ICARDA

International Center
for Agricultural Research
in the Dry Areas

Research to Action

Strategies to reduce the emerging wheat stripe rust disease

Synthesis of a dialog between policy makers and scientists from 31 countries at: International Wheat Stripe Rust Symposium, Aleppo, Syria, April 2011

Solutions for countries:

- Surveillance and rapid response
- Crop breeding
- Sharing of country experiences and information
- Regional and country wheat improvement strategies
- Capacity strengthening
- Scaling-up resistant varieties

The *International Wheat Stripe Rust Symposium* was organized by **ICARDA** – the International Center for Agricultural Research in the Dry Areas – in collaboration with the Borlaug Global Rust Initiative (**BGRI**), the International Maize and Wheat Improvement Center (**CIMMYT**), the Food and Agricultural Organization (**FAO**) of the UN, the International Development Research Center (**IDRC**, Canada), the Association of Agricultural Research Institutions in the Near East & North Africa (**AARINENA**), and the International Fund for Agricultural Development (**IFAD**).

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This report provides a synthesis of concepts, practices and interventions coming from ICARDA's research program with country partners on improving livelihoods, performance of agricultural production systems and sustainable agriculture in the world's dry areas.

It aims to provide decision makers and development professionals with new and practical perspectives – to add value to their programs and inform decision making on agriculture and rural development policies, practices and programs in the world's dry areas.

Feedback

ICARDA welcomes comment and feedback on this publication.
Please visit www.icarda.org/wheatrust to share your views.

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"Rust never sleeps"

Nobel Peace Prize winner
Dr Norman Borlaug.

About Wheat Rust diseases

There are three important types of rust diseases that affect wheat crops –

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- Stem Rust, also called or black rust
- Leaf Rust, also called brown rust

Yellow Rust/Stripe Rust

Yellow rust (also called stripe rust) *Puccinia striiformis* is a very important disease of wheat, particularly in Central and West Asia and North Africa. Here it is reckoned to have caused recurrent, severe damage in crops since the dawn of agriculture.

The historical view is that stripe rust is principally a disease of wheat grown in cooler climates (2°C - 15°C), and generally associated with higher elevations, northern latitudes or cooler years. But recent outbreaks have defied this assumption with current strains of the disease more adapted to high temperatures, and hence countries closer to the equator.

Because the disease attacks from early in the growing season, plants are often stunted and weakened. Crop losses can be severe (50 - 100%), due to damaged plants and shriveled grain.

Epidemics of stripe rust continue to cause severe losses and have been reported in Afghanistan, Azerbaijan, Ethiopia, Georgia, Kenya, Kyrgyzstan, Morocco, Iran, Iraq, India, Pakistan, Syria, Tajikistan Turkey, Turkmenistan, and Uzbekistan in recent years. Stripe rust epidemics have also occurred in the Australia, Europe, China and the United States.

In 2009-10, the outbreak of Yr27 – an aggressive new strain of stripe rust – caused significant yield losses in Azerbaijan, Ethiopia, Iran, Iraq, Kenya, Morocco, Syria, Turkey, Uzbekistan, and threatening the food security and livelihood of resource-poor farmers and their communities.

It is this changing, dangerous face of stripe rust and its growing threat to vast areas of the world's wheat crops that provided the core business of the 2011 International Wheat Stripe Rust Symposium in Aleppo and which is the principal focus of this report.

Black/Stem Rust

Stem rust (also called black rust), is caused by *Puccinia graminis*. It is also referred to as summer rust due to the abundant production of shiny black spores, which form at the end of the crop growing season. Stem rust is favored by humid conditions and warm temperatures of 15°C to 35°C.

The fear of black rust through history – and today – is understandable. An apparently healthy crop three or four weeks before harvest can be reduced to a black tangle of broken stems and shriveled grain. Harvest losses of 100 percent can occur in susceptible crop varieties.

Brown/Leaf rust

Leaf (or brown) rust is chiefly caused by *Puccinia triticina* and occurs to some extent wherever wheat is grown. The disease develops rapidly at temperatures between 10°C and 30°C. Leaf rust losses in grain yield are primarily attributed to reduced flower set and to grain shriveling. In highly susceptible wheat varieties, the crop can be killed by early epidemics. Crop losses due to leaf rust are usually small (less than 10 percent), but have been known to cause up to 30% crop losses.

New ideas, new collaborations, new communications to fight rust in the world's major wheat growing areas

Aggressive new strains of wheat rust diseases – stem rust and stripe rust – have decimated wheat yields in recent harvests. Key areas affected are East Africa, North Africa, the Middle East, Central Asia and the Caucasus. Rust diseases have reduced the wheat harvests is in Egypt, Ethiopia, Iran, Kenya Morocco, Syria, Turkey, Uzbekistan, and Yemen, in the past five years.

"These epidemics increase the price of food and pose a real threat to rural livelihoods and regional food security," says Mahmoud Solh, Director General of the International Center for Agricultural Research in the Dry Areas (ICARDA), which organized and hosted the wheat stripe rust symposium with national and international partners.

In most of the countries in the Middle East, Central Asia and the Caucasus - where wheat can contribute more than 40% of people's food calorie intake and 20% of protein[2] - wheat rust epidemics cause real hardship for farming communities.

Climate change brings rising temperatures, and has increased the variability and intensity of rainfall, contributing to the spread and severity of rust diseases. Emerging variations (or races) of rust are showing that they can adapt to extreme temperatures – a phenomenon not seen before.

Scientists and agricultural specialists around the globe are working to more effectively monitor, track and combat the spread of wheat rust diseases. Early detection and well-organized reporting are the keys to better managing and reducing wheat rust in regions at risk. This helps farmers, policymakers, national agricultural research and extension services to rapidly respond to outbreaks.

Information flows, knowledge and collaboration across countries are key. This synthesis report is an effort to quickly capture the knowledge and experience shared at the meeting, and share these with all concerned.

This report is a synthesis of the evidence debated and best practices shared by a group of leading scientists, with agriculture and development policy makers from many countries. It is a call for interventions, action and long-term investment in combating wheat rusts.

A long-term investment is needed to reduce the threat of stripe rust

A significant investment has been made over the past five years in surveillance and controll of stem rust. This disease is critical, appearing at the end of the growing cycle and capable of decimating an entire harvest in weeks.

The deadly stem rust race Ug99 has not yet spread to major wheat growing areas in Central and West Asia and North Africa, after its first detection in Uganda 1998.

Stripe rust, in contrast, is endemic – farmers and countries live with it every day. And every day it debilitates crops in the countries of East and North Africa, the Middle East Central Asia and the Caucasus. In spite of its favorability to cooler environments, stripe rust is rapidly spreading to new areas where it was not a problem before. Aggressive new stripe rust races are adapting to warmer climates, causing recent outbreaks at the global level.

Comparatively, investments in stripe rust reduction are small and less coordinated across countries. To reduce the current spread of stripe rust, more investment to support countries to improve surveillance, breeding of durable varieties that resist stripe rust are needed as it evolves in these wheat producing regions.

[1] Data from many presentations and discussions at the meeting e.g. 70% loss in Syria, Yahyaoui presentation.

[2] FAO/CIMMYT figures, Braun presentation.

Strategies to address wheat stripe rust disease.

"Cereal rust epidemics increase the price of food and pose a real threat to rural livelihoods and regional food security"

Dr. Mahmoud Solh,
Director General ICARDA.

A call to action for continued investment

The purpose of this report is to provide new perspectives, share countries' experiences and highlight potential solutions to the wheat rust diseases that are re-emerging today, threatening livelihoods and productivity growth in many low-income countries.

It has been prepared to inform government decision-makers and agricultural planners in countries affected by wheat rusts, and in the international development and donor communities – on what is needed to effectively manage the threat of these wheat diseases.

The history and potential dangers of a wheat rust epidemic are known and have been discussed frequently in agriculture and development circles in the past decades. This report takes the discussion one step further. It examines the practical steps that can be taken to reduce the risk of large-scale crop damage from wheat rust, focusing specifically on the needs of low-income countries.

In summary, what is needed to reduce the threat of wheat rust to our harvests and people›s livelihoods, is a sustained investment in strengthening:

- **Surveillance and information exchange** between countries.
- **Planning, awareness and preparedness** to rapidly deliver appropriate seeds and fungicides where they are needed to arrest the spread of wheat rust diseases.
- **New capacity and skills** in ministries, extension services and at the farm level to develop effective strategies for managing rust diseases.
- **Crop research** for a continued, long-term effort of developing of new varieties that are resistant to the emerging races of wheat rust.

The concepts and approach summarized in this report are based on decades of crop science research on developing disease-resistant wheat varieties that are used by farmers today in the world's major wheat growing areas.

This is a synthesis of the debates of over 100 scientists and policymakers from 31 countries – at the *International Wheat Stripe Rust Symposium*, organized by ICARDA in Aleppo, Syria in April 2011– among leading crop scientists, agricultural economists and policy makers from many low income countries that are dealing with stripe rust problems on a daily basis.

The status of world wheat

Wheat is the world's most important food crop and its most traded. In the developing world it is the second most important crop after rice. Wheat feeds about 2.5 billion poor people (living on less than $2 a day) in some 90 countries and is a crucial source of calories and protein.

Amongst all the discussions on world food security, wheat is a central issue. There is currently a red alert for global food security - and much of that alert is down to the state of wheat.

Demand for wheat currently outstrips the world's ability to produce it, so global stocks are constantly under pressure. It's not hard to see that modern, international, commodity-driven markets fail the poor and the under nourished. Such people are now clearly being priced out of the world wheat arena.

There is an urgent need to increase and protect local wheat production in low and middle-income countries. The shepherding of natural systems to deliver boosted wheat production isn't easy. Nature has some surprises up her sleeve – and not all of them are pleasant, wheat rusts included.

1 The urgency of combating wheat rust in a hungry world

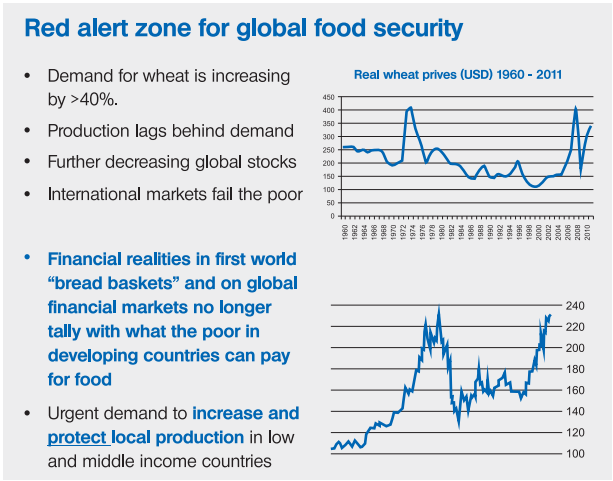
The emergence of new wheat rust diseases and their threat to food security and development

Wheat rust diseases are well known in the world's developing countries. Countries have successfully managed rusts over the past decades using disease-resistant wheat varieties. Today the situation and the threat from wheat rust is fundamentally different from the past. Changes in temperature and rainfall patterns have encouraged the emergence of new races of rust that overcome the currently resistant wheat varieties.

Low-income countries need to put in place strategies now for immediate action, medium-term protection and long-term research efforts to develop new wheat varieties that resist the changing rust diseases.

Across the globe, pressures on food security are being made worse by crop diseases that are emerging more frequently and then rapidly spreading. It's a situation fuelled by climate change and certain farming practices in increasingly fragile ecosystems.

Wheat is one of the most critically important staple foods worldwide. Its harvests have come under increasing threat in recent years from new kinds of fungus infections, such as wheat rusts, that are killing these crops. Wheat rust is well known to farmers and agricultural planners around the world, who have been dealing with it since the early 1900s.[3] But in the past decade, new races have emerged that are overcoming the wheat crops that had been resistant to these rusts to date.



Source: The Economist commodity-price index for food.

A global problem that hits hardest in low-income countries

Wheat rust is a global problem. But perhaps the greatest threat lies in the broad arc from North Africa through to South Asia – from Morocco to India. Any serious crop disease outbreak or epidemic in these wheat-dependent countries could cost billions of dollars in attempted control and lost agricultural output. The resulting spike in food prices would push bread and other basic wheat-based goods out of the reach of many, with potential political implications.

The most critical of these wheat rust diseases are stripe rust and potentially stem rust (*see box page 1*). They are spreading more rapidly than in the past and new variations of the diseases are overcoming presently rust-resistant wheat varieties that have been developed by researchers in the recent years.

[3] Parks presentation (information since 1919). Wanyera Kenta presentation (1909)

Wheat 'mega varieties' susceptible to Stripe Rust – some examples, past and present

- Sardari – Iran
- Gerek – Turkey
- Akhtar – Morocco
- Cham 8 – Syria
- Inquilab 91 – India and Pakistan
- PBW343 – India and Pakistan
- Bezostaya – Central Asia & the Cacauses
- Attila – Central, West Asia and North Africa
- Veery – Central, West Asia and North Africa
- Bobwhite – Central, West Asia and North Africa
- Kauz - Central, West Asia and North Africa

Source: ICARDA.

The most rapid spread of wheat stripe rust we have ever seen?

Plant pathology experts at the *International Wheat Stripe Rust Symposium* in Aleppo and elsewhere say that the world may be witnessing – in these rusts - the most rapid spread of important crop disease ever seen. Under the right conditions wheat stripe rust infection can spread – carried by the wind – from one wheat growing region to another in just 24 hours.

Today, the possibility of a serious stripe rust pandemic that devastates millions of hectares of wheat production is more than a 'scenario'. The disease is widespread and dispersed in almost all wheat growing regions and it presents an uncertain, and changing genetic target for crop researchers and agricultural planners.
Climate change is driving the speed and frequency of today's new wheat rust problems. It provides the ideal conditions for these new rust races to spread, unchecked, across many countries.

Countries can benefit from each others' experience in preparedness and rapid response to wheat rust diseases. Those with a more developed framework in place to deal with wheat rusts are able to reduce its negative impact on crop production. For example, Syria in 2010 lost between 20 and 70 percent of its wheat to stripe rust, while neighboring Turkey kept losses to under 20 percent[4]. In Syria, monitoring was less implemented; three-quarters of the crop consists of a single variety; and fungicides are not readily available. In contrast, Turkey has a well-established rust monitoring network, a wide range of wheat varieties ready for use - some of which are rust resistant; and substantial, ready supplies of fungicides, for rapid action against intrusion of new kinds of wheat rusts.

Status Summary

Component	Stem Rust	Stripe Rust
Coordinated Global Response	✓	x
Clearly defined target	✓	?
Information Systems + Data Management	✓	x (not global)
Surveillance Networks + Tools	✓	Spillover from stem rust (timelinness?)
Pathotyping Capacity	✓(with limitations)	✓(GRRC, some limitations)
Ahead of Disease progress?	✓	x

Source: Hodson, CIMMYT - Rust Status Summary.

Fighting rust as a social disease

One of the core issues for planners and policy makers is that stripe rust does not respect national borders. The tiny spores of the disease can quickly blow from one area to another – the disease multiplies in the year-round wheat fields of Yemen and can easily menace Iran; Kenyan stripe rust (also from year-round growing wheat) moves quickly to Ethiopia.
Regional and international cooperation is vital to seriously addressing rust diseases – no single country or organization can control the disease on its own. In this sense, rust is a 'social disease', and can best be managed by shared agricultural practices and policies agreed across regions. The fight against rust requires good neighbors, working together.
Rust specialists have also likened the disease to a 'fire-storm', which will travel unhindered across a region of wheat varieties if they are not resistant. To defeat a firestorm or bushfire one needs to remove the fuel. To fight rust you need to avoid, prevent or discourage the growing of highly susceptible wheat varieties, says one of the world's most experienced wheat rust scientists, Dr Robert McIntosh, Professor Emeritus of the Plant Breeding Institute of the University of Sydney.

[4] Yahyaoui presentation ICARDA/CIMMYT

A need for effective regional cooperation

At the regional and international level there is a need to build a cooperative attitude to information sharing, the mutual sharing of risk analyses, and trust in each other's actions, says McIntosh.. The datasets that need collecting and sharing across regions include information on monitoring of changing rust disease patterns, wheat variety use per region, changing agronomic practices and observations of climate change and weather patterns.

The recent creation of 'rust trap nurseries' across affected regions is a good example of an effective strategy for early detection and prevention of stripe rust. A trap nursery is a special set of wheat varieties of known rust resistance that is grown in a wheat producing area. As rust moves across a region, researchers and planners can immediately see the effect of new races of rust on wheat varieties, and organize for dissemination of the most resistant varieties for the following season.[5]

So far, compared to the international response to the perceived devastation that could come from stem rust (Ug99), the response status to stripe rust has got some catching up to do.

Increased attention to Stripe Rust – the risk of 'mega-varieties'

There is a call to action for increased attention to the dangers of stripe rust. Two new highly aggressive strains have appeared widely in recent years. Worryingly, researchers have found that a key resistance gene (Yr27) used in the breeding of many susceptible wheat varieties used across Asia and Africa has broken down, laying them open to infection. That worry is compounded by the fact that wheat varieties, with the Yr27 resistance gene included in them, are currently planted on more than 15-20 million hectares in North and East Africa, the Middle East and into Asia. Such hugely ubiquitous varieties are termed mega-varieties.

Stripe Rust surveillance, early warning, and rapid action – examples from Iran

The example of Iran shows how rust surveillance and early warning can provide rapid action to slow the spread of rust and prepare a stock of new resistant varieties for future growing seasons.

Iran has established a network of agricultural extension specialists and researchers, for the rapid exchange of information by e-mail and telephone to report and track the incidence of wheat rust.

In one case, the Iranian network was informed of new races of rust in Syria and Azerbaijan. The Iranian experts visited different fields to assess if this was the known rust strain that was currently being managed, or if it was new. It was found to be a new strain of wheat rust to Iran.

To assess the situation, the monitoring network gathered information in 20 monitoring locations, identified the rust race and the fungicide needed to treat it. They then notified Iran's plant protection office to inform of the product needed.

Fortunately an effective chemical was available, registered for use in the country and was rapidly deployed. Based on these findings, the protection organization prepared a stock of fungicides to treat this rust strain over 400,000 hectares of wheat fields.

In another case, the Iranian network received reports that a new rust strain, called YR27, was spotted in nearby Yemen. Their investigations revealed a small incidence in Southern Iran, but it was very localized.

To manage the situation the Iranian authorities established a trap nursery in the area to test the rust strains to track their characteristics. Wheat breeders across the country sent samples to be included in the nursery. Based on this early warning information, in the past three years in Iran, 10 resistant wheat varieties resistant to YR27 identified. Seed of resistant varieties were prepared and released to farmers across the country.

[5] ICARDA has been involved in the creation of rust trap nurseries to improve rust monitoring in 32 countries.

2. Strategies and best practices for countries to reduce the risk of wheat rust

"Rust is a social issue"

Dr Robert McIntosh,
University of Sydney
Plant Breeding Institute.

Sharing experience and approaches across several low-income countries

An effective national strategy for combating wheat rust has four key components: surveillance and rapid reaction plans; information sharing across countries; capacity strengthening – for government officials, extension services and farmers; and participation in ongoing research programs to develop resistant wheat varieties.

A multi-faceted approach is needed by countries to combat wheat rusts. Immediate action to combat new rust races is often the use of fungicides. Reducing the cropping of susceptible mega-varieties across vast wheat growing areas is perhaps the best insurance policy against widespread rust damage. Countries can consider policies to plant a range of resistant wheat types in their farming systems – greatly reducing the risk of emerging virulent rust types spreading over the entire area. A long-term plan includes continued investments in crop research. Countries can participate in international research efforts to continually develop wheat varieties that resist rust and other diseases.

2.1 Surveillance, preparedness and rapid reaction

Efforts in rust surveillance and research on breeding wheat for rust resistance are being stepped-up across developing countries but much more still needs to be done.

Some effective approaches shared by agricultural planners at the ICARDA Symposium include the creation of national and regional wheat rust networks of scientists and agriculture extension specialists to provide early warning and information exchange on rust incidence in their area.

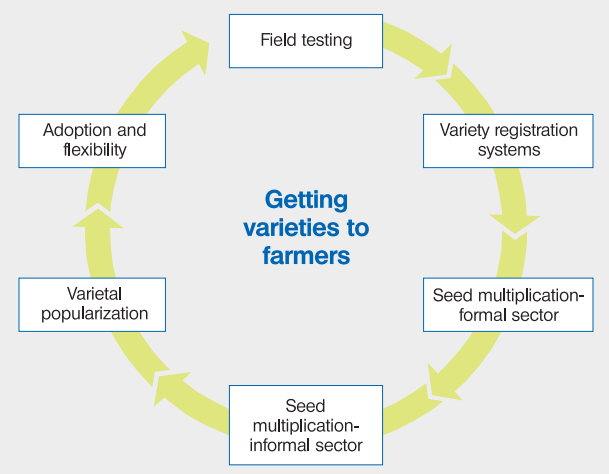
At the global level the *Wheat Rust Toolbox* created by Aarhus University in Denmark uses geographic information systems technology to map rust types and movements around the world. This data should be shared via the internet and the Rust Spore Global Wheat Rust Monitoring system set up by the FAO and the Borlaug Global Rust Initiative (BGRI)[6].

This is complemented by the Global Rust Reference Laboratory[7] also at Aarhus, that is establishing itself as the international centre for rust type analysis and research.

[6] Hodson Slide 11 and Jens Hansen presentation

[7] Hovmoller presentation.

National and regional rust laboratories need upgraded skills and facilities to provide local early warning services at the field level. These local rapid reaction networks are vital to monitor new rust incidence and test rust races to advise on the spread of the disease and appropriate interventions.



Source: adapted from Khoury, FAO.

Because rust can cover a lot of ground in 24-48 hours, these local networks are a vital first line of defense. Global databases may be updated several times a month. During certain times of the growing season, local action even requires daily information.

Colleagues from Iran explained how their surveillance network (a group of colleagues using mobile phones and e-mail) was able to respond to information of a stripe rust outbreak in Yemen – quickly detecting and identifying that a new rust type had entered the country *(see country profile, page 11)*, but was still very localized. This allowed them to prepare an action plan – mobilizing chemicals and resistant seeds – for the next growing season.

This combination of daily local information and the global databases are crucial. As 'rust never sleeps' – neither must the rust watchers and rust information sharers.

Regionally and internationally, preparedness is also being raised through the wider actions of the Borlaug Global Rust Initiative.

But more efforts are needed. Quite simply, every country needs a surveillance and early warning system that links field level information to other parts of the country and beyond. This based on good contacts with colleagues in neighboring countries.

At is most basic level, such a system involves the national plant protection organizations and extends right through to wheat growing farmers. Farmers need training so they can spot, and deal with the disease. Extension specialist need to work with farmers, so they can appreciate that they are the link that can stop rust diseases from spreading.

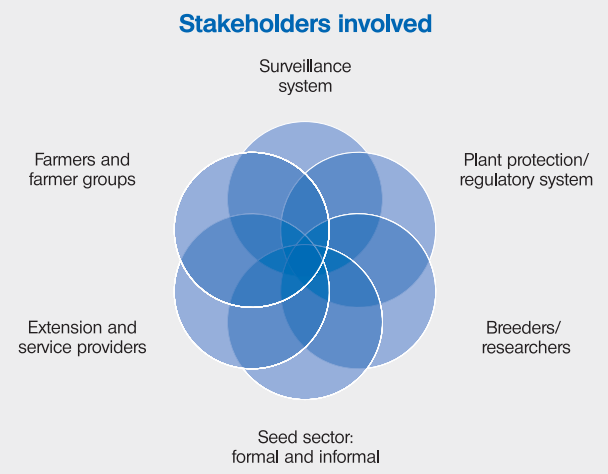
Diversified cropping strategies

Diversified cropping of wheat – avoiding the sowing of mega-varieties across large cropped areas – is another possible defense against wheat rust. In most areas of the Middle East, East Africa and South Asia, farmers have been planting the same varieties for 20-30 years. This practice is not advisable in a situation where the rust races are mutating and new ones are emerging much more rapidly than the past and overcoming resistance the current varieties.

An approach to seed multiplication and farmer engagement with new, diverse varieties

1. Identify rust resistant and high yielding wheat varieties with desirable characteristics.
2. Fast-track variety test and release (e.g. adaptation trials) by pursuing flexible policy/regulatory options with partners.
3. Accelerate pre-release seed multiplication of promising lines and large-scale production of released varieties for distribution through both formal and informal channels.
4. Popularize and promote rust-resistant varieties among farmers (including targeted small-pack seed distribution) to initiate informal farmer-to-farmer seed sharing and diffusion.
5. Build capacity in technical aspects of seed production and in the provision of infrastructure (training and critical equipment).

Source: Adapted from Khoury, FAO.



Source: Khoury, FAO.

As it takes about 10 years to develop a wheat variety with new resistance – and no one knows when and where new rust races will appear – the most effective strategy to combat new rust races is to diversify cropping patterns, and have various types of rust resistant varieties readily available.

In practice, this means that farmers and their extension advisers need to realize that no single variety of wheat should form more than a quarter (or less) of their (or the national) crop.

In many low-income countries, despite growing pressures from rusts and rust epidemics, farmers are still reluctant to move away from the traditional wheat varieties (in some cases 40 years old) that they know and trust. This is because:

- Smallholder farmers are generally risk adverse
- New varieties don't always meet local farmers' needs or preferences
- There is limited information on their availability
- There is limited availability or access to seeds of new and resistant varieties.

With surveillance systems and communication of rust alerts must also come capacity strengthening of extension workers and farmers. Both groups need to be aware of the dangers of mega-cropping in today's new rust environment. This includes being aware of the benefits of using new resistant wheat varieties – that may be new to them but have been tried and tested by researchers and farmers in other regions.

2.2 Breeding and seed solutions

Crop research – the breeding of disease-resistant wheat varieties – is the chief line of long-term defence for wheat crops against stripe rust, and in fact, for all rust diseases.

International efforts to develop new wheat varieties resistant to rusts are spearheaded by agricultural research centers such as ICARDA and CIMMYT, working closely with national research and extension programs and commercial breeders or seed companies. Disease resistance can be built into wheat, but the development cycle is typically about ten years (ten generations of breeding and testing resistance in a new variety) for new varieties to be released and made available to farmers.

The current epidemic threat is from an aggressive new type of stripe rust, that has overcome the in-bred resistance in current wheat varieties, making them susceptible to the disease.

Australia as a "rust lab"

Isolated as it is in the Southern Ocean, Australia and its cereal growing regions provide a unique test bed/laboratory to study and survey cereal rusts.

Over nearly 100 years, researchers in Australia have tracked rust pathogen population dynamics. The key conclusion from the surveys, which started in 1919, is that the pathogenic variability (new strains of rust) observed in cereals in Australia chiefly come from mutation and from periodic incursions of exotic rusts from overseas.

In that period there have been eleven recorded instances of new, 'exotic' rust types – four of them particularly aggressive in their impact on Australia's key cereal crops of wheat and triticale.

The good news is that the Australian cereal breeders have a good track record in responding to these new arrivals. Today they are working hard to breed varieties resistant to the latest incursion – Stripe rust race 134. Until the resistant variety is found, the country is paying some $90 million each year for fungicide bill to control it in the wheat fields of Australia.

There remains the worry – that is clear from the collected Australian data – that exotic rust incursions seem to be occurring ever more frequently. The intercontinental spread of rust over vast ocean distances is driven by many vectors. Wind and the so-called "747 syndrome" of global travel are the main contributors. Agricultural tourism and the movement of farmers and researchers visiting rust-prone sites present a special challenge.

Stripe rust

Early action was not taken by most countries, resulting in several national epidemics, crop loss, a lack of availability of commercial seeds of resistant varieties and a rush to use chemical (fungicide) control.

The good news is that major variety replacement programs are now finally under way in Afghanistan, Ethiopia, India, Pakistan, Syria and Uzbekistan. In Egypt, for example, the faster release and accelerated seed multiplication of new resistant varieties – in just three years – has led to a seed production program that can cover 30% of the country's wheat growing area. The new varieties being used have new resistance genes and mostly offer better grain quality and higher yields – real inducements for enthusiastic farmer adoption of them. Other countries need to follow suit.

Benefits from 'slow-rusting' wheat varieties

An alternative approach in wheat breeding is being pursued - breeding and deployment of slow rusting (or durable) adult-plant resistance (APR). This approach allows wheat to grow and yield acceptably alongside rust, with a low level of disease attack and minimal effect on yield and seed quality.

So far, some wheats with various levels of APR to all three rusts have been bred. Progress has been made in understanding the genetic basis and genetic diversity of resistance to stripe, stem and leaf rusts. There is optimism among crop researchers that high-yielding wheat varieties with a high level of resistance to all three rusts could soon be a reality. In fact, triple rust-resistant (APR) varieties are becoming available that have 10-15% higher yields than presently popular varieties.

Plant breeders though are still frustrated by the generally slow multiplication of seeds of these new varieties, faster release and adoption of their new, superior varieties in the target countries to enhance productivity and increase food security. The breeders' have a mantra - "If uniformity is the core of genetic vulnerability, then diversity is the best insurance against it". It seems common sense.

2.3 Use of fungicides

Fungicides can be the first line of defence against new varieties of wheat rust. In wealthier countries, fungicides are used on a large scale as a key part of the national food security strategy.

"Timely information sharing - from surveillance and plant protection officers, to wheat breeders, seed system and extension agents, and farmers is key."

Dr Wafa El Khoury, coordinator of the Wheat Rust Disease Global Program, (FAO).

Lower-income countries cannot always afford the luxury of large-scale chemical treatment of fields affected by rust. But chemical interventions do provide a practical, rapid-response solution, for example, to stop local intrusions of new rust races – giving the authorities time to assess the races and multiply new resistant varieties.

In the high-income countries of Europe, Australia and the Americas, farmers can manage disease pressures in wheat production with fungicide applications.

It's a different story in the developing world. Many countries do not have the right fungicides registered to combat wheat rusts. The logistical issues faced by low-income countries are how to provide small-scale wheat farmers with the right chemicals, on time and at an affordable cost. Other needs are the necessary sprayers, protective clothing, and knowledge for their use or relevant training. For fungicides to be effective you need information on disease onset to be shared widely and early – surveillance systems are needed.

Despite these hurdles, emergency fungicides are used where possible in developing countries. Examples include Ethiopia in 2010 when 30% of the wheat area was sprayed and over $3 million worth of fungicides were distributed. In Iran fungicides are registered, supplied and regularly used in emergency situations – under rust campaigns directed by the national plant protection organization.

Fungicides registered for fighting wheat rust

Syria
Bayfidan 250 (Baytan 30, Summit): Preventive
Broad spectrum for various disease but also effective on rust
Amistar (Azoxystrobin): Curative
Other names Abound, Heritage, Protégé, Quadris Opti, Quilt
Nativo (Tebuconazole): Broad Spectrum
Other names (Horizon, Foliccur, Gaucho, Raxil, Silvacur, Wolman)
Score (Difenoconazole)
Other names: Dividend, Helix, Bardos, Neptune

Morocco
Opus (Epoxiconazole) Sphere (Cyproconazole + Trifloxystrobine)
Allegro (epoxiconazole + Kresoxim Méthyl)
Impact RM (Flutriafol + Carbendazime)

Turkey
Duet Ultra
Prosper Combination
Mexico
FOLICURE (Tebuconazole)
OPUS (EPOXICONAZOL)
SICO (DIFENOCONAZOLE)

Source: ICARDA.

2.4 The future

While it is highly unlikely that wheat rust can be eradicated, there is some scope for optimism for the future. Rather than reacting to food crises, sustained, proactive investment is needed to support agricultural research and country preparedness actions so that countries can better manage rust problems over the long-term.

The solution for low-income countries and the development partners that support them is a combined strategy of continued disease surveillance, development and dissemination of new resistant varieties, seed multiplication and adoption by farmers, research, and research capacity strengthening. Increased surveillance – both national and regional – involves the testing and tracking of rust races using geo-spatial tools, the monitoring of the wheat varieties they attack and then determining which varieties are rust resistant.

In the shorter term, rapid detection, disease reporting and a good national/ regional contingency plan is required for targeted chemical control on initial rust outbreaks. This 'puts out the fire' of stripe rust and helps stop epidemics in their tracks.

2.5 Sharing country examples: national approaches to combating wheat rusts

Country profile – Ethiopia

Between 10% and 20% of calories in the Ethiopian diet come from wheat. Wheat accounts for about 20% of the crop area in Ethiopia. Wheat productivity was 0.6t/ha in 1960s, now 2.0t/ha and reached up to 6t/ha on research sites.

- Major stripe rust epidemics in Ethiopia in 1970's, 1988, 2010. Disease occurs regularly in highland areas – over 2000m above sea level. In 2010 at least 400,000 ha affected. Serious losses, though difficult to quantify. The epidemic covered almost all wheat growing regions in the country except Tigray Province. Most of the commercial bread wheat cultivars were susceptible.
- National policy (with international help, ICARDA, CIMMYT, etc.) is to develop high yielding, stable, disease resistant varieties with good grain quality and adaptable to the different agro-ecologies in Ethiopia.
- Emergency fungicide applications are used - in 2010 30% of the wheat area was sprayed and over $3 million worth of fungicides were distributed.
- A critical issue in Ethiopia is seed multiplication of new rust resistant varieties. New efforts in both the informal (farmer fields) and formal seed sectors to produce, clean and bulk up seed of resistant varieties. Efforts are so far limited by funding. In the late 1990s the average age of varieties being used in farmers' fields was greater than 14 years.
- In 2010 local agencies, including the Ethiopian Ministry of Agriculture worked on raising rust awareness at all levels of the country's farming sector. A wheat rust control manual was prepared and distributed. Farmers are being encouraged to diversify the wheat varieties they use.

Country profile – Iran

Over 40% of calories in the Iranian diet come from wheat. 6.6 million ha of wheat in Iran – irrigated and rain-fed. Ranked 18th in top world wheat producing countries. Between 1980's and today an 85% increase in wheat yield. Average yield of wheat now 3.7t/ha.

- Major stripe rust epidemics in Iran in 1993, 1995, (15% yield loss), and 2002/4. In 2010 – some 300,000 tons of wheat was lost, valued at $110 million. The situation would have been far worse if effective controls of fungicide use and variety choice were not widely deployed.
- The national wheat breeding program - with international help in four different Iranian climate zones at 33 research stations - released new Yr27 resistant varieties. There was a breeding focus on high-yielding resistant varieties, replacing susceptible ones with resistant ones. Over past three years, ten resistant wheat varieties of YR27 have been released for the different climate zones of Iran.
- In the late 1990's the average age of varieties in farmers' fields in Iran was 8-10 years.
- An advanced system of rust surveillance in-country and with regional neighbours (Yemen, Syria, Azerbaijan etc.). Use of GIS to prepare cropping calendar for regions of the country under threat. Timely communication (phone, email) at all levels of the farming industry - agricultural extension specialists and researchers, individual farmers.
- Fungicides are registered, supplied and used in emergency situations -campaigns directed by national plant protection organization.

Between 30% and 40% of calories in the Pakistani diet come from wheat. Wheat covers 40% of the crop area in Pakistan – it is the tenth largest wheat producer in the world. Wheat production increased nearly 600% between 1948 and 2010 - land area for wheat increased 129% in the same period. Average Pakistan wheat yield 2.5 to 2.7 tonnes per ha.

Country profile – Pakistan

- Last big yellow rust epidemic in Pakistan in 1995 – 20% loss in affected areas. Along with India, Pakistan had a lucky escape from yellow rust in wheat in 2010 as the weather and other environment conditions didn't favour the disease in that season. The disease though remains on Pakistan's doorstep, with big infections in close neighbours such as Uzbekistan in 2009 and 2010.
- Pakistan wheat growing challenged by climate change, narrowing of wheat season, high price (attractiveness) of other crops such as rice and cotton. Along with non-availability/slow distribution of certified seed of rust resistant varieties.
- Fungicide control not feasible over the 8 million ha of wheat in the country – expensive and chemicals/spray machinery not available.
- Reliance on cereal breeding delivering high yielding wheat with rust resistant genes. In late 1990's the average age of wheat varieties being grown in farmers' fields was between 6 and 8 years old.

Stripe Rust in Syria in 2010 – lessons learned

In 2010 a serious epidemic of stripe rust affected the Syrian wheat crop. The first signs of serious infection were logged by farmers and extension workers in February and into March.

Useful lessons have been learned from Syria 2010 stripe rust epidemic. Emergency plans are being developed to avert future serious pest and disease problems across all strategic crops in the country (wheat, cotton, sugar beet, potato).

Crops most seriously affected were bread wheat in northern, north-eastern and central Syrian provinces. The high-yielding modern varieties such as Cham 8 and Cham 10 fields, sown with a high seed rate and irrigated wheat, were particularly hard hit. High seed rates and spray irrigation create humid environments in the crop – ideal for rust infection and spread.

A new race of stripe rust was detected in mid-February 2010 in northeastern Syria, near the Syria-Iraq-Turkey border. This new strain was identified as a Yr27 virulent variety, which adapted to higher temperatures and spread to nearly all wheat growing areas[8].

Why did it happen?

In Syria the winter of 2009/2010 was mild. During the three coldest months (Dec, Jan, Feb) recorded temperatures were 3-6°C above average in wheat growing areas with hardly any days of usual frost. Until mid-February rainfall was above average in most agricultural zones - followed by a spring drought through March and April.

After mid-April (and into May) the weather remained cold and sporadically rainy, favouring new disease cycles. These late infections reached the wheat's flag leaf and even the grain spike in many fields.

[8] K. Nazari, ICARDA.

The unusual weather was exacerbated by some of the agricultural practices of Syria. Traditionally local farmers use a high seed rate; when irrigation is used it is often disorganized; popular varieties such as Cham 8 are mono-cropped across large areas; many farmers are not geared up to use pesticides generally and fungicides in particular. Another issue was the general lack of fungicide availability within Syria, and its expense and lack of registration for use.

Up to two million tons of potential wheat crop were lost in Syria in 2010. About half of this loss is directly attributed to the stripe rust epidemic, the rest to other pests, disease and drought.

Lessons learned?

Useful lessons have been learned from the 2010 Syria experience. At the broadest level - emergency plans for future serious pest and disease problems across all strategic crops in the country (wheat, cotton, sugar beet, potato) are being developed.

Specifically for wheat - the level of awareness for wheat rust diseases across Syria is now very high. Training among farmers for visual detection has been widely promoted by plant protection and extension services in collaboration with ICARDA. But still in 2011 Syrian bread wheat fields were sown with susceptible cultivars and large areas of mono-cropping persists. Local breeders along with international bodies such as ICARDA and CIMMYT are working together to multiply and commercially release resistant varieties as quickly as possible. Within three to five years this should be achieved.

Fungicide control is now recommended to be applied soon after rust detection. Procedures within Syria to register and import new fungicides have been accelerated and simplified. And forecasting/early warning systems for wheat rust are being installed and tested across the country- planned to be up and running in 2012.

There are also moves to reform agricultural higher education in Syria with a new emphasis on training broad-spectrum plant breeders, plant pathologists and agronomists. These are all key specialties that have been lost in many countries – not just Syria – in recent years.

East Africa as a “rust factory”

Rust never sleeps – but it abides in East Africa. Not only is the region the cradle of mankind, it is one of the key cradles for the birth of new rust strains. The stem rust Ug99 first appeared in Uganda and many stripe rust outbreaks and epidemics also have their origins in the region.

As early as 1908 when European settlers arrived in Kenya they found that stripe rust attacked their wheat crops. The disease remains a threat every year and there are no varieties commercially available to local farmers that are fully rust resistant.

Rust disease severity increases with altitude and is thought to be linked to the increased levels of UV radiation at high elevations on the equator. This increases mutation.

But the major factor driving rust development in East Africa (and in Kenya in particular) is the presence of the so-called “Green Bridge”. In no other country on Earth can you find wheat growing every month of the year in all its growth stages. Alongside one Kenyan wheat field being harvested might be another being sown and others at varying growth stages. This provides the perfect environment for rust pathogens to survive and thrive and to mutate into new dangerous, virulent races. In other countries, if a new strain of result is detected in a local area, it can be kept under control. The agricultural service has one year to prepare control measures for the next growing season – the right fungicides and available resistant. The Kenyan year-round cropping model gives planner far less time to prepare.

Researchers note that today, stripe rust is on the increase in Kenya. The latest strains are aggressive and are rapidly defeating wheat varieties that were resistant to other kinds of rust over the years. There is call for a new international effort on stripe rust race typing in Kenya and an equally strong collaborative push on breeding durable and resistant wheat.

3. Planning a national strategy

"Some countries affected by rust epidemics have invested very little in agricultural research and development"

Hans Braun,
Director, Global Wheat Program, International Maize and Wheat Improvement Center (CIMMYT), Mexico.

A range of practical approaches and experiences were shared at the International Wheat Stripe Rust Symposium by participating research and government policy makers. Participating countries are aware of the wheat rust problem and are taking steps to combat it.

It also emerged that agricultural planners and managers countries could benefit from a more structured approach – or framework – for planning and tasking specific groups in the country with responsibility for the various practical aspects of managing wheat rusts.

This guideline refers to practical approaches used by various countries. It is proposed as a guide and planning tool for decision makers to start the process of designing an approach to managing wheat stripe rust – nationally and to linking with other countries.

Guideline for national wheat stripe rust management

Issue		Examples of tasks	Action plan
Organizing surveillance & rapid response	Does a national and regional network exist ? What coordination mechanisms are in place?	Countries will benefit from stripe rust surveillance networks of a similar structure to established stem rust groups.. Establish or re-activate national networks. Allocate financial support for surveillance activities at national level. Develop standard protocol for national and regional rust surveillance. National research systems can endorse and collaboration with international rust centers (such as Global Rust Reference Center, Aarhus University, Denmark). Upgrade national rust laboratories, new surveillance platforms and race analyses. Establish regional rust networks and ongoing communication. Convene an annual rust coordination meeting per region. Data sharing. Create information exchange platform and 'people processes'. Plant protection organizations to become more active in surveillance activities. Harmonized protocol on rust surveillance to be used by both research and plant protection. The Durable Rust Resistance in Wheat framework already exists in Central and West Asia and North Africa for stem rust surveillance. Same framework needs to be established or current coordination networks have to be expanded to yellow rust. With involvement of plant protection, fungicide registration will be easier. Create stripe rust scientific team at national, regional and international level. The team should officially take responsibly in collaborative yellow rust networking, surveillance and data sharing	National agricultural systems are requested to establish, extend and strengthen their surveillance teams and to participate in regional rust surveillance networks. Global and regional actors (e.g. ICARDA, FAO, CIMMYT and BGRI) can facilitate rust networking in Central and West Asia and North Africa). As there is no regional rust laboratory in the stripe rust-affected areas ranging from East Africa to the Middle East, West Asia and North Africa, collaboration with global rust centers is important. It needs to be supported by national systems and the international rust community.
	Coordinator in place linking plant protection office with field level information. Person responsible for liaising with global rust community/ regularly updating global rust databases.	Key contacts list by district. Key contacts list for the region/ neighboring countries. For yellow rust surveillance team, official contact person at national level needs to be identified and nominated by NARS. Surveillance equipment such as GPS and digital cameras to be provided to national systems by national focal person. With development of national yellow rust surveillance and nomination of contact person, a regional/ international coordinator is needed to link the national rust surveillance teams at regional and international level. As the same stripe rust problem threatens neighboring countries, a regional agreement may be necessary to test and recommend effective fungicides. A coordinated regional fungicide evaluation and registration team can facilitate duplication of registration procedures for the disease in different countries.	Financial support and advocacy for all these activities are a key component. Advocacy and search for financial support is requested to be coordinated by CGIAR centers, FAO and BGRI.
Risk assessment and planning.	National assessment of stripe rust risk vs current cropping. Ensure registered fungicides and sufficient quantities for cropping season. Plan for strengthening capacity for seed availability and multiplication.	Asessment proces that is regularly updated. Assess fungicide types, needed obtain registrtaion and build stocks as appropriate. List of resistant seeds available and what other countries are doing Available seeds - rapid Seed multiplication	
Capacity building for stripe rust management.		Provide evidence that changing varieties will not negatively affect yields. Information on available varieties and the characteristics. Help with Rust management plan. Training for plant protection staff on surveillance protocols. Plan for building capacity for surveillance.	Capacity building and training to be developed and supported by national and international rust community. ICARDA is one of the rust labs that can provide technical support to upgrading skills and facilities in national rust laboratories and to provide training in all aspects of wheat rust particularly yellow rust.

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المركز الدولي للبحوث الزراعية في المناطق الجافة
International Center for Agricultural Research in the Dry Areas

Aleppo Declaration on the continuing threat of stripe rust to global wheat production

Aleppo, Syria, April 2011

Scientists, research managers and donors from 31 countries met at the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, during 18-20 April to discuss the risk and potential implications of epidemics of yellow (stripe) rust disease on wheat production.

They warned that global food security could be severely threatened by stripe rust epidemics, and that the CWANA region (Central and West Asia and North Africa) was particularly vulnerable.

This Declaration is a call for sustained, coordinated responses to this threat. Action plans must be developed and implemented in the immediate future, with the full commitment of every stakeholder group: researchers, extension services, public and private sector seed agencies, farmer organizations, national policy makers, regional development fora, and international donors.

This Declaration is also a commitment to support the recently established global wheat rust reference center to provide scientific leadership of yellow rust research; share skill and resources to strengthen rust R&D at national level; and enhance capacity development, particularly in developing countries with a history of stripe rust epidemics.

We pledge to continue to work together to prevent wheat rust – particularly stripe rust – using a science-based approach; to integrate wheat rust

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We, the signatories to this Aleppo Declaration:

1. Pledge our support for strengthening the global rust reference laboratory, and upgrading skills and facilities at national and regional rust laboratories.
2. Urge Ministries of Agriculture in all countries to accelerate the replacement of rust-susceptible varieties by closely integrating research, seed production and dissemination, extension services and farm communities.
3. Recommend the appropriate use of fungicides as a key control measure during the period between detection of varietal susceptibility and availability of new resistant varieties to farmers.
4. Strongly recommend that formal networks be created (with adequate funding and clearly defined roles) for germplasm distribution, disease surveillance, and sharing of information.
5. Commit to greater efforts for capacity development across all rust disciplines including breeding, pathotyping, surveillance, seed production and socio-economics.
6. Strongly urge that epidemic forecasting systems be put in place as part of a regional strategy, to provide advice and support for action by Ministries of Agriculture.
7. Follow up on these recommendations will be through small group coordinated by ICARDA with involvement of BGRI, CIMMYT, FAO and three national programs selected in different regions where Stripe Rust is of economic importance.

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INTERNATIONAL WHEAT STRIPE RUST SYMPOSIUM
ICARDA, ALEPPO, SYRIA

18-20 APRIL 2011

PROGRAM

Day 1, Monday April 18

09:30:10:00 Opening Remarks
Chairperson: **Maarten van Ginkel**

Mahmoud Solh, Director General, ICARDA
Ronnie Coffman, Director, Durable Rust Resistance in Wheat Project; Vice Chair, Borlaug Global Rust Initiative, Cornell University, USA
Mr. Abdulla T. Bin Yehia, FAO Representative, Damascus, Syria
Hans-Joachim Braun, Director Global Wheat Program, CIMMYT

10:00-10:30 Keynote Address Global Threat of Wheat Rusts: Historical Overview of Stripe Rust Research
Robert A. McIntosh, Professor Emeritus, Plant Breeding Institute, University of Sydney, Australia

Session 1. Global Status of Wheat Rusts: The Challenges Ahead

Chairperson: **Michael Baum**

11:20-11:40 The International Status of Yellow (Stripe) Rust: An Imperative to 'Combine our Efforts'
Colin R. Wellings
The University of Sydney, Plant Breeding Institute

11:40-12:00 Country Preparedness to Face Yellow Rust Epidemics: Situation in Developing Countries
Wafa El Khoury,
Wheat Rust Global Program, Plant Production and Protection Division, FAO, Rome, Italy

12:00-12:20 Why Breeding for Resistance Alone is Not Sufficient to Control Yellow Rust Epidemics
Hans-Joachim Braun
Global Wheat Program, International Maize and Wheat Improvement Center (CIMMYT), Mexico

12:20-12:40 Durable Rust Resistance in Wheat (DRRW): Phase I Achievements and Phase II Prospects
Ronnie Coffman, Director, Durable Rust Resistance in Wheat Project; Vice Chair, Borlaug Global Rust Initiative, Cornell University, USA

Session 2. Global Status of Wheat Rusts: Regional and Global action

Chairperson: **Wafa Khoury**

12:40-13:00 BGRI Global Rust Monitoring: Challenges and Opportunities for Stripe Rust
David Hodson
Wheat Rust Disease Global Program, AGP Division, FAO
Rome, Italy

14:00-14:20 Status of Wheat Stripe in CWANA: Analysis of Current Outbreaks
Kumarse Nazari
International Center for Agricultural Research in the Dry Areas
Aleppo, Syria

14:20-14:40 Update on Global Rust Center: Overview and Challenges Ahead
Mogens Hovmøller
Department of Integrated Pest Management, Faculty of Agricultural Sciences, Aarhus University, Denmark

14:40-15:00 Wheat Rust Toolbox Related to New Initiatives on Yellow Rust
Jens Grønbech Hansen
Department of Agroecology and Environment, Faculty of Agricultural Sciences, Aarhus University, Denmark

15:00-15:20 Continental Sweeps and Aggressiveness in Wheat Rust Pathogens
Robert Park, Colin R. Wellings
The University of Sydney, Plant Breeding Institute, University of Sydney, Australia

15:20-15:40 Discussions

Session 3. Breeding Strategies for Wheat Rusts: Challenges

Chairperson: **Mustafa Aghaee**

15:40-16:00 CIMMYT: Breeding Strategies and Methodologies to Develop Stripe Rust Resistant Bread Wheat Germplasm
Ravi Singh
Global Wheat Program, International Maize and Wheat Improvement Center (CIMMYT), Mexico

16:00-16:20 ICARDA: Development of Stripe Rust Resistant Spring Bread Wheat Germplasm for CWANA
Osman Abdalla
International Center for Agricultural Research in the Dry Areas
Aleppo, Syria

17:00-17:20 CIMMYT/ ICARDA Winter Wheat Breeding Strategies and Methodologies to Develop Stripe Rust Resistant Bread Wheat Germplasm
Alexi Morgounov, B. Akin, Y. Kaya, M. Keser, K. Nazari, Z. Mert, R. Sharma, T. Wuletaw
IWWIP, Ankara, Turkey

17:20-17:40 Sources of Resistance to Stripe Rust in Synthetic Hexaploid Wheat
Habte-Mariam Zegeye, K. Nazari, A. Badebo W. Denbel and F. C. Ogbonnaya
Ethiopian Institute of Agricultural Research, Debre Zeit Research Center, Debre Zeit, Ethiopia

17:40-18:00 Status and Constraints of the Seed System in CWANA for Rapid Multiplication of Resistant Varieties
Zewdie Bishaw
International Center for Agricultural Research in the Dry Areas
Aleppo, Syria

18:00-18:15 Targeted Mapping of Loci Conferring Resistance to Yellow Rust in Pavon-76/Borlaug RIL population
Abdulqadir Jighly, A. Yaljarouka, K. Nazari, I. Tahir, O. Abdalla and F.C. Ogbonnaya
International Center for Agricultural Research in the Dry Areas
Aleppo, Syria

18:15-18:30 The Use of Weather Monitoring and Disease Models in Cereal Diseases
Zuhair Al Sett
Debbane & Co, Damascus, Syria

18:30-19:00 Discussion Panel

Day 2, Tuesday April 19

Session 4: Reports from Countries on Stripe Rust Pathogen Status and Variability

Chairperson: **Francis Ogbonnaya**

14:00-14:20 Pathotypic Evolution of Yellow (Stripe) Rust in CWANA (1998-2008)
Amor Yahyaoui, Shafiq Hakim, Mogens Hovmoller
International Center for Agricultural Research in the Dry Areas (ICARDA)

14:20-14:40 Status of Stripe Rust Population in China
Wanquan Chen
Institute of Plant Protection, Chinese Academy of Agricultural Science
Beijing, China

14:40-15:00 Status of Stripe Rust Research in India
Arun Kumar Sharma
Crop Protection (AICW&BIP), Directorate of Wheat Research, Karnal, India

15:00-15:20 Yellow Rust Status in Kenya
Wanyera, R., P. Njau, S. Bhavani, K. Nazari and S. Kilonzo
Kenya Agricultural Research Institute (KARI), Njoro, Kenya

15:20-15:40 Breeding, Survey and Epidemiology of Yellow Rust in Tajikistan in 2010
Mahbubjon Rahmatov, Hafiz Muminjanov, Zebuniso Eshonova, Ahad Ibrohimov, Mirzoali Karimov, Mogens Hovmøller, Kumarse Nazari, Alexey Morgounov
Tajik Agrarian University, Tajikistan

15:40-16:00 Yellow Rust Epidemic on Bread Wheat, and Population of P. striiformis f. sp. tritici Virulences in Syria
Al-Chaabi, S., T. Abu-Fadel, Y. Omran and W. Taweel
Research and Plant Protection Administration, GCSAR, Syria

16:00-16:20 Monitoring and Distribution of Yellow Rust Disease on Wheat in Iraq
Emad Al-Maaroof, , Kumarse Nazari, David Hodson, Laith A. Muhammad, Azad H. Naser, Abdul Hamid M. Abdul Razak, Saman S. Ali, Sherko A. Fatteh, Nebez J. Rasheed, Hatem M. Hussien, Mahdi L. Laize, Reeber S. Naef and Kubad K. Tufeek
Sulaimani University, Iraq

17:00-17:20 Status of Wheat Stripe Rust Disease in Iran during 2009-2010
Farzad Afshari
Seed and Plant Improvement Institute (SPII), Karaj, Iran

17:20-17:40 Virulence and Molecular diversity in Puccinia striiformis f.sp. tritici from Iran
H. Rabbani-Nasab, M.Torabi- M. Abbasi- J. Mozaffari
North Khorassan Agricultural and Natural Resorce Resaerch Center, Iran

17:40-18:30 Discussions Panel

Day 3, Wednesday April 20

Session 5: Disease Impact and Management

Chairperson: **Ravi Singh**

09:00-09:20 Global Threats to Wheat Production
Sanjaya Rajaram and Amor Yahyaoui
International Center for Agricultural Research in the Dry Areas, Aleppo, Syria

09:20-09:40 Lessons From the Stripe Rust Epiphytotic of Syria in 2010: Facing False Concepts
Fawaz Azmeh
Faculty of Agriculture, Damascus University and National Commission for Biotechnology (NCBT), Damascus, Syria

09:40-10:00 Epidemiology and Management of Yellow Rust of Wheat in Jammu Subtropics
Vishal Gupta, Rayees Ahmad Ahanger and V.K. Razdan
Division of Plant Pathology, Faculty of Agriculture, Catha, India

10:00-10:20 Impact of Wheat Stripe Rust in Turkey: Breeding and Control Strategies
Z. Mert, K. Akan, L. Çetin, N. Bolat, T. Akar, A. Yorgancılar, B Ercan, R. Ünsal, A. Tülek, i. Özseven, H. O. Bayramoslu, Ü. Küçüközdemir, H. Ay, N. Dinçer, A. ilkhan, S. Yazar
Central Research Institute for Field Crops, Turkey

10:20-10:40 FAO Regional View on Plant Protection in Central Asia
Hafiz Muminjanov
Plant Production & Protection Officer, FAO, Turkey

11:20-12:00 Discussions Panel

Session 6: Regional Wheat Stripe Rust Epidemics in Recent Years: Control Strategies and Lessons Learnt (Country Case Studies)

Chairperson: **Mogens Hovmoller**

12:00-12:15 Impacts of Wheat Stripe Rust in Syria: Breeding and Control Strategies
Mohamed Walid Taweel
The General Commission for Scientific Agricultural Research (GCSAR), Douma, Damascus, Syria

12:15-12:30 Impacts of Wheat Stripe Rust in Iran: Breeding and Control Strategies
Mostafa Aghaee, General Director, Seed and Plant Improvement Institute, Karaj, Iran

12:30-12:45 Impacts of Wheat Stripe Rust in Morocco: Breeding and Control Strategies
Abdelhamid Ramdani
National Agricultural Research Institute-INRA Meknes, Morocco

12:45-13:00 Impacts of Wheat Stripe Rust in Uzbekistan: Breeding and Control Strategies
Zokhidjon Ziyadullaev
Seed Production Research Institute, Kashkadarya Region, Uzbekistan

14:00-14:15 Impacts of Wheat Stripe Rust in Turkey: Breeding and Control Strategies
Zafer Mert
Central Research Institute for Field Crops, Ankara, Turkey

14:15-14:30 Impacts of Wheat Stripe Rust in Ethiopia: Breeding and Control Strategies
Solomon Assefa, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia (EIAR)

14:30-14:45 Impacts of Wheat Stripe Rust in Pakistan: Breeding and Control Strategies
Pakistan representative

14:45-15:30 Discussions Panel – Lessons Learnt
15:30-16:15 Regional and Global Collaboration
Mahmoud Solh, Hans Braun, Ronnie Coffman, Wafa Al Khoury, Robert McIntosh

Panel open discussion: Panel discussion will address the wheat stripe rust problem and the way to develop regional rust collaboration platforms

16:15-16:30 Symposium Closure
Closing remarks
Sanjaya Rajaram
Aleppo declaration

POSTERS

Characterization of Resistance to Wheat Rusts in Iranian Wheat Cultivars and Advanced Lines
Patpour, M., K. Nazari, F.C. Ogbonnaya, F. Afshari, A. Al-Ahmed, A. Yahyaoui, M. Naimi

Determination of Stripe Rust (*Puccinia striiformis* f. sp. *tritici*) Disease Reaction Against The Common Wheat Which Developed for Konya Province Dry Areas Ecological Conditions
Birol Ercan, Birol Ercan , ilker Topal, ibrahim Kara, Emel Özer, Ahmet Günes

Characterization of Resistance to Wheat Rusts in 27 Cultivars from Azerbaijan
Nazari, K., K. Aslanova, M. Patpour, F. Ogbonnaya, M. Al-Ahmed, B. Hoffmann, A. Morgounov

Sources of Wheat Yellow Rust Infection in Kazakhstan
Rasaliyev, Sh. S.
Research Institute for Biological Safety Problems, Kazakhstan

Cereal Breeding for Resistance to the Stripe Rust in Kazakhstan
Ainebekova B.A., Zhangaziev A.S., Absattarova A.S

Simultaneous Selection for Yellow Rust And Terminal Drought Tolerance in CIMMYT Originated Bread Wheat Genotypes
Gholam Hossein Ahmadi., Y. Mannes, M. R. Jalal Kamali

Status of Wheat Stripe Rust Research in Georgia
Sikharulidze, Z.V., K.T. Natsarishvili, N. Chkhutiashvili

Stripe Rust Distribution and Virulence in the North Caucasus Region of Russia
Yury Shumilov, Galina Volkova

Status of Yellow Rust Research in Kyrgyzstan
Damira Tokoeva

Occurrence and Monitoring of Yellow Rust in Tajikistan During 2003-2010
Otambekova, Munira, M. Rahmatov, H. Muminjanov, B. Husenov, Z. Eshonova, A. Ibrohimov, M. Karimov, A. Morgounov

Biotechnological approaches to combat with Puccinia striiformis f. sp. tritici on Turkish wheat germplasm
Karakas, Ö., S. Hasancebi, F. Ertugrul, K. Akan, Z. Mert, N. Bolat

Distribution of stripe rust in Mazandaran
Foroutan, A.R.
Plant Protection Research Institute, Mazandaran research Center, Sari, Iran

Prevalent Virulences of Wheat Stripe Rust (Puccinia striiformis West f. sp. tritici) and their distribution in Syria During 2006 and 2007»
Shoula Kharouf, Fawaz Azmeh, Amor Yahyaoui and Shady Hamzeh
National Commission of Biotechnology (N.C.B.T), Damascus, Syria

OPINION – SciDev.Net website, May 2011

Mahmoud Solh, director general of the International Center for Agricultural Research in the Dry Areas (ICARDA). Shivaji Pandey, director of the UN Food and Agriculture Organization. Thomas Lumpkin, director general of the International Maize and Wheat Improvement Center (CIMMYT). Ronnie Coffman, vice-chair of the Borlaug Global Rust Initiative (BGRI).

Developing countries need help with crop surveillance and the development of strains resistant to wheat rust, say agricultural research leaders.

Today›s food security situation is being worsened by strains of wheat rust disease that are emerging more frequently and spreading much faster and to new areas – changes fuelled by climate change and conducive environments in increasingly fragile ecosystems.

Perhaps the most problematic wheat diseases are the two kinds of wheat rust: stripe rust (also called yellow rust) and stem rust (black rust).
To protect their crops from the fungus that causes wheat rust, countries need to take pre-emptive action with sustained investment in research, surveillance, a strategy to boost crop diversity, and policies to encourage farmers to adopt disease-resistant crop varieties.

Rust epidemics

A new form of stem rust known as Ug99 took several growing seasons to spread from the highlands of Uganda and Kenya in 1999, via Ethiopia and Yemen, to reach Iran by 2007. The disease could spread even farther – from Iran to the vast wheat fields in Turkey, Afghanistan, Pakistan and India, which are largely sown with varieties not resistant to Ug99.
Stripe rust is also prevalent in most of the world›s major wheat-growing areas. In the past 30 years, it has caused severe economic losses to crops in North America, Europe, Australia, Central Asia, West Asia, South Asia and North Africa. The losses ranged from 30 to 50 per cent of the expected grain yield of a country›s wheat production. And last season, an epidemic of a virulent new kind of stripe rust caused wheat losses of up to 40% in Western Asia.

Epidemics of stripe rust in the 1980s – caused by a strain that overcomes resistance in many wheat varieties – spread from East Africa to the Middle East, Turkey, Iran, Afghanistan, Pakistan and India. They affected major wheat-growing regions and hit the livelihoods of millions of farmers. In the following years, researchers released varieties of wheat that were resistant to this strain in most of these areas. But many of these varieties are susceptible to the new strain of stripe rust that began to spread last season and continues to spread rapidly. This aggressive new strain, called YR27, is tolerant of higher temperatures and adapts rapidly to new environmental conditions.

Growing threat

The threat of a repeat of the 1980s epidemic is growing, and scientists who track wheat rust pathogens are warning countries to be prepared.
An epidemic in these wheat-dependent countries could cost billions of dollars, creating a further spike in food prices, reducing food security and causing political tensions. Developing countries are stepping up their efforts in surveillance and research on breeding wheat for rust resistance.
For example, networks of scientists and agriculture specialists are exchanging information for an early warning of rust incidence in their area; scientists are using ‹slow-rusting› genes to extend the time that varieties can resist the disease in a bid to slow down the progression of epidemics; and farmers are avoiding covering large areas with wheat varieties with similar genetic backgrounds and degrees of resistance.
Although researchers can build disease resistance into wheat, this typically involves a ten-year cycle from development to the release of new varieties.
And while breeding programmes continuously develop resistant varieties, fungicides can be used to control wheat rust in cases of emergency. But this option is not generally affordable for resource-poor farmers, and fungicides are not environmentally friendly.

Sustained investment

Can wheat rust be eradicated? Norman Borlaug, the father of wheat improvement in the 1960s, noted that «rust never sleeps». Rust strains will continue to mutate and overcome crop resistance.

Rather than reacting to food crises, sustained investment is needed to support agricultural research and preparedness to help countries better manage rust problems in the long term.
Donor governments, development agencies and the international research community must increase their attention and support to low-income countries striving to develop strategies to prevent wheat rust. And those countries need robust food-security strategies that include sharing information on crop breeding across regions.

Increased surveillance – both national and regional – involves testing and tracking rust types using geospatial tools, monitoring the wheat varieties they attack and determining which are resistant. Susceptible varieties can then be replaced by resistant ones.
In Iran, for example, a monitoring network of agricultural extension specialists and researchers gathered reports of new strains that prompted the country›s plant protection authorities to stock up on fungicide, and establish a nursery testing rust samples sent in by wheat breeders.

This helped scientists identify 10 varieties resistant to a strain of stripe rust over the past three years, which were then prepared and distributed to farmers.
Wheat-producing countries must also be encouraged to design agricultural systems that enable new seed varieties to be released and multiplied faster. In Egypt, for example, such a system has led to the production of new resistant varieties that can cover 30% of the country›s wheat-growing area in just three years. These varieties often offer better quality and higher yields – a powerful incentive for farmers to adopt them.

Faced with the threat of wheat rust epidemics, the solution for low-income countries and the development partners that support them is to adopt a combined strategy of continued disease surveillance, development and dissemination of new resistant varieties, strengthening research capacity, and ensuring that farmers adopt and multiply new seeds.