

A NOTE ON THE BREEDING OF SUGARCANE VARIETIES RESISTANT TO MOSAIC.

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THE evolving of disease resistant varieties is now an important item in the programme of practically all plant breeding stations. In the sugarcane, the plant breeder has had to contend with diseases from the very first. It will be of interest to those not very familiar with the history of sugarcane breeding to know that it was the serious outbreak of "sereh" in Java in the eighties that called attention to the desirability of producing new varieties by hybridisation which might be resistant to this disease. Kobus came to India in 1890 in search of varieties resistant to "sereh", with a view to utilising them later for breeding purposes in Java. This enterprise of his was rewarded by the variety Chunnee (*Saccharum barberi*, Jeswiet), which not only proved itself resistant to "sereh" but also gave rise, on breeding, to seedlings that were resistant to the disease. Thus began the first series of P. O. J. canes which were crosses between Black Cheribon and Chunnee.

Latterly, the disease, which has claimed the serious attention of sugarcane pathologists and breeders, is mosaic which during recent years assumed such large proportions in certain countries. Mosaic appears to have been first noticed in Java by Musschenbroek in 1892, though it was called by the name 'yellow stripe'. Valuable contributions as to the real nature of mosaic were later made by Wilbrink (1910, 1922), Lyon (1917, 1921), Stevenson (1917), and others. It was in 1919-20 that Brandes was able, successfully, to transmit mosaic under controlled conditions and demonstrate that *Aphis maidis* was the insect vector. As is well known *Aphis maidis* is an insect which feeds commonly on maize, Sorghum and various other grasses. In the words of Earle (1928), "it is a most remarkable fact that so serious a disease can be spread so rapidly by an insect that does not normally feed on the cane plant."

Thanks again to Brandes (1925) and various other workers, the behaviour of the four species of *Saccharum* to mosaic is now known with a fair amount of definiteness. The majority of the recent commercial seedling varieties of sugarcane contain the blood of two or more of the following species of *Saccharum*:—(i) *S. officinarum*, to which belong the thick-stemmed or 'noble' canes like Pundia and Poovan in India and Black Cheribon and Lahaina in other countries. (ii) *S. sinense*, which includes the Pansahi group of Barber, e.g., Uba, etc. (iii) *S. barberi* and (iv) *S. spontaneum* comprising the North Indian and the wild reed-like canes respectively. As regards the first group, i.e., the thick canes (*S. officinarum*) "all of the varieties, so far studied, are susceptible to mosaic and most of them are severely injured when they become infected". Certain of the members of the second group (*S. sinense*) are definitely immune and some are susceptible but "the susceptible ones are remarkably tolerant". The North Indian canes (*S. barberi*) are very susceptible to mosaic but very little injured by it. The last group (*S. spontaneum*) contains several forms or varieties which are characterised by complete immunity to mosaic. Certain of the Papuan wild canes have been put under a new species which has been provisionally named *S. robustum* (Jeswiet). Brandes has reported that one of the varieties belonging to this species—28 N.G. 251—readily became infected with mosaic when exposed to natural infection in Porto Rico (Brandes, 1931).

Excepting the canes of the Pansahi group (*S. sinense*), which are generally infertile under Coimbatore conditions, the other three species have been crossed extensively and seedlings are now available which, in their resistance to mosaic, represent all gradations from susceptible to immune types. We may now consider the behaviour of certain of these interspecific hybrids. Kassoer, which is supposed to be a cross between Black Cheribon and Glagah (the Java form of *S. spontaneum*), is not only itself immune to mosaic but all of its selfed seedlings examined by Brandes (1925) proved immune without exception. From the Co. canes the example of a cross between a thick cane and *S. spontaneum*, is the seedling variety Co. 205, which is a cross between Vellai (a cane resembling Lahaina) and the Coimbatore form of *S. spontaneum*. Co. 205 has been found to be susceptible to mosaic in North India (McRae and Subramaniam, 1928) while in the experiments at Coimbatore (Sundararaman, 1932-33) it has been found to be highly resistant. Co. 229 is a selfed seedling of Co. 205, but no data are available as to its percentage of infection. Co. 317 and Co. 318 are selfed seedlings of Co. 229. Of these, Co. 317 gets about 70 per cent. infection while Co. 318 has, so far, remained free.

The seedlings of the crosses between *S. officinarum* and the North Indian cane Chunnee, which were raised in Java have, according to Brandes (1925), proved susceptible but tolerant to mosaic. Instances are, P. O. J. 36, P. O. J. 213 and P. O. J. 234. At Coimbatore, P. O. J. 213 was crossed with certain North Indian canes. The following are the seedlings of these crosses :—Co. 213, Co. 230, Co. 231, Co. 232 and Co. 233. Of these, Co. 213 and Co. 232 are highly susceptible while the percentage of infection in the other three varieties is not known. P. O. J. 213 was also crossed with Co. 205 and one of the seedlings of this cross, Co. 244, has proved resistant to mosaic at Coimbatore, while it is reported to take the disease in North India. Co. 214 is an interesting case. It is a cross between Striped Mauritius (a variety of *S. officinarum*, and susceptible to mosaic) and a selected seedling of Saretha \times *S. spontaneum*. The ultimate parentage of Co. 214 is, therefore, Str. Mauritius \times Saretha \times *S. spontaneum*. Co. 214 has proved immune to mosaic. Co. 335, a selfed seedling of Co. 214, is also immune to mosaic (Sundararaman, 1933–34). During recent years in the work at Coimbatore for the breeding of thick type of canes for Tropical India as also for the semi-irrigated conditions of North India, the varieties P. O. J. 2725, P. O. J. 2727, P. O. J. 2878 have been extensively employed as female parents. Co. 408 is a seedling of P. O. J. 2725 \times Co. 243, and is reported to get only 13.5 per cent. mosaic at Coimbatore, while Co. 412 and Co. 421 whose ovule parent is P. O. J. 2878 show 10.5 and 28.3 per cent. of mosaic infection respectively. Co. 419 is a seedling of the cross P. O. J. 2878 \times Co. 290 and has shown 43 per cent. infection. Co. 411, a seedling of the cross P. O. J. 2727 \times P. O. J. 2878, has shown 4 per cent. mosaic. It may be mentioned that P. O. J. 2725 is considered to be fairly resistant to mosaic and P. O. J. 2727, though not so resistant as P. O. J. 2725, is known to take the disease very rarely, while P. O. J. 2878 is highly resistant.

Brandes (1925) has shown that “the quality of immunity is proportional to the amount of *S. spontaneum* blood contained in the seedling. When this is increasingly diluted an increasing number of susceptible seedlings are to be expected in the progenies”. The above observation of Brandes is corroborated in a number of cases by the experience at Coimbatore also. Co. 214 has only 25 per cent. *S. spontaneum* blood in it and is immune to mosaic, while the seedlings Co. 223, Co. 241 and Co. 287, which have no *S. spontaneum* blood in them have proved susceptible. The seedlings Co. 317 and Co. 318 bring out the fact that canes of the same parentage having a certain amount of *S. spontaneum* blood in them, may yet vary in their resistance to mosaic and it is for the breeder to select only such as

are resistant to the disease. Co. 313 contains 12.5 per cent. *S. spontaneum* blood and though highly susceptible is tolerant. The usefulness of the introduction of *S. spontaneum* blood is therefore apparent. The sugar industry in India owes much to the foresight of Dr. Barber, who deliberately used *S. spontaneum* in his breeding work for introducing hardiness and vigour into the seedlings. The seedlings containing *S. spontaneum* blood have, besides being vigorous and hardy, the additional advantage of resistance to mosaic. A similar case is the utilisation of Chunnee in Java. Kobus used it in order to fight the "sereh" disease, but Chunnee, in addition to "sereh" resistance, passed on to its seedlings the quality of resistance to cold and frost. Certain of the seedlings of this cross, viz., P. O. J. 36, P. O. J. 213 and P. O. J. 234, have made themselves useful to the sugar industry in certain other countries, though in Java itself these qualities of resistance to cold and frost would hardly be needed to play their part.

We may now refer to the inter-genetic crosses. Broune (1934), working in Florida, has reported that none of the hybrids between the cross P. O. J. 2725 \times Sorghum made in Florida, have been found to be susceptible to mosaic. On the other hand, certain of the seedlings of P. O. J. 2725 at Coimbatore have proved susceptible to mosaic, viz., Co. 354 and Co. 515. It may be mentioned, however, that Co. 355, a seedling of the same cross, has proved resistant to this disease. Though not a strictly parallel case but an interesting one in this connection is "the case of inheritance of resistance to aphid observed by Gernert in F_1 hybrids between teosinte and corn. Both corn root-aphid, *Aphis maidiradicis*, and the corn plantaphid, *A. maidis*, were involved and both the teosinte and the hybrids were completely resistant while the corn was badly infested." (Babcock and Clausen, 1927.)

One handicap in the practical aspect of breeding disease resistant varieties is, that resistance is likely to vary geographically. Two instances of this type have already been mentioned, viz., the differential behaviour of Co. 205 and Co. 244 with regard to mosaic in North and South India. Another instance is the sugarcane variety Pundia, a standard cane in the Bombay-Deccan where it is not known to suffer from mosaic while at Coimbatore it has shown 25 per cent. infection. Co. 290 may also be added to this list, since in North India and in certain foreign countries it is reported to be highly resistant, while in the Coimbatore experiments it has shown about 70 per cent. infection (Sundararaman, 1930-31). The case of Pundia is somewhat unique. It belongs to *S. officinarum* and would, therefore, be expected to suffer from the disease, but no case of mosaic has been reported on Pundia in the Bombay Presidency though the disease has been noticed on certain other canes in that Presidency. As is well known, the geographical

variation in resistance is due, in certain cases, to the existence of physiologic races of the causal agent. In sugarcane also it has recently been found by Summers (1934) that there are four distinct types of mosaic symptoms on the sugarcane varieties C. P. 28/60 and Co. 281 in Louisiana. All the four types have persisted without apparent change through successive vegetative propagations of the infected plants, and all the four were perpetuated readily by transfer of inoculum from diseased to healthy plants of the same variety. These observations are of more than ordinary interest, as one of the types is very destructive to cane varieties formerly regarded as resistant to mosaic. (*Facts About Sugar* 1934, p. 408.)

Correlations between morphological characters and disease resistance, if substantiated, will undoubtedly be a valuable aid to the plant breeder in selecting types resistant to the disease. Venkatraman and Thomas (1928) expressed the opinion that immunity of such varieties as Kassoer might be due to the possession or inheritance of bristles which protect the stomata and the surrounding region from the attack of insect vector. Two of us (Dutt and Krishnaswami) have recently examined over a dozen varieties in this connection. Camera lucida drawings of the lower epidermis of 10 varieties are shown in Fig. 1. It will be seen that the number of bristles in Black Cheribon and Vellai is few. In fact, in the preliminary count of bristles per unit area, the number of bristles was few in all the *S. officinarum* varieties that were examined. Co. 214 was found to have about the same number of bristles per unit area as Vellai and Black Cheribon and yet Vellai is highly susceptible, while Co. 214 is highly resistant. Same is the case as regards P. O. J. 2878. The number of bristles per unit area in Co. 205, which has been found to suffer from mosaic in North India, is far more than in Co. 214 which has proved highly resistant wherever it has been grown. A reference to Fig. 1 will also show that stomata often lie unprotected even in Kassoer and Glagah, while a large majority of them are entirely exposed in Co. 214 and P. O. J. 2878. This preliminary examination, therefore, indicates that there is perhaps no positive correlation between the high number of bristles and disease resistance, nor in the protection supposed to be afforded by the bristles to the stomata.

In this brief note an idea has been given of certain aspects of the question of mosaic resistance in sugarcane varieties. It may be said that the ultimate solution lies in the breeding of varieties that would be resistant to the various cane diseases and as in the sugarcane, a range of varieties and species is available whose behaviour with respect to diseases is known and which fortunately cross freely *inter se*, the prospect for the sugarcane breeder is not discouraging.

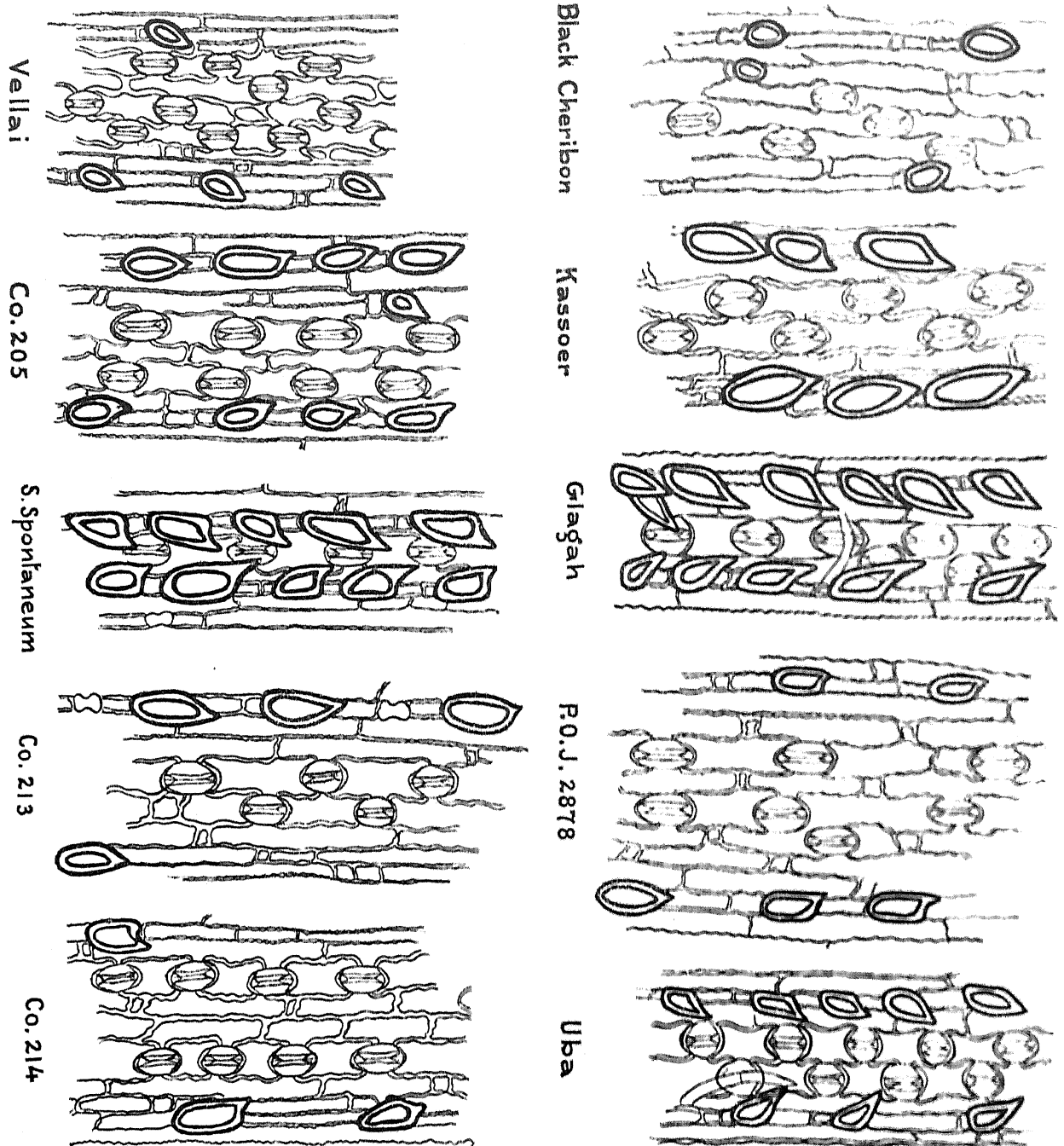


FIG. 1.
Bristles on the Lower Epidermis of certain Sugarcane Varieties.

Summary.

The behaviour of certain Coimbatore sugarcane varieties with reference to the mosaic disease has been discussed, showing that those containing *Saccharum spontaneum* blood are generally resistant or at least tolerant.

Preliminary data regarding the supposed correlation between bristles and mosaic resistance have been presented, which indicate that at least in certain cases there appears to be no positive correlation between the high number of bristles and disease resistance, nor in the protection supposed to be afforded by the bristles to the stomata.

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EXPLANATION OF FIG. 1.

The magnification of all original drawings, $\times 390$.

The drawings have been reduced to $\frac{1}{2}$ in reproduction.

Black Cheribon: A variety of *Saccharum officinarum*.

Kassoer: Supposed to be a seedling of Black Cheribon \times Glagah.

Glagah: The Java form of *S. spontaneum*.

P.O.J.2878: The famous Java seedling variety.

Uba: A variety of *S. sinense*.

Vellai: A variety of *S. officinarum*.

Co.205: A Coimbatore seedling of Vellai \times *S. spontaneum*.

Saccharum spontaneum: The Coimbatore form of *S. spontaneum*.

Co.213: A Coimbatore seedling variety.

Co. 214: A Coimbatore seedling variety.