BGRI 2013 Technical Workshop

19–22 August, New Delhi, India

Index to Posters

Adoption or Rust Resistant Wheat

New Tools for Breeding

Mapping and Molecular Dissection of Rust Resistance

New Sources of Resistance

National and Regional Efforts toward Wheat Rust Resistance

70 **Exploring untapped variability for stripe rust resistance in indigenous wheat germplasm,** *C.N. Mishra et al.*

71 **Identification of slow ruster wheat genotypes for stripe and leaf rusts under artificially inoculated conditions,** *M.S. Sarahan et al.*

72 **Evaluation of barley genotypes for stripe rust (*Puccinia striiformis* f. sp. *hordei*) resistance in India,** *R. Selvakumar et al.*

73 **A need to diversify *Lr24*-based leaf rust resistance of wheat in central India,** *T.L. Prakasha et al.*

74 **Frequency of Ug99 resistant wheat lines derived from segregating populations selected under the Mexican and Mexico-Kenya shuttle breeding schemes,** *J. Huerta-Espino et al.*

Breeding Rust Resistance Durum Wheat

75 **Stem rust resistance in durum wheat,** *P.D. Olivera et al.*

76 **Breeding for leaf rust resistance in durum wheat in Morocco,** *N. Nsarellah et al.*

77 **Preliminary characterization of resistance to stripe rust from six elite durum lines,** *A. Loladze and K. Ammar*

78 **Leaf rust resistance in landraces and wild relatives of durum wheat from the Caucasus region,** *A. Loladze and K. Ammar*

79 **Characterization of leaf rust resistance of durum wheat lines derived from crosses with wild relatives,** *A. Loladze et al.*

80 **Mitigating the threat of leaf rust to durum yield stability in new, *Septoria tritici* blotch resistant, germplasm in Tunisia,** *M.S. Gharbi et al.*

81 **Identification and mapping of markers linked to leaf rust resistance in Indian durum genotype Malvilocal,** *A.L. Bipinraj et al.*

Global Surveillance Tools

82 **Wheat rust information resources: Integrated tools and data for improved decision making,** *D. Hodson et al.*

83 **FAO Global Wheat Rusts Program strengthens national capacities to manage wheat rusts,** *F.Dusunceli et al.*

84 **An SMS network tool for rapid surveillance of wheat rusts through extension offices: A pilot initiative in Turkey,** *F.Dusunceli et al.*

85 **A new early-warning system for stripe rust affecting wheat and triticale: Host-pathogen interactions under different environmental conditions,** *J. Rodríguez-Algaba et al.*

86 **Inferring the origin and trajectories of recent invasions of wheat yellow rust strains from worldwide population structure,** *S. Ali et al.*

87 **Screening for stem rust resistance in East Africa: A global effort to mitigate the threat of Ug99,** *S. Bhavani et al.*

National Surveillance Efforts

88 **SSR analysis of herbarium specimens of *Puccinia graminis* f. sp. *tritici* in South Africa,** *B. Visser et al.*

89 **Variation among *Puccinia graminis* f. sp. *tritici* isolates from wheat in South Africa, 2011 and 2012,** *T.G. Terefe and Z.A. Pretorius*

90 **The rusts of *Secale africanum* in South Africa,** *C.M. Bender et al.*

91 **Wheat rusts: Distribution and virulence analysis of stem rust in the major wheat growing regions of Ethiopia in 2012 and 2013,** *G. Woldeab et al.*

92 **Occurrence of wheat rusts in Algeria and strategies to reduce crop losses,** *A. Benbelkacem and H.J. Braun*

93 **The rusts on winter wheat in southeastern Kazakhstan,** *Y. Dutbaev et al.*

94 **Wheat stem rust research in Georgia,** *Z. Sikharulidze et al.*

95 **Wheat rust virulence in southern Russia,** *G. Volkova et al.*

96 **Phenotypic and genotypic analyses of Turkish *Pgt* samples collected in 2012 ,** *M. Newcomb et al.*

97 **Epidemics and adult-plant responses of Iranian wheat genotypes to the *Yr27*-virulent *Pst* race in 2013,** *F. Afshari et al.*

98 ***Puccinia striiformis* f. sp. *tritci* races and their distribution in Syria during 2008 and,** *S. Kharouf et al.*

99 **Physiologic specialization of *Puccinia triticina* on durum wheat in Syria in 2010,** *M. Kassem and M. Nachit*

100 **Virulence spectra of wheat rusts in Pakistan during 2012-13,** *A.R. Rattu et al.*

101 **Status of stripe rust and virulence patterns of *Pst* in Pakistan,** *J.I. Mirza et al.*

102 **Current status of *Pgt* virulence in Pakistan,** *J.I. Mirza et al.*

103 **Surveillance of wheat rusts in Bangladesh,** *P.K. Malaker et al.*

104 **Prevalence and distribution of wheat stripe rust in Jammu and determination of sources of resistance,** *V. Gupta et al.*

105 **Stripe rust of wheat: An Indian puzzle,** *S.C. Bhardwaj et al.*

106 **Virulence analysis of *Pst* isolates collected from western Canada,** *H.S. Randhawa et al.*

107 **Physiological specialization of *Puccinia triticina* on wheat in Argentina in 2011,** *P. Campos*

108 **Upgrading knowledge of Chilean hexaploid wheat yield losses caused by stripe rust and leaf rust,** *R. Madariaga and I. Matus*

Barberry Surveillance

109 **Barberry rust survey: Developing tools for diagnosis, analysis and data management,** *A.F. Justesen et al.*

110 **Survey of barberry and associated rust pathogens in Nepal ,** *M. Newcomb et al.*

Characterizing Wheat Rusts

111 **EMS mutagenesis of avirulent *Puccinia graminis* f. sp. *tritici* urediniospores,** *G. Singh et al.*

112 **Analysis of simple sequence repeats in genic regions of the wheat rust fungi ,** *R. Singh et al.*

113 **Analysis of effector proteins from the flax rust and wheat stem rust pathogens,** *P. Dodds et al.*

114 **Genome analyses of the wheat yellow (stripe) rust pathogen *Puccinia striiformis* f. sp. *tritici* reveal polymorphic and haustorial expressed secreted proteins as candidate effectors,** D.G.O. Saunders et al.

115 **Next-generation sequencing to characterize *Pst* races from western Canada,** *A. Laroche et al.*

116 **Identification and characterization of microRNAs and their putative target genes in *Puccinia* spp.**, *B. Pandey et al.*

117 **Characterization of seedling yellow rust resistance in wheat commercial cultivars, landraces and elite genotypes from Syria and Lebanon**, *R. Al Amil et al.*

Genetic mapping and QTL analysis of leaf rust resistance genes in Australian wheat cultivar 'Cook'

A. Akhmetova[1,2,3], D. Singh[4], R.F. Park[4], U. Bansal[4] and R.I. Bersimbay[3]

[1]CIMMYT, PO Box 1446, Astana 010000, Kazakhstan; [2]A.I. Barayev Research Institute for Grain Farming, 021601 Shortandy, Kazakhstan; [3]Department of General Biology and Genomics, Faculty of Natural Sciences, L.N. Gumilyov Eurasian National University, 010000 Mirzoyan St. 2, Astana, Kazakhstan; [4]Plant Breeding Institute Cobbitty, Faculty of Agriculture and Environment, The University of Sydney, Private Bag 4011, Narellan, NSW 2567, Australia

E-mail: aigkur@gmail.com

Leaf rust is a frequently occurring disease of wheat. The disease is best controlled by resistant cultivars. Australian cultivar 'Cook' shows moderate levels of adult plant resistance (APR) in the field to prevalent Australian *Pt* pathotypes. To understand and characterize leaf rust resistance in 'Cook', 197 lines from a DH Cook/Avocet S population were screened in the greenhouse at the seedling stage with four *Pt* pathotypes, and in the field with pathotypes virulent to the seedling resistance genes in 'Cook' and 'Avocet S'. Genetic analysis indicated involvement of three seedling resistance genes (*Lr3a*, *Lr13* and tentatively designated gene *LrM*) and a single APR factor. APR responses were completely correlated with existing genotypic data for the csLV34 marker (linked to *Lr34*). Based on multipathotype testing, genotypes (*Lr3/lr3, Lr13/lr13, LrM/lrM*) were deduced for each line. The assigned genotypes were integrated into an existing genetic linkage map of the population (based on 325 DArT markers) which determined the locations of genes *Lr3a* on chromosome 6B, and *Lr13* and *LrM* on 2BS. APR phenotypes in greenhouse and field experiments detected a QTL on chromosome 7D corresponding to *Lr34*. These results genetically validated the presence of genes *Lr3a*, *Lr34* in 'Cook' and *Lr13*, *LrM* in 'Avocet S'. As *Lr3a* is ineffective in Australia, the field leaf rust resistance of 'Cook' seems to be solely based on APR gene *Lr34* and has been effective since its release over forty years ago.

Breeding for durable rust resistance in Texas hard red winter wheat using synthetic-derived wheat lines

B. Reddy[1], A.M.H. Ibrahim[1], J.C. Rudd[2] and S. Liu[2]

[1]Soil and Crop Sciences Department, Texas A&M AgriLife Research, 2474 TAMU, College Station, TX 77843, USA; [2]Texas A&M AgriLife Research, 6500 Amarillo Blvd West, Amarillo, TX 79106, USA

E-mail: breddy@ag.tamu.edu

Texas is the forefront of the U.S. Puccinia pathway with climatic conditions favorable for development and winter survival of wheat rust pathogens. Unfortunately, cultivars widely grown in this region are susceptible to leaf rust, stripe rust and stem rust (including *Pgt* race Ug99). Therefore, multiple and novel resistance genes should be deployed in Texas A&M AgriLife wheat germplasm. Synthetic-derived wheat (SDW) (Synthetic lines × TAM cultivars) lines carry potentially novel alleles for biotic and abiotic stress resistances. To identify new sources of resistance, we evaluated 3,000 accessions of SDW for leaf rust and stripe rust response in naturally infected field nurseries at McGregor, TX, during 2012. Based on agronomic characteristics and disease resistance, 627 lines from 29 populations were selected for further evaluation at Castroville and College Station during 2013. About 28% of selected SDW were scored resistant/moderately resistant, 42% moderately susceptible, and 30% susceptible to leaf rust in 2012. In 2013, around 25%, 15%, and 60% of lines were scored as resistant/moderately resistant, moderately susceptible, and susceptible, respectively. Most of the 29 populations were segregating for resistance. Populations with *Aegilops tauschii* accessions WX518, WX208, WX417, WX879; TA2452, WX408; TA1645, WX458, WX430, WX198 in the pedigree had greater levels of resistance than others. Stripe rust was not severe enough to detect differences among accessions. Research is underway to determine allelic relationships among the sources of resistance within each population.

Resistance to *Pgt* race TTKSF in the wheat cv. Matlabas

Z.A. Pretorius[1], E. Wessels[2], K. Wolmarans[1] and R. Prins[1,2]

[1]Department of Plant Sciences, University of the Free State, Bloemfontein 9300, South Africa; [2]CenGen (Pty) Ltd., 78 Fairbairn Street, Worcester 6850, South Africa

E-mail: pretorza@ufs.ac.za

The South African wheat cv. Matlabas is resistant to *Pgt* races TTKSF, TTKSP and PTKST but susceptible to a variant (TTKSF+) detected in 2010. F_2 and F_3 populations derived from a cross between Matlabas and a stem rust-susceptible line segregated for a single gene for resistance to TTKSF. Both parents and all F_3 families homozygous for resistance to TTKSF were susceptible to TTKSF+. One susceptible (S) and two resistant (R) gDNA bulks were constructed using equimolar amounts of DNA from appropriate F_2 plants. A set of 105 SSR markers, previously developed for a low-resolution genome scan of all 21 linkage groups, was used to screen the bulks and parental lines. Initially only chromosome 2BS markers (GWM148, WMC35, and BARC160) and one multi-locus (2B, 5B) marker (WMC27) amplified alleles that were specific to the R bulks and Matlabas, but absent in the S bulk and susceptible parent. Linkage and QTL mapping using Joinmap V4 and MapQTL V6 of markers in 186 F_2 plants indicated that the gene is located between *Xbarc160* and *Xbarc167* in the centromeric region, and *Xgwm47*, on chromosome 2BL. From genes known to occur on 2B, *Sr9a, Sr9b, Sr9d, Sr9e, Sr10, Sr16, Sr19* and *Sr23* were ineffective whereas *Sr28*, *Sr36*, *Sr39* and *Sr40* were effective to both TTKSF and TTKSF+, indicating that the defeated Matlabas gene is different. Line LCSrWst2-Wst containing *SrWst-2* produced infection type 1, similar as Matlabas, to TTKSF but was susceptible to TTKSF+. Current evidence suggests that stem rust resistance in Matlabas was derived from cv. Webster.

Development of wheat lines with complex resistance to rusts

L. Herselman[1], M.J.P. van der Linde[1], S.L. Sydenham[1,2] and Z.A. Pretorius[1]

[1]Department of Plant Sciences, University of the Free State, PO Box 339, Bloemfontein 9300, South Africa; [2]Agricultural Research Council - Small Grain Institute, Private Bag X29, Bethlehem 9700, South Africa

E-mail: HerselmanL@ufs.ac.za

The aim of this study was to develop South African wheat lines with durable rust resistance, including resistance against all derivatives of *Pgt* race Ug99 (TTKS). Rust resistant wheat lines were developed using six parental lines containing the resistance genes/QTL *Qyr.sgi-2B, Lr34/Yr18*, *YrSp, Sr26*, *Sr2, Lr19, Sr39* and adult plant resistance to stem rust. Introduction of the different rust resistance genes/QTL was followed throughout the breeding program using marker-assisted selection and confirmed through phenotypic screening in the greenhouse using *Pt* race UVPt21, *Pgt* race PTKST and *Pst* race 6E22A+. At least eight promising lines containing five or more resistance genes/QTL were identified. Improved cultivars, and particularly faster development of rust resistant cultivars and lines, will benefit both breeders and producers.

Stripe (yellow) rust resistant spring bread wheat genotypes for the CWANA region

W. Tadesse, O. Abdella, K. Nazari and M. Baum

International Centre for Agricultural Research in the Dry Areas (ICARDA), PO Box 6299, Rabat, Morocco

Email: w.tadesse@cgiar.org

Stripe (yellow) rust and drought are the principal yield limiting factors for wheat production in the CWANA region. ICARDA's germplasm development approach is to identify stripe rust resistant genotypes with high yield potential and drought tolerance in order to maximize yield gains during both drought and good seasons. A total of 201 spring bread wheat genotypes were evaluated for stripe rust response at Tel Hadya during the 2011 and 2012 cropping seasons following inoculation of mixed races including the recent *Yr27*-virulent race 230E150. Seventy seven genotypes showed highly resistant responses (<5% severity) in both years. The grain yield performance of some of these genotypes ranged up to 3 and 7.7 t/ha under rain fed and irrigated conditions, respectively. These genotypes were distributed to the CWANA NARS through ICARDA's international nursery system for the 2012/13 season.

Variation in seedling response to North American *Pgt* and *Pt* races in an inclusive East African bread wheat panel

M. Godwin[1], Y. Jin[2], J. Kolmer[2] and J. Anderson[1]

[1]Department of Agronomy and Plant Genetics, University of Minnesota, 1991 Upper Buford Circle, 411 Borlaug Hall, St. Paul, MN 55108-6026, USA; [2]USDA-ARS, Cereal Disease Laboratory, St. Paul, MN 55108, USA

E-mail: macha081@umn.edu

The emergence of highly virulent wheat rust pathogen races has been implicated as a major impediment to global wheat production. In East Africa, historical and recent races of *Pgt* have forced the region to consistent wheat imports. A continual search for resistance genes in uncharacterized germplasm followed by introduction and exploitation of effective genes through breeding has the potential to reduce losses due to rusts. An inclusive panel of 236 vintage to currently popular Kenyan and Ethiopian bread wheat cultivars was assembled for this study. All lines were screened for reaction to 9 common North American *Pst* and 10 *Pt* races. Three foreign *Pgt* races, including TTKSK (Ug99), were also used to increase the scope of the study. Sixty to ninety percent of the lines were resistant and showed clear low infection types. However, resistance to foreign races was much lower in frequency with only 7% of lines showing some degree of resistance to TTKSK. The frequency of susceptibility to *Pt* races was generally higher, with 5 – 58% showing low infection types. Lines that displayed a wide range of resistance to both rusts were identified and are being further characterized using molecular markers for potential use in resistance breeding.

Evaluation of bread wheat germplasm from the CGIAR Centers against *Pgt* race Ug99 in 2012

T. Zerihun, E. Firdissa, B. Bedada, D. Worku, A. Dawit, Z. Habtemariam, Sh. Yewubdar, S. Tafesse and T. Kebede

Ethiopian Institute of Agricultural Research, PO Box 2003, Addis Ababa, Ethiopia

E-mail: zerbest.2008@gmail.com

The virulent *Puccina graminis tritici* race Ug99 has caused severe losses to wheat production since its appearance in Ethiopia in 2003. Susceptibility of widely grown cultivars to Ug99 and its variants is responsible for these losses. A rigorous evaluation of wheat lines for reaction to stem rust and other major diseases was necessary to overcome the problem. One hundred and sixty nine elite bread wheat lines selected from CIMMYT and ICARDA introductions were planted in disease hot spot areas of Ethiopia (Arsi-Robe and Meraro) and Kenya (Njoro) during summer 2012. Stem rust scores placed 24.3, 29.0 and 46.7% of the lines at Njoro and 8.5, 16.5 and 75.0% at Arsi-Robe into RMR-MR, M and MS-S reaction groups, respectively. Most of the lines tended to be resistant at Njoro but were susceptible to local races in Arsi-Robe. It is not clear whether differences were due to race differences, or to higher disease levels at Arsi-Robe. However, among all lines, 6% at Njoro and 20% at Arsi-Robe, respectively, showed adult plant responses of <20% severity. At Meraro 1.8, 3.6 and 54.4% of lines showed M, MS and S responses to stripe rust, respectively, and 58% of the lines expressed <20% severity. Correlation analysis indicated no significant association between stem rust and stripe rust severities, implying that the genotypes were responding independently to the two diseases. Very few lines had multiple resistances. Finally, based on agronomic performance and disease responses, four lines (ETBW5890, ETBW6093, ETBW6094 and ETBW6098) were selected for variety verification and release.

Yield performance and rust reactions of Ethiopian bread wheat genotypes

Y.S. Ishetu, B. Girma and F.E. Bokore

Wheat Regional Center of Excellence, Ethiopian Institute of Agricultural Research, PO Box 489 Asella, Ethiopia

E-mail: yewb21@gmail.com

Bread wheat is a strategic food security crop in Ethiopia and over 95% of the total harvest is produced by small farmholders. The national wheat research program provides regular technical support to farmers, including seed of improved varieties and advice on production practices. Such support has enabled farmers to make steady increases in productivity. An experiment consisting 15 genotypes from CIMMYT and ICARDA along with 2 checks (Danda'a and Digelu) was conducted at 11 locations for two seasons beginning 2011. A randomized complete block design with four replications was used at all locations. Data were collected on grain yield, agronomic traits and disease reaction. The combined ANOVA over environments indicated that the main effects of environment, genotype and G x E were significant ($P < 0.05$). The mean grain yields ranged from 3,669 to 5,070 kg/ha with a grand mean of 4,294 kg/ha. Six lines were higher yielding than the checks. Three of the top yielders (ETBW5798, ETBW5961 and ETBW5959) were susceptible to stem rust, but ETBW5800, ETBW5879 and ETBW5890 were higher yielding than the checks and resistant to stem rust and yellow rust. We are recommending these three lines for variety verification trials and release to wheat producers.

Zakia: A new Ug99-resistant variety for the heat stressed environments of Sudan

I.S.A. Tahir[1], E.M.E. Elbashier[1], A.H.A. Hussein[1], A.M.A. Elhashimi[1], H.M. Mustafa[1], A.S.I. Saad[1], M.G.A. Abdeldaim[1], A.A.M. Idris[1], M.K. Hassan[1], A.A.E. Elbashir[1], A.M. Ali[1], M.M. Omer[1], A.M.A. Kurmut[1] and R.P. Singh[2]

[1]Agricultural Research Corporation (ARC), PO Box 126, Wad Medani, Sudan; [2]CIMMYT, Apdo. Postal 6-641, 06600 Mexico D.F., Mexico

E-mail: izzatahir@yahoo.com

Development of heat-tolerant high-yielding rust resistant common wheat varieties with good end-use quality under the heat stressed environments of Sudan is a daunting challenge. To determine the grain yield performance and stability of 21 new genotypes and three checks (Debeira, Bohaine and Nebta), field trials were conducted during the 2009-2011 cropping seasons at eight locations representing wheat growing areas in Sudan. AMMI (Additive Main Effect and Multiplicative Interaction) analysis showed that grain yield was significantly affected by genotypes, environments, and genotype × environment interaction. AMMI estimates across environments also showed that the grain yield of Zakia was 117, 102 and 96% of Debeira, Bohaine and Nebta, respectively. Zakia was identified as a leading genotype by GGE biplot analysis across a number of test environments. Zakia also had better end-use quality characteristics for HMW-GS composition, protein content, farinograph dough development time and dough stability time than the three checks. Screening with *Pgt* race Ug99 over four seasons in Kenya confirmed that the adult plant response of Zakia was R-MR. It also has APR to leaf rust and stripe rust. Based on these results, Zakia was officially released for commercial production in Sudan in 2013.

Resistance of some Turkish bread wheat genotypes to yellow rust and stem rust

L. Çetin[1], K. Akan[1], Z. Mert[1], A. Salantur[1], S. Yazar[1], E. Dönmez[1], B. Özdemir[1], M.E. Alyamaç[1], R. Wanyera[2] and S. Bhavani[3]

[1]The Central Research Institute for Field Crops, Sehit Cem Ersever Cd. No.9-11 Yenimahalle, Ankara Turkey; [2]Kenya Agricultural Research Institute National Plant Breeding Research Center, Njoro, Kenya; [3]CIMMYT Kenya, PO Box 1041, Nairobi, Kenya

E-mail: kadir_akan@hotmail.com

Yellow rust and stem rust are the most significant diseases affecting wheat yield and quality on the Central Anatolian Plateau of Turkey. Twenty-five Turkish bread wheat genotypes developed by the Central Research Institute for Field Crops (CRIFC) in advanced yield trials were evaluated for adult plant resistance to local *Pst* and *Pgt* races in Turkey, and to *Pgt* race Ug99 in Kenya. All genotypes were vernalized at 4°C for 6 weeks after germination in pots and then transplanted into the field as hill plots. Reaction types and rust levels based on the modified Cobb scale were recorded at both locations. Coefficients of infection (CI) were calculated and values below 20 were considered resistant. Twenty genotypes were resistant to the local *Pst* race (virulent on seedlings of Lee, Heines Kolben, Heines Peko, Kalyansona, Sonalika, Federation*4/Kavkaz and Avocet S), 16 genotypes were resistant to the local *Pgt* population (avirulent on seedlings with *Sr24, Sr26, Sr27* and *Sr31*) in Turkey and 4 genotypes were resistant to *Pgt* race Ug99 in Kenya.

Acknowledgements: This study was financed and supported by General Directorate of Agriculture Research and Policy, Republic of Turkey Ministry of Food, Agriculture and Livestock (Grant no: TAGEM/TA/03/03/01/031), The Borlaug Global Rust Initiative (BGRI) and Kenya Agriculture Research Institute KARI, (Kenya).

Seedling and adult plant resistance to stripe rust among winter wheat commercial cultivars and advanced breeding lines in Uzbekistan

Z. Ziyaev[1], R.C. Sharma[2], A. Amanov[1], Z. Ziyadullaev[1], Z. Khalikulov[2] and D. Musurmonov[3]

[1]Kashkadarya Research Institute of Grain Breeding and Seed Production, Karshi, Uzbekistan; [2]ICARDA-Central Asia and the Caucasus Regional Program, Tashkent, Uzbekistan,[3]Uzbek Research Institute of Plant Industry, PO Botanika, Kibrai district, Tashkent, Uzbekistan

E-mail: zafaruzripi@gmail.com

Development of rust resistant winter wheat varieties is an important objective of wheat breeding activities in Uzbekistan. Stripe rust is the most important disease of wheat in Uzbekistan. Most of the commercially grown winter wheat cultivars were susceptible during recent epidemics of stripe rust. The objective of this work was to evaluate seedling and adult plant responses of current commercial and candidate cultivars as well as advanced breeding lines. Seedling tests were conducted at the Kashkadarya Research Institute of Grain Breeding and Seed Production and adult plant responses were evaluated in inoculated field nurseries at the Uzbek Research Institute of Plant Industry. Most genotypes were susceptible to stripe rust in the seedling and adult stages. The widely grown cultivars Krasnodar-99, Tanya, Moskvich, Chillaki, Kroshka, Pamyat, Bobur, Andijan-4 and Polovchanka were highly susceptible. Among 78 entries, 7 had all-stage resistance, 3 showed adult plant resistance, 14 were moderately susceptible and 54 were highly susceptible. These results will help in deciding on release of new resistant varieties as well as in deployment of winter wheat varieties in Uzbekistan. The findings are also valuable for neighboring countries in Central Asia and the International Winter Wheat Improvement Program.

Molecular breeding for leaf rust resistance in wheat

A. Kokhmetova[1], Z. Sapakhova[2], A. Madenova[2], M. Atishova[1], G. Yessenbekova[2], K. Galymbek[1], L. Typina[1], R. Eleshev[2] and G. Kampitova[2]

[1]Institute of Plant Biology and Biotechnology, Timiryazev St. 45, Almaty 050040, Kazakhstan; [2]Kazakh National Agrarian University, Almaty, Kazakhstan

E-mail: gen_kalma@mail.ru

Resistance to leaf rust is the most important wheat breeding objective in Central Asia and Kazakhstan as it adversely affects both yield and quality. The most widely grown and high yielding spring and winter wheat cultivars are vulnerable to severe leaf rusting, and therefore it is necessary to search for sources of resistance. The aim of the present study was to screen 75 accessions, including commercial cultivars and elite advanced wheat lines, with markers linked to effective leaf rust genes. For the identification of Lr-gene sources, STS Lr19-130 and SCAR Lr25R19 markers (http://maswheat.usdavis.edu) associated with known effective genes (*Lr19* and *Lr25*) were used in screening the accessions. Seventeen accessions with *Lr19* were identified using the STS GbF/R primers, viz. lines1519-1, 1519-2, 1520-1, 1521-1, 1521-2, 1531, 1538-2, 1539, 1552, 1553, 1555, 1556, 1558, 1562, 1567, 1571 and cv. Pallada. Eleven genotypes with SCAR Lr25F20/R19 generated the DNA fragment associated with *Lr25*. A number of advanced lines showed high yield potential combined with resistance to *P. triticina* races predominant in Central Asia. The results are being used in MAS in wheat breeding programs targeting leaf rust resistance.

Characterization of Afghan landraces for rust diseases

A. Manickavelu[1], Y. Naruoka[2], A.S. Stanikzai[1], M. Osmanzai[3], K. Ayumi[1], H. Sybil[4], J. Huerta-Espino[4], R.P. Singh[4], E. Lagudah[5] and T. Ban[1]

[1]Kihara Institute for Biological Research, Yokohama City University, 641-12 Maioka, Yokohama 2440813, Japan; [2]Washington State University, PO Box 646420 Johnson Hall 291D, Pullman, WA, Pullman, WA 99164, USA; [3]JICA Afghanistan Office, Central Post Office Box 461, Kabul, Afghanistan; [4]CIMMYT, Apdo. Postal 6-641 06600 Mexico, D.F., Mexico; [5]CSIRO Plant Industry - Black Mountain Laboratories, Clunies Ross Street, Acton ACT 2601, Australia.

E-mail: manicks@yokohama-cu.ac.jp

The landraces collections made by Prof. Kihara during 1950's around Afghanistan are having un-tapped potential. Through SATREPS-Afghan project, the landraces are under characterization as well as utilization. To identify novelty of the germplasm, through international collaboration, the materials (~360 landraces) were intensively screened for leaf and stripe rusts. The multi-year (2011-13) and multi-location (CIMMYT – Toluca, Obregon; Afghan – Kabul, Jalalabad) phenotypic screening showed the resistance sources for both diseases. In stripe rust, around 50 lines were showed consistent resistant both in Afghanistan and CIMMYT. The screening made at Obregon helped to find around 50 resistant sources for leaf rust and the data were compared with seedling level screening. Further, genotyping has been carrying-out with gene specific markers for all rust diseases to identify novel resistant genes. The project is hoping to find novel gene with durable resistance for important wheat disease (leaf and stripe rust or multiple disease resistance).

Stem rust reactions of candidate wheat lines under artificially inoculated and natural conditions in southern Pakistan

K.A. Khanzada[1], A.R. Rattu[2], J.I. Mirza[2], A. Munir[2], M. Fayyaz[2], S.A.R. Kazmi[1], M. Imtiaz[3], M.Y. Mujahid[4], S.D. Khanzada[5], S. Masood[6] and I. Ahmad[6]

[1]Crop Diseases Research Institute, SARC, PARC, Karachi University Campus, Karachi, Pakistan; [2]Crop Diseases Research Institute, NARC, PARC, Park Road, Islamabad, Pakistan; [3]CIMMYT Country Office, NARC, Park Road, Islamabad, Pakistan; [4]National Wheat Coordinated Program, NARC, PARC, Park Road, Islamabad, Pakistan; [5]Nuclear Institute of Agriculture, Tandojam, Pakistan; [6]Pakistan Agricultural Research Council, G-5, Islamabad, Pakistan

E-mail: anjums41@yahoo.com

In early 2013 stem rust was recorded in southern Pakistan, especially on late-planted wheat. To protect wheat against the potential threats of exotic *Pgt* race Ug99 and local race RRTTF, monitoring, surveillance and screening of germplasm is conducted at the national level. The National Uniform Wheat Yield Trial (NUWYT) 2012-13 comprising 58 advanced elite lines and commercial cultivars was screened in an inoculated (RRTTF) nursery at CDRI Karachi and under natural conditions at two hotspot locations (Thatta and Kunri) in Sind province. Twenty three (39.7%) lines showed immune to 30MRMS reactions at all three locations. These lines are being promoted as sources of resistance to stem rust.

Response of wheat cv.Seher-06 to leaf rust in Pakistan

J.I. Mirza[1], A. Munir[1], A.R. Rattu[1], M. Fayyaz[1], K.A. Khanzada[1], M. Imtiaz[2], Y. Rauf[2], M.Y. Mujahid[3], I. Ahmad[4], S. Masood[4], R. Ward[2], J. Kolmer[5], F. Muhammad[6], M. Hussain[6], M. Hussain[7], S.A. Khan[8] and M.A. Hussain[8]

[1]Crop Diseases Research Institute, PARC, Park Road, Islamabad, Pakistan; [2]CIMMYT International, NARC, Park Road, Islamabad, Pakistan; [3] National Wheat Coordination Program, NARC, Park Road, Islamabad, Pakistan; [4]Pakistan Agricultural Research Council, G-5, Islamabad, Pakistan; [5]Ceareal Disease Laboratory, USDA, St. Paul, Minnesota 55108, USA;[6]Plant Pathology Research Institute, Ayub Agriculture Research Institute, Jhang Road, Faisalabad, Pakistan; [7]Wheat Research Institute, Ayub Agriculture Research Institute, Jhang Road, Faisalabad, Pakistan;[8]Regional Agricultural Research Institute, Bahawalpur, Pakistan

E-mail: anjums41@yahoo.com

The commercialwheatcultivar Seher-06, a selection from CIMMYT material, was released in Pakistan in 2006. Soon after release, the variety spread and replaced Inqilab 91 in most of the wheat growing areas of the Punjab mainly due to its excellent yield potential and adaptability. This led to a buildup of inoculum with virulence to Seher-06 within five years. As a result, the potential for a major epidemic has been present since the 2011-12 cropping season in areas where Seher-06 is cultivated. Data from the TRAP nursery planted at Bahawalpur and Tandojam and analysis of Seher-06 leaf rusted samples from these locations indicated presence of virulence for leaf rust resistance genes 2bg*, 2c, 3, 3bg, 10, 11, 13, 14a, 14b, 16, 17a, 18, 26, 29,* and *30.* These genes should be avoided from deployment in wheat growing areas of Pakistan to avoid future epidemics. The poster discusses the genetic background of resistance to leaf rust in Seher-06 in relation to previous gene postulations in commercial wheat cultivars and their responses to leaf rust with virulence to Seher-06. Race analysis of Pakistani leaf rust collections with virulence to Seher-06 is being conducted at CDRI Murree and in a parallel analysis at CDL Minnesota.

Wheat cultivation in Bhutan: Prospects and challenges

S. Tshewang[1] and Doe Doe[2]

[1]Renewable Natural Resources Research and Development Sub Center, Tsirang, Bhutan; [2]National Plant Protection Center, Department of Agriculture, Thimphu, Bhutan

E-mail: sangay128@gmail.com

Agriculture is the backbone of this small landlocked country, providing a livelihood for about 60% of the population. The principal cultivated summer cereals include maize and rice, while bread wheat and barley constitute the main winter crops. Although currently considered as a secondary cereal, wheat is gaining importance for both the government and farming communities. The reasons for this could be changes in dietary habits and a preference for wheat and its derived products. This is signified by increases in imported wheat, and the potential of wheat to meet the challenges of climate change and its impacts. The immediate priority for research is to accelerate the discovery and dissemination of improved varieties to replace the current obsolete low yielding and disease susceptible cultivars. Recognizing the limited national capacity for varietal development through breeding, the international centers CIMMYT and ICARDA, and regional centers of South East Asia are assisting in varietal improvement by providing elite germplasm for evaluation. As a result of this collaboration, several promising varieties were identified and are currently under seed multiplication. These will be available for planting in the spring wheat areas. Similar programs for winter wheat improvement are also underway with support from the ICARDA winter and facultative wheat program. The rusts, in particular, are major concerns, and routine surveillance is being undertaken in collaboration with BGRI and the Durable Rust Resistance in Wheat project.

Genetics of rust resistances in Nepalese wheats

B.N. Mahto[1], S. Baidya[1], S.C. Bhardwaj[2], S. Sharma[1] and A.K. Joshi[3]

[1]Plant Pathology Division, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Kathmandu, Nepal; [2]Directorate of Wheat Research, Flowerdale, Shimla , H.P. 171002, India; [3]CIMMYT, Kathmandu, Nepal

E-mail: bnmahto_7@yahoo.com

Stripe rust and leaf rust are major threats in wheat growing areas of Nepal. Stem rust is minor and sporadic. The rusts are best controlled by using resistance genes, but the recurrent problem is the ever-evolving new pathotypes that overcome the deployed resistances. Wheat genotypes collected from different geographical locations were subjected to gene postulation at Directorate of Wheat Research (DWR), Shimla, India, and CIMMYT, Mexico. Twenty-nine *Pst* pathotypes have so far been identified in Nepal. Among them, 46S103, 46S119 and 78S84 have predominated in the last few years. Twenty-two *Pt* pathotypes have been recorded, and among them races 12, 77 and 104 are the most common. Nine *Yr* genes (*Yr2, Yr2 SKA, YrA, Yr6, Yr7, Yr9, Yr27, GA,* and *SU*) were postulated; *Yr9* was the most common. Likewise, 13 *Lr* genes (*Lr1, Lr3, Lr10, Lr13, Lr14a, Lr16, Lr17, Lr19, Lr23*, *Lr26, Lr27+Lr31* and *Lr34*) were postulated and *Lr26* was the most common. For stem rust, nine *Sr* genes (*Sr2, Sr5, Sr7b, Sr8, Sr8a, Sr9b, Sr11, Sr25* and *Sr31*) were postulated with *Sr31* being the most common. Thus Nepalese wheat lines have a diversity of rust resistance genes. The resistance genes postulated from these studies could be helpful for breeders and pathologists in strategic planning of wheat breeding programs and could be used to reduce losses caused by rusts.

Determining rust resistance genes in Nepalese wheat lines using SSR markers

S. Baidya[1], G. Chetal[2], L. Dayton[2], S.M. Shrestha[3], H.K. Manadhar[4], R.B. Thapa[3] and A.K. Joshi[5]

[1]Plant Pathology Division, NARC, Khumaltar, Nepal; [2]DNA Landmarks, Quebec, Canada; [3]Institute of Agriculture and Animal Science, Chitwan, Nepal; [4]Nepal Agricultural Research Council (NARC), Singh Darbar, Kathmandu, Nepal; [5]CIMMYT, South Asia Coordinator, Kathmandu, Nepal

E-mail: Suraj_baidya222@yahoo.co.in

Molecular markers can predict the presence of a specific gene(s) with high probability without the need for disease evaluation. One hundred and three wheat samples were subjected to DNA extraction using the DNA Landmarks standard protocol. DNA concentrations were measured using Hoescht dye and the quality of DNA samples was checked on 0.8% agarose gels. The DNA samples were subjected to PCR amplification with seven SSR primers (STM 773-2 tailed, Sr2 X3B042G11 tailed, WMC221 tailed, Yr36 UHW89 tailed, cfa2123 tailed, csLV34 Lr34sp tailed and Sr X3B028F08) and products separated on an ABI 3730XL capillary electrophoresis system. The genotypic results were scored using gene Mapper software V4.0. Genotyping was successful for six of the seven markers, with an average success rate 99.7% for six of seven markers and an average success rate of 82.4% for all seven markers. However, SSR markers Sr2_X3B042G11_tailed, WMC221_tailed, cfa2123_tailed and csLV34_Lr34sp_tailed were 100% successful in genotyping sequences of all the wheat lines. The study revealed the presence of *Sr2* in 34.3%, *Sr22* (37.9%), *Sr36* (11.7%) and *Lr34* (29.1%) of lines. This information should be useful for combining detected genes with other effective genes in the ongoing wheat breeding program.

Rust resistant wheat varieties released in Bangladesh

N.C.D. Barma[1], P.K. Malaker[2], D.B. Pandit[2], Z.I. Sarker[2], M.A. Hakim[2], M.M. Rahman[1], F. Ahmed[3], M. Mokhlesur Rahman[4], M. Mahbubur Rahman[5], M.J. Uddin[2], T.P. Tiwari[6] and A.K. Joshi[7]

[1]Regional Wheat Research Center, BARI, Gazipur-1701, Bangladesh; [2]Wheat Research Center, BARI, Dinajpur-5200, Bangladesh; [3]Regional Agricultural Research Station, BARI, Jessore-7400, Bangladesh; [4]Regional Agricultural Research Station, BARI, Jamalpur-2000, Bangladesh; [5]Regional Wheat Research Center, Shyampur, Rajshahi-6212, Bangladesh; [6]CIMMYT – Bangladesh, House #9, Road #2/2, Banani, Dhaka-1213; [7]CIMMYT South Asia, Singha Durbar Road, Kathmundu, Nepal

E-mail: ncdbarma@gmail.com

Wheat is the second staple crop in Bangladesh after rice and demand is increasing day by day due to a growing population and, to some extent, changing food habits. Presently, Bangladesh produces only 1 m t of wheat grain towards the demand for about 4 m t per year. Wheat in Bangladesh may face a serious threat from *Pgt* race Ug99 and its derivatives in the near future. To mitigate this threat, the breeding program was reoriented during 2008-09 with the help of CIMMYT and BGRI to develop Ug99-resistant varieties. Consequently, two Ug99 resistant varieties BARI Gom 26 and BARI Gom 27 were released. BARI Gom 26 released in 2010 has a moderate level of adult plant resistance (APR) to Ug99 and to leaf rust, and also a good level of tolerance to spot blotch. Other desirable traits compared to current varieties include higher average yield (5 t/ha), bolder grains, and good tolerance to terminal heat stress with a capacity to yield well under late sown conditions. BARI Gom 27 (Francolin #1), released in 2012, possesses a good level of APR (Sr2+) to Ug99 along with a yield approximately 10% more than the standard check Shatabdi. CIMMYT is playing an important role in the identification of superior rust resistant wheat genotypes having both race-specific and adult plant resistance. Rapid seed multiplication allowing for quick dissemination of both varieties through a USAID famine funded seed multiplication project facilitated by CIMMYT and a Government fund has led to increased adoption of the varieties.

HD-2189: A bread wheat variety undefeated by *Puccinia triticina* for 25 years in India

G.S. Arunkumar, I.K. Kalappanavar, P.E. Pradeep, K.J. Yashavanthkumar, S.A. Desai, S.S. Biradar and V.R. Naik

Dr. Sanjaya Rajaram Wheat Laboratory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India

E-mail: ikkyashu@gmail.com

Bread wheat cultivar HD-2189 has shown slow leaf rusting resistance to leaf rust in India for 25 years. To characterize the nature and number of genes involved in resistance at the pathological and molecular levels, slow rusting components were determined in inoculated field nurseries at the adult plant stage. Earlier workers showed that HD-2189 possessed *Lr34*. In the present study it showed slow rusting with a longer latent period (28.53 days), lower AUDPC (122.15), smaller uredinial size and lower terminal disease severity (10.2%) than the susceptible checks Lalbahadur (8.09 days, 1820.0 and 80%, respectively) and Agra Local (7.32 days, 1942.50 and 76%, respectively). Molecular characterization using closely linked SSR markers revealed the presence of slow rusting resistance gene *Lr46* in addition to *Lr34*. Thus a combination of slow rusting resistance genes has conferred resistance for 25 years despite a constantly changing pathogen population.

Yield reductions caused by stripe rust in a diverse group of Indian wheat genotypes

R. Tiwari, K. Venkatesh, A. Arora, K. Rani, M.S. Saharan, R. Chatrath and I. Sharma

Directorate of Wheat Research, Karnal 132 001, Haryana, India

E-mail: tiwari1964@yahoo.com

Twenty diverse genotypes from six wheat zones of India were selected on the basis of pedigree and diversity of SSR markers. The crop loss experiment was a lattice design with three replications planted in two sets, one stripe rusted, and the other fungicide-protected. Stripe rust was initiated by inoculation with equal amounts of the predominant *Yr9*- (46S119) and *Yr27*-virulent (78S84) races. Rust scores were recorded four times at weekly intervals from the booting stage. Areas under the disease progress curve (AUDPC) ranged from 2.8 to 1318 and there was a significant correlation (0.70) of AUDPC with percentage yield reduction. Biomass in rusted plots was reduced by an average 28% and its correlation with the AUDPC was 0.48. Grain yield losses across individual genotypes ranged from 29 to 82% indicating the heavy toll that this disease can take under severe epiphytotic conditions. There were substantial reductions in harvest index and 1000 grain weight. The average yield of the protected plots was 5.74 t/ha whereas the rusted plots had a mean yield of 3.14 t/ha, an average reduction of 45%.

Screening Indian germplasm for leaf rust resistance

A.L. Bipinraj, B.K. Honrao, S.C. Misra and S.A. Tamhankar

Genetics and Plant Breeding Group, Agharkar Research Institute, GG Agarkar Road, Pune, Maharashtra 411001, India

E-mail: shubhada_at@yahoo.com

Resistant varieties are the most successful and economic approach to combat leaf rust. Ninety six wheat genotypes, including cultivars from advanced varietal trials under test by the All India Co-ordinated Wheat and Barley Program, were screened for the presence of leaf rust resistance genes using molecular markers that reportedly tagged genes *Lr1*, *Lr3*, *Lr9*, *Lr10*, *Lr24*, *Lr26*, *Lr28* and *Lr34*. Genotypes covering all 6 wheat production zones of India were included. Pathological studies and pedigree data was collected to confirm the accuracy of the markers. The objective of this study was twofold: to identify the genes that have been used in Indian wheat breeding programs, and to assess the efficiency of the markers for use in MAS. Our analysis based on pathological studies and pedigree data of 56 cultivars released in the last five decades showed that *Lr26* had been incorporated into a large number of genotypes followed by *Lr23*, *Lr24* and *Lr34*. The other genes identified were *Lr1*, *Lr10*, *Lr13*, *Lr14*a and *Lr28*. The marker for *Lr1* was not very effective in identifying the presence of the gene. Among the others, markers for *Lr3*, *Lr9*, *Lr10*, *Lr24*, *Lr28* and *Lr34* appeared to be accurate.

Utilization of Australian germplasm for enhancing stripe rust resistance in popular Indian wheat cultivars

R. Chatrath[1], M.S. Saharan[1], R. Tiwari[1], D. Rana[1], J. Kumar[1], M. Kumar[1], R. Chaudhary[1], O.P. Tuteja[1], R. Trethowan[2], U. Bansal[2], H. Bariana[2] and I. Sharma[1]

[1]Directorate of Wheat Research, Karnal, 132 001, India; [2]University of Sydney Plant Breeding Institute Cobbitty, 107 Cobbitty Rd, Cobbitty, NSW 2570, Australia

E-mail: r.chatrath@gmail.com

Stripe rust caused by *Puccinia striiformis* is an important disease of wheat in northern India. Eighty Australian lines from the University of Sydney are being used in an Indo-Australian Project "Molecular Marker Technologies for Faster Wheat Breeding". During 2011-12, 34 crosses were attempted between Indian cultivars (DPW 621-50, DBW 17, VL 804, PBW550, HD2967, PBW343, PBW175, RAJ 3765, HD2833, and DBW 14) and selected Australian donor parents. In 2012-13, progenies (F_5) from cross combinations SUNCO/TASMAN #61//PBW 550, HSB 2398/DBW 17 and PAVON*3/*Lr*47//DBW 17 showed good plant type coupled with stripe rust and leaf rust resistances. During 2012-13, 60 crosses were attempted with Australian donors and Indian parents. The 80 Australian genotypes were screened in the field with prevalent *Pst* pathotypes (78S84 & 46S119) at Karnal during 2012-13. Among them, 35 were completely free from stripe rust, 21 showed stripe rust severities of up to 10S, and the others had severities ranging from 20 to 40S. We hope that pyramiding of resistance genes from Indian and Australian parents will lead to genotypes with durable stripe rust resistance for the North Western Plain Zone of India. Since parental sources also carry resistance to leaf rust and stem rust, we will attempt to achieve triple rust resistance in future Indian wheat cultivars.

Marker assisted pyramiding of stem rust resistance genes *Sr24* and *Sr26* in Indian wheat breeding

B.K. Das, K. Arun, V. Rana, A. Shitre and S.G. Bhagwat

Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Center, Trombay, Mumbai 400085, India

E-mail: bikram_das2001@yahoo.com

Stem rust can be a deleterious disease of wheat. Resistance gene *Sr26* derived from *Agropyron elongatum* confers resistance to all *Pgt* races in India and also to race Ug99. Although, *Sr24* (and *Lr24*) from the same wild source has been deployed, *Sr26* so far has not been used in Indian cultivars. Pyramiding of resistance genes is recommended for increasing durability of resistance. We attempted to combine the two genes using molecular markers. A multiplex PCR for simultaneous screening of both genes was developed. SCAR markers $SCS1302_{609}$ and Sr26#43 for *Sr24* and *Sr26* were validated in Indian wheat genotypes and in segregating populations. To recombine the two genes, FLW-2 (*Sr24*) and Australian cv. Kite (*Sr26*) were crossed. Using the SCAR markers selections were made from the F_2 populations. Marker based selection for *Glu-D1d* was also carried out. Seventy-eight plants carrying the three markers were selected from 239 F_2 plants. Further selection was made for amber grains, presence of awns, earliness and field resistance to stripe rust and leaf rust. Nine F_6 selections with the above preferred traits and semi-dwarf stature were grown in 2012-13. Three lines with higher kernel weight and grain yield per plant will be tested further. The new selections with pyramided stem rust resistance genes, earliness and amber grains will hopefully provide durable resistance.

Adult plant leaf rust resistance in Indian bread wheat accessions bearing leaf tip necrosis

J. Kumar, V.K. Vikas, P. Jayaprakash, G.P. Singh, R. Yadav and M. Sivasamy

Regional Station, Indian Agricultural Research Institute, Wellington, Tamil Nadu 643231, India

E-mail: moola01@yahoo.com

Leaf rust is one of the most common bread wheat diseases in India. Many varieties with different resistance genes have been developed and deployed to reduce the yield-depressing effects of leaf rust. One such gene is *Lr34* which acts as a buffer in cases of breakdown of major genes. *Lr34* is recognised by the presence of leaf tip necrosis (LTN), an apparent pleiotropic effect associated with it. *Lr34* either singly or in combination provides effective and durable resistance to leaf rust. This paper reports the status of leaf rust resistance in wheat lines displaying leaf tip necrosis and possibly carrying gene *Lr34*. Among 2,200 accessions screened against leaf rust under field conditions, 1,526 exhibited symptoms of LTN; 98% of these had reduced leaf rust severities ranging from traces to 40% compared to 80 – 100% leaf areas affected on susceptible infectors. Reductions in severity were independent of the levels of expression of LTN. The likely presence of durable resistance gene *Lr34* associated with LTN, either singly or in combination with other resistance genes is discussed.

Assaying stem rust resistance genes in Indian wheat varieties using molecular markers

R. Malik, M.S. Saharan, R. Chatrath and I. Sharma

Directorate of Wheat Research, Karnal 132001, India

E-mail: rekhasmalik1@gmail.com

Stem rust is a major problem of central and southern wheat regions of India. With an objective to assay the presence of *Sr* genes at the molecular level, Indian wheat varieties were screened with available molecular markers for *Sr2, Sr22, Sr24, Sr25, Sr26* and *Sr*39. Diagnostic marker CsSr2 for *Sr*2 identified the Marquis allele or a null allele in many varieties and the Hope allele indicating the presence of *Sr2* was in a few varieties, viz. HD 2781, MP 4010, HD 2278 and GW190. Diagnostic markers cssu22 for *Sr*22, Sr26#43 and STS marker BE518379 for *Sr*26, and Sr39#22R for *Sr*39, confirmed the absence of these genes in Indian wheat genotypes. *Sr24* was postulated with marker Sr24#12 in 16 Indian varieties and registered genetic stocks FLW1, FLW 2, FLW 4 and FLW 5. The dominant marker Gb confirmed the presence of *Sr*25 in variety GW18 and genetic stocks FLW 8, FLW 9, FLW 24 and FWW2. This study provided useful information for stem rust resistance genes available in the selected set of Indian varieties. The results were complemented with gene postulation data from seedling stem rust tests.

An accelerated breeding approach to pyramid resistance genes as a means of addressing wheat rust threats in India

M. Sivasamy[1], J. Kumar[1], P. Jayaprakash[1], V.K. Vikas[1], Vinod[2] and R. Nisha[1]

[1]IARI, Regional Station, Wellington, The Nilgiris 643231, India; [2]Division of Genetics, IARI, Pusa, New Delhi-12, India

E-mail: iariwheatsiva@rediffmail.com

Pyramids of one or more effective rust resistance genes and one or more minor race non-specific resistance genes are expected to provide durable resistance to wheat rusts. An effort was made at IARI, Regional Station, Wellington, to develop wheat varieties having pyramided effective stem rust resistance genes in the backgrounds of adapted Indian bread wheat cultivars, taking advantage of three crop cycles per year. *Sr*2, *Sr24*+*Lr24* and *Sr26* were pyramided into ten bread wheat varieties, namely WH147, HD2285, HUW234, PBW226, C306, Lok-1, HS240, Sonalika, UP2338 and Kalyansona, using marker assisted backcrossing. The stable pyramided genotypes were also subjected to seedling stem rust tests at Wellington. The result is a group of high yielding stem rust resistant lines with combinations of effective resistance genes. These lines could pave the way as sources durable resistance to combat existing and future *Pgt* pathotypes.

Exploring untapped variability for stripe rust resistance in indigenous wheat germplasm

C.N. Mishra, S. Kumar, V. Gupta, S.K. Singh, V. Tiwari and I. Sharma

Directorate of Wheat Research Karnal, Haryana, India 132001

E-mail: mishracn1980@gmail.com

Stripe rust is a major constraint to Indian wheat production especially in the North Western Plains Zone (NWPZ) and Northern Hill Zone (NHZ). The stripe rust pathogen appears to be evolving faster than in the past thereby overcoming resistance and making popular cultivars susceptible. There is therefore an urgent need to identify new sources of resistance to stripe rust. Six hundred and sixteen indigenous wheat accessions (received from NBPGR) were tested with a mixture of *Pst* isolates at DWR Karnal during 2012-13; 197 were resistant, 115 moderately resistant to moderately susceptible; and 304 were susceptible. The resistant lines will be further tested at hotspot locations within India. Lines resistant in these tests will be considered as potential resistance donors for future breeding cycles aimed at developing resistance to stripe rust.

Identification of slow rusting wheat genotypes for response to stripe rust and leaf rust

M.S. Saharan, A.K. Sharma, R. Selvakumar, M. Singh, V. Panwar, J. Kumar and I. Sharma

Directorate of Wheat Research, Karnal, Haryana 132001, India

E-mail: mssaharan7@yahoo.co.in

Stripe (yellow) rust and leaf (brown) rust are the most important wheat diseases in India, a major world wheat producer (93.9 mt in 2011-12). Stripe rust is important in North Western Plain and Northern Hill Zones whereas leaf rust is important throughout the entire country. To identify slow rusting genotypes to both diseases, 200 advanced lines and popular wheat cultivars were evaluated in nurseries inoculated with *Pst* races 78S84 and 46S119, and *Pt* races 77-5 and 104-2 at Karnal in 2011-12. Genotypes were categorized into distinct groups based on Area Under Disease Progress Curve (AUDPC) values. Lines with various stripe rust levels were grouped 56 genotypes stripe rust free, 64 lines with AUDPC values 1-100, 20 lines with values 101-200, 22 lines with values 201-500, and the remaining lines with higher values. Likewise, genotypes exhibiting various AUDPC values for leaf rust response were 49 with values 1-100, 22 with values 101-200, and 12 with values 201-500. Apart from the rust-free lines, genotypes with AUDPC values of less that 500 had levels of rusting that were <20% of those of susceptible controls and were considered slow rusters. Such genotypes can be utilized as parents for incorporating slow rusting resistance into breeding materials.

Evaluation of barley genotypes for stripe rust resistance in India

R. Selvakumar[1], R.P.S. Verma[1], M.S. Saharan[1], S.C. Bharwaj[2], P.S. Shekhawat[3], M.M. Jindal[4], D. Singh[5], R. Devlash[6], S.S. Karwasra[7], S.K. Jain[8] and I. Sharma[1]

[1]Directorate of Wheat Research, Karnal 132001, Haryana, India; [2]Directorate of Wheat Research, Shimla 171004, Himachal Pradesh, India; [3]Rajasthan Agricultural University, Durgapura 302018, Rajasthan, India; [4]Punjab Agricultural University, Ludhiana 141004, Punjab, India; [5]Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Dhaulakuan 173001, Himachal Pradesh, India; [6]Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Bajaura 175125, Himachal Pradesh, India; [7]Chaudhary Charan Singh Hisar Agricultural University, Hisar 125004, Haryana, India; [8]Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora 263601, Uttarakhand, India

E-mail: selvakumar2000@gmail.com

Barley (*Hordeum vulgare* L.) is an important cereal crop in India. The area of production in 2011-12, was 650,000 ha producing 1.6 million, an average yield of 2.5 t/ha. Resistance breeding in India is based on indigenous and exotic landraces, as available sources of resistance are limited. Two hundred and eighty five lines were screened for reaction to stripe rust at Dhaulakuan, Bajaura, Durgapura, Ludhiana and Karnal during 2010-12. During 2011-12, 194 lines shortlisted from 2010-11 screening were tested again and 47 lines were identified as having resistance (ACI<1.0). The 47 lines with adult plant resistance were: BH961, BH962, BH966, BH969, BHS409, DWRB101, DWRB102, DWRB105, DWRB107, DWRB108, HBL711, HBL711, HUB113, HUB221, JB240, JB240, RD2552, RD2784, RD2786, RD2787, RD2794, RD2808, RD2809, RD2811, RD2816, RD2832, RD2833, RD2834, RD2835, RD2836, RD2837, RD2839, RD2840, RD2844, RD2845, RD2846, RD2847, RD2848, RD2849, RD2851, UPB1021, UPB1022, VLB124, VLB130, VLB130, VLB131 and VLB132. This group was evaluated in seedling tests with races 24, 57, G, Q and M at DWR Shimla. The lines BH902, RD2552, RD2784, RD2786, RD2787 and RD2794 possessing resistance both in seedling and adult plant stage may be used as donor lines to provide resistance to stripe rust.

A need to diversify *Lr24*-based leaf rust resistance of wheat in central India

T.L. Prakasha, A.N. Mishra, K. Kaushal and V.G. Dubey

Indian Agricultural Research Institute, Regional Station, Indore 452 001, India

E-mail: prakash7385@gmail.com

Inheritance studies involving bread wheat varieties HI 1500, HI 1531, HI 1544, and MP 4010 showed monogenic control of resistance to leaf rust when using an isolate of *Puccinia triticina* race 77-5 (121R63-1), currently the most prevalent race collected from bread wheat in India. Allelic tests confirmed the presence of leaf rust resistance gene *Lr24* in all these varieties which are under cultivation in central India. Genetic studies earlier showed that two other central Indian bread wheat varieties, HI 1454 and DL 788-2, carried *Lr24*, and this gene was also postulated in HW 2004. To overcome this apparent genetic uniformity there is an urgent need to diversify the leaf rust resistance base of bread wheat in central India by exploiting other *Lr* genes, or pyramiding additional genes with *Lr24*, and by popularizing durum wheat cultivation in the region, particularly in view of the reported presence of virulence for *Lr24* in neighboring Nepal and perhaps Pakistan. Moreover, central India serves as a secondary source of inoculum for the later sown wheat crop in the northwestern plains, the grain basket of the country.

Frequency of Ug99 resistant wheat lines derived from segregating populations selected under the Mexican and Mexico-Kenya shuttle breeding schemes

J. Huerta-Espino[1,2], R.P. Singh[2], S. Bhavani[3], P. Njau[4], E. Autrique[2], S.A. Herrera-Foessel[2], S. Mondal[2], B. Basnet[2], G. Velu[2], C. Lan[2], A.K. Joshi[5] and S. Singh[2]

[1]INIFAP-CEVAMEX, Apdo. Postal 10, 56230 Chapingo, Mexico; [2]CIMMYT, Apdo. Postal 6-641, 06600 Mexico D.F., Mexico; [3]CIMMYT, Nairobi, Kenya; [4]Kenya Agricultural Research Institute, Njoro, Kenya; [5] CIMMYT, Kathmandu, Nepal

E-mail: j.huerta@cgiar.org

Over 10,000 advanced bread wheat lines derived from crosses made in 2008 at CIMMYT, Mexico, were phenotyped for resistance to Ug99 races at KARI-Njoro during the 2012 off-season and simultaneously tested for grain yield at CIMMYT, Mexico. We retained 1,580 lines based on grain yield and resistance to *Pgt* raceUg99 and leaf rust. These lines were phenotyped for stem rust response at Njoro during the 2012 main-season. Lines were identified either as derived from the Mexican shuttle or Mexico-Kenya shuttle breeding schemes. We postulated the presence of effective race-specific or adult-plant resistance (APR) in each line using the pedigree, rust severity and host reaction. APR lines were further categorized as: near-immune resistant (NIR, 1% severity), resistant (R, 5-10% severity), resistant-moderately resistant (R-MR, 15-20% severity), and moderately resistant (MR, 30% severity) compared to 100% disease severity on Cacuke. Results indicated that 35.5% of lines possessed adequate APR in the following categories: NIR = 5.1%, R = 9.2%, R-MR = 13.3% and MR = 7.8%. Resistance of 734 lines could be due to race-specific genes or their combinations (often with *Sr2* and other slow-rusting APR genes): including *Sr13, Sr22, Sr25, Sr26, SrTmp, SrND643, Sr1A.1R, SrSha7, SrNing, SrHuw234, SrWestonia* and *SrCbrd*. Although both shuttle schemes gave lines with excellent levels of APR, the frequency of lines in the NIR category was much higher in the Mexico-Kenya shuttle. As expected many more lines (fourfold higher) with race-specific resistance were also obtained from the Mexico-Kenya shuttle. The results demonstrate the benefit of selecting for resistance, both race-specific and APR, in the presence of high inoculum loads.