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Index to Posters

Adoption or Rust Resistant Wheat

New Tools for Breeding

Mapping and Molecular Dissection of Rust Resistance

15 **Genomic localization and genetic mapping of race-specific stem rust resistance in the Synthetic W7984 x Opata M85 double haploid population,** *S.M. Dunckel et al.*

16 **Seedling resistance to wheat leaf rust in Thatcher isolines carrying race specific and race non-specific genes,** *S. Dugyala et al.*

17 **Breeding high yielding micronutrient-rich wheat varieties with resistance to rusts,** *G. Velu et al.*

18 **Leaf tip necrosis, lesion mimic genes and resistance to spot blotch in spring wheat,** *P.S. Yadav et al.*

19 **Molecular marker assisted accelerated improvement of wheat varieties with multiple rust resistances,** *Vinod et al.*

20 **Comparison of GBS vs. SNP-chip approaches for mapping Ug99-effective APR QTLs,** *P. Bajgain et al.*

21 **Deciphering single nucleotide polymorphism using Next-Generation Sequencing data in hexaploid bread wheat,** *S. Chandra et al.*

22 **Characterization of recombinant *Lr34* protein: A putative wheat ABC transporter involved in leaf rust resistance,** *R. Nandhakishore et al.*

23 ***In silico* identification, annotation and expression profiling of wheat WRKY transcription factors in response to leaf rust pathogenesis using Next Generation Sequencing data,** *L. Satapathy et al.*

24 **Functional characterization of a wheat WRKY transcription factor with protective role in leaf rust pathogenesis and AFM imaging of the protein-DNA complex,** *D. Kumar et al.*

25 **Mining, annotation and characterization of stress responsive transcription factor genes ZIM, GRAS and HSF in wheat,** *Poonam S. and K. Mukhopadhyay*

26 **Evidence of *Yr36*-mediated partial resistance at low temperatures,** *V. Segovia et al.*

27 **Validation of a candidate barley stem rust susceptibility gene determining the recessive nature of rpg4-mediated Ug99 resistance ,** *D. Arora and R. Brueggeman*

27.1 **Genome-wide association analysis on seedling and adult plant resistance of stripe rust in elite Pacific Northwest spring wheat lines,** *K. Ando and M. O. Pumphrey*

New Sources of Resistance

28 **Wheat-alien chromosome addition lines for stem rust and yellow rust resistances,** *M. Rahmatov et al.*

29 **Inheritance of Ug99 resistance in spring wheat landrace PI 374670,** *E.M. Babiker et al.*

30 **Reaction of Turkish wild and landrace wheat and barley accessions to African *Pgt* race TTKSK,** *B. Steffenson et al.*

31 **Introgression of resistance to African Pgt races from Sharon goatgrass (*Aegilops sharonensis*) into wheat,** *E. Millet et al.*

32 **Identification of novel genes for resistance to African *Pgt* races in *Aegilops* spp. ,** *J. Manisterski et al.*

33 **Stem rust resistance in *Aegilops* spp.,** *P.D. Olivera and Y. Jin*

34 **Genetics of resistance to African *Pgt* races in Sharon goatgrass,** *B. Steffenson*

35 **Stem rust and leaf rust resistances in wild relatives of wheat with D genomes,** *V.K. Vikas et al.*

36 **Sources of resistance to stem rust in durum wheat,** *A.N. Mishra et al.*

37 **Identification of new sources of resistance to wheat rusts,** *Satish-Kumar et al.*

38 **A novel gene for leaf rust resistance in Tunisian durum wheat,** *S. Berraies et al.*

39 **Yield evaluation of wheat lines carrying stem rust resistance genes derived from alien species,** *I. Dundas et al.*

40 **Preliminary evaluation of Ethiopian emmer landraces to wheat rusts and *Septoria tritici* blotch in southeastern Ethiopia,** *B. Hundie*

41 **Reactions of Turkish wheat landraces to *Pgt* race TTKTF,** *K. Akan et al.*

42 **Reactions of some Turkish *Aegilops* and *Triticum* materials to *Pgt* race TTKTF,** *K. Akan et al.*

National and Regional Efforts toward Wheat Rust Resistance

43 **Genetic mapping and QTL analysis of leaf rust resistance genes in Australian wheat cultivar 'Cook',** *A. Akhmetova et al.*

44 **Breeding for durable rust resistance in Texas hard red winter wheat using synthetic-derived wheat lines,** *B. Reddy et al.*

45 **Resistance to *Pgt* race TTKSF in the wheat cv. Matlabas,** *Z. Pretorius et al.*

46 **Development of wheat lines with complex resistance to rusts,** *L. Herselman et al.*

47 **Stripe (yellow) rust resistant spring bread wheat genotypes for the CWANA region,** *W. Tadesse et al.*

48 **Variation in seedling response to North American *Pgt* and *Pt* races in an inclusive East African bread wheat panel,** *M. Godwin et al.*

49 **Evaluation of bread wheat germplasm from the CGIAR Centers against *Pgt* race Ug99 in 2012,** *Z. Tadesse*

50 **Yield performance and rust reactions of Ethiopian bread wheat genotypes ,** *Y.S. Ishetu et al.*

51 **Zakia: A new Ug99-resistant variety for the heat stressed environments of Sudan,** *I.S.A. Tahir et al.*

52 **Resistance of some Turkish bread wheat genotypes to yellow rust and stem rust,** *L. Çetin et al.*

53 **Seedling and adult plant resistance to stripe rust among winter wheat commercial cultivars and advanced breeding lines in Uzbekistan,** *Z. Ziyaev et al.*

54 **Molecular breeding for leaf rust resistance in wheat,** *A. Kokhmetova et al.*

55 **Characterization of Afghan wheat landraces for response to rusts,** *A. Manickavelu et al.*

56 **Stem rust reactions of candidate wheat lines under artificially inoculated and natural conditions in southern Pakistan,** *K.A. Khanzada et al.*

57 **Response of wheat cv.Seher-06 to leaf rust in Pakistan,** *J.I. Mizra et al.*

58 **Wheat cultivation in Bhutan: Prospects and challenges,** *S. Tshewang and Doe Doe*

59 **Genetics of rust resistances in Nepalese wheats,** *B.N. Mahto et al.*

60 **Determining rust resistance genes in Nepalese wheat lines using SSR markers ,** *S. Baidya et al.*

61 **Rust resistant wheat varieties released in Bangladesh,** *N.D.C. Barma et al.*

62 **HD-2189: A bread wheat variety undefeated by *Puccinia triticina* for 25 years in India,** *G.S. Arunkumar et al.*

63 **Yield reductions caused by stripe rust in a diverse group of Indian wheat genotypes,** *R. Tiwari et al.*

64 **Screening Indian germplasm for leaf rust resistance,** *A.L. Bipinraj et al.*

65 **Utilization of Australian germplasm for enhancing stripe rust resistance in popular Indian wheat cultivars ,** *R. Chatrath et al.*

66 **Marker assisted pyramiding of stem rust resistance genes *Sr24* and *Sr26* in Indian wheat breeding,** *B.K. Das et al.*

67 **Adult plant leaf rust resistance in Indian bread wheat accessions bearing leaf tip necrosis,** *J Kumar et al.*

68 **Assaying stem rust resistance genes in Indian wheat varieties using molecular markers,** *R. Malik et al.*

69 **An accelerated breeding approach to pyramid resistance genes as a means of addressing wheat rust threats in India,** *M. Sivasamy et al.*

Breeding Rust Resistance Durum Wheat

Global Surveillance Tools

National Surveillance Efforts

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.*

Stem rust resistance in durum wheat

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The objective of our study in durum wheat is to identify resistance genes that are effective against *Pgt* Ug99 and other races and therefore could be utilized in durum breeding. We characterized 3,500 accessions for stem rust response in the field (Debre Zeit, Ethiopia, and St. Paul, MN) and in seedling evaluations. Accessions with resistant to moderately resistant responses in multiple field evaluations were characterized at the seedling stage for reaction to three *Pgt* races: TTKSK (Kenya), TRTTF (Yemen), and TTTTF (USA). Accessions resistant to race TTKSK were further characterized against race JRCQC (Ethiopia), a race with combined virulence to *Sr9e* and *Sr13*, genes that are common in durum germplasm. We also used representative US *Pgt* races to evaluate these resistant accessions. Two hundred and eighty accessions were resistant to moderately resistant in all field evaluations. The highest frequencies of resistant lines were from Northeast Africa (Ethiopia and Egypt) and North America (Mexico and USA). Among the field-resistant accessions, 123 were resistant to all *Pgt* races used in seedling evaluations. These accessions likely possess useful resistance genes. Accessions susceptible at the seedling stage are being evaluated for the presence of adult plant resistance genes. Inheritance studies of TTKSK resistance revealed that resistance to race TTKSK was conferred mostly by one and two genes. A bulk segregant analysis approach is being used to map the resistance genes in selected lines using the 90K SNP platform.

Breeding for leaf rust resistance in durum wheat in Morocco

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Leaf rust is the most important leaf disease on durum wheat in Morocco and other Mediterranean countries. The Moroccan environment is highly variable and most of it is drought prone. The occurrence of leaf rust is therefore highly variable. Historically, breeding for resistance was hampered by irregular epidemics and the lack of artificial inoculation facilities. As the primary goals of breeding in Morocco also include resistance to Hessian fly, resistance to Septoria tritici blotch (STB) and tolerance to drought, it is difficult to produce satisfactory advanced lines with overall superior attributes. In recent years, parents and breeding lines with good resistance to leaf rust were identified and have been crossed and selected to meet Moroccan breeding goals. Several advanced lines possessing leaf rust and/or Hessian fly resistance and drought tolerance have been selected and tested under leaf rust epidemic conditions. Some of these lines are also tolerant to STB. Our presentation will discuss the performance of the most promising lines relative to the breeding objectives. These advanced lines will be proposed for registration and will be used in further crossing.

Preliminary characterization of resistance to stripe rust in six elite durum lines

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Little information is available on the genetics of resistance to stripe rust in durum wheat. There have been occasional and sporadic reports of increasing stripe rust occurrence and perhaps virulence in different durum growing regions. Therefore, it seems important to investigate the genetic basis of the widely effective resistance(s) in this crop in order to prevent, or at least minimize, the impact of a possible breakdown similar to past events regarding leaf rust. Six resistant advanced elite durum lines from the CIMMYT program were crossed to the stripe rust susceptible emmer accession Khapli (CID141002, GID6013). F_3 families (86 to 185) were evaluated in inoculated field nurseries at the CIMMYT Toluca Research Station, where the environment is highly conducive to stripe rust development. Preliminary results indicate that resistance in four lines is controlled by single major gene(s). In one genotype resistance appeared to be conditioned by two dominant genes, and in one genotype two complementary genes were evident. These results indicate that simple, major gene-based resistances predominate in CIMMYT elite germplasm, strongly suggesting a degree of genetic vulnerability and suggesting a need for diversification. Further characterization of these populations is underway to determine possible relationships between the different major genes detected and how they relate to known stripe rust resistance genes in bread wheat.

Leaf rust resistance in landraces and wild relatives of durum wheat from the Caucasus region

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A set of tetraploid wheat landraces and wild relatives originating from the Caucasus (Armenia, Azerbaijan, Georgia) was evaluated for reaction to leaf. The material was tested under inoculated field conditions at Ciudad Obregon and El Batan CIMMYT stations in 2012. It was also tested for seedling reaction to Mexican *Pt* races BBG/BP, BBG/BN, and a race (temporarily designated as race 61/61) carrying virulence to *Lr61*. Twenty seven accessions (21%) carried seedling resistance genes that could not be postulated using the available races. The only resistance gene that could be postulated was *Lr72*, recently identified in durum cv. Altar 84. This gene was postulated alone in 28 accessions (22%) and in combination with adult plant resistance (APR) genes in a further set of 28 accessions (22%). No detectable resistance was present in 35 accessions (28%), and five accessions (4%) carried APR only. The presence of *Lr72* in a high proportion (44%) of accessions from the Caucasus raises questions as to the origin of this gene, which protected most CIMMYT germplasm from Mexican races until 2001. Genetic studies are underway to characterize the unknown seedling resistance and APR genes detected in the material.

Characterization of leaf rust resistance in durum wheat lines derived from crosses with wild relatives

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Landraces and wild relatives (or their derivatives) represent resources of choice to widen the genetic diversity of resistance to rusts in durum, as they are likely to provide genes of limited or no previous use in breeding programs. This is especially useful in the case of leaf rust, against which relatively few genes remain effective in modern durum germplasm. Several leaf rust resistance sources were identified in a previous evaluation of more than 800 accessions from the CIMMYT germplasm repository. The present study focuses on the characterization of the genes involved in four resistant lines originally derived from crosses with *T. dicoccoides* and *T. carthlicum*, and bred in the 1980s in the CIMMYT pre-breeding program. All four sources were crossed with two susceptible genotypes for field evaluation with Mexican race BBG/BP, and also inter-crossed for tests of allelism. Results indicated that two recessive complementary genes conditioned resistance in all four sources. Tests of allelism suggested that the *T. dicoccoides*-derived lines had resistance genes that were either allelic or very closely linked. The line derived from *T. carthlicum* had a different resistance gene. The populations are currently being advanced to develop recombinant inbred lines for further characterization and genetic mapping.

Mitigating the threat of leaf rust to durum yield stability in new, *Septoria tritici* blotch resistant, germplasm in Tunisia

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Septoria leaf blotch (STB), caused by *Mycosphaerella graminicola* (*Septoria tritici*), has traditionally been the most important biotic constraint to durum wheat production in Tunisia, with leaf rust being a secondary yield-limiting factor. Development and spread of STB resistant cultivars, along with warmer temperatures early in the crop cycle, will provide more opportunity for leaf rust to increase in incidence and to cause more damage to durum yields. This has led the national program at INRAT to breed for resistance to both pathogens simultaneously. Results from a 2-year evaluation of a "trap nursery" including genotypes with known leaf rust resistance genes revealed that *Lr3a*, *Lr27+31*, Lr_{CAMAYO} and *Lr61* are still effective against local pathotypes in 3 Tunisian locations. However, clearly susceptible pustules with low to intermediate incidence were observed on lines carrying *Lr14a*, suggesting that this widely used gene will not be useful for durable protection against leaf rust in Tunisia. Based on these results, the crossing strategy in our national program and within the joint INRAT-CIMMYT effort to co-develop STB resistant germplasm has been modified to use non *Lr14a*-based resistances to leaf rust. In addition, our cultivar deployment strategy will discourage cultivation of the successful MAALI (STB moderately resistant, but with *Lr14a*-based resistance to leaf rust) in favor of its rapid replacement by the more recent cultivar SALIM, with better resistance to STB and resistance to leaf rust based on a different gene, mapping of which is underway.

Identification and mapping of markers linked to leaf rust resistance in Indian durum genotype Malvilocal

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Most durum cultivars in India have good resistance to leaf rust, but little is known about the genetics of resistance in durums. In inheritance studies, seedling resistance to *Puccinia triticina* pathotype 77-5 in lines AO90 and Malvilocal possessed single dominant genes for resistance, and Haura carried a single recessive gene. Malvilocal was also resistant to pathotype 104-2 and pathotyping studies indicated the gene in Malvilocal was novel. Mapping of the resistance gene in Malvilocal was therefore undertaken using an $F_{2:3}$.population of Gulab × Malvilocal. In a parental polymorphism analysis using 486 SSR markers, 162 polymorphic markers were identified and used for bulk segregant analysis based on reactions to pathotypes 77-5 and 104-2. Three SSR markers located on chromosome 4AS were linked to the gene for resistance to pathotype 104-2. Marker *barc206* was 6.6 cM distal to the resistance gene, whereas the co-located markers *gwm192* and *gwm165* were 12.6 cM proximal. This resistance gene was tentatively named *LrMl*.