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yellow and white sap colour series, it is seen that there is a definite *wash* character associated with the red and yellow sap colour series of pericarp manifestations. This *wash* factor could be superimposed on the other colours. When the basic colours are deep, the *wash* factor will naturally not show off. When the basic colour is devoid of the—I—factor for intensification and the grains are in consequence pink or light yellow in colour, the superimposition of the *wash* factor, tones up these basic colours by a shade. The best manifestation of the *wash* factor is in the absence of the—W—factor disabling the expression of the other pericarp colours in wholeness and making the grain white in consequence, with the colours red or yellow confined to the base of the grain. On this white background the red wash and yellow wash show off to advantage.

A new factor designated M gives a red or yellow *wash* to the pericarp of the sorghum grain according as the base is red or yellow. The factor operates in the presence of Y or R factor. In the presence of the factor W its expression is too faint to show out. It shows best in the absence of the W factor. In conjunction with the factor—I—(intensification of pericarp colour), this *wash* factor cannot be easily noted. In the absence of the—I—factor, the *wash* factor M slightly tones up the basic light colour.

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SUGARCANE SMUT

BY C. B. FRANCIS,

Cane Superintendent,

East India Distilleries & Sugar Factories, Ltd., Nellikuppam.

I. General. Smut (*Ustilago scitaminea* Syd.) is a well-known disease of sugarcane having been reported from India, Java, Formosa, the Philippines, Natal, Mauritius, Queensland, Italy, and British Guiana (1).

It is principally a disease of the wild cane *Saccharum spontaneum* (1) and those canes which most nearly approach the wild varieties are more susceptible than the noble canes, though the thicker tropical canes are by no means immune (2). The causal organism is also reported to occur on grasses which may be a source of infection (2). It is reported (1) as very severe on Uba and other varieties of the *Saccharum sinense* group. Some varieties are considered to be immune, Earle mentions Badilia* as being one of these, but in the S. Arcot District in South India Badila has recently proved to be susceptible.

II. Symptoms. Sundararaman (3) describes the symptoms as follows:

"The disease is easily recognised in the field. Affected plants are distinguished by the formation of a long, whip-like dusty black shoot from

* Locally known as 'Fiji B'.

the growing shoot. The leaves do not open out but become converted into a long whip-like structure consisting of masses of black spores covered over by a white, papery covering. After a time the white covering ruptures exposing the spores inside. The spores are blown about by the wind and healthy plants are affected. The fungus grows within the plant for a period, and then affects the shoots when in place of the growing shoot the long whip-like structure is formed."

In some cases the side buds of mature canes are infected, in which case the bud "shoots", and when the shoot is about six inches or more long the top shows the typical black spore formation. Sometimes growth is stimulated by the disease so that slender new shoots from the ground or near ground level grow very rapidly upwards and spore formation occurs on a level with the top of the crop where opportunities for dispersal and infection of other plants are the greatest.

III. Control. There is no cure for the smutted plant, and an infected plant can never recover. The only way in which the disease can be stamped out is by removing all sources of infection.

The most successful way of combating any disease is no doubt the planting of an immune variety, but this is often a counsel of perfection. It may happen that the variety affected is one which on account of its suitability from other points of view is considered the best for a particular area, and the discarding of a variety which has hitherto proved to be very useful is likely to be deferred until a serious attempt has been made to control the disease by other less drastic measures. Further, the discovery of an immune and at the same time otherwise suitable variety may take considerable time, and in the meantime some sort of control measures have to be applied immediately. Nevertheless, it is worth while sacrificing an otherwise satisfactory variety if the particular circumstances permit, and if by so doing the main source of infection can be eliminated.

Where an infected variety cannot be completely given up the next best thing is the removal of infected plants.

A wind-borne disease such as smut is very difficult to control as infection can take place without direct contact and at a considerable distance from the source of infection. It is essential therefore that the removal of diseased plants should be done before the spores have had much time to disseminate. Obviously the best time to do this is before the spore formation occurs and in South India it has been found that boys can be trained to recognise a diseased shoot only by its abnormally slender, whiplike nature even before the sooty growth develops. Of course it is not possible for all such shoots to be recognised but the boys can frequently detect them while engaged in removing the more obviously diseased ones. The diagnosis can be confirmed by splitting open the suspicious shoot when in the case of infected shoots the black centre is clearly visible.

There would appear to be three stages during the growth of the cane when this roguing is likely to be most necessary.

(a) *Soon after germination.* At this stage shoots from only some and not all of the buds on a sett may develop the disease. This is probably due to the disease spores having been blown on to the buds of the mature parent canes, the spores remaining on the outside of the bud and infecting the shoot during germination, or by the disease lying dormant in the bud until germination occurs. Some of the buds on the sett may have escaped infection in which case the shoots will be disease-free, while in others the bud or shoot may have been infected, and these shoots will be killed and show the black spore formation.

In this case the whole sett must be removed from the field. If merely cut off some little distance from the sett, tillering will be encouraged and all the tillers will later show the disease.

The fungus enters the cane through the hairs on the buds, more easily through younger buds than older ones. After entry, it spreads throughout the stem but the symptoms become externally visible only at the tip of the shoot. The diseased plants should be rigorously rejected for purposes of propagation.

The soaking of the setts in Bordeaux mixture should go a long way in preventing infection, as although internal infection cannot be treated in this manner any spores on the outside of the bud can be killed by sett disinfection.

(b) *After tillering.* At this time cases may be found in the field in which the infection is due either to bud infection as mentioned above or to shoots being newly infected after germination. The new infection may be caused by spores being carried from diseased bud shoots, or from older cane in the vicinity. Since the harvesting of one crop and the planting of the next overlap, the disease is easily carried over from crop to crop. The only really safe control is the removal of the whole clump as is done for certain bud infection.

(c) *After cane formation.* At this stage buds on apparently healthy canes may show the disease by 'shooting' and then developing the characteristic sorus formation. This is probably caused by the disease spores being carried on to the outside of the cane and infecting the buds as mentioned in (a). In this case it will not be sufficient to break off the shoot close to the cane as not only the bud and shoot will have been infected, but also the older cane. Such clumps should not be used for propagation. The removal of the infected shoot will however minimise the sources of secondary infection.

In the case of (a) and (b) the current crop will be damaged by the death of shoots that would later form canes. In (c) the current crop will not be harmed but the disease will be carried over to infect the next crop.

The above three types of infection will overlap and in order to be effective the roguing must be done continuously throughout the season as the infection may lie dormant for some time before developing. It is essential

that the roughing should be done very frequently as the longer a single diseased shoot is allowed to disseminate the disease spores, the greater will be the extent of new infection.

To reduce the opportunities for the disease to spread among different varieties it is desirable to plant different varieties in separate blocks.

Removal of diseased material from the field and its destruction. As mentioned earlier a smutted shoot can never recover and no treatment is of any avail. The only way of dealing with this disease is to prevent the infection spreading, which can only be done by the destruction of the affected shoot. Destruction inside the field is not practicable and the removal of diseased shoots in which spore formation has occurred is likely, in view of the nature of the disease to result in further spreading unless great care is taken. Careless handling may shake the spores into the wind to be carried to other plants, and contact between diseased shoots and healthy plants can very easily occur during removal of infected plants.

In the Philippines Smut was reported (4) in 1934 to have developed to serious proportions in certain districts and the only promising control so far discovered was the cutting out of the shooty growth that developes from the top of the shoot. To prevent the spores from flying about and spreading the infection it was recommended to carry a five gallon tin of kerosine oil into the field, wet the black tip with kerosine, cut off the end of the stalk and immerse it upside down in the tin. In this manner the infected material could safely be carried out of the field and destroyed.

This is no doubt a safe method of removal, but a tin of oil is a rather awkward thing to carry through a cane field. On the suggestion of Mr. S. Sundararaman, the Government Mycologist, a method has been adopted by the E. I. D. & S. F. in South India which has been found to be safe, simple, inexpensive and effective and which is considered an improvement on the Philippine method.

In this method coolies are sent through the cane, row by row, to search for diseased plants and they are provided with cloth bags, the mouth of which can be closed with a string. The infected shoot is cut off below the black top and is carefully placed in the bag. The remainder of the infected material can then be dug up or removed as necessary, and can be placed in the bag or otherwise carried out of the field, there being no risk of this part without exposed spores spreading infection. The bag containing the infected shoots is kept closed when moving through the field, and when full is carried out of the field, and unopened, complete with the contents, is placed into a drum of boiling water and is kept there for at least fifteen minutes. After boiling, the shoots are dried in the sun and at the end of each day are burned.

Cane trash is usually available for fuel and the only expenses are for labour (boys can do the work quite well), cloth bags, and an old metal drum or other vessel for boiling the water. The bags in use are frequently and

completely sterilised by the boiling so that no infection can be carried by them, and provided they are made of closely woven material and are only opened when necessary, risk of infection during the removal is very small. Placing the unopened bags into the boiling water prevents the spores from being disseminated during destruction, and the boiling completely destroys all infection in the plant. With few clothes to become infected and with frequent opportunities for bathing there is not much risk of the coolies carrying infection on their body.

IV. Results and Cost of Control Measures. A few cases of Smut were found on the estates of the E. I. D. & S. F. Ltd., at Nellikuppam in 1921 the variety worst affected being B. 3412. The planting of this variety was immediately given up. The following season a few canes were found in Badila but these were rogued out and for a few years no trace of the disease was observed.

In 1924—25 Co. 213 was introduced and from the first this variety was found to be susceptible to 'smut.' Cases were continuously being found, but the disease was kept under control by roguing and no infection of other varieties was suspected. In 1932—33, there was a marked increase in the extent to which Co. 213 was infected but other varieties were still considered to be free. The following year Co. 213 developed the disease on a very severe scale, so badly in fact that satisfactory roguing became impossible, and a few cases were also found in Badilla and other varieties. In view of this it was decided to give up the planting of Co. 213 and none was planted after 1933—34. In 1934—35 there was, however, an increase in the extent to which Badilla became affected, and careful searches for the disease showed that many of the promising newer varieties were affected to some extent.

Control measures on the lines mentioned were immediately introduced.

The number of searches for diseased plants, as well as the interval between the searches, varied between different blocks according to the extent to which they were infected, but the average number of searches per acre throughout the entire area was just under ten, and during all the searches the total number of diseased plants removed averaged 371 per acre, giving an average of 39 per acre per search.

The average number of cases removed during the first search soon after germination was 75 per acre. During the 16th search in a small area in which the original infection was heavy only 15 cases per acre were found compared to 100 for the first search in this particular area some five months earlier. In another block the first search revealed 441 cases per acre but the 12th search some six months later showed only 18.

These figures indicate the effectiveness of the control work, not only in keeping the disease from spreading, but in removing the existing infection from the fields.

At the beginning of the control work diseased plants could easily be noticed during a walk through the fields, but at the end of the first season's work they could only be found by careful searching, to a casual observer the fields appearing completely Smut free.

The total cost of the full Season's work on 400 acres was Rs. 1046-11-6, the cost per acre being Rs. 2—9—5, and the cost per search only Rs. 0-4-4 per acre.

The reduction in yield caused by severe infection cannot be accurately estimated, but even if it amounted to only 5% of a 30 ton crop the loss would be about Rs. 15 per acre, and it is likely that if uncontrolled the extent of the damage would rapidly increase in successive seasons.

Since 1934-35 'smut' control has been regularly carried out, the first searches for cases of the disease starting in about May and finishing towards the end of the year when the size of the crop and monsoon weather make it very difficult to continue.

In 1935-36 between 11 and 14 searches were made according to the extent to which different blocks were found to be infected. The highest number of cases found in any block during any one search was 5 per acre. The total number of cases found during the whole season was only 1099 in 150 acres, the average per acre being only 7. The cost of the work for the season was Rs. 1—12—8 per acre.

In 1936-37 the number of searches was between 6 and 13 and the total number of cases found was only 193 in 106 acres, the average per acre for the whole season being less than 2. The cost of the work that season was Rs. 0—13—0 per acre.

In 1937-38 the number of searches was five in all the cane and six in a small area. The total number of cases found during the season was only 55 in 112 acres, an average of less than one case in 2 acres. The cost of the control work for the season was Rs. 1—1—2 per acre.

In 1938-39 the work is being continued as a matter of routine and to the end of August 1938, 156 cases have been found in 108 acres the cost to date being just under 8 annas per acre.

These figures prove that by the adoption of simple control measures the disease can be effectively controlled. That the control measures and not natural causes are responsible for the reduction in infection is proved by the fact that while the disease has for all practical purposes been eliminated from the experimental farms of the E. I. D. & S. F. Ltd. it is still present in the ryots' cane.

It is not possible for all ryots' cane to be examined, but where the disease is noticed the E. I. D. & S. F. Ltd. will undertake at its own cost to initiate control measures. Work in ryots' cane was started in September 1937 and during the 1937-38 season an average of 137 cases per acre were removed from 326 acres in from one to three searches. As many as 325 cases were found in the first search in one plot of 1·20 acres. In 1938

-39, 60 cases per acre have been removed to date from 385 acres examined from one to four times.

V. Varietal Susceptibility. The main varieties grown in the Nellikuppam area are Badila, Co. 281 and POJ 2878. In 1934-35 the year in which 'Smut' was worst in the experimental farms of the E. I. D. & S. F. Ltd., Badilla represented 62% of the area grown by this Company but in 1937-38 the percentage fell to 4. In the same period the percentage of Co. 281 remained approximately the same, 19 and 20 respectively while the percentage of POJ 2878 increased from 7 to 37.

In 1934-35 Badilla was easily the worst infected the average number of diseased plants removed per acre for all inspections being 540. Co. 281 showed only 119 diseased plants per acre or 22% compared to Badilla. POJ 2878 was much less infected with only 16 cases per acre or 14% as compared to the Co. 281 and 3% compared to the Badilla. All other varieties together showed 73 per acre.

In 1937-38 the average number of cases removed from the small area of Badilla grown by the E. I. D. & S. F. Ltd. was 5 per acre, Co. 281 showed an average of 1 per acre, while no case at all was found in POJ 2878.

In the same year the average number of cases removed in all searches from ryots cane was 152 per acre from Badilla, 51 from Co. 281 and 14 from POJ 2878.

VI. Insect associated with Smut. Early in May 1934 a small black beetle was observed to be present in fairly large numbers on smutted plants, and it was thought that this might be in some way associated with the spread of the disease. Specimens were sent to the Government Entomologist, who reported them to be Endomychids which are usually feeders on lichens and fungi and as such are beneficial. It appears possible however that they may carry the disease spores on their body and so assist in spreading the infection.

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