STUDIES IN INDIAN CEREAL SMUTS

I. Cereal Smuts and their Control by the Development of Resistant Varieties

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There is hardly a cereal grown in India which is not attacked by a smut and more than one smut per cereal is the rule rather than the exception. The amount of damage which a particular smut causes depends, of course, on the extent to which environmental conditions favour the development of the fungus and varies from season to season. Several attempts have been made in the past to assess the losses occasioned by smut attack but so far as India is concerned, where accurate disease surveys have not so far been conducted, these estimates must perhaps be considered as speculative rather than authentic.

Nevertheless there is little doubt that the smuts in India cause much damage in certain areas and in certain years and there is no question that endeavours to control them are necessary and indeed have been made in the past with varying degrees of success. To devise successful control measures, however, it is necessary that one should have an accurate knowledge of the life-histories of these smuts, especially of their methods of transmission; whether they are seed-borne, soil-borne or air-borne, without which information not much progress can be made. In some cases this is, of course, already known but in others like the leaf-smut (*Entyloma Oryza* Syd.) of rice (*Oryza sativa* L.), the grain smut (*Tolyposporium Penicillaria* Bref.) of *bajra* (*Pennisetum typhoides* Stapf and Hubbard) or the long smut (*Tolyposporium Ehrenbergii* (Kuehn) Pat.) of *jowar* (*Sorghum vulgare* Pers.) this information is not yet available. Even in the case of the bunt (*Neovossia indica* (Mitra) Mundkur) of wheat (*Triticum vulgare* Host) it is not clear whether the disease is seed- or soil-borne, for the experiments so far reported do not specifically permit any definite conclusion on this point.

In cases where it has been established beyond doubt that a smut is seed-borne, methods of treating the seed so as to control the disease have been evolved and some of them have been used with considerable success.
For example, Uppal and Malelhu (1928) and Uppal and Desai (1931) in the Bombay Presidency tested the efficacy of treating jowar seed with several dust fungicides and observed that sulphur dust of a high degree of fineness was the best fungicidal dust for effectively controlling the grain smut \([Sphacelotheca Sorghi (Link) Clinton]\)—so much so that jowar seed treatment has become common in the Presidency and in the neighbouring provinces where this smut occurs. For controlling both the covered smut \([Ustilago Kollerii Wille]\) and the loose smut \([U. Avena (Pers.) Jensen]\) of oats, Mundkur and Khan (1934) tested the dry-spray method of applying formaldehyde to the smutty grain, which has not only given good results but the treatment has been adopted with success by several oat growers in Bihar and in the military farms elsewhere. Likewise the solar heat treatment of wheat seeds infected by loose smut \([Ustilago Triticci (Pers.) Jensen]\), developed by Luthra and Sattar (1934), has also been reported to be successful and to be getting popular in the Punjab.

But seed treatments, unless they are very cheap and easy of application, like the sulphur dust treatment of jowar mentioned above, not only mean extra cost but involve a certain amount of danger and risk. This is especially true where substances like the organic mercury compounds and formaldehyde have to be used and in those treatments which entail the soaking of seeds in water. In such cases the solution of the smut problem in India lies in the breeding of varieties which resist the attacks of these fungi. Considerable breeding work along these lines is in progress in Europe and America.

A survey of the literature shows that so far no serious systematic endeavour has been made in India either to ascertain the degree of resistance of the cereals to their respective smuts or to evolve new varieties able to withstand these diseases. Notes based on field observations of the relative susceptibility or resistance of the cereal varieties have indeed been published from time to time but, naturally, it is not possible in such instances to determine whether the apparent resistance of the varieties was due to intrinsic resistance or whether they had merely escaped the disease.

Cereal breeders frequently accumulate, in the course of their investigations, a large number of strains obtained both by selection from existing material and by hybridisation. As a rule few of these are agriculturally important and find their way into general cultivation. The remaining varieties may, however, possess characters, such as resistance to certain diseases, which render them valuable as material for breeding purposes; before such strains are discarded it is necessary that they should be subjected
to suitable tests in order to discover those which may possess the factors for disease resistance. Such tests to discover the resistance of the strains of wheat, barley and oats bred at the Imperial Agricultural Research Institute, to the smut diseases to which they are respectively liable, are now in progress at Delhi, and it is proposed to publish the results in a series of papers, to which the present contribution forms an introduction.

Investigations on the covered smut (\textit{U. Kollerii}) of oats were started in 1934 and those on the loose smut (\textit{U. Tritici}) of wheat two years later. In 1937 experiments on flag smut (\textit{Urocystis Tritici Koern.}) of wheat were included but though the work on the covered smut [\textit{Ustilago Hordei} (Pers.) Lagerh.] of barley was started in 1935, it has made little progress because of the failure to get heavy smut attack in artificial infections.

Our experience in the course of these investigations has shown that there are certain attendant difficulties the precise nature of which must first be ascertained and suitable steps taken to overcome them before further proceeding with the work. For example, in the case of the covered smut of oats we have found that both at Delhi and Pusa the spores stored under ordinary laboratory conditions lose their viability in three or four months, contrary to the experience of workers in other countries where the spores are known to remain viable for several years. This however does not apply to the spores of the covered smut of barley, which even when stored under ordinary conditions, have remained viable for the past four years and furthermore, have not shown any falling off in their germination.

The second and the more important experience that has been gained is with regard to infection. Unless an investigator knows methods by the use of which he can bring about a high percentage of disease in a susceptible variety (see Plate XXVI), something of the order of 60 to 70 per cent. at the least, the results of his disease resistance trials are likely to be unsatisfactory and may not have any practical significance. Conditions which bring about high infection in the susceptible varieties and the proper methods of infecting the seed have therefore to be first discovered before one can undertake the development of resistant varieties. A perusal of the literature indicates that in several cases this primary precaution has not been taken with the result that the so-called resistant varieties have reacted in an inconsistent manner in subsequent years. It may be mentioned that failure to obtain encouraging results with the covered smut of barley has been due to our not yet being able to devise a method of infecting the seed which would bring about an appreciable amount of smut in the crop. But in the other cases the methods that have been developed for doing this have been highly
satisfactory. Thus in the case of the loose smut of wheat infection of the order of 100 per cent. has been obtained in susceptible varieties, as for example, in Punjab C. 591. In striking contrast a few varieties, including Pusa 114 and Pusa 165, have shown complete resistance (see Plate XXVII).

Finally, cognisance has to be taken of the possible existence of physiological races in the Indian smut fungi. Should further work reveal the existence of a number of such races, the breeding work will naturally be rendered more difficult. Work done in other countries on the physiological races of cereal smuts indicates that their number would not be as large as in cereal rusts.

It is the view of the authors that a breeder should be in possession of precise and accurate information regarding the degree of resistance or susceptibility of the strains of his crops to their important diseases. They feel that breeders and mycologists should whole-heartedly co-operate in such work and that the time and money spent thereupon are extremely worth while.

Summary

Smuts cause heavy losses to grain crops in India but before effective methods of controlling them can be devised their mode of transmission should be clearly understood. Where a smut is definitely known to be seed transmissible, methods of treating the seed have been devised but many of these methods involve a certain amount of cost and also danger. The development of disease resistant varieties helps in such cases to solve the problem.

Investigations have been started in the Imperial Agricultural Research Institute at Delhi to test the relative resistance of strains of wheat, oats and barley to their respective smuts and encouraging results have been obtained which will be published in a series of papers, of which this forms the introduction.

REFERENCES

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A variety of wheat susceptible to loose smut. Artificial infection has resulted in all ears, with the exception of one on the right, being attacked.
A highly susceptible wheat growing side by side with a highly resistant one. Both wheats were artificially infected in the same way and at the same time.