Network on the development of Wheat Cultivars for Durable Resistance to Leaf and Stem Rusts in the Nile Valley and Red Sea Region

A. SUMMARY

Title of the Project

Development of Wheat Cultivars for Durable Resistance to Leaf and Stem Rusts in the Nile Valley and Red Sea Region.

Duration

Work on the development of wheat cultivars resistant to leaf and stem rusts in the Nile Valley and Red Sea countries started by national and center support in the 1988/89 growing season and continued until 1995 when a Regional Networks Project was established, with support for three years from the Royal Netherlands Government. Network activities continued beyond the conclusion of funding from the Netherlands.

Objective

The goal is to increase wheat productivity in the countries of the region by developing wheat cultivars with durable resistance to the rapidly evolving wheat leaf and stem rusts.

Activities

- Monitoring the present status of leaf and stem rust pathotypes and their frequencies in each country and in the region.
- Identifying effective genes conditioning resistance in the countries/region against the prevalent rust pathotypes.
- Testing the performance of commercially grown cultivars and advanced lines against the rust populations in the region.
- Generating systematic information on leaf and stem rusts in the region to facilitate effective breeding programs.

Area: GRM.

Region: West Asia and North Africa (WANA).

The Project was established under the Nile Valley and Red Sea Regional Program (NVRSRP) coordinated by the International Center for Agricultural Research in the Dry Areas (ICARDA) and involving six partners: Egypt, Ethiopia, Sudan, Yemen, ICARDA, and CIMMYT. Egypt plays the leading technical role in the Regional Network, while ICARDA and CIMMYT, after phasing out technical leadership to Egypt, now provide technical backstopping and contribute to the management of the Network.

A. STAKEHOLDERS
Beneficiaries

The intended beneficiaries are wheat producers in the Nile Valley and Red Sea countries and, ultimately, consumers. As wheat is a major staple food crop in the region, the Project will contribute to food security, rural incomes, improved nutrition of consumers, and more efficient use of inputs and resources through the improvement of the yield level and stability of wheat.

Research Partners

The partners involved are:

- The national research programs of the four countries:
  - the Agricultural Research Center (ARC) of Egypt,
  - the Ethiopian Agricultural Research Organization (EARO),
  - the Agricultural Research Corporation (ARC) of Sudan, and
  - the Agricultural Research and Extension Authority (AREA) of Yemen.

- CGIAR Centers: the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Center for the Improvement of Maize and Wheat (CIMMYT).

Donors

The Network was supported for three years by the Royal Netherlands Government, with a total budget of US$ 1,867,659. The national programs of the four countries contribute their technical staff’s time, laboratory and field equipment, and transportation for staff to visit field sites. They also share the costs of field days and local meetings and seminars conducted in their respective countries. After the completion of donor funding, the national programs and the CG Centers are supporting the work at their own expense.

A. RESULTS AND IMPACT

The Project, in which a multidisciplinary and multi-institutional approach is used, facilitates contact of the national agricultural research systems (NARSs) within and between participating countries to benefit from expertise developed in individual countries, ICARDA, CIMMYT, and other centers of excellence. It also strengthens coordination of research and networking at national and regional levels among the partners and beyond to more efficiently utilize human and physical resources and infrastructure in the national programs of the member countries and ICARDA/CIMMYT Wheat Program.

Wheat leaf and stem rusts, which may have enormous effects on the production of wheat, are addressed. The intensive work that took place within the few years of the Project’s life has produced useful results, which have been contributing to the development of durable resistance to leaf and stem rusts in wheat.

The following are some of the achievements of the Project:

- Nineteen stem rust and 28 leaf rust races were identified in the four countries, and their frequencies of occurrence in the respective countries and across the region were recorded.
The performance of leaf and stem rust isogenic lines was tested, and effective resistant genes for each country and the region were identified as follows:

**Egypt:**
- Lr’s 21, 1, 22b, 18, and 26
- Sr’s Gt+, 30, 7b, 26, and 8a

**Ethiopia:**
- Lr’s 1, 11, 21, 3Ka, and 17
- Sr’s Gt+, 5, 30, 9e, and 7b

**Sudan:**
- Lr’s 24, 26, 9, 17, 21, and 30
- Sr’s 29, 5, 7b, 8a, and Gt+

**Yemen:**
- Lr’s 9, 21, 17, 30, 3Ka, and 23
- Sr’s 7b, Gt+, 5, 8a, and 9e

**Region:**
- Lr’s 21, 17, 3Ka, 30, 11, and 21
- Sr’s Gt+, 7b, 5, 8a, and 30

These genes are now being incorporated into high-yielding but susceptible cultivars in each country. A breeding program is now well established in all four countries to develop high-yielding, adapted, resistant cultivars.

Eleven volumetric Burkard mechanical spore traps are currently in operation in the Nile Valley and Red Sea countries: four in each of Egypt and Ethiopia, one in Sudan, and two in Yemen; these showed the following:

- Spores were trapped throughout the year, except in September for stem rust and June–July for leaf rust in Sudan.
- It was concluded that leaf rust inoculum in Egypt is exogenic and its pathway is from north to south, whereas the inoculum in Ethiopia is endogenic. In Sudan, it also seems that the primary inoculum comes from outside the country, possibly from Yemen, given the presence of the spores all year round, or from other African neighboring countries.
- For stem rust, it appears that the inoculum in Ethiopia and Yemen is present all year round due to the two-cycle cropping system. In Egypt, it may come from the north or from the south depending on wind direction. The question on primary inoculum needs further investigation.
- Rust spores were found throughout the year, and in whatever quantities they occur they can be a source of inoculum to initiate infection.

Five commercial wheat cultivars and advanced lines were found to be resistant to the prevailing leaf rust races in Egypt, 16 in Ethiopia, 18 in Sudan, and 25 in Yemen. With respect to stem rust, 15 cultivars performed well across the region. Seven cultivars had excellent resistance to both leaf and stem rusts across the region from the different countries. These are Sakha 69 from Egypt; Condor’S’ from Sudan; Dashen, ET-13, K 6295-4A and C.T.71/CII from Ethiopia; and Marib 1 from Yemen.

Rust-resistant commercial and newly released cultivars are now grown by farmers in all four countries. This reduces rust sporulation and disease spread in the region.

A. PARTNERSHIPS AND PROJECT IMPLEMENTATION
Project Coordination and Management

The Project is coordinated and managed through ICARDA's Nile Valley and Red Sea Regional Program (NVRSRP). The Network was initiated to contribute to the development of durable solutions to the major problems constraining the productivity of wheat. The outputs of the Network will be used as inputs in the adaptive research and transfer of technology program of NVRSRP.

The research is conducted by the national programs of the four participating countries (see B. Stakeholders). Technical support and germplasm are provided by ICARDA's Germplasm Improvement Program and CIMMYT. The Project also links the national programs with centers of advanced research through ICARDA.

The Project focuses on:

- Enhancement of self-reliance in national programs in basic and applied research through capable leadership, coordination, program planning and execution.

- Enhancement of cooperation among scientists from Egypt, Ethiopia, Sudan, Yemen, ICARDA, and CIMMYT through exchange of technical know-how and germplasm in problems of common interest.

- Complementing research efforts to avoid duplication and make better use of the limited human and physical resources available to the national programs.

Basic research is carried out in the designated lead country where expertise and facilities are most developed in certain problem areas. The outcome of the basic research is then verified through adaptive research under local conditions in other countries participating in the Network. Each country tackles different aspects of the problem area in order to develop a solution to the problem through complementary efforts.

The success of this Network is due to the mechanism by which it is operating. It established a model of partner relationships between two International Centers—ICARDA and CIMMYT—and four NARSSs, which are not limited to researchers, but extend to policy makers and extension systems and farmers. These partner relationships were achieved though the following mechanism:

- The Network is coordinated by a senior scientist from Egypt with contact scientists from Ethiopia, Sudan, Yemen, and ICARDA/CIMMYT Wheat Programs. The Contact Scientists coordinate the activities at the national level, whereas the Network Coordinator coordinates the activity at the regional level. The Centers play a major role in providing technical backstopping and know-how.

- Scientists from the four countries and ICARDA/CIMMYT meet annually to review their activities and plan for the subsequent year's workplan.

- Genetic materials are shared between the countries in a regional rust nursery, and results collected by each country are sent to the Regional Coordinator who consolidates them in a regional report and presents them at the Annual Regional Coordination Meeting.

- Joint publications are produced with co-authors from the four countries and ICARDA/CIMMYT.
- At the policy-making level, the directors of national institutes, and sometimes ministers and deputy ministers, as well as donor representatives attend the meetings and participate in the Steering Committee Meeting of the Network, thereby gaining awareness of the scale of the problem at the regional level.

- The promising germplasm is planted in farmers’ fields, in cooperation with the extension services, to evaluate it and see the farmers’ reaction to its performance under field conditions. At the same time, extension agents become aware of the new developments in research which will be soon ready to be transferred to farmers.

- The scientists from the four countries and from the two Centers have a yearly travelling workshop where they travel to one of the countries, visit research stations and farmers’ fields, discuss the program, exchange experience and modify their work as needed.

Because of this mechanism of cooperation, which goes beyond regular exchange of material and information to partnership, all who are involved in the Network feel that they own the outcomes and that they share the resources on an equal footing. The Centers’ scientists are regarded by the NARSs as partners and not outsiders who just give them instructions.

This model has now been extended to other research activities within each of the national program’s research system. It is successful and sustainable.

1st. CONCLUSION

The results of leaf and stem rust spore trapping from the air revealed that the spores of both rusts are present in the region throughout the year. The major sources of these spores are mainly local, from wheat crops grown in the respective locations. Therefore, considering the region as a unit, there would be no closed season for wheat growing in the region. For example, it is possible that the crop in Ethiopia becomes the source of inoculum for crops in Sudan and Egypt and vice versa, suggesting that there is an effective transport mechanism(s) (e.g. wind) for the spores to travel from one location to another within the region with no physical barriers. Therefore, spores remain biologically viable to initiate infection.

Regional cooperation between the four countries and other neighboring countries is essential for controlling the rust diseases. Moreover, the countries should continue complementing each other and each country taking a leading role of one of the activities across the region.

This work required continuous monitoring and seeking new sources of resistance to the identified pathotypes; therefore, a national support program is required to ensure its sustainability.

It is highly recommended that the partnership developed over the years among the four national programs, ICARDA and CIMMYT continues and be strengthened further. The Centers will share germplasm, knowledge, and advanced technologies with the national programs and will strengthen inter-country collaboration.

It is important for research to link with extension in order to widely disseminate the findings of this Project. This requires an extensive demonstration and popularization program to be conducted in farmers’ fields and with farmers’ participation to show them the potential of the new rust-resistant cultivars under their own conditions.