CIRCULAR

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delivered by

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"SOME ASPECTS OF THE WHEAT RUST PROBLEM".

Damage by rust to wheat crops has been known since the earliest days of man's historical records. Writings of the ancients tell clearly of the devastation done, speculate as to its nature and origin, and give quaint directions for dealing with it.

Down through the ages, further accounts are given of rust in wheat-growing countries. In Australia, some of the first crops sown were ravaged so severely that famine threatened the early settlers, and since those days our crops have continued to suffer from the disease. Recollections are very fresh of the enormous damage, estimated at more than seven million pounds in New South Wales done to the 1947-1948 harvest. World losses caused by the cereal rusts have been estimated to amount to 100 million pounds each year.

In combatting rust, many methods have been used. Proper cultural methods must always be practised. Superphosphate in some cases reduces the incidence of the disease. For many years aeroplanes have been used in America to spread protective dusts like finely-ground sulphur over crops before a rust epidemic develops, and this has proved to be a successful and paying operation to prevent rust damage.

But the only satisfactory approach is that of breeding rust-resistant varieties. In the notable "Rust in Wheat" conferences held some 60 years ago, when the disease was causing consternation in Australia, William James Farrer affirmed his belief that rust could be controlled by breeding resistant varieties, and he set himself this task. In doing so, he also stimulated work of the same nature in other countries. We should not forget that apart from his work on rust, by breeding, he produced outstanding bunt-resistant varieties. Farrer's work, carried out as an officer of the New South Wales Department of Agriculture, was continued ably by G. L. Sutton J. T. Pridham and S. L. Macindoe in similar capacities, and has been described in previous orations.

At the University of Sydney, rust investigations were first started in 1915 by Captain H. Stephens as holder of a University Fellowship. After three months work at the University, he enlisted in the 1st A.I.F. and was killed in action in France - a tragic loss to Australian agriculture.

The present work goes back to 1918, when the first of the field sowings was made at H.A. College, but it was not until 1921, after overseas work in Britain and America had been studied, that it was put upon its present footing. Since then the University work has received help of many kinds. The Principal of H.A. College and officers of the Department of Agriculture, together with many other collaborators in this and other States have given invaluable assistance. Drs. I. A. Watson and E. P. Baker of the University staff have been wonderful colleagues in more recent years, and junior members of the technical staff have rendered loyal and efficient service. Generous financial help has been given by the Rural Bank, the Commonwealth Bank and others, and is gratefully acknowledged.

In Farrer's day, comparatively little was known of the

nature of plant disease. But in his pioneering work he did great things. On one occasion he said that he took up this work so that when he died his lifewould not have been wasted. Without question he accomplished this.

We know now that what we call "rust" is a disease which results from the interaction of three components, any one of which can, under particular conditions, prevent any development of rust. All three must be favourable.

1. Environment. Soil conditions do not affect rust to the extent that they do many other diseases like foot-root and take-all. Atmospheric conditions are all important: unless muggy weather prevails at the time when the crop is approaching maturity, (about early October) serious rust development does not occur. In 1947, very favourable conditions of this sort prevailed widely. Of course, these are the very conditions which enable the wheat plant to grow to best advantage if no disease is present.

2. The host. Grasses like barley grass and rough wheat grass are often rusted and can be the source from which the rust fungus reaches the crop. Barley and rye are also hosts, but not oats: it has its own rust. Wheat is thought of generally as growing between say May and December. But we now have clear evidence that in one place or another it is to be found growing - and rusted - in every month of the year. So it is that the wheat host is available for rust attack all the year round. Rust is always with us. Like other living things, the host is subject to change. Plant breeders deliberately effect changes as they produce new varieties. If rust is to develop in a crop, then quite apart from favourable muggy weather conditions, susceptible wheat must be present.

3. The parasite. In Australia, there are two quite distinct fungal parasites, one causing stem rust, the other leaf rust. A third fungus common in Europe and in America is not found here.

Leaf rust occurs early in the season, and its effect upon the leaves is to reduce the number of grains set in an ear, and not so much a shrivelling of the grain as is the case in stem rust attack. Nevertheless, the damage it does is greater than is usually recognised.

Stem rust is the disease of greater importance in Australia, caused by a fungus different from that which is responsible for leaf rust. It has a very complex life history, producing five different kinds of spores, and living during one phase of its existence on a shrub, the barberry, when conditions are favourable. In Europe and America its persistence through the winter is dependent upon this stage. Although this phase is rare in Australia, it is very important because new physiologic races of the fungus originate in it. Our mild and varied climatic conditions enable the organism to persist in the red spore stage on wheat and grasses without the spore development on the barberry. Its life history is simplified here.

Nevertheless, the fungus demands the closest study. This has shown that like all living things, it is subject to change, and it is this fact that makes the problem of breeding resistant varieties so complex. In William Farrer's day these complexities were not known.

The changes that occur can not be determined by microscopic means, but require plant-house studies in which each collection of rust is tested on a special series of wheat varieties grown in pots and given the most favourable conditions for rust development. Some varieties in this chosen set are found to be resistant, others susceptible. These results are recorded and used to determine what that particular rust really is. The next collection tested may show quite different reactions on these chosen varieties. For example,

one that was resistant to the first collection now proves to be susceptible: one that was susceptible is now resistant. Therefore, the two collections are not the same, but consist of two different physiologic races of the fungus. By such tests, wheat rust has been shown to be not a simple fungus but to comprise more than 200 physiologic races.

It is the occurrence of different physiologic races that makes the control problem so difficult. It will be remembered that when the variety "Eureka" was made available, it was not only an excellent agronomic variety, but it was completely resistant to stem rust. In 1941 some rusted plants were sent to the University for study by Mr. J. A. O'Reilly, who collected them at Narrabri. The tests showed that a new physiologic race capable of attacking "Eureka" had turned up. Next year it was found to be widespread, and now is established in all the Australian wheat-growing areas. In the 1947 epidemic "Eureka" was completely ruined. This was not due to a change in the weather conditions. Nor was it caused by any change in "Eureka": when tested with the original rust it is still quite resistant. The change was in the attacking fungus: it was a new physiologic race.

Last year another quite different race was found in Southern Queensland attacking "Yalta" which has previously been quite resistant. It is likely to prove a virulent and important race, and is calling for a special breeding programme.

It is quite impossible to predict whether a change in physiologic races will occur, or when. The only sound basis for dealing with the problem is to constantly make tests with the rust collections to determine what race is actually present. Such rust surveys have been in progress since 1921, and to date over 9,600 rusts on different cereals and grasses from all parts of Australia and New Zealand have been examined and the physiologic races present determined. Work of this kind, although tedious and time-consuming, must be continued year after year.

When a particular race is found, its capacity to attack commercial varieties and all sorts of wheats can be studied. As each new race turns up, its particular capacities are determined. Varieties formerly resistant may now prove to be susceptible, others may be found to have the double resistance, and thus be valuable as parents in breeding work. As another race arises, a further search for resistance must be made. Field tests are carried out all the time to check the plant-house results. It can be seen that this method means that breeding is based on sure knowledge of the resistance present in the parent, and is not a hit-or-miss attempt to obtain resistant sorts.

It is now known that a number of imported varieties have valuable resistance, although in themselves they are worthless as commercial varieties for Australian conditions because of low yield, colour of the grain, or some other undesirable character. So it is that in addition to incorporating resistance in a new variety, it is essential to have also high-yielding capacity, high quality grain, strong straw and other agronomic characters. Inheritance studies showing how such traits are transmitted from parent to offspring, give the breeder the knowledge that is power in planning effective work, and again eliminates the former haphazard approach.

This is not to say that Farrer's work should be depreciated. On the contrary, had he possessed the knowledge that has been gained during the half century of scientific endeavour since he was doing his work, there is little doubt but that he would have utilised it fully and achieved even greater successes than those for which we honour him to-day.

Of William James Farrer the words spoken by Mr. Winston Churchill about David Lloyd George may well be used:

> "Much of his work abides: those who come after us will find the pillars of his life's toil upstanding, massive and indestructible."