1 Background

1.1 Introduction

The recent crisis of soaring food prices is one of the challenges the world faces in attempts to reduce hunger and poverty. Moreover, a solution seems unlikely in the near future. In some countries, the rising price of food has even led to political unrest.

Wheat has been one of the major victims of this phenomenon. As with other grain crops, wheat prices have doubled in the last year, largely as a result of several years of severe drought, the high cost of fuel and an increased demand for grains. Any additional reduction in wheat yields would result in further price increases.

Wheat is grown on more than 200 million hectares of land and is a source of food and livelihoods for over a billion people in developing countries. The Near East, East and North Africa and Central and South Asia alone 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 countries rely heavily on wheat production for their subsistence and livelihoods.

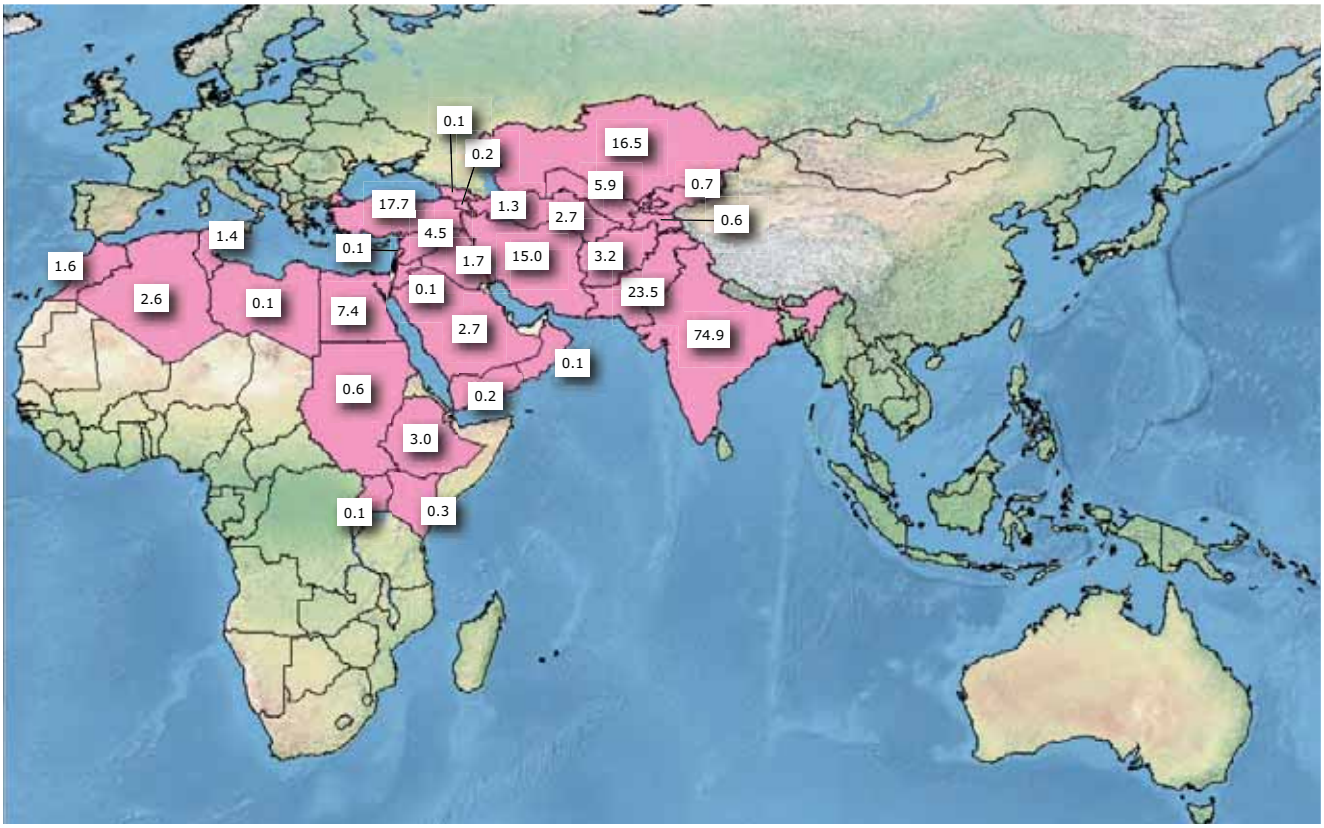
Rising prices are not the only problem these vulnerable populations face, however. With wheat crops coming under pressure from climatic stress, especially in rainfed regions, the impact of diseases is also expected to increase, resulting in severe yield losses. A major new threat has already surfaced – Ug99, a virulent strain of stem rust, also scientifically known as TTKS, an important fungal disease of wheat. In 1999, Ug99 emerged in East Africa, and by late 2007 it had reached the Islamic Republic of Iran. Ug99 is highly virulent for almost all wheat varieties currently grown throughout the world, and the risk that it could cause a global epidemic is very real. If this happens, wheat production would suffer devastating yield losses.

Based on weather patterns and previous experiences with similar rust strains, Ug99 is likely to affect all countries in the Near East, East and North Africa and Central and South Asia in only a matter of years. These countries cultivate around 80 million hectares of wheat. With a realistic assumption that Ug99 might cause an average yield loss of 10 percent at a wheat price of USD 400 per ton, the value of losses in these countries would reach over USD 7,5 billion (Figure 1).

Though some climate-related agricultural disasters may be difficult to predict and prevent, those resulting from pests and diseases are often the result of unsound agriculture-related policies, mismanagement of resources, and insufficient national and regional 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 too many years governments have reduced their investments in agriculture, especially with respect to farmer education and extension, agricultural research, rural development through infrastructure, and market access.

Through its Wheat Rust Disease Global Programme, the Food and Agriculture Organization of the United Nations (FAO) is taking global action to prevent a wheat production crisis. FAO is working in close collaboration with national governments, International Agricultural Research Centres (IARCs) and other international institutions to manage the Ug99 threat and to prevent future crises caused by similar wheat rust diseases. FAO is well positioned to lead such international efforts because of the Organization's: (i) experience with the international dimensions of other transboundary pests such as locusts; (ii) position as a neutral international forum for information sharing; and (iii) linkages with grassroots rural communities, national governments, regional bodies, international agriculture research and development institutions, the private sector and the donor community.

Figure 1: Wheat cultivation in countries* affected by and at direct risk of Ug99



*Countries threatened by Ug99 produce 37 percent of the world's wheat. Figures in boxes indicate 2006 wheat production in millions of tons.

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, are stem rust (also called black rust), stripe rust (also called yellow rust), and leaf rust (also called brown rust). Although all three are 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.

Rust fungi have been known to attack wheat since the earliest records of its cultivation – in classical times, the Romans made sacrifices to Robigus,

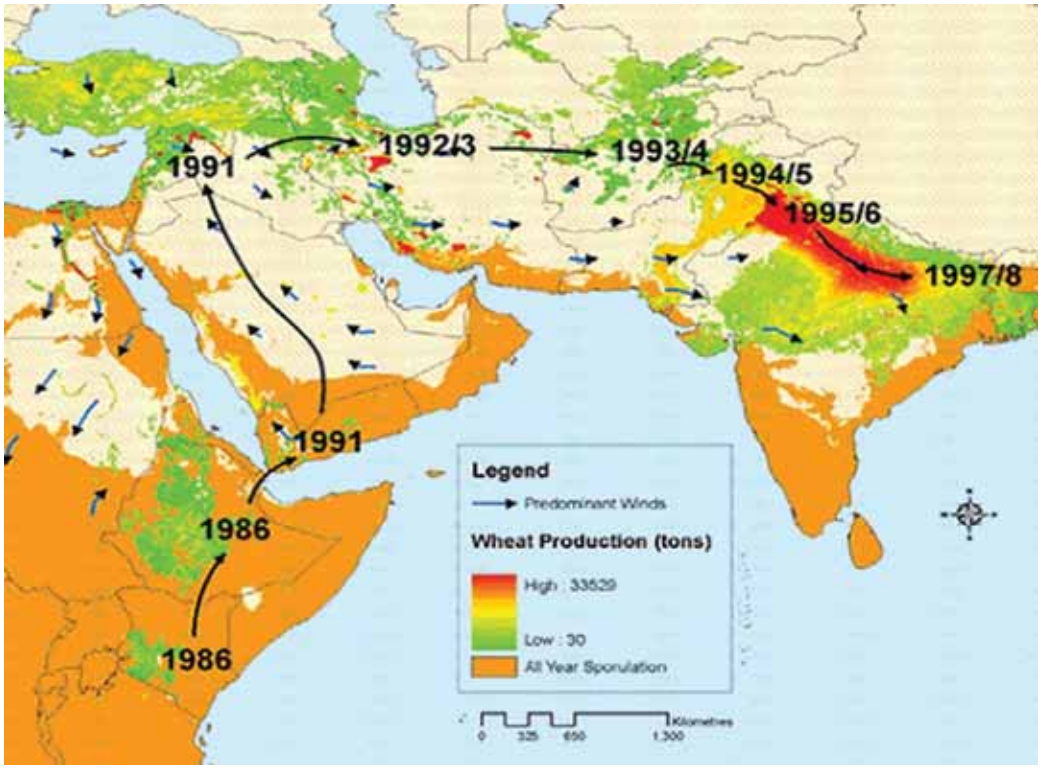
the Rust God, to protect their wheat from epidemics. Rust fungi produce a large number of spores (i.e. inocula) that are carried by wind. When environmental conditions are favourable and wheat varieties susceptible, they may cause severe epidemics resulting in yield losses of over 60 percent.

Wheat rusts can be controlled worldwide by planting resistant varieties of wheat. Fungicides may be biologically effective, but for wheat rust they are not economically feasible. Fungicides are only recommended when based on accurate monitoring data and as an emergency control measure 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 multi-lines or varietal mixtures are also recommended because they are effective in reducing the levels of inocula and disease.

However, rust control using resistant varieties has faced the limited durability of resistance. 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. However, these genes are race-specific and function only if the infecting rust population is of a pathotype that lacks virulence with regard 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, most of the wheat varieties currently grown worldwide are at continuous risk of becoming susceptible to the selection of new virulent wheat rust strains. The recent explosion of Ug99 has dramatically revealed this genetic vulnerability.

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 South, West and Central 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 2). This caused crop losses amounting to several hundred million dollars and affected the livelihoods of millions of poor farmers.

Figure 2: Yellow rust pathway (1986–1993)



The emergence of Ug99, the new virulent strain of the wheat stem rust fungus, is expected to become a similar potential global threat to wheat production. Studies have shown that Ug99 defeats virtually every race-specific resistance gene used in commercial varieties grown throughout the world. It is estimated that over 90 percent of all wheat varieties planted along its potential pathway are now highly susceptible to Ug99, despite having been resistant to stem rust since the Green Revolution.

Since the Ug99 strain was first identified in East Africa in 1999, it has spread to other countries, including the Sudan, Yemen and most recently the Islamic Republic of Iran in the Near East in late 2007. The arrival of Ug99 in the Near East poses a new and heightened risk to wheat production in Asia. Typical weather patterns and experience with prevailing winds1 suggest that countries to the east (i.e. Afghanistan, India and Pakistan) are most at risk, followed 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, the Syrian Arab Republic and Turkey) at similar risk. Ug99 is expected to affect North African countries at a later date.

1 Based on desert locust forecasting studies

In response to Ug99, the Global Rust Initiative was first established in 2005 and later expanded to what is now known as the Borlaug Global Rust Initiative (BGRI)[2]. It includes the International Center for Agricultural Research in the Dry Areas (ICARDA), the International Maize and Wheat Improvement Center (CIMMYT), Cornell University and FAO. Both ICARDA and CIMMYT are IARCs of the Consultative Group on International Agricultural Research (CGIAR) and share the global mandate for wheat improvement. 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 threats[3].

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.

Activities have already been initiated in an increasingly coordinated fashion by all BGRI partners, most of whose mandates are primarily for research and education. Their wheat rust activities and national partners are therefore linked to research in the sectors of pathotyping, breeding and, to a limited extent, seed multiplication. FAO, through the Wheat Rust Disease Global Programme, complements these research efforts by working directly with governments and national authorities. This work focuses on the policy and regulatory issues especially related to national contingency planning and to enhanced national, regional and international cooperation in surveillance, monitoring and early warning, information exchange, improved varietal registration, seed multiplication and distribution systems to ensure the quick availability of quality seeds of resistant varieties to the most vulnerable farmers. The Programme also focuses on participatory farmer training to ensure proper management in the field to reduce disease risk and optimize yields under local ecological and farming conditions. The Programme covers activities at the farm, district, national, regional, and international levels. Furthermore, it fully reinforces and complements the activities of FAO's Initiative on Soaring Food Prices.

2 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

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

2 Rationale

2.1 Issues to be addressed

Recognizing that wheat rusts are recurrent potential threats, actions that reduce the risk of spread and allow for quick response to and management of these threats have to be undertaken at the national, regional and global levels.

2.1.1 Advocacy and policy support in contingency planning

Any national action to prevent or manage the threat of Ug99 requires the consensus and support of the national authorities. Governments will need support in devising contingency plans for dealing with potential wheat rust epidemics. Contingency plans should include specific strategies and scenarios and the corresponding actions needed to deal with the risk that Ug99 or similar virulent wheat rust strains that lead to 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 main elements of contingency plans for wheat rust diseases include:

1. multidisciplinary / multi-institutional teams representing all concerned national stakeholders and sectors in the process of developing such a plan;

- Planning will involve units of the national plant protection, agricultural research, breeder and seed sectors (i.e. public, private and informal systems), extension services and wheat farmer organizations.

2. a monitoring process with key factors that trigger the initiation of planned actions within the contingency plans; and

- 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 could be developed when harmonized national and regional data are available (refer to section 2.1.2).

3. immediate action and long-term measures to respond to emergencies and their future mitigation.

- Action to reduce the build-up of pathogen populations includes:
  - changing planting dates and using early maturing or shorter duration varieties to reduce the number of generations/cycles of pathogen in a given season;
  - elimination through tillage or herbicides application on "Green Bridges" – susceptible wheat / barley and wild grasses growing out of season or in abandoned fields, that would carry 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 varietal mixtures or multi-lines when available within the same field.
- Action to improve systems for quick varietal registration and release are listed in section 2.1.3.

- Action 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 the education of farmers in field management practices for disease risk reduction and improved implementation of contingency plans are listed in section 2.1.5.

- Socio-economic impact assessments related to wheat production and losses from rust diseases will be needed 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 and reaction. 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. A variant of the Ug99 that differs from the type identified in Kenya and Uganda has already been detected in Yemen, and this variant is able to overcome even more of the wheat resistant genes in the cultivated varieties.

Pathotyping for Ug99 and other wheat rusts require special greenhouse and laboratory facilities and human skills. Most of the countries affected by or at risk from Ug99 do not possess such facilities or skills. Currently, all rust samples are sent to the United States of America or Canada for pathotyping. Besides being a costly process, this increases the risk of spreading virulence into new regions. It is limited through logistical procedures that result in delays and uncertainties in the results obtained. The availability of the necessary greenhouse and laboratory facilities and trained personnel to permit virulence analysis at the regional or preferably national level is a priority for pathogen monitoring.

The availability of reliable, harmonized and regular disease survey data as well as information on wheat growing areas and the varieties grown is the basis for the development of an early warning system. The commitment of national counterparts to share survey data will be a major contribution. On this basis, FAO will develop a global early warning system for wheat rusts.

2.1.3 Improving the breeding strategies and development of wheat rust resistant varieties

As indicated above, wheat breeding strategies for a number of years involved the stacking or pyramiding of pathotype-specific genes. While early action measures to stack genes could be considered, longer term breeding solutions through durable host plant resistance should be advocated strongly. Global efforts to improve wheat breeding strategies for durable resistance are already under way. Searches for sources of resistance to Ug99 from existing wheat varieties and wild

wheat relatives and conventional and modern breeding technologies are being carried out. The international research centres and various advanced research and academic institutions worldwide are studying durable resistance (i.e. Cornell University is implementing a large-scale wheat programme).

In order to quickly replace susceptible wheat varieties with new resistant varieties, countries will need support to enhance the effectiveness of their national systems for varietal registration and release, through which all potentially resistant varieties must pass before they can be multiplied for distribution. 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 Ug99 and its variants in the international Ug99 nurseries in Njoro, Kenya (for bread wheat) and in Debra Zeit, Ethiopia (for durum wheat) before they can be released and multiplied. Currently, several varieties showing resistance to Ug99 have been identified within the breeding material of the joint ICARDA-CIMMYT wheat improvement programme, and two Ethiopian resistant varieties are already being multiplied for distribution to farmers in that country.

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 of the 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 Ug99 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.

2.1.5 Wheat rust disease management in the field

Extension services and farmer education have been given too little attention in recent years in most of the countries threatened by Ug99. Participatory farmer education methods have proved 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 help in early recognition and reporting of changes in disease severity and virulence in the field, and in understanding the risks associated with virulent strains and the importance of the various field management practices (planting dates, planting periods, choice of varieties, etc.) for disease development and yield improvement.

2.2 Stakeholders and beneficiaries

The beneficiaries of this Programme are the most vulnerable wheat growers and consumers in East Africa, Near East and Asia in particular. Governments and policy-makers in these countries will directly benefit from the Programme's enhancement of their abilities to develop and implement contingency plans allowing for quick response to and early rehabilitation in present and future wheat rust crises.

However, given that it is only a matter of time before Ug99 moves globally, wheat producers in all parts of the world, whether in developing or developed countries, will also benefit from the Programme, because it should lead to: (i) a reduction in the build-up of the strain's inocula; (ii) improved assessment of its movement and changes in its virulence; and (iii) increased international cooperation in breeding for resistance and information sharing for management practices.

Wheat is not only the staple food crop in many parts of the world; it is also a commodity on the international market. Diseases such as Ug99 that threaten to cause reductions in yield may result in uncontrolled increases in international wheat prices, thus threatening food security, the livelihoods of millions of vulnerable people who depend on wheat as their staple food and world trade markets.

Beneficiaries of this Programme will be the international research institutions whether within the IARCs or advanced research institutes and universities. These include international, public and private breeding institutions.

2.3 Strategic approach and countries covered

FAO's Wheat Rust Disease Global Programme falls within the scope of the Organization's Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES). Specifically, the EMPRES plant programme focuses on emergency prevention and early warning for transboundary plant diseases. Preventing the Ug99 threat from becoming a global crisis requires immediate action at the national level in countries at risk. However, measures can only be effective through strong regional and international collaborative action.

While some countries will require support in capacity building, equipment and infrastructure, all countries will require policy support for contingency planning and knowledge and information 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 neutral fora, FAO and its IARC partners can play a leading role in the exchange of information and genetic materials.

The programme will work closely and primarily with national governments. Discussions, meetings and workshops will be the basis for awareness raising, needs assessments and consensus on the most adapted and effective national options and action to take. Governmental concurrence will be required for sharing national information at the global level (as with FAO's Desert Locust Information System), and for assigning focal points responsible for sharing that information. National and regional workshops and meetings will be the basis on which the Programme will: (i) prioritize activities; (ii) decide modes of implementation; and (iii) establish methods for updating contingency plans.

The Programme will cover 29 countries (see table 1), representing most wheat-producing countries either already affected or at direct risk from Ug99 and its variants. However, the Programme will not cover all countries equally. The scope of activities, length of the implementation phase and level of funding will vary by country according to the: (i) local needs; (ii) importance of wheat production to food security; and (iii) risk of Ug99 infection.

Table 1: Countries included in the Wheat Rust Disease Global Programme

A. Countries already affected by Ug99	B. Countries at immediate risk
1. Ethiopia 2. Iran (Islamic Republic of) 3. Kenya 4. Sudan 5. Uganda 6. Yemen	7. Afghanistan 8. Eritrea 9. Iraq 10. Oman 11. Pakistan
C. Countries at high risk	**D. Countries at risk**
12. Armenia 13. Azerbaijan 14. Egypt 15. Georgia 16. India 17. Jordan 18. Kazakhstan 19. Kyrgyzstan 20. Lebanon 21. Syrian Arab Republic 22. Tajikistan 23. Turkey 24. Turkmenistan 25. Uzbekistan	26. Algeria 27. Libyan Arab Jamahiriya 28. Morocco 29. Tunisia

The Programme foresees the possibility of contingency activities taking place for other wheat-producing countries not in the above-mentioned list should problems related to Ug99 arise.

2.4 Past and related work

FAO has been involved in activities related to the management of the Ug99 crisis since the alarm was sounded by Dr Norman Borlaug, 1970 Nobel Peace Prize winner, during the Rust Summit in Nairobi, Kenya, in September 2005. FAO participated in the Rockefeller Foundation supported Nairobi summit and during which the Global Rust Initiative (later renamed BGRI) was officially launched and endorsed by all countries and institutions attending the summit.

Since the Rust Summit, FAO has convened, in cooperation with its BGRI partners, several expert meetings and workshops in Rome to share international knowledge

on the status of the disease and risk of its spread, virulence changes, breeding developments and potential breeding strategies and options for field disease management and international cooperation.

BGRI partners have been active in developing projects both jointly and independently to obtain funds in support to help countries manage the Ug99 crisis. Apart from its own funds, BGRI has obtained funds from the United States Agency for International Development, the Canadian International Development Agency, the Indian Council of Agricultural Research, the Arab Fund for Social and Economic Development, the International Fund for Agricultural Development (IFAD) and Cornell University.

Figure 3: Participants to the Nairobi Summit visiting the Ug99 disease international nursery in Njoro, Kenya (2005)

Funds have been used to support countries affected by or at risk of Ug99, mostly in capacity building (i.e. surveillance, pathotyping and breeding) and infrastructure support.

FAO's Wheat Rust Disease Global Programme will be implemented through a number of complementary projects funded by various donors including FAO. FAO has already secured funds for field activities over the next three years totalling over USD 1.7 million. Funding sources include the Spanish and Italian Trust Funds and Cornell University's special project on "Durable Rust Resistance in Wheat". Activities include capacity building in pathotyping and field surveillance as well as coordination meetings for awareness raising, needs assessment and preparation for contingency planning.

2.5 FAO's comparative advantage

2.5.1 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.

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

Through the EMPRES Desert Locust programme, FAO has 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.

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

Through working closely with national governments, most recently with its Initiative on Soaring Food Prices, FAO 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; FAO is also well positioned to lead in the development of an international early warning system for Ug99 and other potential virulent wheat rust strains.

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

FAO has vast experience with national seed systems in its member countries 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.

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

Through farmer field schools (FFSs), 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 management of the disease 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).

2.5.6 Accelerated varietal 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). FAO's Global Plant Breeding can also facilitate the breeding capacity building activities to be provided to national counterparts through BGRI partners.

2.5.7 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 (WFP), FAO is most suited to lead the 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 the international wheat trade and prices.

2.5.8 FAO and emergency response

FAO has decade-long experience in emergency response, recovery and rehabilitation in a number of countries that are either affected by or at risk of Ug99. This is particularly true for countries in East Africa as well as Pakistan and Afghanistan, where FAO Emergency 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.