomerations of hyphæ, white in colour. Later the mycelium becomes dirty white and then drab coloured. The conglomeration of hyphæ which are at first white also change their colour to different shades of brown ; usually they are surrounded by a fringe of hyphal strands which are of a lighter colour or even white ; they vary in shape and size. On the sides of test tubes these collections of hyphæ may be membranous or papery or they may grow into hard thick lumps. On the medium itself these collections of hyphæ do not remain papery or membranous but develop into hard thick woody bodies ; they are not uniform in shape. Their surface is uneven and covered with white or light brown or drab coloured mycelium. Drops of brown liquid ooze out from their fuzzy surface. The papery or membranous sclerotial masses are formed of a loose woven network of coloured hyphæ ; but the thick sclerotial masses are formed of a closely woven network of hyphæ. In both cases the hyphæ are closely septate, the cells being short and barrel shaped ; in the thick sclerotia in addition to these broad many septate hyphæ of light brown drab coloured bodies there may be another type of hyphæ which have narrow long cells and coloured very dark brown.

*Inoculations.*

Inoculations of pan plants with these sclerotial fungi have not been very successful. Plants inoculated with *Sclerotia Rolfsii* have in a few cases given positive results but in a majority of cases the inoculations have failed.

for several generations the sclerotia may lose their individuality and several may fuse together forming a hard shapeless mass of the same colour as the single round sclerotium. The surface of this sclerotial mass is also smooth and not pitted.

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Inoculations of pan plants with these sclerotial fungi have not been very successful. Plants inoculated with *Sclerotia Rolfsii* have in a few cases given positive results but in a majority of cases the inoculations have failed.

Inoculations with *Rhizoctonia bataticola* and *R. Solani* have given negative results.

*Leaf-Rot.*

During the monsoon under very wet conditions pan leaves also are susceptible to a rot caused by *Phytophthora parasitica* var. *piperina*. The extent of the loss caused by this disease depends upon the prevailing climatic conditions. At times the disease may be in an epidemic form especially when there are long periods of rainy and cloudy days, sunny days being few and far between. These conditions are favourable for the development of zoospores which are readily splashed from the infected soil surface against the low hanging leaves by the rain water. Leaves within a couple of feet from the ground surface are particularly liable to infection. The topmost leaves are seldom found diseased.

The first symptom of the disease is the presence of a circular black or brownish spot which is more or less wet in appearance. Under continuous wet conditions the black spot rapidly increases in diameter and develops a wet rot of the major part of the leaf; the rot extends to the petiole and from the petiole to the stem. When the infection reaches a mid-rib or one of the main veins, it spreads more rapidly along their length than between the veins; the diseased parts of the vein or mid-rib are readily located by their brown wet discolouration. If wet conditions are not continuous and if the rain lasts only for a day or two with dry warm periods between, the diseased areas show distinct concentric puckerings and wrinkles on account of an unequal growth of the tissues; such a leaf generally looks smaller in size than a healthy leaf. Under dry conditions the progress of the disease is checked and the black spots usually surrounded by a brown ring remain dry and localised. More than one spot are often found on a leaf; the spots may coalesce together.

*Anthracnose.*

The anthracnose disease is chiefly a disease of the aerial stem and branches. The leaves have not so far been found to be attacked, but in a few cases the fungi causing anthracnose have been isolated from the underground stem, very often associated with *Phytophthora* or *Pythium*. The causal fungi are *Glœosporium* sp. and *Colletotrichum* spp. The symptoms produced by these fungi are identical. The first sign of infection is the presence of a small, black speck, which is generally circular, on the green bark of the stem; the progress of this black lesion is dependent on the prevailing climatic conditions. Under dry atmospheric conditions the lesion may not increase in size and may remain as a stain on the shining green bark; at times the

bark of the infected area dries up and ruptures exposing the wood underneath it, but under moist atmospheric conditions the lesion grows rapidly in size and may involve a greater part of the affected internode; the lesion generally increases more rapidly along the length of the stem than along its circumference. The lesions very often form vertical narrow streaks (Plate LXXVII, Fig. 19); one lesion may more or less completely encircle the stem or two or more lesions may run together and coalesce involving the whole or a greater part of the circumference of the stem; when this happens the part of the stem above the diseased internode wilts and rapidly collapses. The infection spreads also to the lower parts of the stem as well and ultimately under favourable conditions the whole plant is involved and killed; usually many parts of the stem are infected at the same time and so the death of the plant is all the quicker. When the black lesion first appears on the stem there is no visible sign of depression of the infected part (Plate LXXVII, Fig. 19); but as the lesion increases in size the blackened area becomes distinctly depressed on account of the death and drying of the infected tissues. With the progress of the disease, vertical cracks are produced on the lesions and droplets of gum may exude from the cracks (Plate LXXVII, Fig. 18). A badly infected internode is distinctly constricted and its tissues may be longitudinally split (Plate LXXVII, Fig. 18). In the gardens sporulation of the causal fungi on the diseased aerial parts of the plants does not take place, because they rapidly dry up; but on the underground parts acervuli have been found; but when an infected part of the stem is incubated under moist conditions sporulation readily takes place.

*Microscopic characters.*

As in the case of tissues attacked by the foot-rot fungi, *Phytophthora parasitica* var. *piperina* and *pythium piperinum*, the tissues of the stem attacked by the anthracnose fungi also show brown or black necrotic areas, which are more or less confined to the epidermis and the sub-epidermal tissues upto the peripheral ring of the vascular bundles (Plate LXXVI, Fig. 13). It is seldom that the tissues beyond the peripheral ring of the vascular bundles are affected. The cell walls first turn brown and swell; later the cell contents also become discoloured; in the cortical tissues because of the disintegration of the cells cavities are produced; but they are not filled with a granular or gummy substance (Plate LXXVI, Fig. 14). Hyphæ are found in these cavities in the cortex. The inner rings of the vascular bundles or the medullary vascular bundles are not usually affected but the peripheral ring may be necrotic and the walls of the vessels may be disorganised; the cavity being filled with a gummy or granular substance and parts of the disintegrated walls of the vessels as in the tissues affected by *Phytophthora* or

*Pythium* (Plate LXXVI, Fig. 15). A necrotic vascular bundle of an anthracnose affected stem cannot be differentiated from a necrotic vascular bundle of a foot-rot affected stem.

The browning and swelling of cell walls is very often in advance of the hyphæ; the hyphæ in the discoloured parts of the tissues may be similarly discoloured; these hyphæ do not take the Cotton Blue or Rosazurin dye. Hyphæ are both inter- and intra-cellular.

From diseased plants two species of *Colletotrichum* have been isolated; they can be readily differentiated by their acervuli and the shape of their spores.

The stroma of the acervuli in one species is long and chiefly embedded in the cortical tissues, but is also partly above the epidermis; the stroma is not conspicuously erumpent; it extends to a large number of cortical cells underneath the epidermis which under the pressure of the developing spores is ultimately ruptured more or less along the whole length of the stroma (Plate LXXVI, Fig. 16).

The conidia in this species are elliptical in shape, both ends being broadly rounded (Text-Fig. 15); but at times the conidia are distinctly club shaped, the upper end being broadly rounded and the basal end being more or less pointed. They have a central vacuole. The spores are hyaline.

In cultures at first there is no definite coloured stroma from which the spores arise; at first there is a collection of hyphæ, hyaline in colour, from the tips of which conidia are budded off. These hyphæ later change to brown or olivaceous in colour and grow into a stroma with a tuft of elongated cells from the tips of which conidia are cut off. These conidia are hyaline in colour but in old cultures they are distinctly tinted brown. In the early stages of development of stroma setæ are not found but later they may be developed. They are many celled and considerably vary in length but not much in breadth. They measure 40–120 $\vee$ 6 $\mu$. The apical cells of the setæ may be at times hyaline or less lightly coloured than the remaining cells which are brown or olivaceous in colour. From the apical cells of setæ spores or branches may be developed. Acervuli may be with or without setæ. The conidia measure 10·0—16·2 $\vee$ 3·7–6·2 $\mu$; generally they measure 12·5–15·0 $\vee$ 5·0 $\mu$.

The *Glæosporium* sp. found on anthracnose affected plants is exactly identical with the *Colletotrichum* described above except that the acervuli are without setæ. In the acervuli of the *Colletotrichum* setæ are not invariably present; even in single spore cultures the acervuli may have at times only a single seta and at times even this may be wanting. Since the

presence of the setæ is not a constant factor and since the two fungi resemble each other in every other respect they are considered to be identical.

In the other species of *Colletotrichum* the acervuli are distinctly erumpent and look like tufts seated on the epidermis with a narrow base; the stroma within the plant tissues is limited to the uppermost layers of the cortex and the epidermis; it is not spread out in the cells of these tissues, but only a few cells are involved and the stroma breaks through the epidermis through a narrow opening; outside the epidermis the stroma opens out like a fan, and stands high and erect (Plate LXXVI, Fig. 17). The spores are falcate and pointed at both ends like those of *Vermicularia capsici* Syd. and *C. indicum* Dast. (Text-Fig. 16), but the spores at times may be linear or straight. They vary in length but not in width. They measure 13·7–23·7 ⩒ 2·5–3·7 $\mu$; generally they measure 20·0–22·5 ⩒ 2·5 $\mu$; the spores have a central vacuole but it is not always conspicuous.

The setæ are much longer and broader than those of the *Colletotrichum* already described. They measure 71·4–204·0 ⩒ 5·1–7·6 $\mu$. The acervuli have not been found to be without setæ.

The stroma consists of basal layers of pseudo–parenchymatous cells which are small and more or less round in shape and brown in colour; and of upper layers of elongated cells which are also brown in colour and from which arises a layer of conidia bearing cells which are usually hyaline, but may be slightly tinted brown from the tips of which spores are budded off; the setæ develop from the basal pseudo-parenchymatous cells, the basal cell of the setæ is not enlarged. Setæ have varying number of cells. The apical cell may be pointed or blunt.

*Inoculations.*

The two species of *Colletotrichum* and *Glœosporium* sp. isolated from diseased pan plants when inoculated on stems and branches of healthy pan plants have been found to be parasitic. Under moist conditions typical lesions have been produced by artificial inoculations; under dry conditions the inoculum produces a very localised lesion which rapidly dries up; as a result the bark is ruptured and the wood underneath is exposed.

The pan anthracnose fungi when inoculated on chilli (*Capsicum* spp.) fruits, tomato fruits, cotton bolls and sugarcane leaves have given negative results.

*Summary.*

(1) A general account of the methods of pan cultivation practised in the Central Provinces and Berar is given.

(2) A detailed account of the foot-rot diseases of pan caused by

*Phytophthora* and a new species of *Pythium*, of the leaf-rot caused by *Phytophthora* and of the anthracnose disease caused by *Colletotrichum* spp. is given.

(3) A short account of the foot-rot diseases suspected to be caused by *Sclerotia Rolfsii*, *Rhizoctonia bataticola* and *R. Solani* is given.

(4) The *Phytophthora* causing the foot-rot and leaf-rot disease is considered to be *P. parasitica* var. *piperina*, n. var.

(5) The *Pythium* causing the foot-rot disease is named *P. piperinum* n. sp.

(6) Remedial measures for the control of the foot-rot, leaf-rot and anthracnose diseases are described.

*Abstract.*

An account of the different methods of pan cultivation practised in some parts of Berar and the Central Provinces is given. In Berar and Nimar pan is grown as a mixed crop with *Sesbania aculeata*, *S. grandiflora*, *Erythrina indica*, and other plants which serve as supports, shade and wind-breaks for the pan vines. The fencing round a pan garden is also made of similar living plants. In the Central Provinces pan is grown by itself in specially constructed "chick-houses". The pan "seed" in some places is a single internode with one leaf; in other places it is a cutting several inches long bearing many leaves. The methods of planting the "seed" and irrigating the gardens vary from place to place.

A detailed account of foot-rot, leaf-rot and anthracnose diseases which are known to occur in epidemic form is given.

The foot-rot disease of pan caused by *Phytophthora*, which is considered to be a variety of *P. parasitica* and which is named *P. parasitica* var. *piperina*, is found in many parts of the Central Provinces and some parts of Berar; the foot-rot disease caused by a new species of *Pythium*, which is named *P. piperinum*, is so far known to occur only in Timarni (Hoshangabad District). Both these diseases have been shown to be capable of control by treating the soil with Bordeaux Mixture. Where ridges are directly irrigated only they need to be treated but where the irrigation is through specially made water channels both the ridges and the water channels have to be treated.

Leaf-rot which is caused by *P. parasitica* var. *piperina* and anthracnose which is caused by two species of *Colletotrichum* and which attacks stems and branches are found in only a few places in the Central Provinces. These diseases can be controlled by spraying the plants with Bordeaux Mixture or Bouisol.

*Sclerotia Rolfsii*, *R. bataticola* and *R. Solani* have been isolated from some foot-rot affected plants but it is probable that these fungi are only weak parasites and do not cause much damage to the pan vines.

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## EXPLANATION OF THE TEXT-FIGURES.

FIGS. 1 & 2.—Sporangia discharging through a discharge tube.

FIGS. 3–6.—Sporangia discharging through an opening in the wall. In Figs. 3–5 the contents are broken up into zoospore units before the discharge has taken place. In Figs. 1, 2 and 6 the protoplasm is being discharged before it has divided into zoospore units.

FIG. 7.—Some of the zoospores collected round a discharged sporangium.

FIG. 8.—Motile zoospores with cilia.

FIG. 9.—Two motile zoospores separating by a constriction in the middle.

FIG. 10.—A motile zoospore with a cilium.

FIGS. 11 & 13.—Oospores with many antheridia.

FIG. 12.—An oogonium with many antheridia.

FIG. 14.—Section of the underground stem of pan showing bits of *Phytophthora* hyphæ in the swollen inter-cellular places.

FIGS. 15 & 16.—Elliptical and falcate spores of *Colletotrichum* spp.

## EXPLANATION OF PLATES.

FIGS. 1 & 1 (*a*).—Sporangia. One has discharged its undifferentiated contents through an opening in the wall; two of the sporangia have not discharged their contents but which are already differentiated into zoospore units.

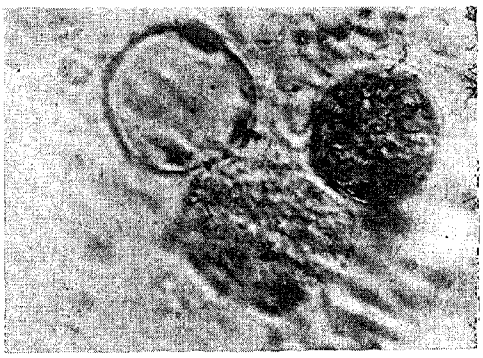
FIG. 2.—A sporangium discharging its differentiated contents through an opening.

FIG. 3.—The discharged contents of a sporangium broken up into zoospore units collected outside the sporangial opening.

FIG. 4.—A sporangium discharging its undifferentiated contents through an opening.

FIGS. 5 & 6.—Sporangia discharging their undifferentiated contents through a discharge tube.

1



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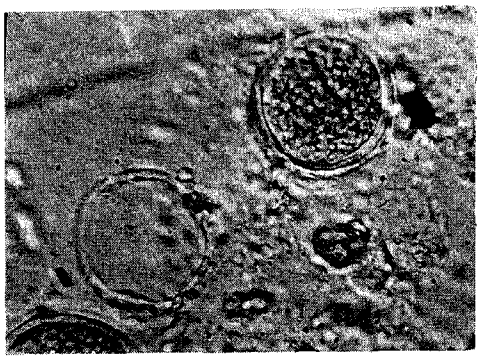

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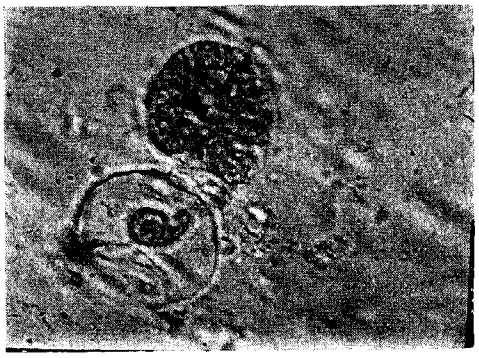

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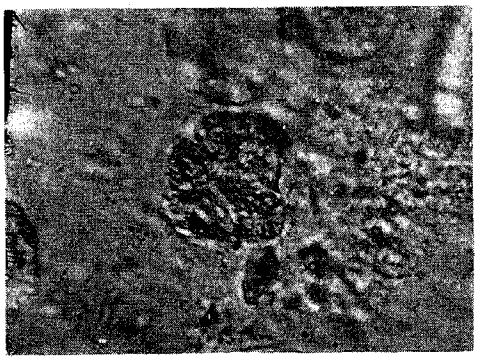

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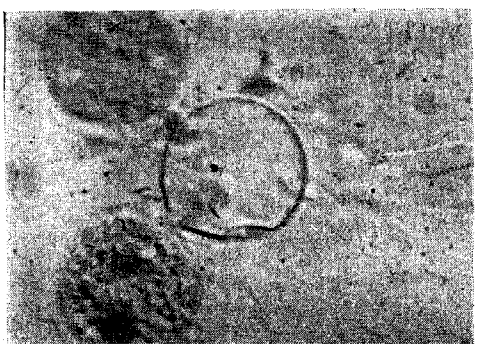

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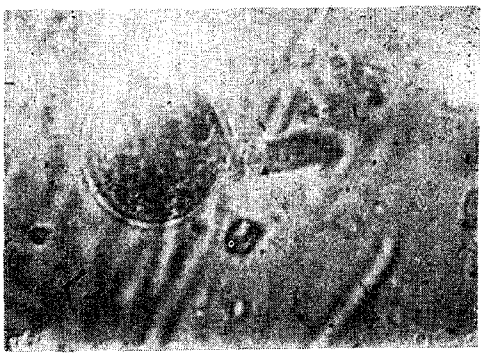

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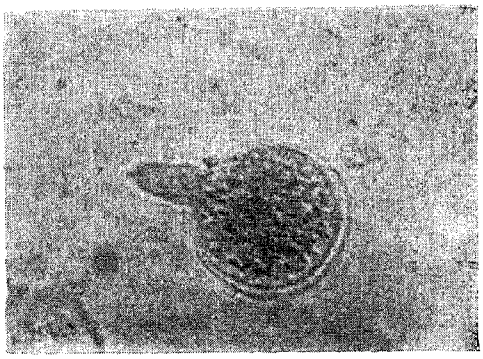

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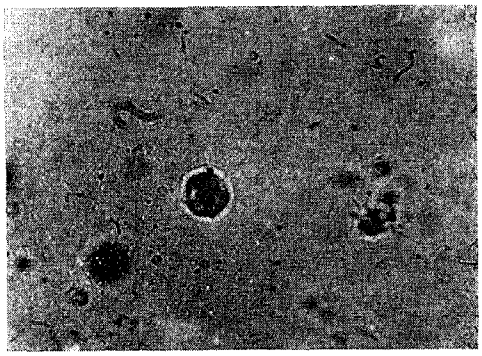

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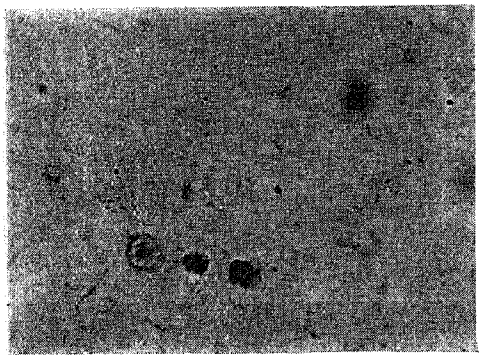

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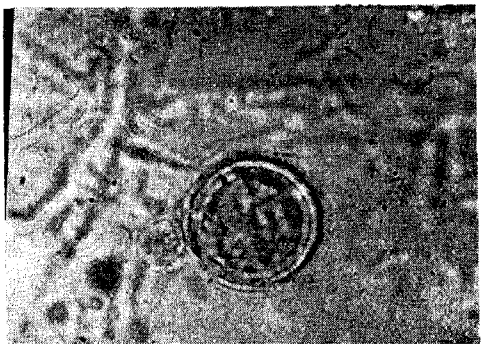

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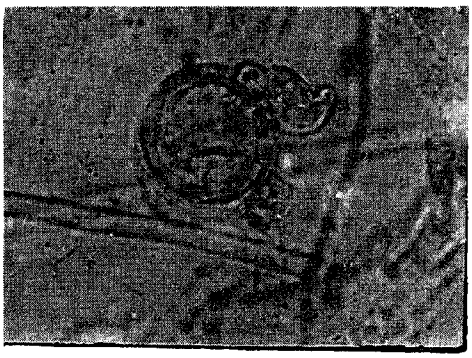

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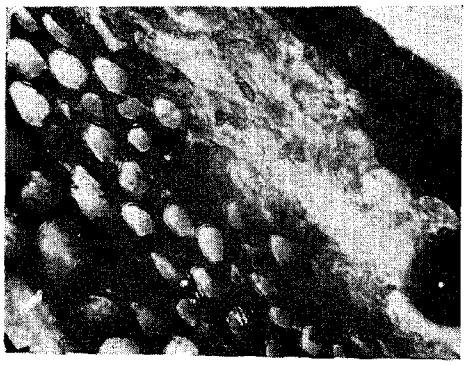

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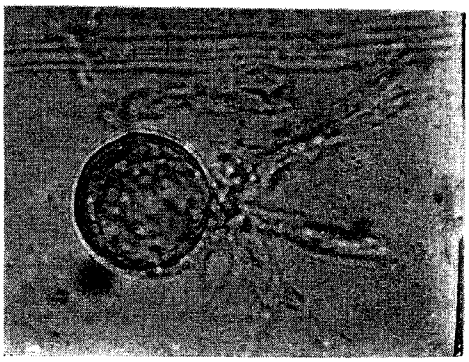

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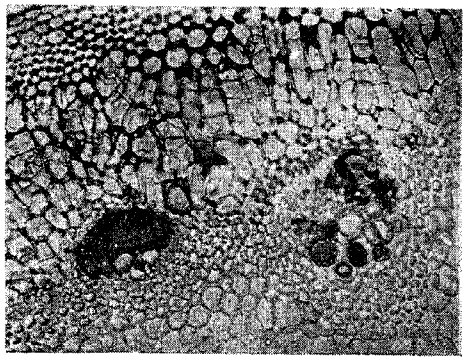

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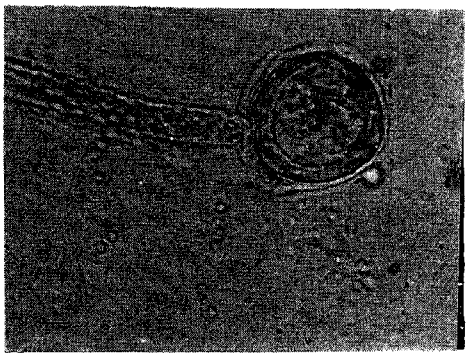

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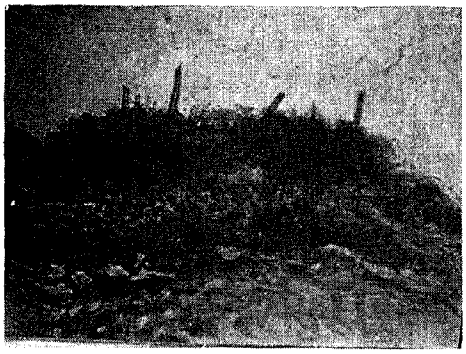

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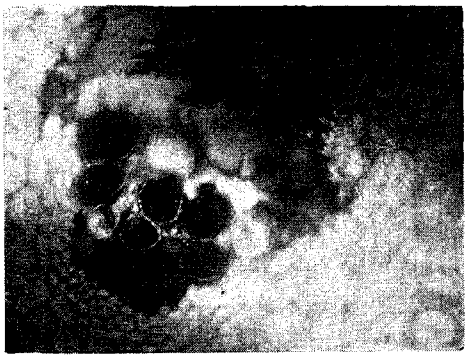

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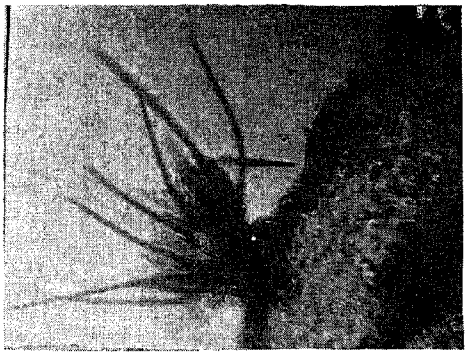

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