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Poster Abstracts

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Poster Abstracts
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43. Shortening the *Lr62/Yr42* Translocation in Common Wheat

GF Marais[1], AS Marais[1], A Eksteen[1], ZA Pretorius[2]

The *Lr62/Yr42* translocation (from *Aegilops neglecta*) in wheat consists of alien chromatin, and only the distal end of the wheat chromosome arm 6AL, including the telomere, is of wheat origin. Because the large amount of associated foreign chromatin prohibits commercial use of the resistance an attempt was made to remodel the translocation through allosyndetic pairing induction. Plants heterozygous for the translocation, but lacking the *Ph1* locus, were testcrossed with CS nullisomic 6A tetrasomic 6B (or 6D) plants. Resistant testcross F_1 progeny, were characterized with three markers (including a newly-developed SCAR marker, Sopw7) and the data were used to do a three-point genetic mapping analysis. It appeared that *Lr62/Yr42* is located towards the distal end of 6AS. Fourty one recombinants were subsequently characterized with further microsatellite markers. The recombination data were complex and indicative of areas of homoeology between the wheat (CS *ph1b* mutant) and translocated chromosomes 6A; however, there was also evidence of major structural differences between the two chromosomes, including a duplication and a translocation. The structural differences led to the formation of irregular meiotic pairing structures. Single crossovers within these configurations produced complex segregation patterns that were difficult to interpret. It was, however, possible to explain the origin of the majority of recombination products, and to identify a subset of the most useful recombinants. DArT markers could be used to further discriminate among the selected recombinants and those that retain comparatively small regions of foreign DNA together with the *Lr62/Yr42* resistance genes and SCAR marker were kept for further use.

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44. Resistance to Stem Rust Race Ug99 in the Canadian Spring Wheat Cultivar 'Peace'

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Stem rust, caused by *Puccinia graminis* f. sp. *tritici*, is a highly destructive fungal disease of wheat. This pathogen has been effectively controlled in western Canada through resistance since the 1950s. In 1999, a new highly virulent race of stem rust was identified in Uganda. The new strain, named "Ug99", was given the North American race designation TTKSK. *In situ* screening has demonstrated that approximately 75% of Canadian wheat cultivars are susceptible to this new race of stem rust. Fortunately, two cultivars, Peace and AC Cadillac, were highly resistant to Ug99. A doubled haploid population was generated from the cross: RL6071/Peace, where RL6071 was the stem rust susceptible parent. In 2008, 189 DH lines from this population were evaluated for response to Ug99 in Kenya. RL6071 and Peace were rated: 80 S and 5 R, respectively. Disease ratings of the DH lines, ranged from 80 S to 1 R. Mendelian evaluation of the stem rust scores indicated a two-gene model (X^2=5.51; 0.25<P<0.10; d.f.=3) of inheritance. Peace has the positive allele for the diagnostic *Lr34* DNA marker (csLVMS1) published by Spielmeyer et al. (2008). It is believed that Peace carries *Lr34* and that this gene may be one of the genes responsible for Ug99 resistance in this cultivar. Molecular mapping of the Ug99 resistance in cultivar Peace is underway.

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45. Molecular Mapping of Rust Resistance Genes and Marker-Assisted Breeding in Wheat

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Molecular markers make possible the deployment of multiple rust genes in adapted elite lines. In this study we report a summary of the microsatellite tagging of a number of leaf rust, stem rust and stripe rust resistance genes from a variety of sources. Segregating Leichardt/WAWHT2071 and Sunland/Arrino populations were used for mapping *Lr13* and *Lr28* where Leichardt and Sunland were the respective sources of the resistance genes. Lines C77.19/3*77W:549-163658 and *Sr33*/2*Shortim//4*3/Jacup resistance lines were used as sources of *Sr32* and *Sr33*. F_2 and $F_{2:3}$ populations were used for microsatellite tagging of the genes. Very closely linked SSR markers were identified for *Lr13*, *Lr28*, *Sr32* and *Sr33* on chromosomes 2BS, 4AL, 2BS and 1DS, respectively. Results from field-based studies of various mapping populations for the characterization of adult plant rust (APR) resistances from a variety of sources such as Wyalkatchem, Yitpi and Frame will also be discussed. Molecular markers for a range of other rust resistance genes (*Lr9, Lr19/Sr25, Lr24/Sr24, Lr34/Yr18, Lr46/Yr29*, *Lr47*, *Sr26* and *Sr36*) are currently being implemented for variety development and germplasm enhancement. The likely impact of these applications on wheat improvement will be discussed.

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46. The Multi-State Rust Screening Nursery at Castroville, Texas, U.S.A.

AMH Ibrahim[1], J Rudd[1], A Klatt[2], A Fritz[3]

Wheat (*Tricticum aestivum* L.) leaf rust (caused by *Puccinia triticina*), is a devastating foliar disease in the US Great Plains where short-lived, major gene resistances are mainly utilized. A hotspot rust screening nursery, established at Castroville, Texas, the forefront of the *Puccinia* pathway in the US, is a joint effort between Texas A&M University (TAMU), Oklahoma State University (OSU), and Kansas State University (KSU). It has grown into a 20 acre (8.3 ha) nursery and now involves the participation of almost all wheat breeders from eight Universities and three USDA research centers across the US.

The nursery was mainly established to screen wheat for reaction to leaf rust, stem rust (caused by *Puccinia graminis* f. sp. *tritici* and stripe rust (*Puccinia striiformis*), as well as oats for reaction to crown rust (*Puccinia coronata*) and stem rust (*Puccinia graminis* f. sp. *avenae*). Heavy wheat leaf rust and oat crown rust infections are an annual event and reliable data are obtained on advanced experimental lines as well as established wheat and oat varieties. The nursery has also been utilized for selection of single plants from segregating bulks. A first look at promising resistant germplasm from CIMMYT was conducted in collaboration with OSU. This nursery has provided warnings regarding the weakening resistance of key Great Plains wheat cultivars.

Clearly, the rust screening nursery at Castroville has provided a rust screening hotspot for US breeders and has proven indispensable since its inception in 2000.

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47. Evaluation in Kenya of Global Diversity in Winter Wheat for Resistance to Stem Rust

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The International Winter Wheat Improvement Program (www.iwwip.org) is a joint project between the Ministry of Agriculture and Rural Affairs of Turkey, CIMMYT and ICARDA, and was established more than 20 years ago. The objective of the program is to develop facultative and winter wheat germplasm for the region of Central and West Asia. The materials address both irrigated and rainfed environments. IWWIP also facilitates global germplasm exchange of winter wheat by receiving breeding lines and varieties from our own and other programs, evaluating them, and distributing selected entries through the system of international nurseries. Four different international nurseries are distributed globally on an annual basis to more than 50 countries and more than 100 co-operators. Breeding for resistance to yellow (stripe), leaf and stem rust is high priority along with broad adaptation and grain quality. Due to the recent emergence of stem rust as a global threat, routine evaluation of winter and facultative germplasm in Kenya started in 2006. However, the pathogen population dynamics in Kenya and challenges with vernalization in an equatorial environment did not permit satisfactory screening until the summer cycle of 2008. Close to 700 entries representing germplasm from all continents and from major winter wheat producing countries were evaluated at KARI, Njoro, in October 2008. Two readings were taken with an interval of 10 days. Overall, 120 entries were selected with variable degrees of resistance. The evaluation data and resistant entries for the 15th and 16th FAWWON (Facultative and Winter Wheat Observation Nursery) and 10th and 11th IWWYT (International Winter Wheat Yield Trial) is available at the program web site. Additional disease data of germplasm not included in the nurseries is available from IWWIP upon request.

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48. Breeding for Rust Resistance in Winter Wheat in Szeged, Hungary

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Among the wheat rusts in Hungary, stem rust (caused by *Puccinia graminis* f. sp. *tritici*) caused large losses at the end of the19th and the first part of the 20th centuries. Since 1950, the significance of leaf rust (*P. triticina* has increased steadily, and it is currently the most important wheat disease in the area. The occurrence and damage caused by yellow (stripe) rust (*P. striiformis* f. sp. *tritici*) is much less, the last epidemic occurring in 2001.

According to annual observations on near-isogenic lines in Hungary, leaf rust resistance genes *Lr9*, *Lr19*, *Lr24*, *Lr25*, *Lr29*, *Lr35* and *Lr38*, and stem rust resistance genes *Sr36*, *Sr27* and *Sr31* provide effective resistances in the field. However, there is a lack of information on the effectiveness of adult resistances to yellow rust as natural infections are a rare occurrence.

We realized in the 1980s that *Sr36* provided a durable and high level resistance. As a result of extensive crosses with appropriate parental lines, *Sr36* resistance is present in a large proportion of the winter wheat varieties developed at Szeged, Hungary.

Besides the applied field research, molecular markers are increasingly being adopted in our breeding program. Tests using microsatellite markers on 220 cultivars registered in Hungary in the past 35 years showed that the frequency of the *Sr31* resistance gene reached 49% (in 1994). The frequency peak for *Sr36* was 32% reached in 1983-84.

Although both the *Sr36* and *Sr31* genes are still effective, the predominant use of one or the other might be dangerous.

We developed mapping populations using susceptible cultivars and leaf rust near-isogenic lines (*Lr9*, *Lr20*, *Lr29* and *Lr52*). Using these populations several RAPD, SSR and SCAR markers were identified for the genes.

Marker assisted selection was used to transfer these and other resistance genes and gene complexes (*Lr19/Sr25*, *Lr20/Sr15*, *Lr24/Sr24*, *Lr34/Yr18*, *Lr37/Yr17/Sr38*, *Lr46/Yr2*; *Lr21*, *Lr29*; *Sr36*, *Yr5*; *Yr15*) to cultivars developed at our institute.

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49. Breeding Leaf Rust Resistant Wheat Varieties in Martonvásár, Hungary

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Wheat in Hungary is threatened by all three rusts, viz. leaf rust, stem rust and stripe rust. All three diseases are capable of causing substantial economic losses, but their incidence varies due to their diverse ecological requirements. The greatest damage is currently caused by leaf rust, which infects wheat fields every year. The most environmentally sound, low cost method of controlling leaf rust is to breed and grow resistant varieties. Both traditional and molecular breeding methods are used to improve the leaf rust resistance of wheat varieties bred in Martonvásár, Hungary.

The field reponses of wheat genotypes carrying designated *Lr* genes have been assessed for many years in order to determine the effectiveness of major leaf rust resistance genes. The 'Thatcher'-based near-isogenic lines, carrying single genes for resistance are sown each year. Eight NILs remain immune or highly resistant: these include lines with *Lr9*, *Lr19*, *Lr24*, *Lr25*, *Lr28*, *Lr29*, *Lr35* and *Lr37*. The levels of infection on four further lines (*Lr23*, *Lr32*, *Lr3ka* and *Lr22a*) were also quite low. The line exhibiting the greatest degree of infection was the NIL carrying *Lr26*.

The segregating populations in the breeding program are tested and selected continuously under artificially inoculated conditions. A special nursery is devoted to testing the leaf rust resistance of advanced breeding lines, special genetic stocks and potential leaf rust resistance sources. The levels of resistance in the released and cultivated winter wheat varieties bred in Martonvásár, namely, 'Mv Magvas', 'Mv Marsall', 'Mv Toborzó', 'Mv Béres', 'Mv Matyó', 'Mv Vekni', 'Mv Laura' and 'Mv Lucia' at 0–20MR, are sufficient to negate the need for chemical control in farmers' fields.

Using marker-assisted selection (MAS), the resistance genes *Lr9, Lr24, Lr25, Lr29, Lr35* and *Lr37* were incorporated into four Martonvásár winter wheat varieties. A marker- assisted backcross program to track the transfer of effective *Lr* genes has begun. Wheat varieties susceptible or moderately resistant to leaf rust were crossed with NILs of 'Thatcher' each carrying a different *Lr* gene (*Lr9, Lr24, Lr25, Lr29* or *Lr35*) and with the variety 'Renan' (*Lr37*). Plants in the fifth backcross generation had agronomic traits resembling the recurrent parent.

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50. Combined Resistance to the Most Important Wheat Diseases in the Czech Republic

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All three rust diseases of wheat occur in the Czech Republic. Leaf rust is most frequent. The last stem rust epidemics occurred in 1972, and the last significant yellow (stripe) rust outbreak was in 1999-2001. Resistance breeding aims at combined resistance to all three rusts. Combined resistance was present in 11 of 29 new breeding lines recently tested. The highest resistance occurred in breeding line SG-S-469-07, followed by BR-05-082 and SG-S-316-06. On average the highest degrees of resistance were to yellow rust. Of the winter wheat cultivars registered in the Czech Republic, the highest combined resistance to all three rusts was in cultivars possessing the translocation from *Aegilops ventricosa* (*Yr17, Lr37*, *Sr38*). In addition to rusts, attention is also given to fusarium head blight, powdery mildew, tan spot, Septoria leaf blotch, Septoria glume blotch and BYDV (barley yellow dwarf virus). Ring tests are organized at several different locations to screen new breeding lines for resistance to the various diseases. Spreaders are inoculated when natural infection is not adequate.

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51. Screening Wheat Germplasm for Resistance to Stem Rust in Georgia

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Stem rust was a major threat to wheat production in Georgia before the 1970s. However, promotion of stem rust resistant varieties, such as Bezostaia 1, reduced its impact on production. Recently, there has been an increase in stem rust occurrence in some areas of Georgia. There is also a possibility that race Ug99 will eventually reach Georgia. Barberry is widespread in the country. Identification and promotion of rust resistant germplasm is an important strategy for wheat rust control, especially because the use of fungicides on wheat is not a common practice in Georgia. The

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objective of the present study was to identify effective rust resistance genes under Georgian conditions and to select resistant genotypes for further utilization in breeding. The 2nd and 3rd ISRTN ICARDA-CIMMYT nurseries were tested in inoculated stem rust nurseries during 2006-7 and 2007-8 in Kobuleti, respectively. Resistance genes *Sr13, Sr22, Sr24, Sr25, Sr26, Sr27, Sr31* and S*r36* were effective. However, in seedling tests, a level of virulence occurred for *Sr36* (0.3-2.9%). In 2007, the Ug99 Stem Rust Trap Nursery was planted in the Akhaltsikhe region in South Georgia, where stem rust occurs every year.

The search for resistant varieties began with screening of the Caucasian Regional Winter Wheat Nursery, which included 108 Georgian, Armenian, Azeri, Turkish and Russian varieties, for resistance to stem rust induced by inoculum collected across the entire wheat-growing area of Georgia. About 50% of entries were resistant. The same nursery was sent to Kenya for screening against Ug99. Only a few entries showed moderate resistance to Ug99, which was not confirmed after repeated testing in the following year.

The CIMMYT STEMRRS Nurseries were used to identify and promote stem rust resistant germplasm in Georgia. The 1stSTEMRRSN was tested in an inoculated rust nursery. Only 3.8% of entries showed full resistance, but 70.5% were moderately resistant; the remaining 13.3% and 10.5% were moderately susceptible and susceptible, respectively. No selections were made as the nursery was planted in a non-wheat producing area where the environment was not conducive for the production of healthy grain. In the following season, the 2nd STEMRRSN was planted in the wheat-growing area, and the following lines were selected and advanced to the multiplication and agronomic assessment levels: Babax/Lr42//Babax*2/3/Brambling (6004), three sister lines of Babax/Lr42//Babax*2/3/Kuruku (6007, 6009 and 6012), Babax/Lr42//Babax*2/3/Vivitsi (6022), Croc_1/ Ae.Squarrosa (205)//FCT/3/Pastor (6136), Thelin#2/ Tukuru (6069), Waxwing*2/Kuruku (6086) and Canadian/ Cunningham//Kennedy (6137).

The results obtained from the present study provided useful information for breeders on effective rust resistance genes and allowed for identification of resistant germplasm.

52. Wheat Breeding for Durable Rust Resistance in Pakistan

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Most of the major genes available for resistance to stem rust, leaf rust and yellow rust are currently ineffective. Wheat varieties released in Pakistan in the past possessed at least *Lr1, Lr10, Lr13, Lr 23, Lr26, Yr9, Yr27* and *Sr31*. Virulences for all these genes, except *Sr31*, are widespread. Historical evidence has shown that resistances based on major genes have short durations of effectiveness whereas those based on minor genes have durability, e.g. Inqilab 91 and Lylpur 73. Numerous minor genes have been identified and it has been established that accumulations of 4-5 minor genes give resistance levels approaching immunity, whereas, 2-3 minor genes confer adequate levels of adult plant resistance (APR). At the Wheat Research Institue, Faisalabad, a project was launched in 1992-93 for the development of wheat varieties having minor gene-based resistance. Wheat germplasm was assessed for resistance by inoculating materials with diversified inocula and observing the rust development patterns for 2 or 3 years. Accessions carrying minor genes were identified and crossed following single cross, double cross, tropcross and backcross approaches for pyramiding minor genes for rust resistance. Segregating materials were evaluated in inoculated nurseries using the selected bulk method. Homozygous resistant lines selected in F_7 were evaluated in replicated trials, in the different ecological zones of Pakistan. The most promising crosses were Wattan/2*Inqilab, Pb96/Wattan//MH97, Shalimar 88/2*Attila, Shalimar 88/ Wattan//MH97 and Luan/Kohistan. Two varieties Shafaq-06 and Lasani-08 were released to farmers and several lines having better resistance than the parents are in the pipeline. Shafaq-06 has high yield potential and durable types of resistance to yellow (stripe) rust and leaf rust. Lasani-08 has high yield potential and durable types of resistance to yellow rust, leaf rust and stem rust (including Ug99).

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53. Breeding Rust Resistant Wheat Varieties in Tajikistan

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Wheat is the main staple food crop in Tajikistan and it is of increasing importance to develop high yielding varieties with disease resistance and good bread making quality. International collaboration has been established, and nurseries are received especially from the Turkey-CIMMYT-ICARDA International Winter Wheat Improvement Program (IWWIP), located in Turkey, but also more recently from Oklahoma State University in the USA.

Together with tan spot, yellow (stripe) rust is a major biotic constraint faced by wheat farmers in Tajikistan. Through a multilocation testing system, several high yielding and resistant lines were identified and are in the process of being released.

In order to test for resistance to race Ug99 in Tajik wheat germplasm a number of varieties and advanced lines were tested in Kenya in collaboration with CIMMYT. The results demonstrated a low level of resistance in Tajik germplasm, indicating an urgent need to initiate breeding activities to reduce the consequences of a possible incursion of Ug99 to Tajikistan. A collaborative project has been initiated with the Swedish Agricultural University to introgress novel genes for resistance to race Ug99 into Tajik wheat germplasm.

This paper evaluates the results of multilocation trials conducted during 2005, 2006 and 2007 through which high yielding and disease resistant lines were identified and recommended for submission to official variety testing trials. Furthermore, the paper discusses the future breeding strategy to increase the level of resistance to race Ug99 in Tajik wheat germplasm.

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54. Identification of Stem Rust Resistance Germplasm in Kazakhstan

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Kazakhstan is one of the largest wheat producers in central Asia. Wheat rusts are important problems in our country. Stem rust (pathogen, *Puccinia graminis* f. sp. *tritici*) causes considerable damage, especially in wetter years. In order to combat the menace of rust, screening of various nurseries from national and international breeding programs was initiated. The aim of the present work was to find sources of stem rust resistance and to develop disease-free germplasm. The material was screened with the predominant races in the region. Cultivar Steklovidnaya 24 was used as a susceptible check. A total of 55 wheat genotypes were included in the 2008 tests; 33 lines showed high or moderate levels of resistance in the field. Tests of the material under artificial conditions identified eight entries with stem rust immunity ; viz. 86003/F9Norin10/Steklovidnaya24, 86004 /F7322-MA/118-SI, 86006/F6KSI-21/Arthur, 86007/F6KSI-21/Arthur, 86018/Lawson/Currawong, 86019/Moro*2(C90) /More*2//Marcuis)2, 86022/F5Janbash/Anza, 86023/F4KLDN33/MK-3832, 86024/F4Tilek/KLDN-95. Two lines were characterized as moderately resistant; viz. 86005/F6 Progress/*T. monococcum* and 86008/F6KSI-21/97Sr25. Evaluation for agronomic traits allowed selection of 10 advanced lines with high yield potential and resistance to stem rust. Because Ug99 is virulent to the great majority of wheat varieties, we sent our promising material to Kenya for testing. Based on the results we will be able to develop cultivars possessing genes, or combinations of genes, efective against this widely virulent race of the pathogen.

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55. Employing Male Sterility Mediated Marker Assisted Recurrent Mass Selection in a Pre-Breeding Strategy for Accumulating Disease Resistance Genes

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A pre-breeding strategy based on the recurrent mass selection population developed by Stellenbosch University's Plant breeding laboratory (SU-PBL) is currently being implemented to enhance resistance against the most prevalent stem rust pathotypes occurring in the winter rainfall cereal production region of South Africa. The male sterility-mediated marker assisted recurrent mass selection (MS-MARS) scheme makes use of the dominant male sterility gene, *Ms3*, and hydroponic culturing in order to facilitate large scale hybridization of material. Male parents for this particular study were selected based on their resistance to three predominant *Puccinia graminis tritici* pathotypes, and the results obtained by molecular marker screening. The three pathotypes were 2SA88, 2SA100 and 2SA102. Markers were used to screen for the presence of *Sr2*, *Sr26* and *Sr36*. According to marker data, Kite, Songlen, Steenbras, Timgalen and Zaragoza carried *Sr2*. Only Songlen and Steenbras gave sufficient resistance to all three pathotypes. The two lines postulated to carry *Sr26*, Avocet and Eagle, both gave positive amplification for the relevant marker. The stem rust resistance reactions were also sufficient for breeding purposes. The female lines were all sourced from the SU-PBL's recurrent mass selection program. By using molecular markers for the identification of resistance gene complexes *Lr24*/*Sr24*, *Lr37*/*Sr38*/*Yr17* and *Sr31*/*Lr26*/*Yr9*, female lines were selected which carry all three complexes. In total 180 lines from the SU-PBL's RMS program were screened, and 11 were identified to carry all three complexes. Currently we are in the process of intercrossing the selected male and female parents.

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56. Pyramiding Slow Rusting Genes for Durable Resistance to Leaf Rust in Durum Wheat

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Variants of *Puccinia triticina* race BBG/BN, separately overcoming three resistance genes, were identified from durum wheat (*Triticum turgidum* ssp. *durum*) fields in northwestern Mexico since its introduction in 2001. Major genes available for use in breeding programs are limited and an alternative strategy is required. Previous studies indicated that slow rusting resistance in eight CIMMYT durums was determined by 2 to 3 minor genes with additive effects. Twenty-eight 4-way crosses were made between these lines with the aim of developing new germplasm with enhanced levels of resistance through pyramiding diverse minor genes. Plants in F_1 (4-way) through F_3 generations were selected for slow rusting under high leaf rust pressure at the Cd. Obregon and El Batan field sites in Mexico and spikes from selected plants were harvested as bulks. Plants in the F_4 generation were individually harvested and1,843 advanced lines obtained, among which 106 lines with enhanced resistance, and desirable agronomic and grain characteristics were selected for non-replicated yield and leaf rust evaluation trials at Obregon during the 2007-2008 season. The best 19 lines, exhibiting near-immunity but with the presence of a few susceptible type pustules, parents and susceptible checks were evaluated for leaf rust resistance under very high disease pressure in replicated trials sown on two dates (16 May and 6 June) at El Batan during 2008. Spreader rows of susceptible cultivar 'Banamichi C2004', sown as border and as hills on one side of each plot, were inoculated with *P. triticina* race BBG/BP. Leaf rust severities, and host responses to infection were determined from weekly readings, and area under the disease progress curves (AUDPC) were calculated. Several lines were identified with significantly lower final leaf rust severity responses and AUDPC values than the most resistant parent in each cross. Our results show that enhanced levels of slow rusting can be generated by pyramiding diverse genes present in different parents. The trial is being repeated during the 2008-2009 season at Obregon to validate the results. In addition these lines are being used for transferring slow rusting resistance into high yielding, superior quality adapted backgrounds using the single-backcross approach.

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57. Stacking Leaf Rust Resistance Genes in Wheat Breeding Populations Using Telocentric Chromosomes

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Resistance to the wheat rusts is improved in level and durability when resistance genes are stacked. Selecting gene stacks in breeding populations by phenotype can be difficult or impossible and marker-assisted selection is expensive. Furthermore, when stacks are selected the effective size of the population is reduced thus limiting the available variability from which to select other characters. We propose using telocentric chromosomes to fix resistance gene stacks in breeding populations by selecting double monotelodisomic F1 plants (2n = 40 + t + t) with the pair of resistance genes in the hemizygous condition. This method was demonstrated in two wheat populations, each with a different two-gene stack of leaf rust resistance genes. The presence of critical telocentric chromosomes in the populations rapidly drove stack frequencies toward fixation by a combination of selection for euhaploid pollen and zygotic selection for diploid and near-diploid (i.e. no ditelosomics) plants. Thus, telocentric chromosomes provide a tool to fix gene stacks in a population while maintaining the effective size of the population for selection on other criteria. One point of consideration is the relatively large size of the linkage blocks being fixed.

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58. A Systemic Approach to Germplasm Development: a Simple Way to Reach a Complex Goal

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The fight against rusts relied heavily on major genes, but other genes also exist. Our own experience has been mostly with BYDV and FHB, both diseases having very complex genetics. Twenty five years of attempts to breed resistance based on major genes gave poor results. Then we undertook to seek simultaneous resistances to all diseases present in Eastern Canada. We thus breed against rusts, powdery mildew, BYDV and FHB. Using much more biodiversity and selecting intensively for resistance to all diseases should single out plants that resist nearly all diseases. Doing this, more than 99% of the germplasm was destroyed by diseases. Among 10,000 F_1 plants inoculated, one single cross combination gave the sought-after result. Within one year, we had introgressed in one genotype the FHB resistance of Sumai 3, very good BYDV and powdery mildew resistances, and rust resistance equal to that of the most resistant parent. Important lessons follow. The value of a gene source cannot be fully judged by its disease reaction because epistatic hidden genes can exist in any line. Making many crosses is the way to get the most out of the hidden genetics. A very severe, complex selection protocol can work. The method gave resistance to all Eastern rust races. BYDV tolerance correlated with yield and biomass potential. Applying a multiple-stress system to more rust species is worth a try. Good outcomes are expected in pyramiding slow rusting genes, and multiple genes form durable horizontal resistance. Multiple approaches constitute the best strategy to address a disease that can ruin part of the world food basket.

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59. Addressing Old Challenges to a Sustainable Durum Wheat Production in Tunisia while Preparing to Face New Threats: Development and Deployment of Cultivars with Combined Resistance to *Septoria Tritici,* Leaf Rust and Stem Rust Ug99+

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While durum wheat represents only 8-10% of the total wheat area worldwide, its relative importance around the Mediterranean basin is much higher, superior to 50% in several countries. For decades in Tunisia, durum has represented 85% of the 0.9-1.2 million hectares sown to wheat each year. It is grown under a wide range of weather and management conditions, some being highly conducive to the development of *Septoria tritici* and, to a lesser extent, to attacks of leaf rust. Widely grown (more than 90% of the total area) cultivars such as Karim, Razzak and Khiar are highly susceptible to both diseases. Yield losses, of up to 60%, have been reported in favorable years due to *Septoria tritici*. Genetic resistance to the Tunisian strains of this pathogen has been, and remains, the primary focus of the Tunisian National Breeding Program at INRAT. However, concerns were recently raised as to the threat posed by stem rust race Ug99 and variants, should its predicted advance path change direction westward and start threatening North Africa. As new resistant cultivars were released to farmers in Tunisia and new sources of resistance to *Septoria* were identified by INRAT at the Béja experiment station, these were evaluated for their reaction to stem rust race Ug99 and its newer variants (in Kenya and Ethiopia) as part of an on-going collaborative testing effort with CIMMYT. Results indicate that 2 of the 3 *Septoria* resistant cultivars recently released in Tunisia, namely MAALI and SELIM, show promisingly low stem rust infection both at the Njoro-Kenya (traces) and Debre Zeit-Ethiopia (10-15 MS/S) sites. In addition, these two cultivars are resistant to the prevailing leaf rust races in Tunisia and exhibited excellent levels of resistance to the Mexican races of the same pathogen, including to the latest virulence (BBG/BP) which appeared in 2008. The other previously released cultivar, namely NASR 99, has excellent *Septoria* resistance but does not provide a good enough genetic protection against either rust. These preliminary results have allowed the Tunisian National Program to target its seed multiplication efforts toward the deployment of MAALI and more recently SELIM in order to provide effective protection against the current main production-limiting factor, *Septoria tritici*, and at the same time against the potentially devastating threat of stem rust. MAALI is already commercially deployed in farmers' fields (around 1000 hectares sown in 2008-09) while SELIM is under accelerated seed multiplication. Both have been used extensively in a collaborative crossing/selection program with CIMMYT and advanced segregating populations are being selected in parallel between Tunisia (for Septoria) and Mexico (fast advance and leaf rust resistance) to produce more advanced lines combining *Septoria tritici*, leaf rust and stem rust resistance.

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