

These determinations being those of a small number of varieties and there having been variations among the varieties themselves in each of the groups, cannot probably be taken as really accurate but still they give a general indication of the differences occurring in the several groups.

Summary. Observations have been recorded regarding the growth phases of early and late strains of paddy. The relative rates of growth in the seed bed stage of the two groups early short and late tall do not disclose any significant difference. After transplanting, however, the early variety manifests a fairly rapid rate of growth which soon attains a maximum value and comes to a termination whereas, in the late variety, the rate of growth is sustained and there is even a period when there is practically no growth, and attains ascendancy just when the early one has reached its maximum limit. In both the groups the growth rate is at its maximum when the plants start their reproductive phase. There is no significant difference in the maturation phase of the two groups.

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MOSAIC DISEASE OF SUGARCANE*.

D. MARUDARAJAN, B. A.,

Assistant in Mycology.

Introduction:—The most serious disease of sugarcane which is at present engaging the attention of the Pathologists of the cane growing countries, is the one which is known as the mosaic, mottling or yellow stripe. The disease was first noticed in Java in 1892 and is now a very serious problem in all sugarcane areas except in Mauritius. For a long time it was thought that India was free from the devastation of this much feared epidemic. The disease was first observed in India in 1921 by Dastur on two varieties D. 99 and Sathi 131 growing on the Pusa farm. Even

then the other cane growing places in India were thought to be free from it. In our own Presidency the disease was first noticed in June 1925 and a preliminary survey has shown that it is present in most of the important cane tracts. How and when the disease was introduced here is not known. Now that we find that the disease has come to stay an effort is being made to study the disease in all its aspects under conditions existing in our Province. Before tackling the problem it is necessary to collect all the available information regarding the subject and the present paper is the outcome of such an endeavour. The writer's observations also have been included to a certain extent.

Symptoms (general) :—As was said before the disease was first noticed in Java and there it was known as 'yellow stripe disease'; but the choice of the name is very unfortunate for the term does not convey a correct idea of the disease. When the disease appeared in Porto Rico, Stevenson proposed the name 'Mottling disease' which about describes it. Earle sometimes later proposed the word 'mosaic' and Stevenson says that it has nothing to recommend it in preference to mottling. The terms mottled, blotched, marbled describe the symptoms of the disease as aptly as 'mosaic.' When it was found that the malady is closely allied to the mosaic diseases of tobacco, tomato, potato and others, the disease is now generally known as the 'mosaic' disease of sugarcane.

This disease is characterised by the mosaic effect produced on the leaves caused by the varying density of the green colour in the tissues. This variability may be found in all gradations. In some cases, the blotches are formed by the paling of the normal green colour in some others by whitening and in others by yellowing of portions of the leaf. In some cases all these gradations are found in one and the same leaf. The chlorotic areas are always linear and are distributed all over the surface of the leaf sometimes in a regular manner and at others very irregularly. Though the mosaic symptoms are generally variable, each variety has its own characteristic symptoms.

Symptoms (varietal.) Detailed observations were made on 4 varieties (Java Hebbal, Co. 1, Vellai and Poovan) growing in the Central Farm, Coimbatore.

In Java Hebbal, the disease is quite conspicuous on the young leaves just unfolding from the spindle and also on the one surrounding it. The whole leaf appears chlorotic with only a few islands of green here and there.

In Co. 1, the young leaf enclosing the spindle is not so severely chlorotic as in Java Hebbal. The leaf is fairly green with only a few inconspicuous pale green linear areas here and there. The leaf just outside the spindle shows these chlorotic islands conspicuously.

In Vellai, the symptoms on the young leaves resemble somewhat that of Java Hebbal; but the green islands in this variety are in larger numbers and the paling of the chlorotic areas is much deeper than in Java Hebbal.

In Poovan the mosaic symptoms are quite conspicuous and far different from any of the other varieties observed. Even the young leaf in the unfolded spindle shows symptoms of blotching. The mottling in the other variety is only a paling of the normal green colour whereas in this case some of them are white. Consequently they are in evidence even on very young pale green leaves before they acquire the normal green colour. These white spots are smaller than in the other varieties and are distributed in larger numbers, all over the green surface; but in no case do they become so large in numbers as to make the whole leaf chlorotic with only a few islands of green as in Java Hebbal. In older leaves these spots coalesce and form irregular patches. In some cases as the leaf ages these white spots gradually turn yellow.

These chlorotic symptoms are also present in the leaf sheaths of diseased plants but not in such a conspicuous manner as in the leaves.

Although the symptoms described above are the invariable features of mosaic canes, there are cases in which the stalks are also similarly affected. In canes which have red or purple colour on the rind, whitish or yellowish linear blotches are seen near the nodes. These symptoms have been observed here in the varieties Fiji B, Red Mauritius and J 247. In Porto Rico, cankers are formed resulting in the complete destruction of tissues. Such

instances have not been observed here. A few cases of cankered canes were met with but in no case was it possible to trace the cause directly to mosaic infection. Frequent instances have been met with where the affected canes were lanky, stunted and of poor growth.

Transmission of the disease by insects:—It has been positively shown by carefully conducted experiments by Brandes, Kunkel and others in Hawaii and other places that the natural transmission of the disease is through the agency of *Aphis maidis*. As these insects were never or only rarely found on sugarcane, the mere fact of its ability to transmit the disease was held by some as of no practical value as it failed to account for the rapid spread of the disease. In Coimbatore also it has never been found colonising on sugarcane and some doubts were expressed that if they were forced to confine themselves to canes, they would die.

To set this point beyond dispute, some experiments were carried out to see whether *Aphis maidis* could live and thrive on sugarcane. Individuals of these Aphids were collected from cholam fields and transferred with a fine brush to some Poovan cane seedlings about a month old. They were found flourishing and multiplying for nearly a month.

Another case was observed where a cane growing in a pot in the Pot-culture house was found naturally infected with a huge colony of *Aphis maidis*.

After thus proving beyond all doubt that these insects are able to thrive well on sugarcane, the writer introduced a large number of these Aphids and transferred them to a mosaic cane in order to conduct some inoculations. After allowing these Aphids to remain on the mosaic leaves for 5 days, some of them were transferred to three vigorously growing cane seedlings about 2 months old. The controls were similarly treated with Aphids collected from healthy cholam. None of the plants thus inoculated gave any positive results. These should be repeated again on a much larger scale. It was not then possible to do so for want of a sufficient number of insect-proof cages. Observations of a number of fields here indicate the possibility that there might be other insects serving as carriers of the disease besides *Aphis maidis*. A list of sucking insects frequently found on sugarcane

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is being collected, determination of the potentialities of these insects as vectors is to be one of the future lines of work.

Transmission of the disease by artificial inoculations.

Brandes was again the first to show that the disease can be transmitted by artificial methods. He obtained juice from the youngest leaves and upper joints of mosaic canes and used it for inoculating healthy plants. The controls also were similarly treated from juice obtained from healthy canes. Two methods were successfully used by him. One was by injecting $\frac{1}{2}$ c. c of mosaic juice into each shoot of a healthy cane and the other was by making numerous pricks on the young leaves with a needle dipped in the mosaic virus. Later on Kunkel was able to confirm these results. Dastur in Pusa also has successfully transmitted the disease by mechanical means. All these methods have been tried here, but as yet it has not been possible to get any positive results. Elmer says that inoculations are more successful when the inoculum is macerated in a solution of acetone. This method will also be utilised when the next set of inoculations is done.

Though it has not yet been possible to get successful inoculations, it has been definitely ascertained that when diseased setts are planted they always reproduce the disease. A number of top setts from CO. 1, Java Hebbal, Poovan, Vellai and Red Mauritius were planted to see whether they developed mosaic. Two months after planting it was observed that all the setts had developed mosaic. This shows that whatever may be the nature of second-infection, the distribution of diseased setts has been one of the surest means of introducing the disease in places where it has not been previously known to exist.

Distribution of the disease in Madras.—It was said in the beginning that the disease was present in most of the important cane growing tracts. Mosaic has been found in Samalkota, and in North Arcot, South Arcot, Salem, Trichinopoly, Coimbatore and Malabar districts. Of all these the most severely affected district is South Arcot.

Varieties attacked.—In East Godavari, Red Mauritius, B 254, A 95, Java Hebbal, Purple Mauritius, D 625, D 1135, A 2, Q 116, B 6388, B 208, Q 813 and J 247 are found to be affected. In South Arcot, Fiji B, Red Mauritius, B 203, B 174 ashly Mauritius and local reed canes and local striped are diseased.

In North Arcot the disease has been found only on a few red Mauritius canes in two gardens. The most severely affected place in Coimbatore has been the Central Farm. Four varieties of cane were cultivated, two of which CO. 1 and Java Hebbal showed 100 per cent infection. The other two local varieties Poovan and Vellai also showed some cases of mosaic. Round about Coimbatore in addition to Poovan and Vellai, local striped cane known as Chittan also showed the disease. In Salem, Java Hebbal showed mosaic as the setts were obtained from Coimbatore Central Farm. In Malabar also only those varieties that were obtained from Coimbatore showed mosaic. In Trichinopoly, CO.1, Fiji B and B 208 showed mottling of the leaves. The CO. 1 setts were obtained from Coimbatore in 1924. This fact throws some light about the existence of the disease in Coimbatore in the past few years. The very first observation in Coimbatore showed 100% attack in CO.1 and Java Hebbal. Such a heavy infestation is hardly possible if the disease had not been in existence for a considerable period of time. Now by the observation of Trichinopoly CO. 1 canes, we can conclude that mosaic was present in the year 1923 on the Central Farm.

Varietal susceptibilities :—It is a common observation that different varieties react differently whenever they are attacked by any disease. This fact holds good for sugarcane, also when they are subject to mosaic infection. Some varieties are susceptible, others resistant and some others are tolerant, i. e., though the plants show mosaic there is no appreciable difference either in the manner of growth or yield. In fact they are practically as good as healthy canes. Our observations so far indicate that Red Mauritius and CO. 1 are the most susceptible varieties. The Deputy Director of Agriculture, I Circle also says in his report that Red Mauritius was the only variety that showed as high an infection as 67% in the Samalkota station. CO. 1 showed 100% infection in Coimbatore Central Farm and also a very heavy percentage of infection in Trichinopoly. As regards Java Hebbal it is not possible to say anything conclusively about it. Though the farm canes showed 100% infection this variety showed very little infection in Malabar except those setts distributed from Coimbatore Central Farm; but in Samalkota, there were 14% of infected plants. J 247 and Fiji B seem to be the most resistant of all the varieties observed. J 247 has nowhere been found to have more than $\frac{1}{2}$ % infection and

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Fiji B was found to be seriously affected only in one place (Mudiyanur demonstration farm). It is not quite possible to pronounce any variety tolerant by mere observations alone. Only after comparing the yields of healthy and diseased canes, one can be in a position to say which variety is tolerant and which is not. Experiments are in progress to determine this and many other points. As regards the Barbados varieties, all of them seem to be generally susceptible to mosaic.

Loss caused by mosaic:—As experiments are just being conducted it has not been possible to determine the loss under conditions existing in the Madras Presidency. Various opinions are expressed regarding the actual loss by this disease. Some say that it does not cause any appreciable damage; some others that it is one of the worst diseases a sugarcane planter has to deal with. In Hawaii it has been found to be a very serious disease and the loss caused by it has been exactly determined for some of the varieties grown there. The following table gives the results of these experiments:—

Variety.	Weight of cane	
	from healthy plot.	from diseased plot
	lbs.	lbs.
Badila	5466	1196
Striped Tip	5386	941
Yellow Caledonia	8613	2470
H 109	7280	4573
Lahaina	5425	2835
D 1135	6530	4201

Transmissibility of Sugarcane mosaic:—Hitherto it was thought that the cane mosaic could only be transmitted to other grasses. Mosaic was first noticed on tobacco and the virus from these plants was found to transmit the disease to plants of closely related families. When sugarcane was found to be affected, it was thought that it was due to a strain far different from the one occurring on tobacco. Brandes again showed that the strain on sugarcane was transmissible to other grasses. However all his inoculations were confined to the families of Gramineae. It

was never suspected that cane mosaic could be transmitted to any families of Dicotyledons. Elmer has now shown that it is transmissible to widely separated species of plants. Inoculations on tomato and tobacco and other plants have been successfully carried out with the strain on sugarcane. He has obtained 15 inter-family and 11 inter-order transmissions.

Masking of symptoms. Some species of plants even though they are affected, do not show any signs of mottling on the leaves. But if we utilise these plants for inoculation purposes as the source of inoculum we find that the virus is still active and able to inoculate other plants. Dastur has shown that the inoculated plants do not always show signs of infection in the first season but if setts are taken and planted from these inoculated plants, they invariably showed the characteristic mottling of the leaves. Many writers have reported that in some cases, affected canes after producing diseased leaves for some time, begin to produce normal and green shoots without any signs of mosaic. It has not yet been definitely ascertained whether it is an actual recovery or only masking of the symptoms with the virus still active.

Control measures. The measures that are to be pursued in putting down the disease must depend on the conditions existing in those localities. If the percentage of affected plants is very low, it should be dealt with at once by removing and destroying the affected ones. This method is known as roguing. On the other hand if the fields show a large percentage of infection roguing is impracticable and expensive. These canes should be allowed to stand and when ripe should all be milled. Setts from these should on no account be taken for seed. Setts should only be obtained from places where the disease is not known to exist. Opening of farms for distribution of disease-free setts will go a long way to solve the problem of eradication of this disease.

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