DDDR:IAR/73/33 Restricted
November, 1973

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

Seventh Meeting, Rome, 4-8 February, 1974

CIMMYT INTERNATIONAL WHEAT PROGRAMME

BREEDING FOR HORIZONTAL DISEASE RESISTANCE IN WHEAT

(Information Paper)

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ROME 1973

WS/E5263

CIMMYT

El Batan, Mexico

October 16, 1973

CIMMYT INTERNATIONAL WHEAT PROGRAMME

BREEDING FOR HORIZONTAL DISEASE RESISTANCE IN WHEAT

Note:

Sir John Crawford, Chairman of TAC, asked for a brief description of the work at CIMMYT on horizontal disease resistance in wheat. This paper was prepared by CIMMYT for the use of TAC.

The Nature of Vertical and Horizontal Resistance

The nature and performance of vertical resistance is well known. Most of the resistance to the fungal diseases of wheat, such as the rusts, has been of this type. Usually it is controlled by a single gene and has been of shortlived usefulness, although there are notable exceptions. Generally, it has been associated with host cell hypersensitivity, resulting in death of the infected cells thus automatically sealing off the further spread of the infection.

This specific type of resistance has a wide array of names including physiologic, seedling, hypersensitive, major-gene, monogenic, racial and most recently vertical resistance.

There has been considerable confusion regarding the concept of a broader type of resistance. It also has been designated by an array of descriptive names including field resistance, polygenic resistance, partial resistance, generalized resistance, minor-gene resistance, tolerance and more recently horizontal resistance.

Horizontal resistance is resistance that experience and adequate testing in nature have shown to confer an enduring and stable protection against a pathogen or disease.

Conceptually, horizontal resistances are envisaged to be such that no natural variants of a pathogen are able to compensate for the restrictions to their penetration, development or dispersion that such resistances impose. This can usually be determined only by prolonged testing.

CIMMYT scientists take somewhat less stringent criteria for horizontal resistance. They recognise an urgent need for more permanent forms of resistance. They also recognise that commercial varieties do not need 'ever-lasting' resistance (even if such was possible in a dynamic biological system), because they will be superseded by further improved varieties from the breeding programs.

CIMMYT scientists breed and select for a number of different types of horizontal resistances capable of prolonging the useful economic life of wheat varieties. Some of these are:

a) Polygenic resistance
b) Mature plant resistance
c) Slow rusting
d) Tolerance
e) Multilines

a) Polygenic resistance

There is extensive evidence to support the view that a complex of resistance polygenes (with or without superimposed hypersensitive or vertical genes) are able to provide a form of resistance which will take longer to be eroded by the changes in virulence of the pathogen.

An integral part of CIMMYT's wheat breeding program is the inter-crossing of very large numbers of varieties and hybrid selections from programs throughout the world, (some 5000 different cross combinations are made annually). A high percentage of this parental material has been chosen for its disease resistance characteristics.

Single and multiple cross combinations are made to produce segregating populations containing individual plants and lines with complexes of genes resistant to many diseases.

The segregating material is subjected to a severe screening process to identify lines with superior horizontal resistance characteristics. This screening process includes in Mexico, individual plant inoculation with a mixture of rust strains (about 2 million individual plant inoculations in each of two generations per year); inoculation of plants or soil with Septoria; testing all parental material and some segregating material in the green-house by seedling and adult plant inoculation with rusts. In collaboration with scientists in 71 different countries throughout the world, bulk F_2 populations are tested at 215 sites; segregating F_3-F_7 lines at 117 sites; Elite selections at 20 sites; Septoria resistant material at 25 sites; and varieties at 116 sites. These figures apply only to bread wheat. Durum wheat and triticale are tested by a similar network of world scientists.

The significance of this very extensive testing is that at all stages of development CIMMYT wheat varieties are subjected to attack by a wide spectrum of diseases and races of diseases. Only those lines possessing multigene resistance will resist specific diseases throughout the world.

Experience has shown that it is difficult to combine a high degree of resistance to many diseases plus select for high yield and desirable agronomic characters. A few lines with these characteristics are currently under test.

For the past 3 years, a disease early warning surveillance network has been in operation in collaboration with the Arid Lands Agricultural Development Program (ALAD) in Beirut. It consists of a trap nursery comprising the principle commercial varieties of the Eastern Hemisphere countries, which is grown in countries from India to Morocco. The purpose is to provide an early warning of the increase in virulence of diseases on these varieties, thus allowing an opportunity for a change of variety in commercial production.

Coupled with the extensive screening mentioned above and a Regional Disease and Insect Screening Nursery (RDISN) monitored by ALAD, this provides the basic defense against a sudden widespread disaster caused by disease. A similar regional project was initiated in Latin America during the past year.

b) & c) Mature plant resistance and slow rusting

Some wheats are susceptible to rusts in the seedling stage, but are resistant as adult plants. There are two types of resistance that can account for 'mature or adult plant resistance'; (i) plants which develop only resistant pustules producing few spores and (ii) the slow rusters, having susceptible pustules, but the disease is slow spreading and does not develop a wide spread attack until too late in the season to significantly reduce grain yield.

Both of these types of resistance affect the epidemiology of the disease, reducing its damaging effects.

In most instances, the resistance is horizontal in nature because it controls many races of the diseases.

CIMMYT scientists continue to select for these types of resistances and reincorporate the relevant genes into the breeding gene pool.

d) Tolerance

Because of the extensive world-wide testing of CIMMYT breeding material for yield as well as disease resistance, it has been possible for CIMMYT scientists to identify some lines which, although susceptible, are little affected in yielding ability.

The genes responsible for this tolerance are also fed
pool. No varieties have been selected for commercial production with this type of resistance as their only defense against disease attack.

e) Multilines

As originally conceived by Dr. N.E. Borlaug in the early 1950's, a multiline was a cultivar developed by mechanically mixing seed from many different backcrossed lines of a particular variety. Each individual line had a different form of disease resistance obtained by backcrossing to a different resistant parent. By mechanically mixing these lines, a population is formed in which there is variability from plant to plant with regard to disease resistance. Other varietal characters are maintained constant.

Should one form of resistance break down, the percentage of infected plants would be small thus avoiding an epidemic.

During the past three years an organized collective effort has been made by CIMMYT and some of the cooperating National Programs to develop a multiline in the complex of varieties arising from the highly successful, widely adapted, high yielding cross known as 8156. These varieties are better known as Mexipak, Kalyansona, Siete Cerros, PV18, Indus, Super X, Espigas, Laketch and a host of other names in various countries. Lines with different sources of resistance have been evolved in several National Programs and at CIMMYT.

In the CIMMYT breeding program, all the 8156 types have been systematically selected from all generations and placed in a separate 8156 multiline nursery. These have undergone tests to all existing Mexican strains of the three rusts and Septoria tritici. The nursery now contains more than two hundred lines. During 1973, thirty one sets of these lines have gone out to collaborators in many different countries for exposure to prevalent strains of disease in a broad geographic area.

By this means it will be possible to establish which lines have useable resistance in different regions. Aliquot mixtures can then be made up for each region.

No attempt is being made to maintain exactness of the 8156 type for agronomic characters. The lines are coming from the normal breeding program with no backcrossing to regain the exact 8156 type. Within a mixture all will generally resemble 8156 in type by having approximately equal maturity, height, chaff colour and seed colour.

It is necessary to grow all of the lines each year as individual lines. As one or more become susceptible to disease, they are removed and replaced by new ones with resistance before making up the new seed supply.

In Mexico, CIMMYT is working on multilines in two other series which have demonstrated broad adaptability.

Only two multilines have been developed so far in wheat and only one of these has entered commercial production. Miramar, a Frocor based variety was developed and grown in Colombia several years ago. It still maintains its overall resistance to this day. A second multiline was developed in Gabo 56 in Mexico which was due for release in 1961. However, the dwarf varieties came along at the same time and their higher yield made this multiline unusable.

It will be obvious from the above brief summary that CIMMYT and its network of collaborators already have a worldwide coordinated research project on horizontal resistance to wheat diseases. It is very broadly based in terms of germplasm, types of resistance and cooperating manpower.

CIMMYT wheat scientists would recommend support for further fundamental work to elucidate the basis of horizontal resistance to wheat diseases. The best work known to them at the moment is being conducted at the Plant Breeding Institute, Cambridge, England.