



Strengthening capacities
and promoting collaboration
to prevent wheat rust epidemics

WHEAT RUST DISEASES Global Programme

2014–2017





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Table of content

List of tables	iv
List of figures	iv
List of highlights	iv
Abbreviations and acronyms	v
Executive summary	vi

Part I – Background 1

1.1 Introduction	1
1.2 Sectoral context	4

Part II – Rationale 11

2.1 Issues to be addressed	11
2.2 Beneficiaries	18
2.3 Stakeholders	19
2.4 Strategic approach and countries covered	20
2.5 Past and related work	22
2.6 FAO comparative advantages	24

Part III – Programme framework 29

3.1 Goal	29
3.2 Objectives	29
3.3 Outcomes	29
3.4 Outputs and activities	29
3.5 Sustainability	41

Part IV – Implementation arrangements 43

4.1 Institutional framework and coordination	43
4.2 Methodology	44
4.3 Technical support and programme staff	44
4.4 Work plan	45
4.5 Budget	47

Annexes 48

Annex 1. Implementation plan	48
Annex 2. Logical framework	52

List of tables

Table 1. Countries included in the Wheat Rust Diseases Global Programme	21
Table 2. Summary indicative budget	47

List of figures

iv

Figure 1. Countries affected or at risk of wheat rust diseases	3
Figure 2. Integrated management and prevention of wheat rust diseases	5
Figure 3. Spread of Ug99 race of stem rust and occurrence of yellow rust epidemic in 2013	6
Figure 4. Stakeholders involved in the management of wheat rust diseases	19
Figure 5. Programme hierarchy	30

List of highlights

Highlight 1. Coordinated action plans are essential for effective rust management	9
Highlight 2. Surveillance and rapid communication is the key for timely response	13
Highlight 3. Genetic resistance is the primary tool to protect wheat crops from wheat rust diseases	15
Highlight 4. Capacity building and training of farmers and technical officers are essential for integrated management	27

Abbreviations and acronyms

BGRI	Borlaug Global Rust Initiative
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
EMPRES	Emergency Prevention System, FAO
FAO	Food and Agriculture Organization of the United Nations
FCC	Food Chain Crisis Management Framework, FAO
GIS	Geographic information system
IARC	International Agricultural Research Centre
IAEA	International Atomic Energy Agency
ICARDA	International Center for Agricultural Research in the Dry Areas
Ug99	Virulent strain of wheat stem rust
Yr27	Virulent strain of yellow rust

v

EXECUTIVE SUMMARY

Wheat is a source of food and livelihoods for over 1 billion people in developing countries. A major staple food crop in many countries, it is an important source of nutrition, providing on average 40 percent of per capita calorie intake.

Drought, floods and diseases severely affect wheat production. Exacerbated by climatic stress, especially in rainfed areas, the impact of wheat diseases is expected to increase.

During the past decade a number of virulent strains of wheat rust diseases have emerged, causing global concerns to wheat production. The wheat stem rust race Ug99 is highly virulent on the majority of world wheat varieties – the risk that it could cause a global epidemic is real. Ug99 is well established in East Africa and Yemen and has spread to the Islamic Republic of Iran and South Africa. In 2010 and 2013, a new, virulent strain of yellow rust, Yr27, has caused severe outbreaks and losses in many countries in North and East Africa, the Near East and South Asia. Due to ever changing genetics of these pathogens they need to be monitored continuously.

Wheat production in Northern and Eastern Africa, the Near East and West, Central and South Asia is vulnerable to rust diseases. These regions account for around 37 percent of global wheat production. The cost of a 10 percent loss in areas at risk is estimated to exceed USD 5.8 billion. The impact on food and nutrition security is estimable. To combat wheat rust diseases continuous surveillance as well as a programmatic management approach are essential.

Considering these challenges, the Food and Agriculture Organization of the United Nations (FAO) launched the **Wheat Rust Diseases Global Programme** in 2008. The second phase of the programme (2014–2017) builds on the lessons learned and experience gained thus far. It places specific emphasis on strengthening national surveillance and disease management capacities as well as improved regional and international collaboration and information sharing.

The goal of the programme is to contribute to global food security through the prevention and management of emerging wheat rust diseases and sustainable enhancement of wheat productivity.

The two outcomes of activities undertaken will be:

- improved awareness level and surveillance, preparedness and response capacity of the countries;
- improved prevention and integrated management of wheat rust diseases at the field level.

The programme proposes six outputs relating to:

- support to national policy development and contingency planning;
- enhancement of surveillance and early warning systems;
- enhancement of national wheat variety registration processes for release and promotion of resistant varieties;
- enhancement of seed systems for quick multiplication and distribution of quality seeds of resistant varieties;
- improvement of wheat rust management at the field level through participatory farmer training to minimize risks and improve yields under local farming conditions;
- enhancement of regional and international collaborations to promote lesson learning and minimize the risk of spread of rust diseases.

The programme covers 40 countries¹ in Africa, the Near East, Eastern Europe and Asia. It involves countries already affected or those at risk of wheat rust diseases. The total budget required for the complete implementation of the four-year programme is estimated at USD 48 million.

The programme reinforces and complements the activities of the Borlaug Global Rust Initiative, FAO's Strategic Framework and national institutions. Through this four-year programme, FAO aims to further support the efforts of national governments and the international community to sustainably manage and prevent wheat rust epidemics and crises.

Programme activities are implemented in close collaboration and partnership with national governments, International Agricultural Research Centres and other international institutions, such as the International Maize and Wheat Improvement Center, the International Center for Agricultural Research in the Dry Areas, the International Fund for Agricultural Development, the International Atomic Energy Agency and the Borlaug Global Rust Initiative.

¹ Countries included in the Wheat Rust Diseases Global Programme: Afghanistan, Algeria, Armenia, Azerbaijan, Bangladesh, Bhutan, China, Egypt, Eritrea, Ethiopia, Georgia, India, Iran (Islamic Republic of), Iraq, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lebanon, Libya, Morocco, Mozambique, Nepal, Oman, Pakistan, Russian Federation, Rwanda, South Africa, Sudan, Syrian Arab Republic, Tajikistan, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Republic of Tanzania, Uzbekistan, Yemen and Zimbabwe



Yellow rust infection on flag leaf

Credit: FAO

Part I – BACKGROUND

1.1 Introduction

Wheat is a source of food and livelihoods for over 1 billion people in developing countries. Grown on more than 200 million hectares, world wheat production in 2014 is forecasted to exceed 707 million tonnes¹. North and East Africa, the Near East and Central and South Asia account for some 37 percent of global wheat production. In most countries in these regions, wheat is the staple food crop, providing on average some 40 percent of the per capita calorie supply. Wheat is especially important in the diets of the most vulnerable, and many people in these regions rely heavily on wheat production for their subsistence and livelihoods. These regions are vulnerable to epidemics of wheat rust diseases caused by stripe rust (*Puccinia graminis f.sp. striiformis*), stem rust (*Puccinia graminis f.sp. tritici*) and leaf rust (*Puccinia triticina*) also known as yellow, black and brown rust respectively.

Wheat rust diseases have long been among the major biotic threats to wheat productivity. Their frequency, extent and impact have increased significantly in the last decade. Ug99, a virulent strain of wheat stem rust, has become a major global challenge to wheat production. This race, first established in East Africa in 1999, spread rapidly in the region. By late 2007, Ug99 had reached as far as the Islamic Republic of Iran and South Africa by 2012. This race, also scientifically known as TTKSK, is highly virulent on the majority of registered wheat cultivars, posing a great risk to global wheat production. Moreover, it is capable of further changing its genetics producing new variants. Already seven derivatives have been identified during its spread to north and east. More recently in late 2013, an epidemic of stem rust affecting over 18 000 hectares of wheat crop in Ethiopia was caused by a new strain of stem rust, temporarily designated as TKTT-. This puts the widely grown variety Digelu at risk and its further spread in the region is likely. The risk of a global wheat rust epidemic is real threatening regional and global wheat production seriously.

Much has been done in this respect. Recently, international and national institutions driven by the Borlaug Global Rust Initiative (BGRI), the International Maize and Wheat Improvement Center (CIMMYT), the International Center for Agricultural Research in the Dry Areas (ICARDA) and supported by the initial phase of the Wheat Rust Diseases Global Programme of the Food and Agriculture Organization of the United Nations (FAO) and various resource partners have developed a global monitoring system and introduced cultivars resistant to Ug99 into the seed systems.

However, more needs to be done. The use of resistant cultivars needs to be expanded and further improved to address the challenges posed by new strains of these pathogens.

The challenge of wheat rust diseases is not limited to stem rust. Recently, Yr27 a new, virulent strain of yellow rust, caused epidemics in Asia, Near East and North Africa. In 2010, it caused significant losses from the Near East to Central Asia. In 2013, Yr27 affected wheat production in a number of countries, including Afghanistan,

¹FAO Crop Prospects and Food Situation. No. 3. July 2014: <http://www.fao.org/3/a-i3899e/index.html>

Azerbaijan, Ethiopia, India, Iran, Iraq, Morocco, Pakistan, Turkey and Uzbekistan, requiring fungicide applications in some cases.

These rust strains and their derivatives are already among the major constraints of wheat production in these regions. Based on weather patterns and previous experiences with similar rust strains, wheat production in countries in Northern and Eastern Africa and the Near East, as well as West, Central and South Asia is threatened by wheat rust diseases. These regions cultivate around 80 million hectares of wheat. With a realistic assumption, wheat rust diseases could easily cause an average yield loss of 10 percent. At a wheat price of USD 310 per tonne, economic losses in these countries could exceed USD 5.8 billion. This would seriously affect the livelihoods of the poorest smallholders.

2

Though some climate-related agricultural disasters may be difficult to predict and prevent, those resulting from pests and diseases are often the result of inadequate agriculture-related policies, mismanagement of resources, and insufficient national and regional planning and preparedness for prevention and early response. These areas require attention at all levels and with all stakeholders, including farmer communities, governments and the international community. For many years, governments have reduced their investments in agriculture, especially with respect to farmer education and extension, agricultural research, rural development and market access.

Through its **Wheat Rust Diseases Global Programme (2014–2017)**, FAO aims to provide policy and technical assistance to vulnerable countries to fight against the threats of wheat rust diseases, such as Ug99 and Yr27 strains, to minimize the risks of sudden epidemics and wheat production crises.

As a BGRI member, FAO works in close collaboration with national governments, key national institutions and International Agricultural Research Centres (IARCs), such as CIMMYT and ICARDA and other international institutions. FAO has strong comparative advantages to contribute to such international efforts because of:

- (i) its experience with the international dimensions of other transboundary pests, such as locusts;
- (ii) FAO is a neutral international forum for information sharing; and
- (iii) its linkages with grassroots rural communities, national governments, regional bodies, international agriculture research and development institutions, the private sector and the donor community.

Moreover, the strong breeding capacity of the FAO/International Atomic Energy Agency (IAEA) Joint Division of Nuclear Techniques in Food and Agriculture and its international network adds further value.

FAO's Strategic Framework aims to promote sustainable production practices and address the challenges of transboundary threats and emergencies. In this respect, FAO is in a key position to complement international efforts to promote sustainable crop management practices as well as better preparedness and prevention approaches to minimize and manage risks of wheat rust epidemics.

Figure 1. Countries affected or at risk of wheat rust diseases
Grouping is based on the risks posed by Ug99 race of stem rust. Yellow rust is a risk for all the countries.

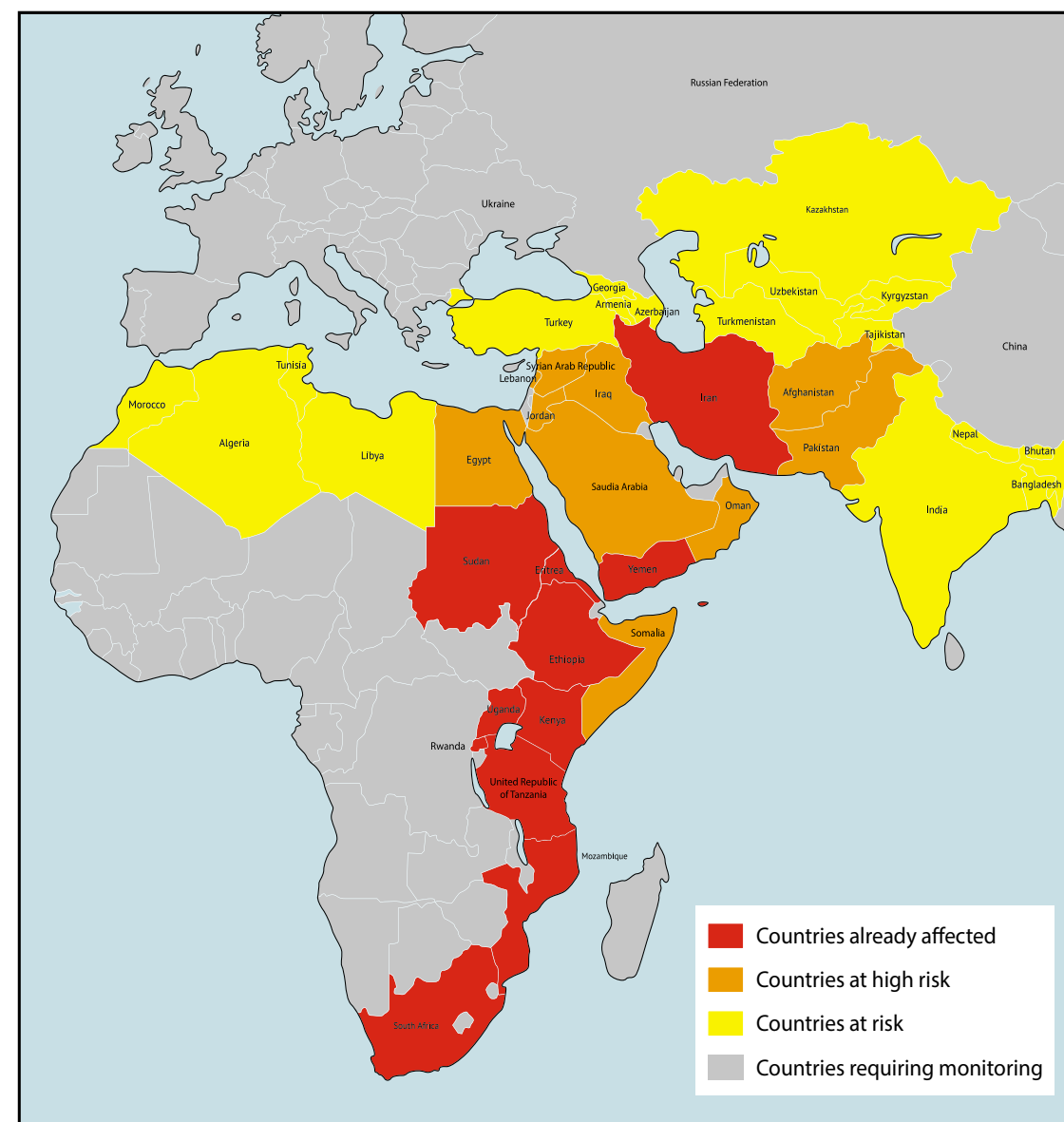
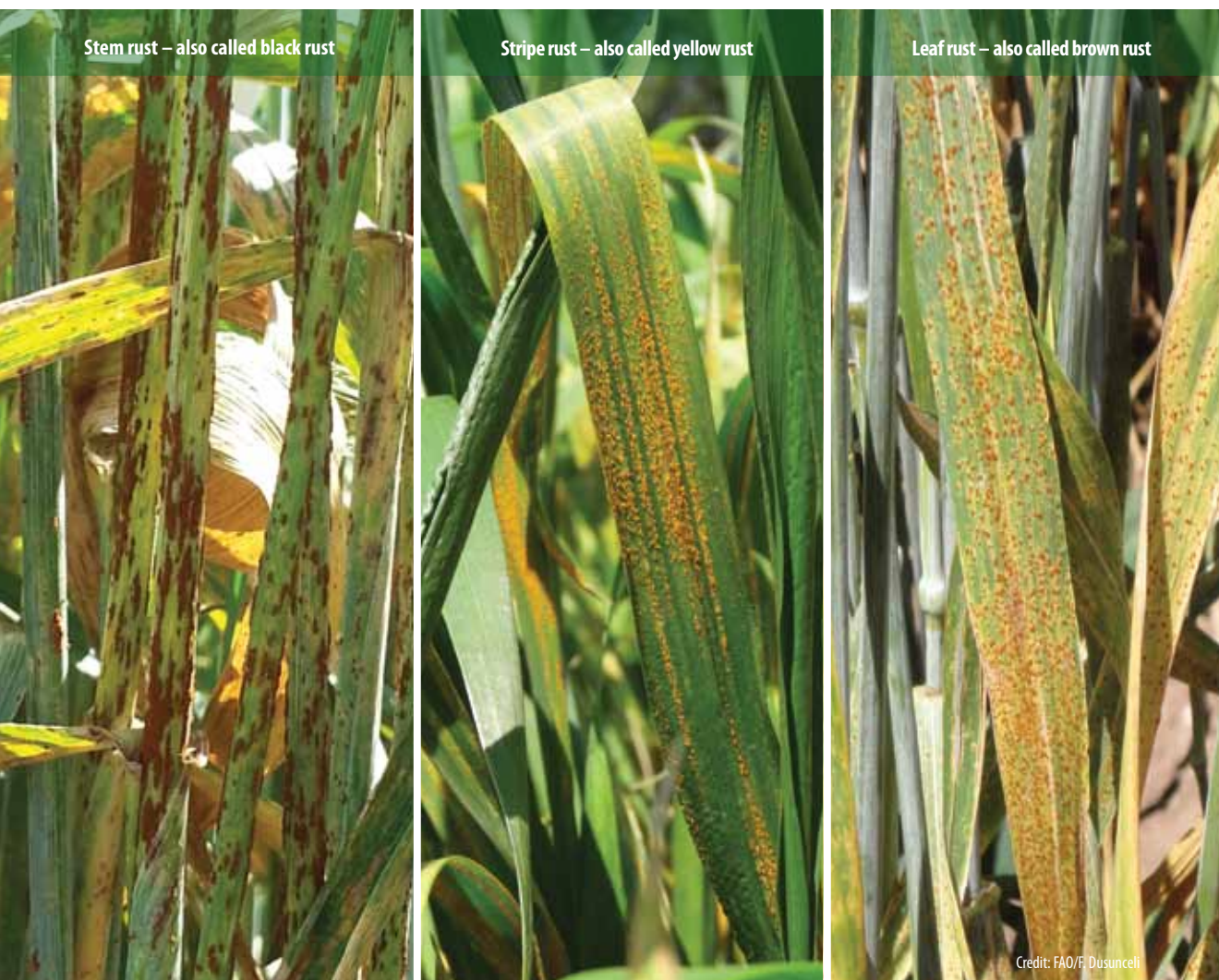


Figure 1 illustrates the wheat producing countries affected by or at risk of wheat stem rust epidemics resulting from Ug99. All countries illustrated are at risk of yellow rust epidemics.

1.2 Sectoral context

Wheat yields are affected by various abiotic and biotic stresses. Drought has been very important in causing yield losses, especially in recent years, because most of the wheat grown in the developing world is rainfed. Of the biotic stresses, wheat rusts are definitely the most important diseases that reduce wheat yields at the global level. The most important wheat rusts, a group of diseases caused by fungal pathogens (*Puccinia spp.*), are stem rust (also called black rust), stripe rust (also called yellow rust) and leaf rust (also called brown rust). Although all three could be present wherever wheat is grown, weather and other conditions cause some rust types to be more prevalent and severe in some regions, while others are more destructive elsewhere.

4



Rust fungi have been known to attack wheat since the earliest records of its cultivation – in classical times, the Romans made sacrifices to Robigus, the Rust God, to protect their wheat from epidemics. Rust fungi produce a large number of spores (i.e. inoculum) that are carried by wind. When environmental conditions are favourable and wheat varieties susceptible, they may cause severe epidemics resulting in yield losses of up to 80 percent, and in some cases causing total crop failure.

There are numerous tools that can be considered for management of wheat rust diseases. The most effective strategy for long-term management would be to consider all possible options in an integrated manner (Figure 2).

Figure 2. Integrated management and prevention of wheat rust diseases

5

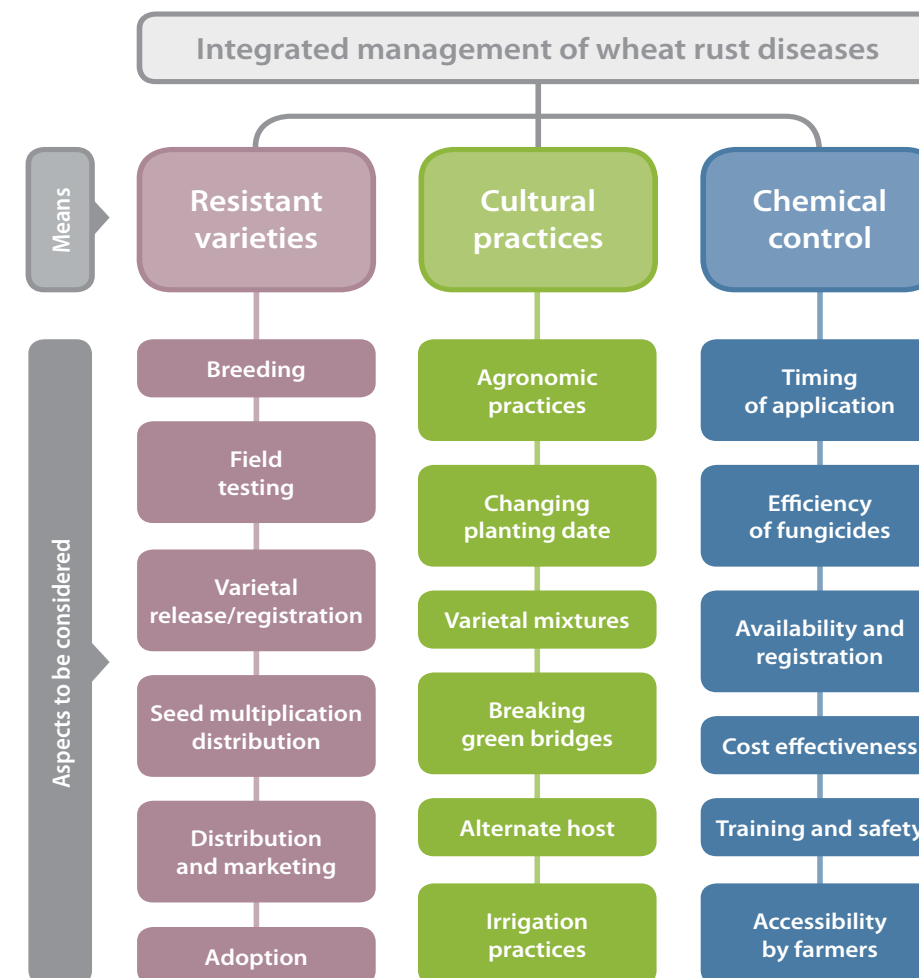
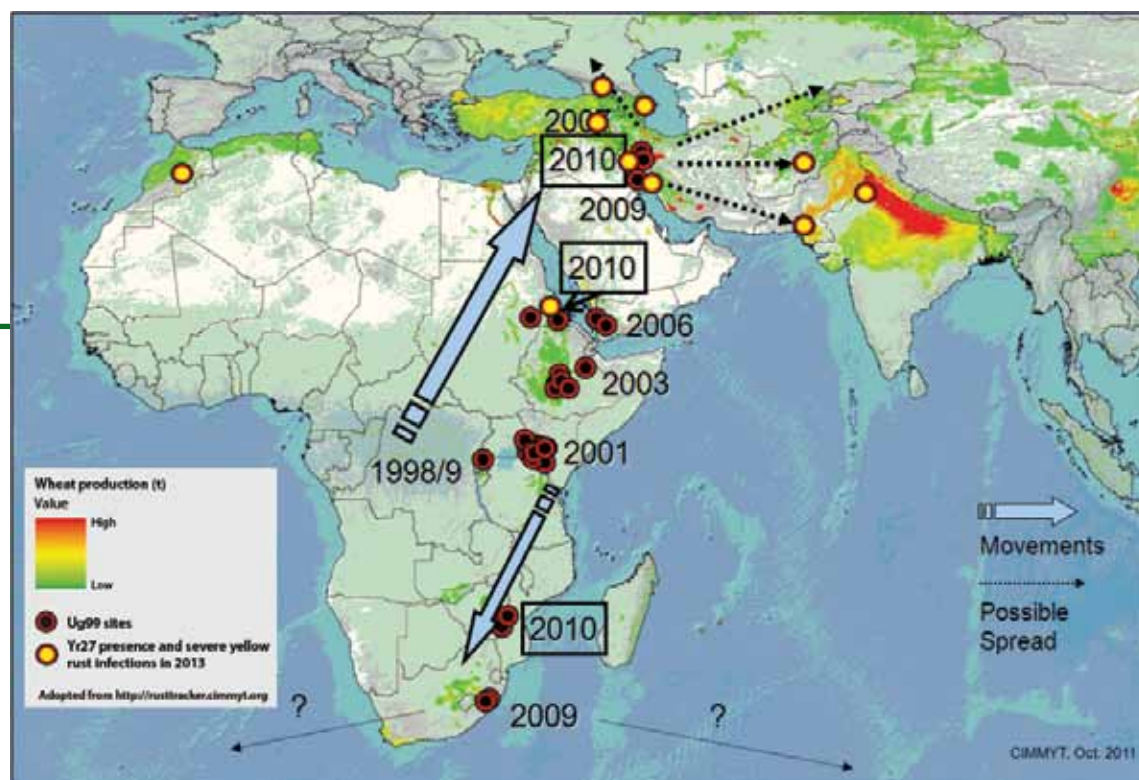


Figure 3. Spread of Ug99 race of stem rust and occurrence of yellow rust epidemic in 2013²



Planting resistant varieties of wheat is the most effective means of preventing wheat rust diseases. Fungicides may be biologically effective, but for wheat rusts they are not economically and practically feasible, especially for smallholder producers in low-yielding environments. Fungicides are recommended in the absence of resistant cultivars as an emergency control measure in case of sudden epidemics until resistant wheat varieties are again available. There is also a high risk that pathogens may develop resistance to fungicides, rendering them ineffective. Cultural practices, such as changing planting dates, destroying volunteer and alternate host plants, employing early maturing varieties and using multilines or varietal mixtures, are also recommended because they are effective in reducing the levels of inoculum and hence the disease pressure.

² Adapted from a map produced by CIMMYT in 2011

However, rust control using resistant varieties has faced the limited durability of resistance in some cases. For decades, wheat rust resistance breeding followed by national wheat breeding programmes and the international research centres has been based on the deployment of a few genes that are sufficiently potent to preclude rust spore production even if the plant possesses only a single gene. Indeed, many cultivars carrying one or few resistant genes provided successful resistance to wheat rusts for certain periods of time. However, these race-specific genes function only if the infecting rust population is of a pathotype that lacks virulence with regards to those specific genes. Against the rapid rate of change in the genetic make-up of rust populations, induced by mutation and selection pressure from current resistance breeding strategies, the increasingly narrow deployment of resistance in the field is easily overcome by the pathogen. As a result, such wheat varieties currently grown in many regions are vulnerable to new virulent wheat rust strains. The spread of Ug99 dramatically revealed this genetic vulnerability. Similarly the recent stripe rust strain, defeating the Yr27 gene spreading around East Africa, Near East and Central and West Asia, has put currently more than 20 million hectares of wheat sown to susceptible varieties directly at risk.

During the 1980s and 1990s, the world experienced a series of major epidemics of wheat stripe (yellow) rust due to a breakdown of the yellow rust resistance gene Yr9, present in several cultivars that were grown in West, Central and South Asia. The virulent strain of this rust moved from East Africa, where it was first detected, through Yemen to the Near East and into Central Asia, Pakistan and India (Figure 3). This caused crop losses amounting to several hundred million dollars and affected the livelihoods of millions of poor farmers.

The emergence of Ug99, the virulent strain of the wheat stem rust fungus, quickly became a potential threat to wheat production. Studies have shown that Ug99 defeats virtually every race-specific resistance gene present in almost 90 percent of commercial varieties grown throughout the world. International breeding programmes and some national programmes have recently developed a number of cultivars resistant to Ug99 and put them in use, mostly thanks to the Durable Rust Resistance in Wheat project. However, there is no room for complacency as new strains continue to evolve adding new challenges. Continuous monitoring, planning and strategic adjustment at the country level, as well as effective international collaboration and technical assistance are essential.

Since the Ug99 strain was first identified in Eastern Africa in 1999, it has spread to other countries in Southern Africa and the Near East, including Eritrea, Ethiopia, Iran (Islamic Republic of), Mozambique, Rwanda, South Africa, Sudan, United Republic of Tanzania, Yemen and Zimbabwe. The arrival of Ug99 in the Near East posed a new and heightened risk to wheat production in Asia.

Typical weather patterns and experience with prevailing winds³ suggest that countries to the east (i.e. Afghanistan, India and Pakistan) are most at risk, followed

³ Based on desert locust forecasting studies

by the countries of the Caucasus and Central Asia (i.e. Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan). Furthermore, rust fungus is easily transported short distances by wind gusts, which puts most countries of the Near East (i.e. Egypt, Iraq, Jordan, Lebanon, Syrian Arab Republic and Turkey) at similar risk. Ug99 is expected to affect North African countries subsequently. Eventually there is also the risk of its further spread to China, Russian Federation and Ukraine which are among the key wheat producers.

In response to Ug99, the Global Rust Initiative was established in 2005 and then later expanded to what is now known as the Borlaug Global Rust Initiative (BGRI)⁴. Its permanent members include ICARDA, CIMMYT, Cornell University and FAO. Both CIMMYT and ICARDA are IARCs of the Consultative Group on International Agricultural Research (CGIAR) and share the mandate for wheat improvement in Central and West Asia and North Africa region. The overall objective of BGRI is to systematically reduce the world's vulnerability to stem, yellow and leaf rusts of wheat by advocating and facilitating the evolution of a sustainable international system to contain the threat of wheat rusts and consolidating the enhancements in productivity required to withstand future global threats⁵.

To date, the activities of BGRI have concentrated on three main pillars:

- analysis of pathogen isolates to support and improve surveillance and monitoring;
- capacity building through human resource development and infrastructural scientific enhancement; and
- accelerated breeding, multiplication and distribution of resistant replacement wheat varieties.

⁴ Named after its chair, U.S. agronomist Dr Norman Borlaug, Nobel Peace Prize winner in 1970 and widely acclaimed as the “father of the Green Revolution”

⁵ An expert panel report, “Sounding the Alarm on Global Stem Rust,” issued 29 May 2005 (see www.globalrust.org)

Coordinated action plans are essential for effective rust management

Wheat rust diseases can develop and turn into epidemics quickly. For their effective control, relevant institutions have to work together through well-defined coordination arrangements. For effective prevention and rapid response short- and medium-term actions have to be planned ahead of epidemics.

In many countries connection is not strong among the institutions involved in management of wheat rusts and there is a lack of coordinated action plans. A major effort has been made to promote a collective and participatory approach for development of national contingency plans for prevention of rust epidemics.

The national contingency plan developed for Morocco can serve as a good model for adaptation in other countries.



Morocco was the first country to develop a comprehensive contingency plan with support from the FAO-Italy Cooperative Programme

Credit: FAO



Heavy yellow rust infection – yellow rust reduces photosynthesis area

Credit: FAO

PART II – RATIONALE

2.1 Issues to be addressed

Wheat rust diseases are recurrent potential global threats. Coordinated actions that reduce the risk of spread and strengthen quick response capacities for management of wheat rust diseases have to be undertaken at the national, regional and global levels.

The specific elements needed to address wheat rust diseases are detailed in this section.

2.1.1 Advocacy and policy support in contingency planning

11

Any national action to prevent or manage the threat of wheat rust diseases requires the consensus and support of national authorities. Governments need support in devising contingency plans to be able to deal with potential wheat rust epidemics. Contingency plans should include specific strategies and scenarios as well as the corresponding actions needed to deal with the risk that virulent wheat rust strains, such as Ug99 and Yr27, pose and the possible widespread disease outbreaks and yield losses. Contingency plans should help governments respond to potential emergencies with minimum time, cost and loss. Governments should be supported in identifying their critical resources and the functions needed for the implementation of the contingency plans and in their documentation, testing and regular update.

The three main principles of contingency plans for wheat rust diseases include:

1. **Multidisciplinary / multi-institutional teams that represent all concerned national stakeholders and sectors are involved in the development of the contingency plans**
 - Planning involves units of the national plant protection, agricultural research, breeder and seed sectors (i.e. public, private and informal systems), extension services, wheat producer organizations and other actors which may be relevant.
2. **A monitoring process to detect the key events and factors that trigger the initiation of planned actions within the contingency plans**
 - Surveillance and monitoring of the occurrence of rusts in the field and monitoring the shifts in virulence of wheat rusts through trap nurseries and pathotyping of field samples as well as early warning systems where possible.
3. **Immediate actions and long-term measures to respond to emergencies and their future mitigation**
 - Actions to reduce the build-up of pathogen populations include:
 - changing planting dates and using early maturing or shorter duration varieties to reduce the number of generations/cycles of pathogen in a given season;

12

- measures to avoid and eliminate “green bridges”, such as regional crop production planning to avoid continuous wheat growing and to promote tillage or herbicide application on “green bridges”⁶. This could include elimination of volunteer susceptible wheat and wild grasses growing out of season or in abandoned fields to prevent carryover of rust populations during a period normally not cultivated;
- strip planting and creation of patchwork field layouts of different varieties with different resistance profiles; and
- planting variety mixtures or multilines, when available, within the same field.
- Actions to improve systems for quick variety registration and release (refer to section 2.1.3).
- Actions to improve national seed systems should allow resistant varieties to move quickly through the national regulatory systems, be quickly multiplied and effectively distributed to the most vulnerable farmers who are at highest risk (refer to section 2.1.4).
- Support to education of farmers in field management practices for disease risk reduction and improved implementation of contingency plans (refer to section 2.1.5).
- Socio-economic impact assessments related to wheat production and losses from rust diseases need to allow for a better rationalization of national contingency plans.

2.1.2 Surveillance, monitoring and early warning

Rust surveillance and the monitoring of spread and change in the virulence pattern of wheat rusts is the basis for early response. Key to the process of surveillance is regularity as well as coordinated information sharing for timely decision-making and response.

Disease surveillance includes the assessment of disease incidence and severity in wheat-growing areas. It also includes pathotyping of the wheat rusts causing disease on previously resistant varieties, and tracking the virulence changes in the rust populations using field trap nurseries. Variants of the Ug99 that differs from the type identified in Kenya and Uganda have already been detected in East Africa and Yemen. These are able to overcome even more of the wheat resistant genes in the cultivated varieties.

Pathotyping for wheat rusts require special greenhouse and laboratory facilities and technical skills. Most of the countries affected do not possess such facilities or skills. Currently, rust samples are either studied by international research centres or sent to

⁶ In certain parts of Africa, continuous wheat production is possible, meaning that wheat rust diseases can affect crop at different stages. Spores move from mature infected plants to seedlings increasing the risk of rust diseases. Also volunteer plants can serve as a bridge for the transmission of spores from one generation of crop to another

Canada, Denmark or the United States of America for pathotyping. The effectiveness of this approach is limited due to logistical procedures that delay the results. Therefore, availability of the necessary greenhouse and laboratory facilities as well as trained personnel to facilitate virulence analysis at the regional or preferably the national level is important for pathogen monitoring. A number of national laboratories, including those based in Njoro (Kenya), Shimla (India) and Izmir (Turkey) will be considered for this purpose, which will also facilitate regional training activities.

The availability of reliable, harmonized and regular disease survey data and speedy exchange of information from the field to the plant protection office and research institutions are the basis for the development of an early warning system. On this account, FAO will develop national web and mobile rust surveillance systems to serve as rapid survey and early warning tools in the countries in support of the global rust monitoring system, which has been developed in the context of the initial phase of this programme and currently based in CIMMYT, Ethiopia. The commitment of national counterparts to utilize and support such systems and the provision of training will be critical.

13

Surveillance and rapid communication is the key for timely response

Monitoring of wheat rusts is critical for early detection of wheat rust epidemics to facilitate timely responses. An effective network is needed among the institutions and sharing of information has to be rapid.

In this respect, a surveillance system has been developed based on mobile tools as a pilot activity in Turkey. The system connects the extension units in districts with the coordination centre and the research institutions. This enables real-time exchange of information on disease occurrence facilitating timely mobilization of efforts for any likely emergency response that may be needed. This tool shows great prospect for utilization in other vulnerable countries also supporting the global rust monitoring system.



A mobile surveillance system – as piloted in Turkey – facilitates real time exchange of information on wheat rust disease occurrence and connects extension and research institutions through mobile tools (with support from IFAD)

Credit: FAO/F. Dusunceli

2.1.3 Improved breeding strategies and development of varieties with durable rust-resistance

Breeding strategies can be built on stacking or pyramiding pathotype-specific genes and the utilization of minor genes from tested genetic resources. While for immediate use stacking of major genes could be considered, for longer-term breeding solutions, durable host plant resistance should be encouraged and advocated strongly. Global efforts to improve wheat breeding strategies for durable resistance are already under way. Search for sources of resistance in existing wheat varieties and wild wheat relatives are being carried out through conventional and modern breeding technologies. The international research centres and various advanced research and academic institutions worldwide are focusing on durable resistance (i.e. Cornell University is implementing a large-scale wheat programme). This international network also includes the FAO/IAEA Joint Division of Nuclear Techniques in Food and Agriculture, which runs a breeding programme to develop rust-resistant cultivars through the use of nuclear techniques.

Contribution of the programme to these areas will be on capacity building and training as well as exposure of farmers to such technologies and improved varieties through participatory selection processes, in collaboration with research and extension institutions.

In order to quickly replace susceptible wheat varieties with new resistant ones, countries will need support to enhance the effectiveness of their national systems for variety registration and release, through which all potentially resistant varieties must pass before they can be multiplied for distribution. For this, in most cases multilocation adaptation trials, pest and disease resistance trials and quality testing are required. In addition, all old and new varieties must be tested for their susceptibility to prevailing strains and their variants. For this purpose, capacities have been established in a number of locations to facilitate testing of international wheat germplasms. These include stem rust testing in Njoro, Kenya (for bread wheat) and in Debra Zeit, Ethiopia (for durum wheat) and yellow rust testing in Ankara and Izmir in Turkey.

Currently, there are a number of cultivars that are resistant to Ug99 strain of stem rust and Yr27 strain of yellow rust in various countries, originating from national breeding programmes or from international programmes of CIMMYT, ICARDA, Durable Rust Resistance in Wheat project and FAO/IAEA Joint Division on Nuclear Techniques. Deployment of such varieties has been more successful in some countries than others. For example, in Ethiopia the share of rust-resistant cultivars among the cultivated registered varieties has reached almost 50 percent, which is an exemplary success. This was possible through joint efforts of CIMMYT, ICARDA, the Durable Rust Resistance in Wheat project as well as the seed multiplication efforts of FAO during the initial phase of this programme. Registration of two Ug99 resistant wheat varieties in Kenya resulting from the Joint FAO/IAEA Joint Division on Nuclear Techniques has been added to these achievements in 2013. Such successes need to be shared and expanded in other countries as well.

Genetic resistance is the primary tool to protect wheat crops from wheat rust diseases

The most practical and environmentally friendly means of protecting wheat crops from the rust diseases is use of resistant cultivars. Strong national programmes are needed for breeding improved resistant cultivars and international collaboration is essential in this regard. Recently numerous resistant varieties have been developed by national research systems supported by international research centres, such as CIMMYT and ICARDA as well as BGRI and other advanced institutions.

Critical steps in deploying such resistant varieties in farmer fields at large include rapid multiplication and distribution of seeds and farmers' access to them. The links with research, seed sector, extension and farmers are critical in transferring these technologies into practice effectively. FAO has been supporting the efforts of vulnerable countries in strengthening such linkages through policy support, seed system enhancement and capacity development and field demonstrations, in collaboration with national and international partners.



Genetic resistance provides protection to yellow rust (middle) as compared to the susceptible varieties (left and right)

Credit: FAO

2.1.4 Enhanced seed systems for multiplication and distribution of resistant varieties

Before rust-resistant wheat varieties are nationally registered and ready for release, a national strategy should already be in place for the multiplication and distribution of quality seed of rust-resistant varieties to replace rust susceptible varieties. Although some countries threatened by Ug99 already have a system for seed multiplication, modifications may be needed to cope with the urgency of large-scale rapid multiplication and distribution of resistant varieties, especially to serve the most vulnerable small farmers. Production urgency should not compromise the quality of certified seeds. Many of the countries will therefore require training and some basic equipment to maximize the yield obtained from early generation seed multiplication. Support will be required for the nation-wide establishment of demonstration plots to popularize among farmers the varieties that will be released.

Wheat rust diseases affect crop production and quality of seeds



Healthy wheat seed (left); wheat seed affected by wheat rust (right)

Credit: Central Research Institute for Field Crops, Turkey

2.1.5 Wheat rust disease management at the field level

Extension services and farmer education are given little attention in most of the countries threatened by new rust races. Participatory farmer education methods, such as farmer field schools, have proven to be extremely effective, empowering farmers with strong observation and decision-making abilities. Properly trained farmers will be a major support to the implementation of national contingency plans. They could play a role in early recognition and reporting of changes in disease severity and virulence in their fields. Thus, they need to be trained to understand the risks associated with virulent strains and the importance of the various field management practices (planting dates, planting periods, choice of varieties, responsible fungicide use, etc.) for disease control and yield improvement.

2.1.6 Regional and interregional coordination and planning

Wheat rust diseases are exemplary transboundary threats to wheat production. Wheat rust disease development in one region or country is a great concern for neighbouring countries and regions due to its airborne and transboundary nature. Therefore, coordinated efforts are essential to facilitate interactions and collaborations among the countries and regions. Regular workshops and consultations within and among the regions would facilitate exchange of experiences, developments, disease occurrence, knowledge and materials and technology transfer in general. These actions would need to be organized with an inclusive approach, ensuring engagement of all related sectors, institutions and organizations in the process.

In this context regional and interregional consultations are foreseen as follows:

- East and South Africa
- Near East and North Africa
- Central and West Asia
- South and East Asia

As for the national contingency planning, interaction and collaboration among the institutions from various disciplines are critical at the regional and international levels. Thus, through regional consultations all related institutions from various fields, such as research, crop protection, seeds and extension, will be brought together to ensure dialogue and exchange of experiences at the regional level with a view to promote successful approaches. Experiences gained through the activities carried out during the initial phase of the programme in Morocco, Nepal and Turkey will be utilized for this purpose.



South Asia Regional Workshop on Contingency Planning for Management of Wheat Rust Diseases (December 2012)

Credit: FAO Nepal

2.2 Beneficiaries

The beneficiaries of this programme are the most vulnerable wheat growers and consumers in East and North Africa, Near East and West, Central and South Asia. Governments and policy-makers in these countries will directly benefit. The programme aims to enhance their abilities to develop and implement effective integrated wheat rust diseases management procedures and contingency plans, allowing for quick responses and early rehabilitation that may be needed.

With many countries in Africa, the Near East and Asia already affected by Yr27 and with the potential of Ug99 to spread globally, wheat producers worldwide, whether in developing or developed countries, will benefit from the programme. This will be achieved through:

- a reduction in the build-up of inoculums of the pathogens;
- improved surveillance and monitoring;
- improved national capacities for disease management; and
- increased international cooperation in information sharing for breeding and management practices.

Wheat is not only the staple food crop in many parts of the world; it is also a major commodity for the international market. Diseases, such as rusts, can cause severe reductions in yields. This would surely threaten the food and nutrition security as well as the livelihoods of millions of vulnerable people who depend on wheat as their main source of income and staple food.

Beneficiaries of this programme will also include national government institutions working in various areas related to the management of wheat rust diseases. These include institutions in the sectors of research, extension, plant protection, cultivar registration, seed certification and production.

International institutions whether within the IARCs or advanced research institutes and universities will also be indirect beneficiaries as partners.

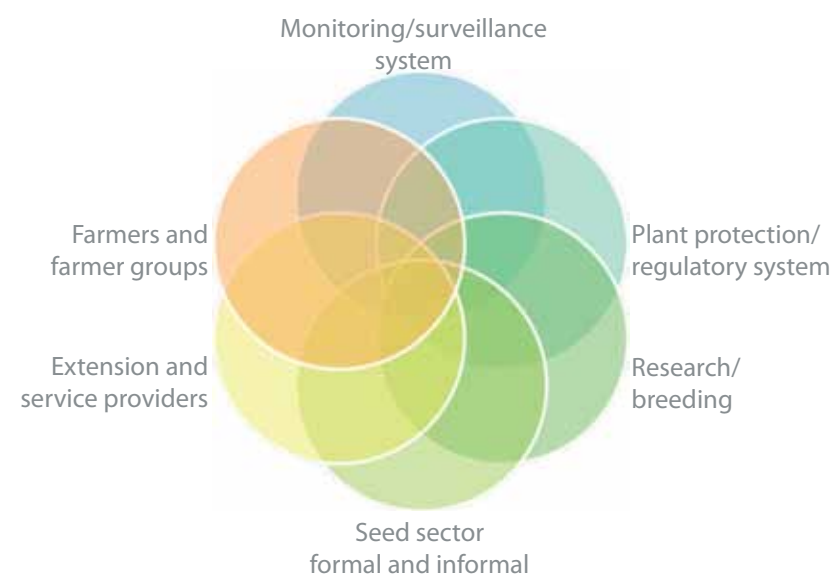
2.3 Stakeholders

Management of wheat rust diseases is a complex process requiring long-term policy development and planning. To achieve this goal effectively, such policies and plans must be prepared and implemented through collective processes with contributions from all the relevant stakeholders that are related to management of wheat rust diseases and wheat improvement chain.

There are many national institutions and actors relevant to management of wheat rusts. Institutional settings and coordination mechanisms vary from country to country, but in general such institutions include those from the sectors of plant protection, surveillance and planning, the research system, seed sector, extension network and farmers themselves (Figure 4). The effectiveness of the national strategy for wheat rust management depends on the efficiency of collaboration and coordination among these institutions. In many cases, such coordination mechanisms are either not present or ineffective. With little investments, these could be strengthened significantly to improve effectiveness of rust management efforts.

The programme aims to assist countries in their efforts to address the challenges faced by the stakeholders involved in this process. For all the activities planned, the links and interactions among the relevant institutions will be an important point of consideration. A major effort will be made to strengthen the collaboration and coordination among these institutions through promoting a participatory systems approach for management of wheat rust diseases.

Figure 4. Stakeholders involved in management of wheat rust diseases



2.4 Strategic approach and countries covered

The **FAO Wheat Rust Diseases Global Programme** is aligned with the current Strategic Framework of the Organization. Its outcomes and outputs fall under the relevant parts of FAO's Strategic Framework. It is implemented within the FAO Food Chain Crisis Management Framework (FCC), which includes the Emergency Prevention System (EMPRES). Specifically, EMPRES Plant Protection focuses on emergency prevention and early warning for transboundary plant pests and diseases. The prevention of wheat rust epidemics requires immediate actions in countries at risk. The programme is also linked strongly with sustainable crop production intensification.

Preventive measures can only be effective through strong regional and international collaborative actions and differentiated national approaches. While some countries will require support in capacity building, equipment and infrastructure, all will need policy and technical support for contingency planning, monitoring and knowledge sharing. Better exchange of information on surveillance, pathogen virulence shifts, breeding results and scientific achievements is critical for decision-makers to set national priorities and contingency planning in both developing and developed countries. As a neutral platform, FAO and its IARC partners can play a leading role in facilitating the exchange of knowledge and experiences.

The programme will work closely and primarily with national governments. Consultations, meetings and workshops will be the basis for awareness raising, needs assessments and consensus on the most adapted and effective national options and planning actions to take. Governmental concurrence will be required for sharing national information at the global level and for assigning focal points responsible for sharing that information.

Through national and regional workshops and meetings, the programme will:

- prioritize activities;
- decide modes of implementation;
- establish methods for updating contingency plans; and
- facilitate regional and interregional collaboration and lessons sharing.

The programme is designed to cover 40 countries (Table 1). It includes most wheat-producing countries either already affected or at direct risk of stem rust and yellow rust epidemics, particularly Ug99 and Yr27.

The programme foresees a differentiated approach based on national needs. The scope of activities at the national level will vary depending on:

- local needs;
- importance of wheat production to food security;
- risk of epidemics; and
- nature of funding.

The programme foresees the possibility of contingency planning or other activities in other wheat-producing countries should a need occur, a request be made or problems arise related to Ug99, Yr27 or other wheat rust strains.

Table 1. Countries included in the Wheat Rust Diseases Global Programme.
Grouping is based on the risks posed by Ug99 race of stem rust. Yellow rust is a risk for all the countries.

Countries already affected (by Ug99)	
Eritrea	South Africa
Ethiopia	Sudan
Iran (Islamic Republic of)	Uganda
Kenya	United Republic of Tanzania
Mozambique	Yemen
Rwanda	Zimbabwe
Countries at high risk (of Ug99)	
Afghanistan	Lebanon
Egypt	Oman
Iraq	Pakistan
Jordan	Syrian Arab Republic
Countries at risk (of Ug99)	
Algeria	Libya
Armenia	Morocco
Azerbaijan	Nepal
Bangladesh	Tajikistan
Bhutan	Tunisia
Georgia	Turkey
India	Turkmenistan
Kazakhstan	Uzbekistan
Kyrgyzstan	
Others	
China	Ukraine
Russian Federation	

2.5 Past and related work

FAO has been involved in activities related to the management of Ug99 since September 2005 when Dr Norman Borlaug⁷ sounded the alarm during the Rust Summit in Nairobi, Kenya. FAO participated in the Nairobi Rust Summit during which the Global Rust Initiative (later renamed BGRI) was officially launched and endorsed by all countries and institutions attending the Summit.

Since then, and in cooperation with its BGRI partners, FAO has facilitated, promoted and supported international knowledge sharing on the status of the disease and risk of its spread, virulence changes, breeding developments and strategies, and options for field disease management and international cooperation through several international meetings and workshops.

BGRI partners have been active in developing projects both jointly and independently to obtain funds in support of assisting countries to manage wheat rust epidemics. Since its establishment, BGRI has obtained funds from a number of resources for a number of international projects, the most pronounced one being the Durable Rust Resistance in Wheat project.

⁷ 1970 Nobel Peace Prize winner



Participants to the Nairobi Summit visiting the Ug99 disease international nursery in Njoro, Kenya (2005)

Credit: FAO/W. Khoury

The **FAO Wheat Rust Diseases Global Programme** was first established in 2008, through which a number of complementary projects funded by various resource partners have been implemented. Resource partners included the Italian and Spanish Trust Funds, the United States Department of Agriculture, United Nations Office for the Coordination of Humanitarian Affairs and the International Fund for Agricultural Development. The programme also received substantial support from the project “Durable Rust Resistance in Wheat” coordinated by the Cornell University and funded by Bill and Melinda Gates Foundation.

The programme activities have successfully supported field activities, capacity development efforts, international cooperation and the development of a surveillance and early warning system. The initial four-year programme focused on needs assessments, capacity building in pathotyping and field surveillance, seed system development, training, coordination meetings and awareness raising as well as promotion and preparation of contingency plans in a number of countries, including Morocco, Nepal and the Syrian Arab Republic. A vast amount of knowledge and experience has been gathered. Some of the key achievements include 60 farmer field schools, expansion of resistant cultivars, model contingency plans, a global monitoring system and a pilot SMS system for rapid surveillance.

The current phase of the programme (2014–2017) is built on the experiences and achievements of these projects. The programme targets stem and yellow rusts and will consider leaf rust where necessary.

The programme focuses on strengthening national capacities in the areas of:

- policy support, awareness raising and contingency planning;
- surveillance and monitoring;
- promotion of use of resistant cultivars;
- seed production system development;
- integrated management through training at the field level; and
- regional and international collaboration.

2.6 FAO comparative advantages

FAO supports global efforts, international collaboration and national capacities to prevent wheat rust epidemics and potential wheat production crises. FAO is well placed to facilitate such international efforts through its status as a neutral international forum and through its linkages with rural communities, national governments, regional bodies and international agriculture research and development institutions.

The main FAO comparative advantage is that the Organization acts as a facilitator to promote dialogue and collaboration among all partners and stakeholders at the national, regional and international levels to develop and implement joint strategies to address wheat rusts diseases. FAO contributes to strengthening the roles of partners and institutions from various sectors through inclusive, harmonized and technically sound approaches.

The specific FAO comparative advantages include:

2.6.1 Policy support to national authorities in emergency prevention, contingency planning, coordination and information sharing

FAO works closely and directly with governments and is therefore best situated to provide policy advice and advocacy in the areas of prevention, contingency planning and rehabilitation through the development of scenarios and action plans. These include disease surveillance and monitoring, national and international information sharing and enhancement of national varietal registration and seed systems for the quick availability of resistant replacement varieties to the most vulnerable farmers.

2.6.2 Surveillance and monitoring of disease occurrence and severity in the field coupled with analysis of changing pathogen virulence

Through EMPRES, FAO has substantial experience in building and training surveillance teams in the field, and in establishing monitoring and early warning systems. FAO is well positioned to enhance national coordination between the National Agriculture Research System and the plant protection units of ministries to combine field disease survey data with scientific virulence tracking data.

In addition, various mobile technologies developed and experimented have proven to be adequate rapid surveillance tools. The pilot SMS system developed for surveillance of wheat rusts during the initial phase of the programme will be further scaled up in other countries. The SMS surveillance system provides real-time information exchange among institutions for effective early warning, and promotes stronger linkages among the relevant institutions.

2.6.3 Networking, international cooperation and knowledge sharing, including awareness raising, advocacy and early warning

FAO links the field to national, regional and global initiatives in a mutually reinforcing cycle. The Organization is best placed to raise awareness on and advocate with policy- and decision-makers the importance of information sharing at the national, regional and international levels.

Strengthened national capacities for surveillance of wheat rusts through this programme will be a valuable contribution to the global rust monitoring system facilitating also functioning of an international early warning system for occurrence of rust diseases.

2.6.4 National multiplication and distribution of seeds of resistant adapted replacement varieties to the most vulnerable farmers

FAO has vast experience with national seed systems through policy support for national regulatory frameworks and regional harmonization, and capacity building activities in the formal and informal seed systems for multiplication and distribution of quality seeds as well as in emergency and rehabilitation activities with national authorities and farmers.



A farmer speaking with FAO project officers about crop results using quality wheat seeds

2.6.5 Capacity building of small farmers for disease management in the field

Through farmer field schools, FAO has a large network of trained farmers and facilitators in many of the countries affected by or at risk of Ug99 and can therefore take a lead in supporting farmers to better manage wheat rust diseases at the field level (i.e. trained and empowered farmers provide the necessary support to governments in the implementation of contingency plans in the field).

2.6.6 Accelerated variety registration and release procedures and regulations for quick replacement of susceptible wheat varieties

Breeding activities and identification and development of resistant varieties is beyond the scope of FAO's activities and falls within the mandate of its research partners within the BGRI. However, through its work with national governments, FAO has a critical role to play in providing policy and technical support to enhance the process of national varietal registration and release procedures (e.g. through support to multilocation adaptation, pest and disease resistance trials and quality testing). The FAO Global Plant Breeding initiative can also facilitate the breeding capacity building activities to be provided to national counterparts through BGRI partners.

2.6.7 Socio-economic and livelihood surveys and impact assessment of wheat producers

Through its specialized social, economic and livelihoods units, its emergency activities and its various comprehensive databases as well as through its close cooperation with the World Food Programme, FAO is well suited for assessment of socio-economic risks and impacts of wheat rust diseases on the livelihoods of rural communities. This will be carried out in close cooperation with partner IARCs and national counterparts, and it is particularly important in view of food security and international wheat trade and prices.

2.6.8 FAO and emergency response

FAO has decades-long experience in emergency response, recovery and rehabilitation in many countries that have been facing crises. In this context, support has been provided to countries either affected by or at risk of Ug99. This is particularly important for countries in East Africa as well as Afghanistan and Pakistan, where FAO Emergency and Rehabilitation Coordination Units have contributed over the past decade to on-farm production and storage of seeds, building on the local knowledge and development of farmer-based seed enterprises. Experiences in Ethiopia during the epidemics of 2010 will also be a valuable asset to future activities.

Capacity building and training of farmers and technical officers are essential for integrated management

Management of wheat rust diseases is a complex process requiring a multidisciplinary approach for effective control. This is because of the formation of new strains of the pathogen and involvement of many stakeholders in wheat rust management.

Development and use of resistant cultivars is the most effective means of control but strong seed systems and extension structures are needed to use this tool effectively. During an emergency, chemical control may be necessary, but applications must be made timely and effectively. For this, capacities need to be improved and technical officers and farmers need to be exposed to adequate training.

The extensive farmer training activities through farmer field schools in Pakistan could be repeated in other countries.



Farmers attending a weekly class at the farmer field school and listening to fellow students give a presentation on agricultural practices learned at the school

Credit: FAO/ F. Naeem



Infection of Ug99 race of stem rust on wheat. Stem rust can heavily infect wheat plants and if it develops early it can cause total yield losses.

Credit: FAO/W. Khoury

PART III – PROGRAMME FRAMEWORK

3.1 Goal

The overall goal of the **FAO Wheat Rust Diseases Global Programme** is to contribute to global food security and livelihoods of wheat producers. This will be achieved by reducing their vulnerability to the threats of existing and emerging wheat rust diseases and enhancing wheat productivity in East and North Africa and Near East as well as in West, Central and South Asia.

29

3.2 Objectives

The programme focuses on improving national capacities and international collaboration to prevent and reduce risks of rust epidemics in wheat producing countries already affected and at risk of wheat rust diseases through support for surveillance and monitoring, seed systems, integrated management, preparedness, timely response and collaboration.

3.3 Outcomes

The two outcomes of the **FAO Wheat Rust Diseases Global Programme** are:

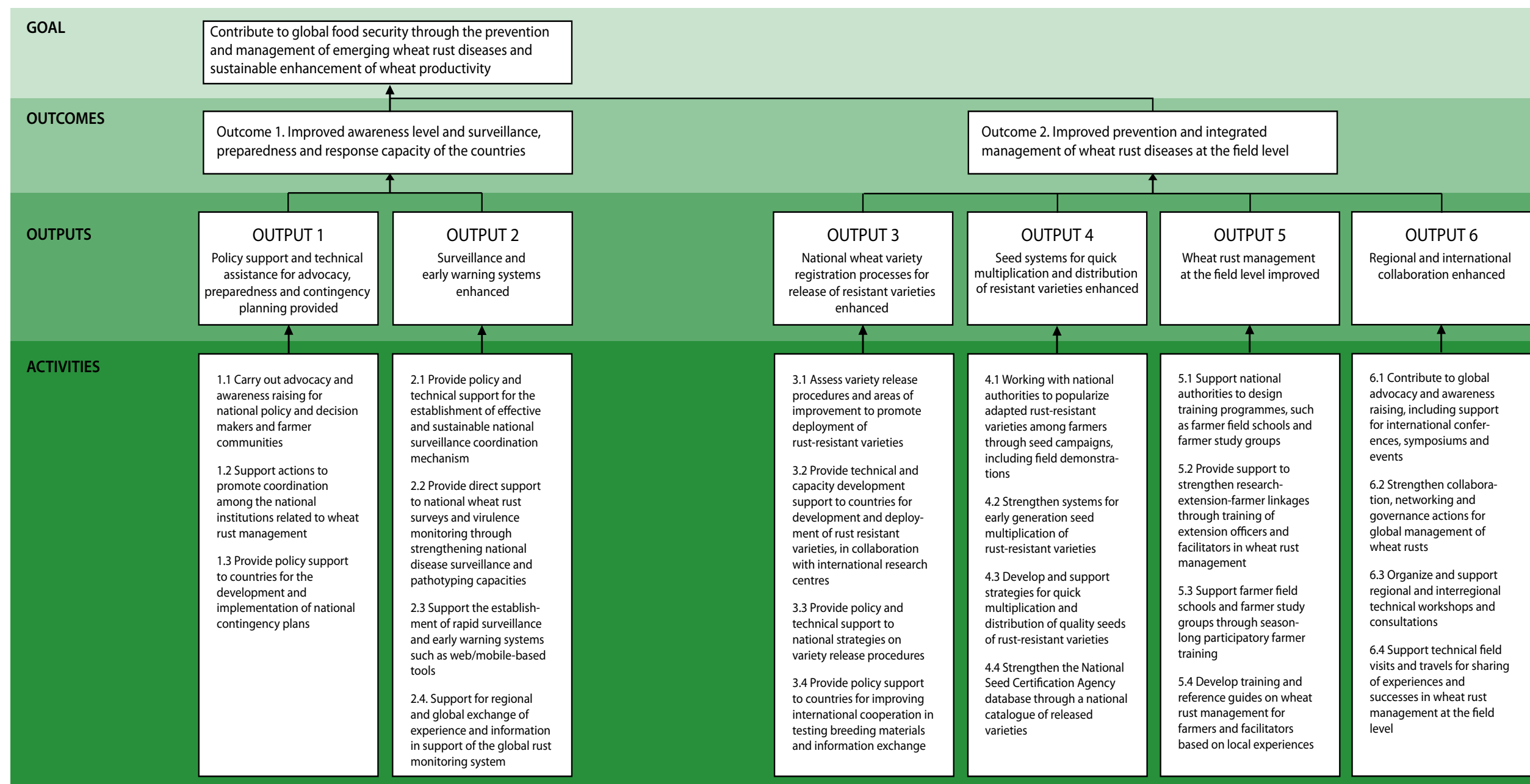
- improved awareness level and surveillance, preparedness and response capacity of the countries; and
- improved prevention and integrated management of wheat rust diseases at the field level.

3.4 Outputs and activities

The programme objectives are achieved through activities which are formulated to produce six major outputs that are in line with FAO's Strategic Framework and needs of the targeted regions.

The activities are considered as options for implementation in the target countries. This would vary from country to country depending on their needs, priorities, absorption capacity and availability of resources.

Figure 5. Programme hierarchy



Outcome 1. Improved awareness level and surveillance, preparedness and response capacity of the countries

Output 1: Policy support and technical assistance for advocacy, preparedness and contingency planning provided

Activity 1.1: Carry out advocacy and awareness raising for national policy and decision-makers and farmer communities.

- Hold awareness raising meetings for high-level policy-makers and technical decision-makers to inform them on all aspects of rust epidemics and risks, such as Ug99 and Yr27 strains, including status of rusts, potential path of spread, availability of resistant varieties, and actions being taken at the international level, specifically by FAO and its partners within BGRI.
- Prepare for and distribute to the countries concerned, awareness and information material addressed to different audiences and in various languages.
- Carry out web-based advocacy and promotion.

Activity 1.2: Support actions to promote coordination among the national institutions related to wheat rust management.

- Organize policy-makers' meetings to assess and coordinate national contingency plans.
- Provide policy support for coordination among the national institutions for management of wheat rust diseases and for national contingency planning.
- With the relevant policy-makers, develop mechanisms for networking and information sharing among the institutions.

Activity 1.3: Provide policy support to countries for the development and implementation of national contingency plans.

- Organize national and regional meetings to assess country situations in terms of status of systems for surveillance and monitoring, seed information, multiplication and distribution, breeding programme structures and needs, coordination and information exchange within the country and region. Availability of national information on wheat growing areas, agro-ecological systems and agricultural landscapes, social vulnerability, and political and administrative structures.
- Organize national and regional meetings for development of the most appropriate policy options, strategies and actions needed for risk reduction, prevention and control of wheat rusts.

- With national authorities, assess requirements for implementation of suggested contingency actions.
- Support countries in implementation of contingency plans through provision of capacity building, infrastructure development, regulatory support (registration of varieties and pesticides, etc.) and information and knowledge systems.
- When necessary, carry out required control operations, in full collaboration with national authorities.
- Review and update contingency plans on the basis of the developments regarding status of wheat rusts, latest information from field surveys and global analysis.

Output 2: Surveillance and early warning systems enhanced

Activity 2.1: Provide policy and technical support for the establishment of effective and sustainable national surveillance coordination mechanism.

- Hold national and regional meetings to assess the national status of wheat field surveys (i.e. regularity, unit carrying out surveys, methodology, information sharing, responsibilities of various units, and limitations and constraints).
- Provide technical and policy support to agree with national authorities on the:
 - most appropriate structure for the establishment of sustainable and coordinated multi-institutional surveillance teams;
 - type and level of survey information to be officially shared and exchanged regionally and internationally;
 - national focal point(s) or way to ensure quality of national survey data and its transmission to concerned parties nationally and internationally; and
 - long-term surveillance programme and identification of lead institutions.
- Establish coordinated surveillance teams and obtain the nomination of a national focal point to coordinate national activities with FAO.

Activity 2.2: Provide direct support to national wheat rust surveys and virulence monitoring through strengthening national disease surveillance and pathotyping capacities.

- Conduct regional workshops for harmonization of surveillance methodologies, survey work plans, national responsibilities and compilation of available information in wheat distribution maps.
- Assess national surveillance material, infrastructure and human capacities.
- Provide necessary field survey support equipment, including global positioning systems, computers and printers and vehicles.

- Upgrade laboratories and greenhouses in key countries and equip them with the infrastructure and material necessary for pathogen characterization.
- Support establishment of national rust trap nurseries in key positions in countries and have access to the results.
- Train relevant national staff on field surveys pathotype analysis, including field rust trap nurseries.
- Direct support to undertake surveys.

Activity 2.3: Support the establishment of rapid surveillance and early warning systems, such as web/mobile-based tools.

- Establish web- and mobile-based national surveillance systems for timely surveys and information exchange.
- Explore suitability of weather-based prediction tools for early warning.
- Predict occurrence and disease risk.
- Establish an information dissemination system to issue recommendations on disease status, alert levels and recommended actions for prevention and control addressed to relevant stakeholders (i.e. Web site and bulletins).

Activity 2.4: Support for regional and global exchange of experience and information in support of the global rust monitoring system.

- Organize national and regional workshops and field days in order to ensure continuous national and regional interaction.
- Prepare awareness materials on the disease risks and status for distribution.
- Utilize web-based resources to enhance public awareness and advocacy, informing the global community on severe cases.

Outcome 2. Improved prevention and integrated management of wheat rust diseases at the field level

Output 3: National wheat variety registration processes for release of resistant varieties enhanced

Activity 3.1: Assess variety release procedures and areas of improvement to promote deployment of rust-resistant varieties.

- Undertake baseline assessments on the current situation of wheat rust disease resistance breeding, variety development and registration capacities in the countries concerned using available data from the FAO Global Initiative for Plant Breeding and the relevant IARCs, ICARDA and CIMMYT, and in close cooperation with national programmes.
- Organize national workshops to identify the support needed by countries in terms of capacity and infrastructure building for national testing and release of rust-resistant wheat varieties.

Activity 3.2: Provide technical and capacity development support to countries for development and deployment of rust-resistant varieties, in collaboration with international research centres.

- In close cooperation with ICARDA, CIMMYT, FAO/IAEA Joint Division of Nuclear Techniques and other leading advanced breeding institutions, facilitate provision of the technical support needed in the area of breeding methodologies, variety multilocation adaptation testing and disease resistance trials through study tours of IARCs and training.
- Provide the necessary equipment for variety quality testing and harvesting field trials.

Activity 3.3: Provide policy and technical support to national strategies on variety release procedures.

- In close cooperation with ICARDA, CIMMYT and the International Treaty for Plant Genetic Resources for Food and Agriculture, organize national workshops to provide policy and technical support on the development of national strategies for variety registration and the implementation of variety release procedures, and on opportunities and limitations regarding the exchange of wheat resistant genetic material.

- Provide the technical training needed for the implementation of variety release procedures.
- Support to the establishment of a database for released varieties, including attributes of rust-resistance.
- Prepare awareness material in the relevant languages on the procedures of variety testing and release.

Activity 3.4: Provide policy support to countries for improving international cooperation in testing breeding materials and information exchange.

- Provide policy, technical and financial support for establishing international and regional agreements and cooperation for testing national breeding material in international wheat rust nurseries (where a virulent pathogen is already present), and in sending infected wheat samples to advanced pathotyping laboratories (i.e. when facilities and capacities are not available nationally).
- Organize regional workshops for information exchange on the status of pathogen virulence, available resistant breeding material and mechanisms for cooperation in the fields of material and information exchange.

Output 4: Seed systems for quick multiplication and distribution of resistant varieties enhanced

Activity 4.1: Working with national authorities popularize adapted rust-resistant varieties among farmers through seed campaigns, including field demonstrations.

- Organize demonstration plots to enable farmers to observe new varieties and learn about wheat rusts and better wheat production practices (it is assumed that because the entire production area will not be covered in the first year, new demonstration plots will be established each year to cover the whole country within three to four years).
- Organize training sessions for farmers at the demonstration plots on the assessment and evaluation of agronomic and quality characteristics of the new varieties.
- Organize training sessions for extension workers on the management of demonstration plots.
- Prepare awareness material on the characteristics of various resistant varieties and their field management.

Activity 4.2: Strengthen systems for early generation seed multiplication of rust-resistant varieties.

- Where necessary, support countries through the training of technical staff in procedures for early generation seed production to minimize disease risks and maximize the yields.
- Provide the equipment needed for early generation seed multiplication, including production-related equipment, irrigation systems, seed cleaners, small-scale equipment and agricultural inputs.
- Support seed multiplication, including the cost of water, labour, inputs and fuel.
- At national level, FAO Representations will facilitate variety diffusion and seed exchange using FAO's extensive network and experience in strengthening local seed systems (experience has demonstrated that taking the local seed system as a starting point offers many opportunities for improving seed supply).

Activity 4.3: With national authorities, develop and support strategies for quick multiplication and distribution of quality seeds of rust-resistant varieties to replace susceptible ones through both the public and private sector.

- Organize workshops in support of the development of a national strategy for seed multiplication, distribution and variety replacement (workshops are to be held at the district and national levels, and should include participants from various concerned ministries and public boards, the private sector, farmers associations, and civil organizations directly or indirectly involved in the seed sector).
- FAO Representations will facilitate linkages between different seed systems and actors, at national level, in order to overcome the weaknesses and optimize the strengths of both systems.
- Follow-up workshops should be also organized at the district and national levels for updating implementation of the strategy.

Activity 4.4: Strengthen the National Seed Certification Agency database through a national catalogue of released varieties with information on their tolerance to pests and diseases in particular to rusts.

- Organize a national workshop in preparation for the establishment/strengthening of the National Seed Certification Agency's seed inventory database.
- Provide the necessary hardware and software support for establishing/strengthening the seed database.
- Provide the necessary training for database management and updating.

Output 5: Wheat rust management at the field level improved

Activity 5.1: Support national authorities to design training programmes, including participatory approaches, such as farmer field schools and farmer study groups.

- Organize national workshops with concerned stakeholders to discuss and agree on:
 - the participatory methods (farmer field schools or variations thereof) most adapted for the national extension system;
 - the plan of work for the support of established farmer groups or farmer field schools, including the location and number of experimental sites, and training needed; and
 - identification of areas for enhancement of farmer field schools and extension tools and their adaptation to the wheat crop.

Activity 5.2: Provide support to strengthen research-extension-farmer linkages through training of extension officers and facilitators in wheat rust management.

- Organize joint workshops, including research, extension and crop protection institutions, on integrated management of rusts.
- Organize interactive training programmes for the extension and crop protection technicians.
- Design regular information exchange forums and meetings.

Activity 5.3: Support farmer field schools and farmer study groups through season-long participatory farmer training.

- Establish experimental farmer sites/on-field trials for farmers' training or establish farmer field schools when one or the other already present or is accepted as a participatory extension method.
- Train farmers over the whole season using participatory methods on wheat field management practices using agro-ecosystem analysis, experimentation in local ecologies, and farmers' indigenous knowledge and experience (training will emphasize rusts, variety selection and seed multiplication).
- Organize national and regional travelling workshops and field days to exchange field experiences.

Activity 5.4: Develop training and reference guides on wheat rust management for farmers and facilitators based on local experiences.

- Produce reference guides and farmer field schools training manuals on wheat production and protection to be used by farmers and facilitators.

Output 6: Regional and international collaboration enhanced

Activity 6.1: Contribute to global advocacy and awareness raising, including support for international conferences, symposiums and events.

- Monitor global developments in the field of wheat rust and identify issues that need public attention.
- Publish the issues that need public attention through appropriate means.
- Organize and contribute to, as appropriate, international events related to wheat rust management.

Activity 6.2: Strengthen collaboration, networking and governance actions for global management of wheat rusts.

- Collaborate with international institutions and governments on surveillance, information sharing and advocacy.
- Support BGRI activities.

Activity 6.3: Organize and support regional and interregional technical workshops and consultations.

- Regional consultations are foreseen as follows:
 - East and South Africa
 - Near East and North Africa
 - Central and West Asia
 - South Asia
- Organize national and regional meetings and workshops for development of the most appropriate policy options, strategies and actions needed for risk reduction, prevention and control of wheat rusts.
- Organize and support regional and travelling workshops.

Activity 6.4: Support technical field visits and travels for sharing of experiences and successes in wheat rust management at the field level.

- Organize and support specific technical visits to facilitate sharing of successes.
- Support training of junior officers in advanced institutions.
- Support for south-south cooperation.



Wheat is a key staple crop for the livelihoods of millions of small-holder farmers

Credit: FAO/D. Dennis

3.5 Sustainability

While a number of activities are urgently required, this second phase of the programme will last four years with the possibility of extension. It covers 40 countries that differ in development status, human and infrastructure capacities, the relative importance of wheat in the economy and the level of risk of being affected by Ug99 and other rust strains. All these factors will affect the success of programme implementation and the sustainability of its activities, but the awareness raised during the first phase of the programme will serve as a basis for the successful implementation and sustainability of the activities of this phase.

Within the duration of the programme, participating countries will have improved the necessary infrastructure and sufficient critical mass of trained scientists will be able to undertake surveys and pathotyping. A surveillance system will be in place to share information within the target countries and at the regional and global levels. Equipment and technical capacities for wheat variety evaluation and registration, and the quick multiplication and distribution of replacement resistant varieties will be available. National strategies for seed increase and distribution will also be in place facilitating sustainability. Within the duration of the programme, a critical mass of wheat farmers and facilitators will have been trained and empowered through participatory methods, enabling them to improve their productivity, reduce the risk of diseases and support their national extension systems. In order to ensure sustainability of such extension activities, special emphasis will be given to strengthen the linkages between research and extension institutions.

The programme activities respond to the needs of countries facing the threat of wheat rust diseases, such as Ug99 and Yr27, and incorporate a system that strengthens capacities of the countries for management of current risks and prevention of wheat rust epidemics that might emerge in the future. Because the programme deals with prevention and risk reduction, the awareness of policy-makers and managers is probably the most critical factor for sustainability of programme activities. Thus, the importance of the risks and consequences of lack of preparation and preventive measures are highlighted and development of appropriate contingency plans and their implementation has been emphasized and given adequate attention. The programme activities will contribute to safeguarding wheat production in the concerned countries, which will ultimately contribute to long-term sustainable economic, social and political stability.



Wheat is grown in larger area than any other crop being a major crop for food security and livelihoods

Credit: FAO

PART IV – IMPLEMENTATION ARRANGEMENTS

4.1 Institutional framework and coordination

In close collaboration with the recipient institutions (i.e. the ministries of agriculture of participating countries), the **FAO Wheat Rust Diseases Global Programme** will be implemented through the FAO Food Chain Crisis Management Framework (FCC). The FCC approach combines the whole range of technical and operational expertise within the Organization. It supports member countries in the global fight against threats to the human food chain. This model integrates prevention, early warning, preparedness and response at all stages of the food chain, from production to consumption.

The FAO Plant Production and Protection and FAO Emergency and Rehabilitation divisions will jointly execute the programme. The Plant Production and Protection division, supported by regional and subregional plant production and protection officers, will provide technical leadership. The Emergency and Rehabilitation division will coordinate operational activities, in close cooperation with the FAO Representations in the concerned regions, subregions and countries.

At the country level, activities will be carried out through the FAO Representations, in close collaboration with FAO regional and subregional offices. The programme will work in synergy with ongoing FAO activities.

The programme team will actively liaise with all stakeholders and agencies in order to:

- avoid duplication of efforts;
- ensure complementarities with other initiatives; and
- promote local ownership of programme activities.

Technical guidance will be provided by:

- staff from the Plant Production and Protection division, in particular from the EMPRES Plant Protection team;
- regional technical coordinators;
- international and national consultants; and
- relevant technical staff from BGRI partners, including ICARDA, CIMMYT and Cornell University.

The ministries of agriculture of the participating countries will act as the government counterpart institutions responsible for implementation. The ministries will make available the services of qualified staff as necessary and ensure the clearance of programme inputs free from custom duties.

As a member of the BGRI, the programme will benefit from the technical and scientific guidance of the BGRI Executive and Technical Committees, which include participants from the National Agricultural Research Systems of the concerned countries. This will also ensure coordination between programme activities and those of BGRI.

The programme will have an FAO Oversight Committee responsible for overseeing the operational and managerial implementation of the programme. The Committee will ensure that activities are delivered in a proper and timely manner as per the work plan, donor requirements and the overall vision and priorities of FAO.

FAO will closely collaborate with BGRI, CIMMYT and ICARDA as well as the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture. In addition, for specific tasks collaboration is foreseen with various Universities with international missions, including University of Minnesota, Washington State University (USA), University of AARHUS (Denmark), University of Sydney (Australia) and others.

4.2 Methodology

The general methodological approach will be consultative. At an early stage of the process, regular national and regional meetings and workshops will be held with national counterparts to raise awareness with policy-makers of the programme components, and to assess country situation and needs. Based on these consultative meetings, the most appropriate and adapted modes for the implementation of national activities, including the development of contingency plans, will be identified and a work plan will be agreed. National focal points will be determined and given the authority to communicate, coordinate and share information with FAO, its partners and other identified stakeholders.

The programme will also focus on capacity building, which will start through engaging national counterparts at early stages of the activities. Capacity building component will also include physical strengthening of field and laboratory facilities as well as training of technicians, extension officers and farmers.

4.3 Technical support and programme staff

Technical and operational support for the programme will be provided through the following human resources:

- Lead technical coordinator, based at headquarters: responsible for overall technical coordination of the programme.
- Assistant technical officer or consultant, based at headquarters: assist the lead technical coordinator, liaison with regional and subregional technical officers and responsible for the preparation of specific project proposals.
- Operations officer, based at headquarters: operational support to the entire programme.
- Information and communication expert, based at headquarters.
- Subject matter specialists (international consultants): wheat breeders, seed specialists, plant pathologists, geographic information system specialists, web/ database/ information technology specialists, socio-economists.
- Subject matter specialists (national consultants).

- National focal points for surveillance and monitoring activities, seed multiplication and support to improved field management.
- Operational and technical backstopping provided from operational and technical divisions, based at headquarters.

4.4 Work plan

The programme combines both short- and medium- to longer-term activities. The recommended activities and related budget requirements for this programme refer to a four-year period, which may be modified in light of emerging issues and special projects funded within the programme.

The level of support to each country will also be dependent on the estimated need for infrastructure, capacity building and area planted to wheat in the country. Beneficiary countries within this programme are grouped into three categories based on the presence or risk of being affected by Ug99 and prevalence of yellow rust (it should be noted that most countries already face challenges of yellow rust):

1. Countries already affected by Ug99 and with yellow rust prevalence.
2. Countries with high risk of Ug99 and with yellow rust prevalence.
3. Countries at risk of Ug99 and with yellow rust prevalence, and those requiring monitoring.

The four-year work plan based on the categories of beneficiary countries is shown in Annex 1. The logical framework is presented in Annex 2.



Egypt field training: extension officers and farmers are trained through field demonstration of improved resistant cultivars



Training of farmers is a key component of capacity building for better rust management

Credit: FAO/W. Khoury

4.5 Budget

The total indicative budget required for the complete implementation of the four-year Wheat Rust Diseases Global Programme is USD 48 million. Table 2 provides the budget by output and by beneficiary countries.

Table 2. Estimated budget by output and by beneficiary countries, based on the presence of Ug99 and by level of risk of being affected by Ug99 (USD)

Output	Countries already affected	Countries at high risk	Countries at risk	Other countries	Coordination	TOTAL	%
Output 1: Policy support and technical assistance for advocacy, preparedness and contingency planning provided	686 000	1 592 000	989 000	350 000	-	3 617 000	8
Output 2: Surveillance and early warning systems enhanced	1 897 000	4 581 000	2 946 000	1 010 000	-	10 434 000	22
Output 3: National wheat varietal registration programmes for release of resistant varieties enhanced	558 000	1 302 000	906 000	288 000	-	3 054 000	6
Output 4: Seed systems for quick multiplication and distribution of resistant varieties enhanced	2 247 000	4 221 000	4 243 000	1 469 000	-	12 180 000	25
Output 5: Wheat rust management at the field level improved	3 021 000	4 857 000	3 639 000	2 198 000	-	13 715 000	29
Output 6: Regional and international collaboration mechanisms enhanced	-	-	-	-	5 000 000	5 000 000	10
Total	8 409 000	16 553 000	12 723 000	5 315 000	5 000 000	48 000 000	100
%	18	34	27	11	10	100	

ANNEXES

Annex 1. Implementation plan

Output/Activity	Already affected by Ug99				At high risk of Ug99				At risk of Ug99			
	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4
Output 1: Policy support and technical assistance for advocacy, preparedness and contingency planning												
Activity 1.1 Carry out advocacy and awareness raising for national policy and decision-makers and farmer communities												
Activity 1.2 Support actions to promote of coordination among the national institutions related to wheat rust management												
Activity 1.3 Provide policy support to countries for the development and implementation of national contingency plans												
Output 2: Enhancement of surveillance and early warning systems												
Activity 2.1 Provide policy and technical support for the establishment of effective and sustainable national surveillance coordination mechanism												
Activity 2.2 Support to national wheat rust surveys and virulence monitoring through strengthening national disease surveillance and pathotyping capacities												
Activity 2.3 Support for establishment of rapid surveillance and early warning systems, such as web/mobile-based tools												
Activity 2.4 Support for regional and global exchange of experience and information in support of the global rust monitoring system												
Output 3: National wheat rust disease resistance breeding/variatal development programmes for release of resistant varieties												
Activity 3.1 Assess variety release procedures and areas for improvement to promote deployment of rust-resistant varieties												
Activity 3.2 Provide technical and capacity development support to countries for development and deployment of rust-resistant varieties												
Activity 3.3 Provide policy and technical support to national strategies and varietal release procedures												
Activity 3.4 Provide policy support to countries for improving international cooperation in testing breeding material and information exchange												

Annex 1. Implementation plan (cont.)

Output/Activity	Already affected by Ug99				At high risk of Ug99				At risk of Ug99			
	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4
Output 4: Seed systems for quick multiplication and distribution of resistant varieties enhanced												
Activity 4.1 Popularize adapted rust-resistant varieties among farmers through seed campaigns, including field demonstration plots												
Activity 4.2 Strengthen systems for early generation seed multiplication of rust-resistant varieties in each country												
Activity 4.3 Develop and support strategies for quick multiplication and distribution of quality seed of rust-resistant varieties to replace rust susceptible varieties												
Activity 4.4 Strengthen the database of the National Seed Certification Agencies to produce variety catalogues												
Output 5: Wheat rust management at the field level improved												
Activity 5.1 Support to national authorities to design training programmes, including participatory approaches, such as farmer field schools and farmer study groups												
Activity 5.2 Provide support to strengthen research-extension-farmer linkages through training of extension officers and facilitators in wheat rust management												
Activity 5.3 Support farmer field schools and farmer study groups through season-long participatory training												
Activity 5.4 Develop training and reference guides on wheat rust management for farmers and facilitators based on local experience												
Output 6: Regional and interregional coordination mechanisms enhanced												
Activity 6.1 Contribute to global advocacy and awareness raising, including support for international conferences, symposiums and events												
Activity 6.2 Strengthen collaboration, networking and governance actions for global management of wheat rusts												
Activity 6.3 Organize and support regional and interregional technical workshops and consultations												
Activity 6.4 Support technical field visits and travels for sharing of experiences and successes in wheat rust management at the field level												

Annex 2. Logical framework matrix

	Programme element	Verifiable indicators	Means of verification	Assumptions
Goal	Contribute to improvement of food security and livelihoods of wheat producers through reducing their vulnerability to the threats of existing and emerging wheat rust diseases in East and North Africa, Near East, West, Central and South Asia	Increase in wheat production by 1-2 percent Decrease in crop losses caused by wheat rust epidemics by 3-5 percent	FAO statistics and reports Reports of BGRI partners (ICARDA, CIMMYT and Cornell University) Reports from national systems Global rust monitoring system resources	National authorities cooperate and agree on disease surveillance and sharing information Availability of funds
Objective	Improve national capacities and international collaboration to prevent and reduce risks of rust epidemics through support for surveillance and monitoring, seed systems, integrated management, preparedness, timely response and collaboration	National rust management strategies are in place in ten countries Rust surveillance systems and networks are supported and improved in 15 countries Integrated rust management procedures improved in 15 countries	FAO reports Reports of BGRI partners (ICARDA, CIMMYT and Cornell University) National agricultural research reports Consultants reports	Governments cooperate in disease surveillance and information sharing Availability of resistant varieties Availability of funds
Outcome 1	<i>Improved awareness level and surveillance, preparedness and response capacity of the countries</i>			
Output 1	<i>Policy support and technical assistance for advocacy, preparedness and contingency planning provided</i>	Contingency plans reflecting a change in wheat rust management policy in place in at least ten countries Contingency plans implemented in at least five countries	National contingency plans FAO and other BGRI partner reports Reports from national systems Consultants reports	Governments willing to commit to national and regional coordination and information sharing Availability of funds
Output 2	<i>Surveillance and early warning systems enhanced</i>	Harmonized surveillance systems established Surveillance teams in at least ten countries established, trained and equipped At least 40 technical officers trained in surveillance and pathotyping in international centres Wheat rust surveys supported in at least 25 countries Pathotyping facilities (laboratories and greenhouses) improved and staff trained in at least six countries Web- and mobile-based surveillance systems are established in at least six countries Alert communications are issued and awareness materials distributed	National surveillance reports Trap nursery reports Training reports Early warning bulletins and press releases Awareness materials of FAO and other BGRI partners	Cooperation of governments in establishment of surveillance systems, information sharing and support to national surveillance Availability of funds

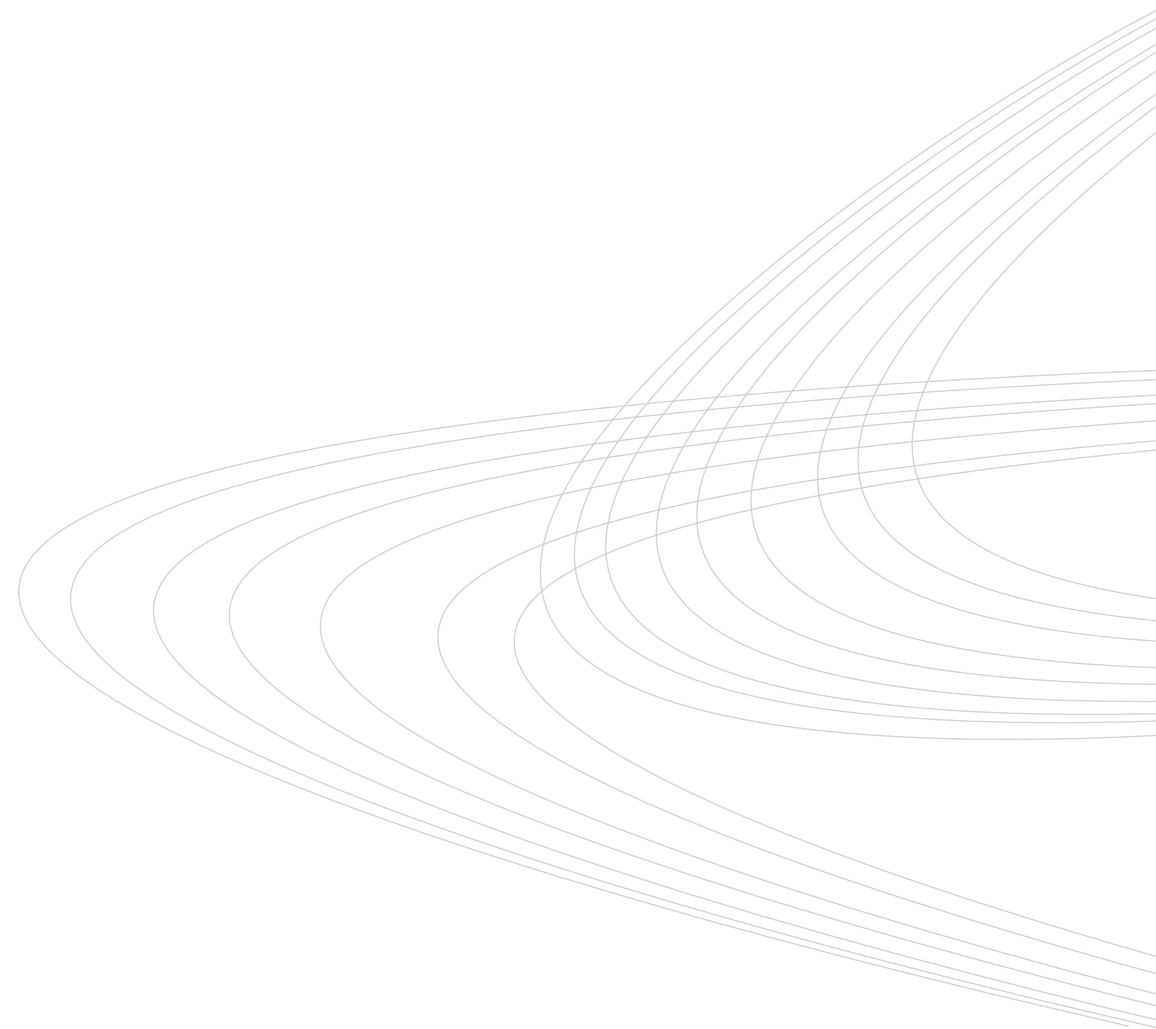
Annex 2. Logical framework matrix (cont.)

	Programme element	Verifiable indicators	Means of verification	Assumptions
Outcome 2	<i>Improved prevention and integrated management of wheat rust diseases at the field level</i>			
Output 3	<i>National wheat variety registration processes for release of resistant varieties enhanced</i>	<p>Efficient variety registration systems in place in at least six countries</p> <p>At least 15 technical officers are trained in variety data base management and implementation of variety release procedures</p> <p>Databases for released varieties, including attributes of resistance to rust diseases, established in at least six countries</p> <p>At least four national and regional workshops undertaken to improve exchange of information and genetic material</p>	<p>Reports of FAO and other BGRI partners</p> <p>Reports from national systems</p> <p>Published material on the procedures of variety testing and registration</p> <p>Reports from the workshops and meetings</p> <p>Consultant reports</p>	<p>Government ready to cooperate in improving variety registration processes and in information sharing</p> <p>Availability of funds</p>
Output 4	<i>Seed systems for quick multiplication and distribution of resistant varieties enhanced</i>	<p>Resistant varieties identified and basic seeds increased at least in ten countries through the national and international research system</p> <p>Seeds of resistant cultivars multiplied by various stakeholders in at least ten countries</p> <p>Major seed producers (public, private or farmers) are trained in rust management and seed production in at least ten countries</p> <p>Seeds of resistant varieties distributed to small farmers in at least six countries at high risk of Ug99 or yellow rust</p>	<p>Reports of FAO and other BGRI partners</p> <p>Reports from national systems indicating the varieties and quantities of seeds multiplied</p> <p>Training reports</p> <p>List of farmers receiving seeds of resistant varieties</p>	<p>Availability of wheat varieties with rust-resistance</p> <p>Variety registration system in place in the concerned countries for quick adoption of the varieties</p> <p>Availability of funds</p>
Output 5	<i>Wheat rust management at the field level improved</i>	<p>At least five pilot sites established for participatory training of farmers on integrated management of wheat rusts in each of the 15 countries</p> <p>At least 160 facilitators (trainers) identified and trained in country training programmes in 15 countries</p> <p>At least 35 farmers field schools established and running in ten countries at risk of Ug99 or yellow rust</p> <p>Field demonstrations conducted in 20 countries</p> <p>At least 4 000 farmers trained or exposed to field demonstrations in at least ten countries at risk of Ug99 or yellow rust</p>	<p>Meeting reports</p> <p>Reports from training of trainers activities</p> <p>List of farmer field schools, demonstrations and beneficiaries registered and receiving support</p> <p>Farmer field schools curricula developed</p>	<p>Identification of appropriate sites and facilitators</p> <p>Agreement of the governments to release facilitators</p> <p>Availability of funds</p>
Output 6	<i>Regional and interregional collaboration mechanisms enhanced</i>	<p>Four regional and two interregional technical workshops or consultation meetings are held for enhanced collaboration</p> <p>At least four technical travelling workshops are held in countries where achievements are made in management of wheat rust diseases</p>	<p>Workshop programmes, reports and proceedings</p> <p>Regional status reports and policy recommendations</p> <p>Back to office reports</p>	<p>Identification of appropriate locations</p> <p>Agreement of the governments to participate in the events</p> <p>Availability of funds</p>



Severe yellow rust infection on a susceptible cultivar causing around 60 percent yield loss and severe quality degradation

Credit: FAO/F. Dusunceli





FOOD CHAIN CRISIS Management Framework

The **Food Chain Crisis Management Framework (FCC)** supports FAO member countries in the fight against threats to the human food chain at all stages from production to consumption.

Such threats emerge from transboundary animal, fish and aquatic diseases, plant and forest pests and diseases, food safety hazards, and nuclear and radiological incidents.

The **Wheat Rust Diseases Global Programme** is implemented through the FCC.

www.fao.org/foodchain

For more information on FAO's Wheat Rust Diseases Global Programme:

www.fao.org/agriculture/crops/wheatrust

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