CONTRIBUTION OF THE INTERNATIONAL SPRING WHEAT RUST NURSERY TO HUMAN PROGRESS AND INTERNATIONAL GOOD WILL

W. Q. Loegering and N. E. Borlaug [1]

The containment of emergencies often requires a modification of usual procedures. The unexpected and indirect benefits resulting from such modified procedures may prove to be greater than the direct benefits obtained by containment of the emergency.

The International Spring Wheat Rust Nursery Program, started in 1950, is an excellent example of this. Scientists in many countries of the world cooperate in this program, which is coordinated by the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture. The initial objectives of the program have been realized. Source of resistance to the rust diseases of wheat have been found, and it has been shown that these resistances have been transferred to improved varieties of wheat recommended for growing in the United States. Indirect values resulting from this cooperative international program include bringing together workers of many countries, facilitating the exchange of materials and information concerning wheat rust organisms and wheat varieties, and contributing to increased production of basic food supplies in many countries. These direct and indirect benefits could have been obtained only through the international cooperation of hundreds of scientists in over 40 countries, who plant and care for the wheats, take data, and furnish the entries for the nursery.

In 1894, Mark Alfred Carleton was placed in charge of cereal crops investigations for the U.S. Department of Agriculture. Almost immediately he began collecting wheats from all over the world. This activity has continued ever since without interruption. The resulting World Collection of Wheats, now containing more than 17,000 entries, is housed at Beltsville, Md., and is the backbone of the International Spring Wheat Rust Nursery. Soon after the collecting of wheat started, the materials were made available to workers everywhere on an exchange basis. Unfortunately, data on rust reaction were exchanged but rarely until 1919, when some experiment stations in Canada began cooperating in testing the rust reaction of wheat varieties in the United States Uniform Rust Nursery. International cooperation in making such tests can be traced to this program, which was initiated by E. C. Stakman, H. B. Humphrey, and J. A. Clark. During the 1940's, B. B. Bayles of the U.S. Department of Agriculture started a testing program in Mexico in cooperation with the Mexican Department of Agriculture and the Rockefeller Foundation. Thus data on the reaction of wheat varieties to rust began to accumulate on an international basis.

An emergency developed in the United States in the summer of 1950, when race 15B of wheat stem rust became prevalent. [2] This race was virulent on all commercial varieties

---

[1] Pathologist, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Md., and Pathologist, Inter-American Wheat Improvement Program, Rockefeller Foundation, Mexico City, Mexico.

[2] Anonymous. 1954. A situation report, race 15B stem rust of wheat. U.S. Dept. Agr., Agr. Res. Ser., Spec. Rpt. ARS 22-10.

of wheat. A catastrophe was in the making and actually occurred in 1953 and 1954 when 60 and 75 percent, respectively, of the potential durum wheat crop in the United States was destroyed. Solving the emergency called for speeding up the procedures for testing wheat varieties for rust resistance.

A race similar to 15B occurred in the wheat regions of southern South America, and a race with a wider host range occurred in Peru. In the spring of 1950, H. A. Rodenhiser of the U.S. Department of Agriculture made arrangements with scientists in Mexico, Colombia, Ecuador, Peru, Chile, Argentina, and Brazil to plant in the field about 1,000 lines of wheat selected from the World Wheat Collection. These wheats were thus exposed to the stem rust populations in those countries. The results of this first International Spring Wheat Rust Nursery exceeded expectations, and today much of the rust resistance in the commercial wheat of the United States and other countries can be traced to the resistant breeding material selected from that nursery.

Cooperators in Latin America were very enthusiastic and asked that the program be continued. New sets of varieties were made up in succeeding years, and the number of locations in Latin America at which they were planted was increased. The entire program is operated on a cooperative basis and each cooperator furnishes his time, talents, and facilities.

In 1952, B. B. Bayles attended the Food and Agriculture Organization Regional Wheat and Barley Meeting in the Near East and made arrangements for growing the nursery in a number of countries of Africa and Asia. In 1955 the Congress of the United States made a special appropriation for foreign testing and seed increase of cereals. These funds made it possible to organize the work more adequately and efficiently, to expand the nursery locations to other parts of the world, and to start nurseries with other cereals.

At the present time, 64 Spring Wheat Nurseries of approximately 600 entries, 32 Winter Wheat Nurseries of 300 entries, 32 Oat Nurseries of 75 entries, and 48 Barley Nurseries of 150 entries are being grown throughout the world (figs. 1 and 2). The varieties included in these nurseries are screened from the World Collection or are contributed by cooperators from many countries. They represent a cross section of the best resistance to rust that can be found. Approximately 150 scientists are at present cooperating in the program at about 85 locations in 40 countries. These scientists plant one or more of the nurseries, take notes, and make the data available. Each year the data are compiled and distributed to all cooperators. To date, 40 reports have been distributed. These reports are considered a basic need in planning wheat-breeding programs.

During the first few years that the nurseries were planted, many wheats were found to be highly resistant to the prevalent and dangerous races of stem rust that occurred in the United States. Such varieties were immediately used in breeding wheats in the United States and other countries. By 1954, promising lines of wheat incorporating this resistance were being tested internationally. In 1956, the first commercially acceptable varieties--Langdon, Ramsey, Towner, and Yuma--were being released to farmers in the United States.

While the initial emphasis was to obtain resistance to stem rust, specifically race 15B, it was clear from the beginning that resistance to other diseases could be found and proved in the same manner. Data were accumulated on leaf and stripe rust resistance of

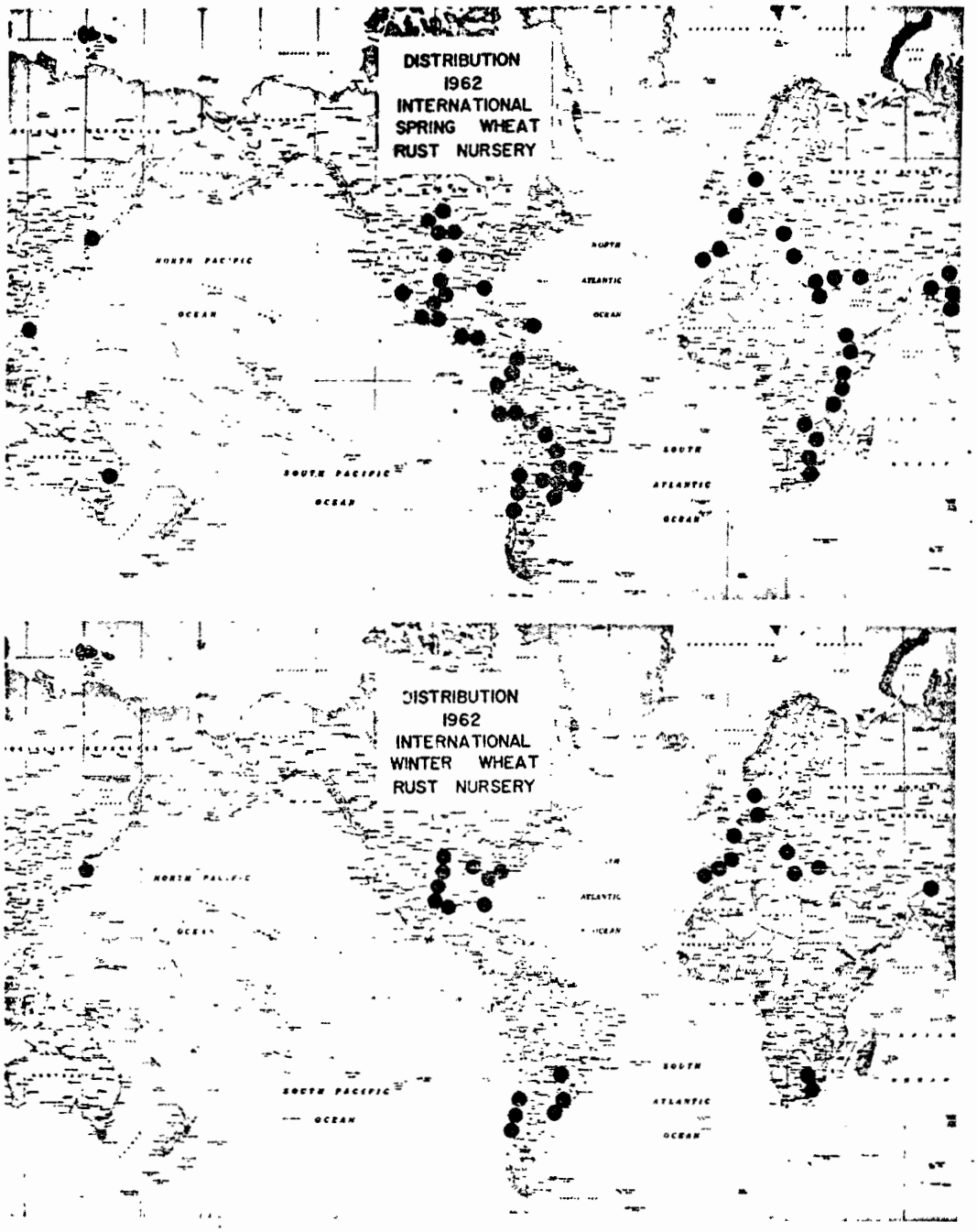

Figure 1.--Locations in the world at which the 1962 International Spring Wheat and Winter Wheat Rust Nurseries were planted.

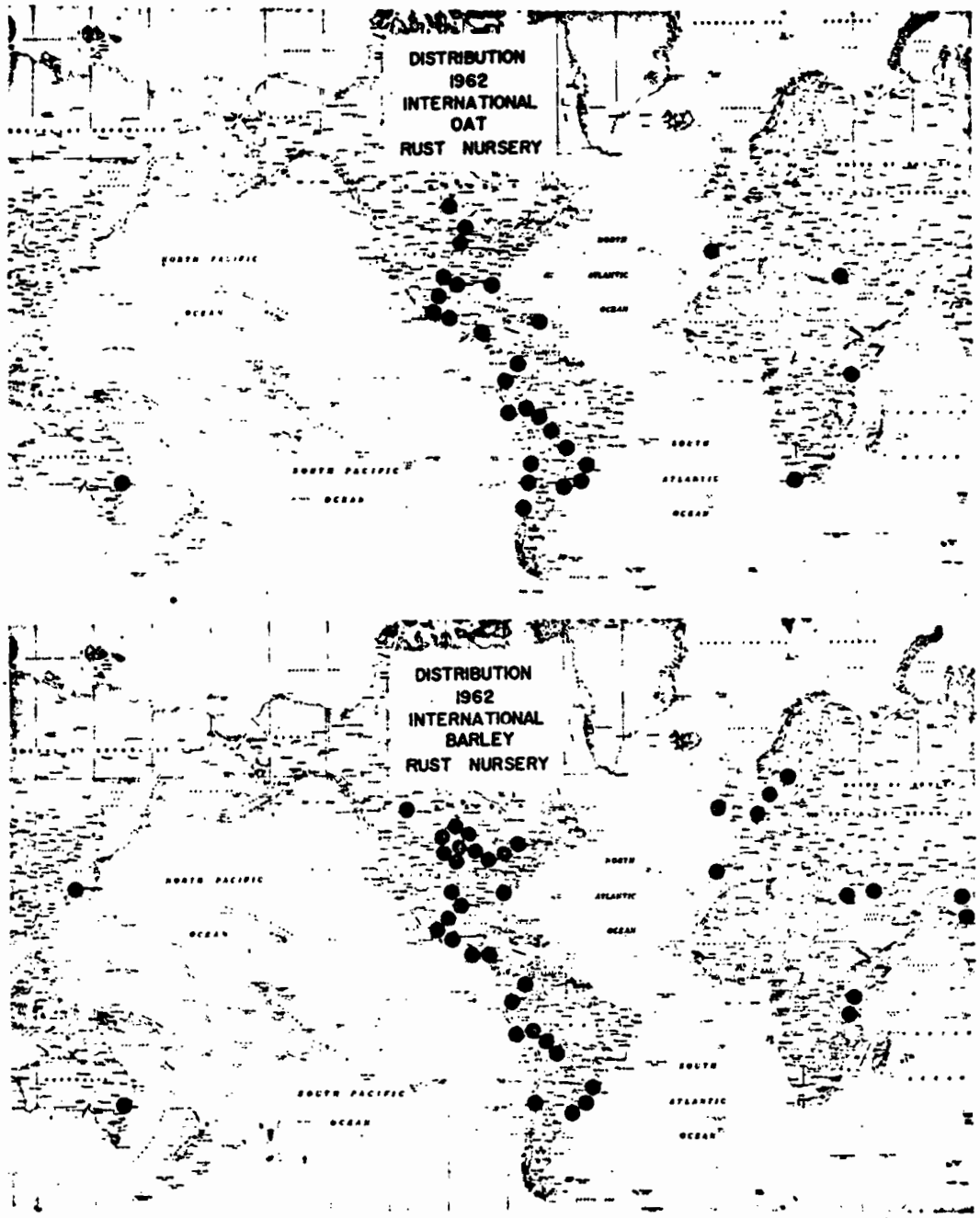

Figure 2.--Locations in the world at which the 1962 International Oat and Barley Rust Nurseries were planted.

wheat, and nurseries were initiated to find resistance to rusts and other diseases of oats and barley. Thus, each year more and better resistance to diseases in cereal crops is becoming available. As rapidly as possible, intelligent use is being made of this resistance by plant breeders. Resulting new varieties are then tested to determine if all resistance has been transferred. Commercial wheat varieties that have passed this test are Conley, Justin, Wells, and Lakota. Thus, the initial objective of the nursery has been achieved.

In addition, the program has made significant contributions to human progress and international good will. The nurseries and the reports are being widely used in cereal improvement programs throughout the world. In literature, reports, official communications, and letters, reference is repeatedly made to the importance of the International Rust Nursery as the source of rust-resistant commercial varieties and parents for breeding. The following selected citations indicate the importance that plant pathologists and plant breeders throughout the world place on this program.

At the III Latin American Meeting of Plant Scientists sponsored by the Rockefeller Foundation and held at Bogota, Colombia, in 1955, the following resolution (translated) was adopted and printed in the proceedings:[3]

(1) Considering that in the last five years there have been international nurseries of wheat, oats, and barley in various Latin American countries, the United States of America and Canada;

(2) That the information from these nurseries has been of enormous value in the programs of breeding in these cereals;

(3) That the opportunity for technical specialists to observe these nurseries has permitted the exchange of information valuable to these programs;

(4) That these nurseries have been made possible thanks to the cooperation of the United States Department of Agriculture;

It is agreed to give a vote of applause and thanks to the U.S. Department of Agriculture, and we desire to indicate the necessity of continuing this work.

In an official document transmitted by the Charge d'Affaires of the Republic of South Africa to the State Department of the United States on August 11, 1958, is found the following:

> "Members of the conference of South African wheat breeders, plant pathologists, and agronomists wish to express appreciation to the U.S. Department of Agriculture for establishing the existing system of international cooperation whereby wheat breeding material is evaluated on a world wide basis.
>
> "South Africa's participation in this scheme has not only rendered available valuable information as to the merits of potential breeding parents, but it has made available a range of wheat varieties which, otherwise, would have been difficult, if not impossible, to assemble in one single collection."

[3] Proceedings of the III Reunion Interamericana de Fitogenetistas, Fitopatologos, Entomologos, y Edafologos, June 20-July 1, 1955, Bogota, Colombia. 1958. Ministerio de Agricultura de Colombia.

In a paper presented at the Sixth F.A.O. meeting on Wheat and Barley Breeding in the Near East held at Ankara, Turkey, in 1959, G. E. Dixon of the Plant Breeding Station, Njoro, Kenya said:

> "It was in 1953 that Kenya first took part in the International Spring Wheat Nursery, and with this it can be said that the modern era of breeding actually began.
>
> "The most significant point of all at this stage in the history of wheat breeding in Kenya is the need for the greatest possible genetic breadth in any breeding against rust diseases. Kenya has learnt this the hard way, and hence it is the dominant theme in this paper. With this goes the recognition that the International and F.A.O. Nurseries collectively provide the best possible means of achieving that breadth. This development in international cooperation has already had a profound influence on wheat breeding in Kenya, and it is confidently hoped, has turned the tide again."

A. Campos of the Graduate School, National College of Agriculture at Chapingo, Mexico, in a general bulletin[4] on cereal rusts in Mexico, says (translation):

> "The International Rust Nursery offers an excellent opportunity for the selection of parental material with good resistance to stem rust of wheat."

In the President's Review of the 1960 Rockefeller Foundation Annual Report is found the following:

> "The Inter-American Wheat Improvement Project grew out of several previous activities, one of which was the (International) Spring Wheat Rust Nursery established in 1950 under the leadership of the United States Department of Agriculture which has proved extremely helpful in throwing light on rust races and resistance to them in a number of different countries."

Certainly these citations indicate the good will that has been engendered by the International Rust Nursery program. They also show that the values of the program touch every cooperating country to a greater or lesser extent. These values are of both a technical and a scientific nature and have been large and varied.

Before the nursery was established some wheat breeders throughout the world had been reluctant to release lines from their breeding programs to fellow scientists for fear of unethical competition. Thus, release of materials at a given location to other scientists often was delayed until the variety was named. In only a few cases were early generation materials distributed to other scientists. Today it is an accepted procedure of most wheat breeders to have early generation materials tested in the nursery and an accepted policy that any wheats so tested may be used by the collaborating scientists for breeding purposes or commercial increase, provided acknowledgment of the source of the material is given. These developments represent the penetration of a psychological barrier and have greatly accelerated the advancement in wheat-breeding programs around the world.

[4] Campos, A. 1960. Importancia de las razas fisiologicas de Puccinia graminis var. tritici Eriks. y Henn. en la produccion de variedades de trigo resistentes a la roya. Boletin Tecnico Num. 2, Escuela Nacional de Agricultura, Chapingo, Mexico.

The inclusion in the Nursery of varieties and cereals from all parts of the world has afforded each cooperator the opportunity to observe adaptation to local conditions. As a result, collaborators communicate directly with scientists in other areas from which the adapted varieties come, in order to obtain additional promising lines. Also, agencies that operate internationally, such as the Food and Agriculture Organization, (FAO), the Rockefeller Foundation, and the Agency for International Development (AID), have been able to determine more quickly the best source from which to obtain adapted material useful in a given area. The Nursery has also served as a model for similar types of programs such as the European Rust Nursery, the FAO Near East Disease Nurseries, and the Inter-American and FAO Spring Wheat Yield Nurseries.

The International Spring Wheat Rust Nursery has served the practical needs of wheat breeding in several ways: (1) As a direct source of commercial varieties; (2) as a source of rust-resistant parents in breeding programs; (3) as a vehicle to assist in selecting the most resistant lines for commercial release; and (4) as a means of decreasing the time needed for testing for resistance in local areas.

In various countries of the world, varieties have been selected directly from the Nursery and distributed for commercial production. The two principal varieties now being grown in Guatemala--Lerma Rojo (Mexico) and Narino 59 (Colombia)--were first identified as potentially valuable on the basis of performance in the Nursery. In Peru, the varieties Sierra I and Sierra II, developed cooperatively by the Rockefeller Foundation Agricultural Programs in Colombia and Mexico, were selected from the Nursery and have been grown on farms in the high valleys. In Kenya, a number of varieties originating in the United States, Mexico, Brazil, South Africa, and Colombia have been selected and are now being recommended for commercial production. Israel has selected a sib of the Colombian variety Andes for commercial increase because of its performance in the nursery. In southern Pakistan, several Mexican wheat varieties that were included in the Nursery were found to be promising and are being considered for release.

Nearly all rust-resistant parental materials used in the more advanced breeding programs around the world have been identified and proved in the International Rust Nursery. These materials originated from collections made by plant explorers as well as from complex breeding programs and laboratory research. In general, they possess agronomic defects and so are not used commercially; nevertheless, their importance as parents in current breeding programs has been fundamental to developing successful and valuable commercial varieties.

Many commercial wheat varieties that have been released in various countries of the world owe their final selection partly to their performance in the International Spring Wheat Rust Nursery. Frequently, two sister lines may look identical under local conditions but may perform very differently at one or more locations in other parts of the world. This indicates that one of the lines must have at least one additional gene for resistance to rust. Many of the final choices of new lines for distribution have been made because of evidence of this kind. Examples are to be found in many countries. In Mexico the Nursery has contributed to the development of the Kentana 48, Lerma 50, Chapingo 52, Chapingo 53, Yaqui 53, Yaqui 54, Lerma Rojo, and Nainari varieties. It has assisted in developing Bonza, Andes, and Narino in Colombia. In Chile, the variety Orofen, a sister of Peru's Sierra I and Sierra II and of the Mexican variety Yaktana, owes its selection in part to its performance in the Nursery. Nearly all rust-resistant spring and durum wheats released in the United States and Canada since 1956 had previously been tested in the Nursery.

In the past, tests of wheat for rust resistance had to be made under field conditions in local areas for a number of years before a sound decision could be reached as to which lines under test had the best resistance. At present, the same kind of materials can be tested in the International Rust Nursery and more meaningful information obtained in 1 or 2 years than could have been obtained in many years under the old system.

A byproduct of the Nursery has been information obtained on the reaction of cereals to diseases other than rusts. The information on powdery mildew has been very helpful from the practical standpoint. The data on Septoria infection of wheat indicate that no high resistance to this organism of a usable nature is available in any part of the world. This fact has focused attention on the need for basic studies to determine the best method of controlling this disease. Evaluation of the sensitivity of varieties to brown necrosis, a genetic weakness in wheat, has been possible in certain locations every year. Symptoms usually are not evident in many wheat-growing areas, although in some years the wheats become blackened and considerable loss in yield may result. Thus, the Nursery makes it possible to screen out immediately lines with this weakness. Data on other agronomic characters such as earliness, lodging, shattering, adaptation, and height have also been accumulated. This kind of information has practical and basic values.

The scientific values of the program are diverse. As a result of information on the reaction of varieties in the field, it has been possible to characterize different regions according to their rust populations. These regions are North America, the Andean Region of northern South America, southeast South America, Kenya and East Africa, the Mediterranean region and Europe, southeast Asia, and Australia. Such information helps to determine areas in which tests are most important. It also emphasizes the fact that varieties should not be moved from one region to another without first being tested.

Accumulation of data on adaptation of wheats is another basic value. These data are not summarized in the reports, but the observations that have been made led to the development by the Rockefeller Foundation of the Inter-American and FAO Wheat Yield Nurseries, which primarily measure the adaptability of the commercially grown spring wheats of the Americas, Australia, and the Near East.

A happy result of the Nursery has been the strengthening of cooperative work on basic problems among the scientists in different countries. This cooperation has made possible studies on the genetics of disease resistance in which different cultures of the pathogen are used without actually moving the cultures outside the area where they occur naturally. In this way, the Nursery has increased greatly the direct communication between scientists of different countries and has led to greater exchange of ideas.

Thus, the overall contribution to human progress and international good will made by the International Spring Wheat Rust Nursery over the past 12 years has been significant. Many national and international organizations have had a part in this achievement with the Nursery serving as a thread to bring together the fine efforts and accomplishments of these organizations. But over and beyond this is the fact that little could have been accomplished without the wonderful cooperation that individual scientists around the world have given to the International Rust Nursery program.