Wheat rust diseases in Central and West Asia and North Africa (CWANA) and breeding for the multiple disease resistance

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Wheat is a staple food for the majority of the population in North Africa, West Asia, Central Asia (CWANA) and the Caucasus, and the Nile Valley sub-regions with average wheat consumption of about 185 kg/capita/year, the highest in the world. The total wheat area in this region is about 52 million hectares involving spring bread and durum wheat and winter/facultative wheat, encompassing a diversity of production environments. The area extends east-west from the irrigated Indus Valley in Pakistan to the Atlas Mountains in Morocco; and south-north from the hot desert climate of Sudan to the temperate areas of Kazakhstan. This geographic expanse harbours all kinds of wheat of different growth habits: spring (61%), facultative (21%) and winter (18%). Wheat yields and production in CWANA are generally low and highly variable due to the variability in rainfall both between and within seasons, and a variety of abiotic (drought, cold and heat stress) and biotic (rusts, Septoria leaf blotch, root rots, Hessian fly, Sawfly and Sunn Pest) stresses. Several diseases of wheat, caused by parasitic fungi, viruses, bacteria, and nematodes, are capable of devastating wheat yields globally. Among these are the cereal rust diseases. Three wheat rusts; yellow rust, leaf rust and stem rust; caused by fungal pathogens *Puccinia striiformis* f. sp. *tritici* (*Pst*), *P. triticina* (*Pt*) and *P. graminis* f. sp. *tritici* (*Pgt*), respectively, are the most destructive plant pathogens threatening wheat production worldwide. Several epidemics of wheat rusts have been reported in the CWANA region causing significant crop losses. In the 1980s, high yielding cultivars carrying a common resistance gene to yellow rust (*Yr9*) occupied the majority of the wheat growing areas in the CWANA region from Ethiopia to Pakistan. A yellow rust epidemic in the 1980s and 1990s coincided with the appearance of virulence for *Yr9* throughout wheat growing areas in the region challenging sustainable wheat production. The *Yr9* virulence detected in Ethiopia in 1986 migrated to Yemen in 1991 then to Egypt and West Asia (1991-1992) and reached India (1996) over a period of 10 years riding on wind currents from west to east. One example of crop losses caused by wheat yellow rust is the estimated losses in Iran of 1.0 and 1.2 million tonnes in 1992 and 1994, respectively. Mega cultivars with *Yr27* (PBW343 in India, Inquilab 91 in Pakistan, Chamran and Shiroudi in Iran, Kubsa in Ethiopia, and Imam in Sudan) are currently occupying more than 15 million hectares in these countries. Recent evidence shows that a highly aggressive population (race) of *Pst* is widely distributed in India, Pakistan, Iran, and Central Asia. Using yellow rust trap nursery data and occasionally race analysis, it is concluded that recent outbreaks of yellow rust in CWANA region are largely because of the wide spread of a yellow rust population (race) with virulence for *Yr27*, which has in turn caused significant crop losses. Very recent reports from Uzbekistan indicate a widespread outbreak of yellow rust in Uzbekistan, which can move to other neighbouring countries in central Asia and Caucasus.

Stem (black) rust caused by *Pgt* was once the most serious disease of wheat worldwide. The damage caused by wheat *Pgt* can be more severe than any other cereal disease. Farmers are understandably fearful of stem rust, which can reduce an apparently healthy crop to a black tangle of broken stems and shriveled grain just three weeks before harvest. The widespread use of resistant varieties in the major wheat-growing countries has significantly reduced disease incidence and, on occasion, averted major epidemics for more than four decades.

From the 1970s, the alien translocation comprising a 1RS chromosome from rye attached to the 1BL chromosome of wheat became widely established in wheat cultivars around the world. The disease resistance genes in the 1BL.1RS translocation included *Sr31*, and varieties with this gene became

established even in areas where stem rust was not a recognized problem. *Sr31* is common in European winter wheat cultivars and spring wheat germplasms developed by CIMMYT and ICARDA. Stem rust race TTKSK (commonly referred to as Ug99), and its derivatives carrying virulence for *Sr24* and *Sr36*, are the only known races that possess virulence for *Sr31*. Ug99 was first detected in Uganda in 1998. The spread of Ug99 to Kenya (1999 to 2002), Ethiopia (2003), Yemen and Sudan (2006), and Iran (2007) suggests progressive migration from Uganda, following the pattern believed to have occurred for the spread of wheat stripe rust pathogen from East Africa in 1986 to India in 1998. Global screening of wheat genotypes in Kenya and Ethiopia where Ug99 was present indicated that more than 80% of wheat cultivars and advanced lines are susceptible to Ug99 including the most grown wheat cultivars in the CWANA region.

Leaf rust caused by *Pt* is the most common rust disease of wheat occurs to some extent wherever wheat is grown. The importance of wheat leaf rust is masked by frequent severe epidemics of yellow rust and is also controlled by cultivation of resistant cultivars in many wheat growing areas. Leaf rust has a great potential to cause severe crop losses if favorable conditions coincide with cultivation of susceptible cultivars. In CWANA, particularly in North Africa, leaf rust is a serious threat to bread and durum wheat production. The importance of wheat leaf rust is also increasing in Egypt, Sudan, Turkey, coastal areas in Syria, Yemen, the Caspian Sea shore and southern parts of Iran, and Central Asia and Caucasus regions. This might be because of pathogenic shifts in leaf rust populations.

Foliar diseases of wheat are also going to be very important limiting factors in wheat production particularly for the new farming zero tillage cropping systems in CWANA. Recently septoria leaf blotch caused by *Septoria tritici* Rob. Ex Desm has been recognized as one of the most economically serious disease of bread and durum wheat in CWANA region particularly in North Africa, Central and West Asia. Although the occurrence of septoria disease depends highly on favorable weather conditions for its establishment and spread, the disease appears every year in all wheat growing areas in North Africa and can be very damaging during favorable growing seasons. It is known to cause considerable yield losses in Tunisia on durum wheat, on bread wheat in Morocco, and on both durum and bread wheat in Algeria. In Tunisia, higher Septoria severity was noted on durum compared to bread wheat; whereas in Morocco, septoria is more important on bread wheat. This indicates that pathotypes in Tunisia are more adapted to durum then bread wheat; whereas in Morocco, the reverse is the case.

The major objectives of the wheat breeding- pathology program at ICARDA is to develop, in collaboration with NARS in the CWANA region, improved bread and durum wheat varieties with high and stable yields and better grain quality, that are resistant to biotic and abiotic stresses and adapted to targeted agro-ecosystems and production environments, including temperate rainfed (dryland) environments, favorable irrigated environments, continental areas where cold stress is predominant, and low latitude hot environments.

The most commonly applied strategies to control wheat rust diseases are host resistance and chemical control. The resistance strategy is preferable because it is relatively inexpensive in the long term, environmentally safe and will not add additional direct costs to farmers particularly in low yielding farming systems. The option of using fungicides may become even less favourable in the future because of restrictions in their use and by the increasing costs of discovery and registration of new active ingredients. It is not economically advisable to use even the highly effective systemic fungicides where crop productivity is low, which is common in less productive agricultural areas in CWANA and most of developing countries.

Understanding of wheat: rust pathosystems and implementation of host: pathogen knowledge is fundamental to breeding for rust resistance. Since wheat rusts have been considered as the major limiting factor in wheat production in CWANA, different approaches have been used by ICARDA's wheat breeding- pathology programs including conventional and molecular approaches to understand genetic

basis of pathogenicity and breeding for resistance. Taking into account diverse agro-climatical zones, high diversity of biotic stresses and plasticity of rust pathogens in this region, breeding for high yielding rust resistance and monitoring pathogenic variation of rust pathogens have been used by ICARDA's breeding-pathology program. In collaboration with CIMMYT and NARS pathogenic variation of rust pathogens has been studied for more than 2 decades using biological trap plots and to some extent by analysis of physiological races of rust pathogens.

Multilocation testing and breeding for the major pests is the main strategy that has been used for the identification and selection of germplasms adapted to the different agro-climatic conditions in CWANA. Multilocation testing is carried out at ICARDA's experimental stations and test sites at Tel Hadya and Breda in Syria, and Terbol and Kfardan in Lebanon. In addition to local testing sites and ICARDA's experiment stations, breeding germplasms are annually evaluated against biotic and abiotic stresses by regional multilocation tests and ICARDA's shuttle breeding.

This presentation will discuss the current situation of wheat rust diseases in CWANA, current pathology and breeding research activities and achievements and challenges ahead for multiple disease resistance. Emphasis will be given to pathogenic surveys and breeding for resistance to the three wheat rusts and also septoria leaf blotch disease of bread and durum wheat germplasm using conventional breeding and molecular approaches.