SELECTION FOR DISEASE RESISTANCE IN CIMMYTS MAIZE PROGRAM

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Background

Before explaining how we try to incorporate disease resistance in CIMMYT's Maize Program populations I will briefly describe the evolution of our program in Mexico and how breeding for disease resistance became an integral part of the pathologists and breeders program. The maize program began in 1945 with the posting of scientists from the Rockefeller Foundation at the request of the Mexican Government. These scientists and their Mexican colleagues collected local varieties, improved them and, in time, crossed them to exotic germplasm. These crosses underwent improvement for several years and were tested for adaptation on a limited scale in several countries. In 1966, CIMMYT was founded and the process of limited testing on an international scale continued until 1973. The tests provided good information on adaptation of most of the populations under improvement. Therefore, we decided to give the program a more dynamic approach by offering world wide service to national programs and farmers. Most of our maize materials are now grouped into Advanced and Back-Up Units, based on their relative adaptation uniformity.

The Advanced Unit

The most highly improved populations are included in the Advanced Unit. Full-sibbed progenies extracted from these populations are tested in the International Progeny Testing Trial (IPTT). The IPTT's are made up of 250 families, replicated twice and evaluated at six locations in a 16 × 16 simple lattice design, with one location being at a CIMMYT station in Mexico. After data from test locations are received experimental varieties are formed from reserve seed by intercrossing about 10 of the best families. These varieties are then tested by collaborators at 20-25 sites in the world.

Companion Nurseries

Simultaneous to the yield evaluation of families, the three following companion nurseries are planted in Mexico:

(a) High Density Nursery, where agronomists evaluate the response of the families to plant densities of 40-50,000 to 80,000 per hectare;

(b) Insect Nursery, where entomologists evaluate the reaction of the families to fall army worm *(Spodoptera frugiperda)* and the sugarcane stem borer *(Diatraea saccharalis)* by mass-rearing large quantities of these insects and artificially infesting the nurseries; and,

(c) Disease Nursery, where we artificially inoculate all families with ear *(Diplodia maydis* and *D. macrospora)*, and stalk *(Fusarium roseum, F. moniliforme* and *Cephalosporium acremonium)* rotting pathogens.

The evaluation for the reaction to foliar diseases is made in the yield trials. The families selected to regenerate a population must pass the tests in these three nurseries, as well as the international trials. Ways to more intensively use the insect and disease nurseries are under consideration.

Disease Resistance in the Back-Up Unit

Genetic variability is lowered after a few cycles of recombination and improvement of selected families in the Advanced Unit populations. The Back-Up Unit maintains and improves gene pools of various grain texture, color and maturity. These gene pools can serve as Advanced Unit populations when needed, but are generally used to feed superior genetic variation into the advanced materials. They are handled in a half-sib family structure in Mexico and periodically the families are evaluated in yield trials and companion nurseries, similar to IPTT's. The full-sib families developed among the best families are then used to replace the poor families in the advanced populations. Through this process a continuous improvement program is ensured. The Back-Up Unit pools are routinely improved for ear rot resistance by inoculating half of each female row with ear rot pathogens in the recombination block and selection of non-rotted ears produced on the most agronomically desirable plants.

Major Diseases That Need Our Attention

There are some important diseases of wide occurrence in addition to ear and stalk rots. CIMMYT recognizes three major diseases of maize about which little can be done under Mexican conditions because they either do not exist or are too erratic and sporadic in nature. These diseases are corn stunt, downy mildew (DM) and streak virus. Let us consider each of them independently.

Corn stunt is a major disease. It limits production throughout the tropical lowlands of Latin American countries and is most severe in Central America. The disease is now known to be caused by a spiroplasma which is transmitted by several species of Cicadellidae, perhaps the most important being *Dalbulus* spp. The problem, first reported in Southern USA in 1945 (5), is now present as far south as the lowlands of Bolivia. In newly infested areas "of-season plantings" may suffer 25-100% yield losses (4). Fortunately, a few sources of resistance against corn stunt are already known, mainly materials from Cuban and Dominican Republic. However, under very heavy infestations of the leafhopper vectors this resistance breaks down. Resistant sources that have been identified show it to be polygenic and additive in nature (6, 9). Since the causal agent is not seed transmitted there is no concern of possible movement of the disease to other continents.

Lately sorghum downy mildew (SDM), caused by the fungus *Sclerospora sorghi*, has caused much concern to maize and sorghum breeders in Latin American countries. The disease was first reported in Northern Mexico and Southeastern USA in 1964 (8) and is now causing appreciable damage in countries like Mexico, Guatemala, Honduras, Venezuela, Brazil and Northern Argentina. SDM is also a major limiting factor of maize and sorghum production in some countries of Africa and Asia from where it seems to have moved to the American Continent.

Fortunately, good sources of resistance are available against SDM. The most stable resistant sources are Philippine DMR 2, 4, 6 and Comp.2 in white kerneled types, and Philippine DMR 1, 3, 5 and Comp. 1, and Thai DMR Comp. # 1 in the yellow kernel types. However, agronomic characters of most of these sources warrant further improvement. There is concern in the movement of seed from infected areas because of the seed-borne nature of the fungus. The concern is not completely justified as the diseased plants either do not produce ears or produce nubbins which are not selected for seed purposes. Besides, drying of the kernels avoids further possible dissemination. The case of mass movement of commercial seed from a DM area into a disease free country, however, is beyond these considerations.

The maize streak disease is caused by the virus of the same name. This disease has been known in African countries for many years and is of concern in maize-producing areas of that Continent. The virus is transmitted by the leafhopper *Cicadullina* spp. and perhaps has several strains (1). Reports from India also indicate its presence in that country (10). Very little information is available on this disease in the literature and good sources of resistance have not been developed. Resistance is reported to be monogenic dominant to polygenic in different sources reported from Nigeria. Some known sources of resistance are TZB, TZY, SA-32 and SA-37.

CIMMYT's Program to Control These Diseases

Since selection for resistance to these three diseases cannot be effectively carried out in Mexico, a Collaborative Research Project was launched in 1974 with the idea of using fields and facilities of various national programs that have been involved in selection for resistance to these diseases. Selection for DM could be done effectively in Thailand and Philippines, stunt resistance in Nicaragua and El Salvador, and streak resistance in Zaire and Tanzania.

In 1974, three broad based populations were developed which could fit the requirements of grain type and maturity in several national programs once disease resistance was incorporated in them. These populations are:

Population 1, a Tropical Late White Dent (TLWD);

Population 2, a Tropical Intermediate White Flint (TIWF); and,

Population 3, a Tropical Late/Intermediate Yellow Flint/Dent (TYFD).

During 1974, a crossing block was established where all pools and advanced materials were crossed with the DMR sources within their own kernels colors. In August 1975 all the above crosses, the three base populations, and the crosses of the populations with all known sources of resistance to DM, stunt and streak were sent for screening for DM to Thailand and Philippines, for stunt to Nicaragua and El Salvador and for streak virus to Nigeria and Tanzania. The plantings in both collaborating African countries were lost due to drought. In the other countries, non-infected plants were selected and self pollinated — in Thailand and Philippines after artificial inoculation with DM conidia and in Nicaragua and El Salvador under natural incidence of stunt. Seed of S_1 families, that were resistant to stunt both in Nicaragua and El Salvador, were planted in a modified ear-to-row recombination block while seed of the DMR families from both Thailand and Philippines were planted using seed from Thailand in the same modified ear-to-row recombination block. Female rows represented the independent families rated good from at least two locations, while the male rows were planted with a balanced composite of all female entries. Concurrently, the selected S_1 ears were planted in Thailand and the DM data obtained were used for selection purposes in the recombination block in Mexico.

Unfortunately, the modified ear-to-row method does not eliminate the large amount of pollen produced by susceptible plants. A scheme based on full-sibs, S_1 development and testing of these S_1 progenies is proposed in Fig. 1. It is intended to develop sub-populations with high levels of resistance independently to stunt, DM and streak virus and, secondarily, to develop sub-populations resistant to both stunt and DM.

By this procedure, and in collaboration with the program in Thailand, we were able to plant DMR S_1 progenies and backcross them to our advanced populations which were previously crossed to DMR sources in 1975. The same procedure for incorporating resistance to stunt disease and streak virus in CIMMYT's advanced populations and Back-Up pools is envisioned.

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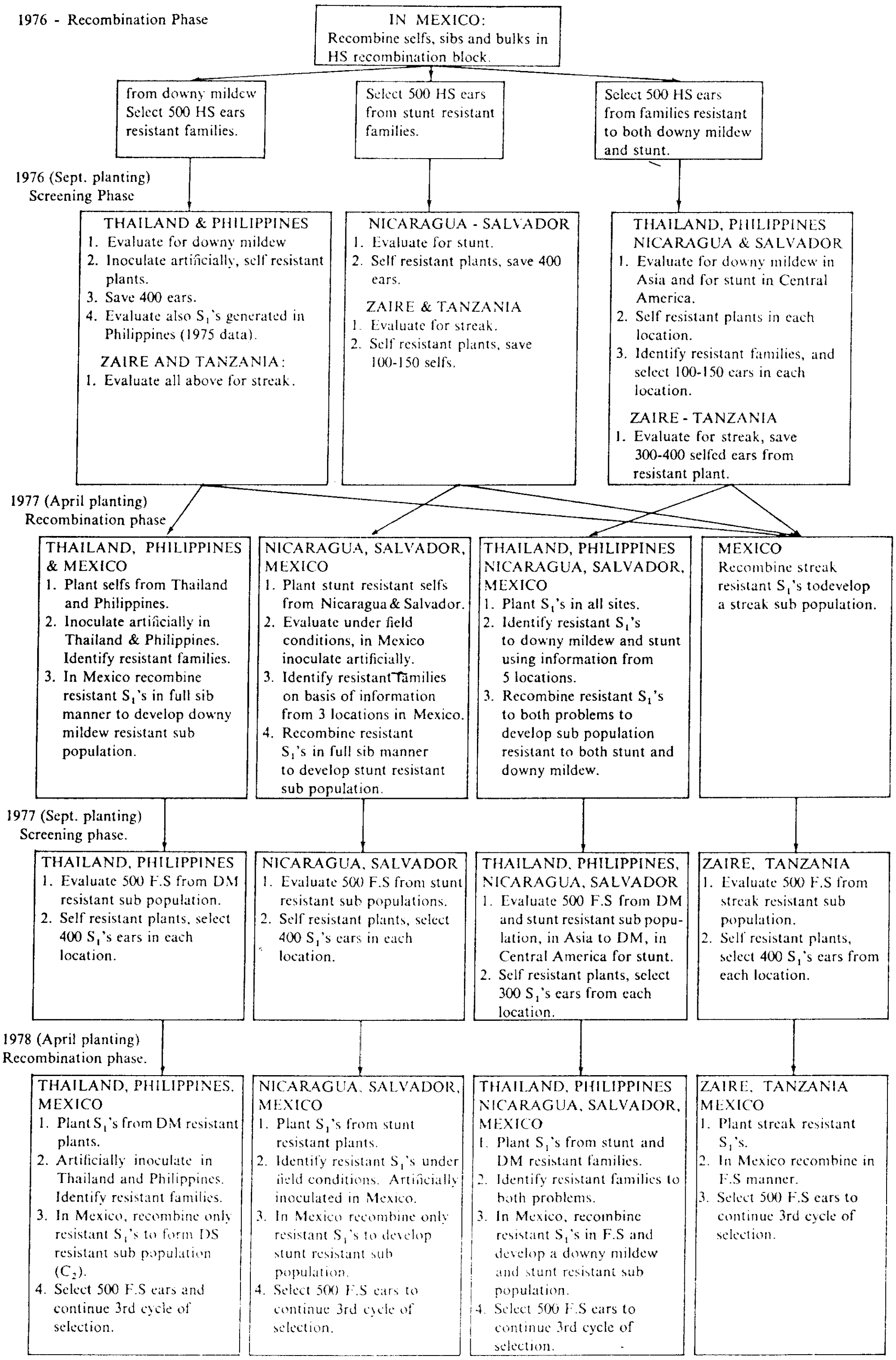
figure 1. Development of downy mildew, streak and stunt resistant populations in CIMMYT's Collaborative Research Program



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