13.0 BREEDING FOR DISEASE RESISTANCE

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13.1 INTRODUCTION

In 1981, James estimated that diseases caused a worldwide loss of 540 million tons of crop production valued at 50 billion US dollars (1). Diseases were estimated to reduce potential production of wheat (Triticum aestivum L.) by 9.1%, rice (Oryza sativa L.) by 8.9%, maize (corn) (Zea mays L.) by 9.4%, potato (Solanum tuberosum L.) by 21.8%, vegetable crops by 10.1%, fruit crops by 16.4%, oil crops by 10.2%, and fiber and rubber crops by 11.8%. These losses occurred despite the use of over one billion US dollars worth of fungicides. In some years and locations, the complete crop may be lost to disease as occurred in Ireland in 1845 when the potato crop was destroyed by late blight (incited by Phytophthora infestans (Mont.) de Bary) and in the 1880's in Sri Lanka (formerly Ceylon) where the coffee crop (Coffea spp.) was devastated by coffee rust (incited by Hemileia vastatrix Berk. and Br.). More recently, serious losses from a stem rust epidemic on wheat in 1953 to 1954 caused by the appearance of a new race (15B) of Puccinia graminis Pers. f. sp. tritici Erik. and Henn. were recorded in the central United States. In 1970 southern corn leaf blight incited by Cochliobolus heterostrophus Drechs. (the perfect stage of Helminthosporium maydis Nisik. and Miyake) caused severe loss to the U.S. corn crop (2). In addition to direct losses caused by diseases, diseases can have severe economic consequences by restricting international trade.
For example, wheat from the northwestern United States cannot be certified as being free of dwarf bunt (Tilletia controversa Kuhn) spores, hence is banned for importation by the People's Republic of China which is a potential market for 2.2 to 2.7 million metric tons of wheat (3). Although many major diseases are controlled by resistant cultivars, many other diseases are devastating for agriculture and those who derive their livelihood from it.

The annual loss from diseases would undoubtedly be much larger if it were not for the progress made in research on disease control over the past seven decades. Among the many diseases usually controlled by resistance are leaf, stripe, and stem rust of cereals; anthracnose, bacterial wilt, common leaf spot, Fusarium wilt, Phytophthora root rot, and stem nematode of alfalfa (Medicago sativa L.); black shank, Granville wilt, wildfire, mosaic, black root rot, and root knot of tobacco (Nicotiana tabacum L.); Fusarium wilt and Verticillium wilt of tomatoes (Lycopersicon esculentum Mill.); cabbage (Brassica oleracea L.) yellows; common mosaic of bean (Phaseolus vulgaris L.); Phytophthora rot of soybean (Glycine max (L.) Merr.); and potato scab to name a few (4, 5, 6).

Breeding for disease resistance is the least expensive method of protecting a crop from disease. However, before plant breeders begin a breeding program and select their objectives, they must first decide if the problems they propose to solve are of sufficient importance to justify use of project resources. They must also decide if there is sufficient information available to develop a strategy to solve the problem. Simply, the problem must be understood before it can be solved. Finally, they must determine if there are sources of resistance available that can be incorporated into agronomically acceptable plant types.

Fortunately, the answers to these questions as they relate to a disease problem are often clear, since disease is frequently the major limitation to realizing the full yield potential of a cultivar. Because diseases are so important, considerable