CIMMYT — INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
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Marker-assisted selection in the CIMMYT wheat breeding programs.

Marker-assisted selection (MAS) summary 2010. The number of data points produced to assist phenotypic selection with molecular markers in the CIMMYT wheat breeding programs remained constant in 2010 compared to previous years. During the selection cycles in Cd. Obregon and Toluca, about 28,000 and 18,000 DNA extractions, along with 49,700 and 39,000 marker data points, respectively, were provided. Thus, a total of about 46,000 DNA extractions and 88,700 marker data points were performed in the laboratories in El Batan and Cd. Obregon in 2010. Molecular markers were applied across all breeding programs. In the programs targeted to rain-fed and irrigated environments and the durum wheat and wide crosses program, parental lines to be used for crosses were initially characterized. Markers were subsequently used for allele enrichment in the top cross and F_2 generations in the program targeted to rain-fed environments and durum wheat program during selection. Marker or gene presence was confirmed in the F_3 to F_7 and advanced backcross generations. In the winter wheat program, the 18th FAWWON and various selected sets of germ plasm, e.g., a historical set of winter wheat cultivars, were screened with a subset of markers.

The markers applied in the wheat programs during 2010 are listed in Table 1. Markers linked to rust resistance genes were most frequently used in bread and durum wheat. The amplification of the markers commonly revealed the

Table 1. Markers applied for marker-assisted selection in the bread and durum wheat programs in 2010 at CIMMYT–Mexico.

Gene	Reference	Data points	Gene	Reference	Data points
Bread wheat			Durum wheat		
T1A·1R/T1B·1R	Weng et al. 2007	12,050	*Lr19/Sr25*	Zhang et al. 2008	9,059
Lr19/Sr25	William, personal communication	8,318	*Lr14a*	Herrera-Foessil et al. 2008	7,009
Sr26	Liu et al. 2010	3,964	*Lr47*	Dubcovsky et al. 1998	5,249
Rht1, *Rht2*	Ellis et al. 2002	3,720	*Sr22*	Khan et al. 2005	2,905
Cre1	Ogbonnaya et al. 2001	3,547	*Cre1*	Ogbonnaya et al. 2001	1,239
Sr2	Anderson et al. 2001, Spielmayr et al. 2010	3,179	*GPC-B1*	Distelfeld et al. 2006	974
Vrn-A1	Yan et al. 2004	1,772	*Vrn-A1*, *Vrn-B1*	Fu et al. 2005, Yan et al. 2004	704
Ppd-D1	Beales et al. 2007	1,472	*VPM*	Helguera et al 2003	700
Vrn-B1, *Vrn-D1*	Fu et al. 2005, Yan et al. 2004	1,472	*Fhb1*	Liu et al. 2008	500
Lr34	Lagudah et al. 2009	1,472	*Ppd-A1*	Bentley et al. 2010	176
Sr24	Mago et al. 2005	1,297	*Bo1*	Schnurbusch et al. 2007	171
VPM	Helguera et al. 2003	1,297	*Lr53*	Wellings, personal communication	172
Cre3	Martin et al. 2004	1,032	*Rln1*	Mather, personal communication	81
Sr36	Tsilo et al. 2007	1,032			
Sr22	Khan et al. 2005	1,032			
Ppd-A1	Bentley et al. 2010	265			
SrCad	Hiebert et al. 2010	89			

expected results, with some exceptions. Similar to previous years, the marker for *Cre1* showed segregation distortion in various populations. Less individuals than expected were observed containing the tolerance allele for *Cre1*. The comparison of marker data for *Cre1* and phenotypic screening in Turkey furthermore indicated that *Cre1* might not be effective in some Middle East and South Asian countries, which has to be confirmed in subsequent screenings in 2011. When characterizing parental materials, we noticed that the marker for VPM amplified in various synthetic derivatives, which are not expected to have the *Ae. ventricosa* fragment.

New markers – optimization and validation. New markers tested were linked to the genes *Ppd-A1*, *SrCad*, *Sr26*, *Sr2*, *Lr47* (co-dominant marker), and *H25*. For the first time, the marker diagnostic for *Ppd-A1* in durum wheat was tested in germ plasm targeted to rain-fed environments. The *Ppd-A1* allele G105 from durum wheat was confirmed to be present in the CIMMYT germ plasm, introduced via a synthetic hexaploid wheat and its derivatives. The stem rust resistance gene *SrCad* was confirmed in the Canadian sources AC Cadillac, AC Taber, and AC Vista. The gene was not present in a set of CIMMYT germ plasm tested to date. The new CAPS marker for *Sr2* (Spielmayr et al. 2010) was evaluated in the 1st Stem Rust Screening Nursery and germ plasm targeted to irrigated environments. The marker confirmed the presence of the gene in CIMMYT lines, however with exceptions. Examples are the cultivar Siete Cerros, released in 1966, and the Pastor, which were expected to carry *Sr2* but lacked the characteristic SNP detected in Hope. The cultivar Thatcher is not known to carry *Sr2* but amplified the corresponding allele with the CAPS marker. Thus, the marker does coincide with the presumed *Sr2* genotype in various, but not all, cases.

The marker linked to *H25* was used to validate the source of the gene and a set of parents that will be used for crosses in durum wheat. The only marker that could not be successfully optimized is the co-dominant marker for *Lr47*. Amplification was not able to clearly distinguish between lines carrying the genes and heterozygotes. Markers successfully tested will be further validated and subsequently used in the wheat breeding programs.

SNP development.

Gene polymorphisms based on SNP or indels (insertion/delitions) have been converted to 'KASPar' SNP assays, a platform provided by the company KBioscience (http://www.kbioscience.co.uk) in order to move the marker technology at the Batan laboratories from slab gels to a higher throughput platform. SNP assays designed and validated on a larger set of CIMMYT germ plasm are given (Table 2). Primers required for the SNP assay were designed on the basis of available sequence information of the respective genes. Validation was performed with a set of lines known to carry or not carry the genes. SNP assays are to be used for MAS via outsourcing up to 5,000 samples to KBioscience. Outsourcing is expected to increase in 2011.

Table 2. Validated SNP markers with a set of lines known to carry or not carry the gene of interest.

Gene	SNP ID
Lr34	Lr34_TCCIND
Glu-D1	Glu-D1d_SNP
GPC-B1	GPC-B1_DUP
Cre8	Cre8_SNP
Rht-B1	Susan_RhtB1_SNP
Rht-D1	Susan_RhtD1_SNP
Rln1 (DW)	Rlnn1_SNP/1

During the validation of the SNP assays in Batan, a number of advantages of the SNP assays in comparison of the previously used markers were observed. The SNP assays provided marker data three times faster and, based on initial cost analyses, at least two times more cost efficient and under the current conditions of the Batan laboratories. The amplification of the SNPs was simpler and more robust. A unique PCR program was used across all assays, and amplification was more stable with less missing data or weak amplifications. The assays required similar to SSR or STS markers, only standard DNA quality and reactions permitted varying DNA quantity across samples so that no DNA adjustments were required. The design of SNP assays for an additional set of genes was initiated during 2010 (Table 3) and will be validated in 2011.

The design of some SNP assays failed (VPM, PinA, PinB), mainly due to the amplification of primers in one of the nontargeted homologous genomes. The assay development will be repeated for those genes.

Table 3. SNP markers under development and validation at CIMMYT-Mexico.

Gene	SNP ID
Fhb1	Fhb1_UMN10_IND
VPM	VPM_SNP
Rln1	Rlnn1_SNP2
Rln1	Rlnn1_SNP3
Glu-A1	Glu-Ax1/x2*_SNP
Glu-A1	Glu-Ax2*_IND
Glu-B1	Glu-Bx17_IND
Glu-B1	Glu-By8_SNP
Glu-B1	Glu-By9_IND
Glu-A3a to *Glu-A3g*	Glu-A3a to GluA3g_SNP
Glu-B3a to *Glu-B3i*	Glu-B3a to GluB3i_SNP
Sr36	STM773-2_IND
Lr19/Sr25	WMC221_IND

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Greenhouse evaluation of germ plasm for reaction to tan spot and Stagonospora nodorum blotch.

Wide-crosses material. Successful evaluation of 86 entries (including four checks) for tan spot was possible and 38 entries were resistant and 48 were susceptible. For *Stagonospora nodorum* blotch, 84 entries (including four checks) were evaluated of which 25 were resistant and 59 were observed to be susceptible. There were nine entries giving resistant reactions to both diseases (Table 4, continued on p. 47).

Table 4. Disease reaction of the most promising breeding lines of the Wide-Crosses and Durum Programs to tan spot (TS) and *Stagonospora nodorum* blotch (SNB) under greenhouse tests.

GID	Cross/name	TS	SNB
Resistant Wide-Crosses Lines			
6002836	GAN/*Ae. tauschii* (408)//2*BERKUT	1.83	1.83
6123554	GAN/*Ae. tauschii* (897)//OPATA/3/BERKUT	1.92	1.69
6123557	GAN/*Ae. tauschii* (897)//OPATA/3/BERKUT	1.92	1.96
6123505	YAV_3/SCO//JO69/CRA/3/YAV79/4/*Ae. tauschii* (498)/5/OPATA/6/PASTOR	1.71	1.99
6123562	GAN/*Ae. tauschii* (897)//Opata/3/BERKUT	1.25	1.50
6123563	GAN/*Ae. tauschii* (897)//Opata/3/BERKUT	1.38	1.50
6123569	YAV_3/SCO//JO69/CRA/3/YAV79/4/*Ae. tauschii* (498)/5/2*OPATA	1.75	1.37
5929330	GAN/*Ae. tauschii* (236)//CETA/*Ae. tauschii* (895)/3/MAIZ/4/2*INQALAB 91	1.25	1.50
5929356	GAN/*Ae. tauschii* (236)//CETA/*Ae. tauschii* (895)/3/MAIZ/4/2*INQALAB 91	1.50	1.34
Resistant Durum Lines			
3829630	Svevo	1.85	1.53
5081890	Meridiano	1.72	1.33
5532383	SOOTY_9/RASCON_37//LLARETA INIA	1.72	1.57
5081011	1A.1D 5+10-6/3*MOJO//RCOL/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1	1.68	1.40
5545239	GUAYACAN INIA/POMA_2//SNITAN/4/D86135/ACO89//PORRON_4/3/SNITAN	1.77	1.71
5546969	CMH83.2578/4/D88059//WARD/YAV79/3/ACO89/5/2*SOOTY_9/ RASCON_37/6/1A.1D 5+10-6/3*MOJO/3/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)// PLATA_13	1.97	1.90
5541716	SILK_3/DIPPER_6/3/ACO89/DUKEM_4//5*ACO89/4/PLATA_7/ILBOR_1//SOMAT_3	1.88	1.79
5828212	BCRIS/BICUM//LLARETA INIA/3/DUKEM_12/2*RASCON_21/4/1A.1D 5+10-6/2*WB881//1A.1D 5+10-6/3*MOJO/3/BISU_1/PATKA_3	1.83	1.94
5828385	NUS/SULA//5*NUS/4/SULA/RBCE_2/3/HUI//CIT71/CII*2/5/ARMENT//SRN_3/NI-GRIS_4/3/CANELO_9.1	1.88	1.83
5828419	PLATA_10/6/MQUE/4/USDA573//QFN/AA_7/3/ALBAD/5/AVO/HUI/7/PLATA_13/8/ RAFI97/9/MALMUK_1/SERRATOR_1/10/ARMENT//SRN_3/NIGRIS_4/3/CANE-LO_9.1/11/SHAG_21/DIPPER_2//PATA_2/6/ARAM_7//CREX/ALLA/5/ENTE/ MEXI_2//HUI/4/YAV_1/3/LD357E/2*TC60//JO69	1.75	1.50
5827254	LLARETA INIA/4/SKEST//HUI/TUB/3/SILVER/5/LHNKE/RASCON//CONA-D/6/ GREEN_32/CHEN_7//SILVER_14/3/DIPPER_2/BUSHEN_3/4/SNITAN	1.42	1.67
5828254	STOT//ALTAR84/ALD/3/THB/CEP7780//2*MUSK_4/6/ECO/CMH76A.722//BIT/3/ ALTAR84/4/AJAIA_2/5/KJOVE_1/7/RASCON_37/2*TARRO_2/4/ROK/FGO//STIL/3/ BISU_1/5/MALMUK_1/SERRATOR_1	1.93	1.63
5828341	ALBIA_1/ALTAR84//YAZI_1/4/CREX//BOY/YAV_1/3/PLATA_6/5/SOMAT_4/IN-TER_8/6/LIRO_2/CANELO_9	1.52	1.53
5828439	ALTAR84/BINTEPE85/3/STOT//ALTAR84/ALD/4/POD_11/YAZI_1/5/ VANRRIKSE_12/SNITAN/6/SOOTY_9/RASCON_37//WODUCK/CHAM_3	1.83	1.92

Table 4. Disease reaction of the most promising breeding lines of the Wide-Crosses and Durum Programs to tan spot (TS) and *Stagonospora nodorum* blotch (SNB) under greenhouse tests.

GID	Cross/name	TS	SNB
6004713	SOMAT_4/INTER_8/4/GODRIN/GUTROS//DUKEM/3/THKNEE_11/5/1A.1D5+10-6/2*WB881//1A.1D 5+10-6/3*MOJO/3/BISU_1/PATKA_3/4/GODRIN/GUTROS//DUKEM/3/THKNEE_11	1.75	1.72
6004721	ODIN_15/WITNEK_1//ISLOM_1/5/TARRO_1/TISOMA_2//TARRO_1/3/COMB-DUCK_2/ALAS//4*COMB DUCK_2/4/SHAG_9/BUTO_17/6/VANRRIKSE_6.2//1A-1D 2+12-5/3*WB881/5/TARRO_1/TISOMA_2//TARRO_1/3/COMBDUCK_2/ALAS//4*COMBDUCK_2/4/SHAG_9/BUTO_17	1.44	1.64
6005034	SWAHEN_2/KIRKI_8//PROZANA_1/4/ADAMAR_15//ALBIA_1/ALTAR 84/3/SNITAN/11/GUAYACANINIA/GUANAY/10/LD357E/2*TC60//JO69/3/FGO/4/GTA/5/SRN_1/6/TOTUS/7/ENTE/MEXI_2//HUI/4/YAV1/3/LD357E/2*TC60//JO69/8/SOM-BRA20/9/JUPAREC 2001	1.62	1.73
6004804	MOHAWK/5/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/3/SOMAT_3/4/SOOTY_9/RASCON_37	1.90	1.50
5549135	SNITAN/5/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/3/SOMAT_3/4/SOOTY_9/RASCON_37/6/SNITAN	1.42	1.99
5550695	TOPDY_18/FOCHA_1//ALTAR84/3/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/4/SOMAT_3/GREEN_22/5/VRKS_3/3/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13	1.76	1.90
6004507	USDA595/3/D67.3/RABI//CRA/4/ALO/5/HUI/YAV1/6/ARDENTE/7/HUI/YAV79/8/POD9/9/ADAMAR_15//ALBIA_1/ALTAR84/3/SNITAN/10/MINIMUS_6/PLATA_16//IMMER/3/SOOTY_9/RASCON_37	1.92	1.94
6004540	ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1/4/TOSKA_26/RASCON_37//SNITAN/5/PLAYERO	1.42	1.85

Durum material. A total of 104 entries (including four checks) were screened for tan spot and 31 entries were resistant and 73 were susceptible. For *Stagonospora nodorum* blotch, a higher proportion of resistance was observed with 63 entries showing resistant reaction and 41 entries susceptible. A total of 22 entries had resistant reactions to both diseases (Table 4, continued on p. 46). Some of the parents of the mapping populations gave differential reaction, so genetic analysis of tan spot and *Stagonospora nodorum* blotch resistance in these populations will be attempted.

Evaluation of germ plasm for reaction to spot blotch.

A total of 1,380 genotypes from the Bread Wheat Irrigated (EPCBWIR09-10, entries = 540), Bread Wheat Rainfed (C29SAWSN, entries = 382), Durum (D10PR-SETHLB, entries = 100), Nepal Program (HLB Resistance Stocks, entries = 100), and 1st CSISA Spot Blotch Trial (entries = 258) were evaluated for reaction to spot blotch under field conditions at Agua Fria. Additionally, inoculum was provided to the Wide Crosses Program to facilitate their efforts in developing spot blotch resistant germ plasm.

Bread Wheat Irrigated Trial. Spot blotch development in the nursery was good and consistent throughout the nursery. Twenty lines were early of which 19 entries were the checks Sonalika (18) and CIANO T 79 (1) and the breeding line 'Fret2*2 / Kukuna*2 / SNLG' (GID: 5993859) that had heading less than 63 days. Normal heading was found in 278 entries and 242 lines had late maturity. The AUDPC scores of this nursery ranged from 302.47 to 1,408.64 with a mean score of 632.38. Based on the selection criteria's from the EPCBWIR nursery, 190 breeding lines have been selected to be evaluated in 2011 in replicated trials. The ten most promising lines are given in the Table 5 (p. 48-49).

Bread Wheat Rainfed Trial. The check Sonalika (seven entries) was only early maturing and had heading less than 63 days. Normal heading was found in 280 entries and 95 lines had late maturity. The AUDPC scores of this nursery ranged from 388.89 to 1,330.86 with a mean score of 623.13. Based on the selection criteria's from the C29SAWSN nursery, 105 breeding lines have been selected to be evaluated in 2011 in replicated trials. The ten most promising lines from this nursery are given in the Table 5 (pp. 48-49).

Table 5. Disease reaction of the ten most promising breeding lines of different nurseries evaluated for spot blotch resistance at Agua Frias, Mexico, in 2010.

GID	Cross/name	AUPDC score
Resistant Bread Wheat Irrigated (EPCBWIR09-10) lines.		
5996123	SHA7/VEE#5//ARIV92/3/PBW343*2/KUKUNA	302.47
5996302	YUNMAI 48/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ	362.96
5849285	TILHI/SOKOLL	371.60
5996303	YUNMAI 48/4/2*SERI.1B*2/3/KAUZ*2/BOW//KAUZ	388.89
5994383	PBW343*2/KHVAKI//PARUS/3/PBW343/PASTOR	388.89
5996554	PBW343/PASTOR/4/YAR/*Ae. tauschii* (783)//MILAN/3/BAV92/5/PBW343*2/KUKUNA	406.17
5995752	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/CROC1/*Ae. tauschii* (205)//KAUZ/3/2*KAUZ*2/YACO//KAUZ	406.17
5996837	FRET2/KUKUNA//FRET2/3/YANAC/4/FRET2/KIRITATI	406.17
5996681	NSM*4/14-2/5/2*FRET2*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ	414.81
5996430	ALTAR84/AE.SQ//OPATA/3/2*WH542/7/VEE#8//JUP/BJY/3/F3.71/TRM/4/BCN/5/KAUZ/6/MILAN/KAUZ/8/ATTILA*2/PBW65	414.81
Resistant Bread Wheat Rainfed (C29SAWSN) lines.		
6000943	SW89-5124*2/FASAN//2*UP262	388.89
6001233	BAV92/SERI	388.89
6001232	BAV92/SERI	401.85
5999827	VORB/4/CROC_1/*Ae. tauschii* (205)//BORL95/3/KENNEDY	406.17
5999832	VORB/4/CROC_1/*Ae. tauschii* (205)//BORL95/3/KENNEDY	406.17
6000906	SOKOLL*2/TROST	406.17
6000909	SOKOLL*2/TROST	406.17
6001064	SOKOLL/TRCH	406.17
6001175	SOKOLL//FRTL/2*PIFED	406.17
5999831	VORB/4/CROC_1/*Ae. tauschii* (205)//BORL95/3/KENNEDY	414.81
Resistant durum (D10PR-SETHLB) lines.		
5828254	STOT//ALTAR84/ALD/3/THB/CEP7780//2*MUSK_4/6/ECO/CMH76A.722//BIT/3/ALTAR84/4/AJAIA_2/5/KJOVE_1/7/RASCON_37/2*TARRO_2/4/ROK/FGO//STIL/3/BISU_1/5/MALMUK1/SERRATOR1	388.89
6005064	ALTAR84/CMH82A.1062//ALTAR84/3/DIPPER/RISSA//ALTAR84/AOS/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1/5/MINIMUS/COMBDUCK_2//CHAM_3/3/RCOL/4/YAZI_1/AKAKI_4//SOMAT_3/3/AUK/GUIL//GREEN	425.62
5081011	1A.1D 5+10-6/3*MOJO//RCOL/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1	427.78
6004809	MOHAWK/4/DUKEM_1//PATKA_7/YAZI_1/3/PATKA_7/YAZI_1	427.78
5548129	CAMAYO/GUANAY/4/ARMENT//SRN_3/NIGRIS_4/3/CANELO_9.1	432.10
5828350	LD357E/2*TC60//JO69/3/FGO/4/GTA/5/SRN_1/6/TOTUS/7/ENTE/MEXI_2//HUI/4/YAV_1/3/LD357E/2*TC60//JO69/8/SOMBRA_20/9/JUPAREC2001/10/SOMAT_3/PHAX_1//TILO_1/LOTUS_4/11/SOOTY_9/RASCON_37//WODUCK/CHAM_3	432.10
6004804	MOHAWK/5/AJAIA_12/F3LOCAL(SEL.ETHIO.135.85)//PLATA_13/3/SOMAT_3/4/SOOTY_9/RASCON_37	432.10
6004488	RASCON_37/GREEN_2/9/USDA595/3/D67.3/RABI//CRA/4/ALO/5/HUI/YAV_1/6/ARDENTE/7/HUI/YAV79/8/POD_9	434.26
5512003	AG 1-23/2*ACONCHI//2*UC1113	434.26
5543994	TADIZ/9/USDA595/3/D67.3/RABI//CRA/4/ALO/5/HUI/YAV_1/6/ARDENTE/7/HUI/YAV79/8/POD_9	436.42
Resistant 1st CSISA Spot Blotch Trial (CSISA) lines.		
911521	CHIRYA.3	303.91
5793174	TILHI/4/CROC_1/*Ae. tauschii* (213)//PGO/3/CMH81.38/2*KAUZ	309.67
5793393	CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/4/TROST	337.04

Table 5. Disease reaction of the ten most promising breeding lines of different nurseries evaluated for spot blotch resistance at Agua Frias, Mexico, in 2010.

GID	Cross/name	AUPDC score
5792804	SERI.1B*2/3/KAUZ*2/BOW//KAUZ*2/4/KRONSTAD F2004	341.36
5793392	CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/4/TROST	345.68
5792823	PBW343*2/KUKUNA//KRONSTAD F2004/3/PBW343*2/KUKUNA	348.56
5792874	SERI.1B*2/3/KAUZ*2/BOW//KAUZ*2/5/CNO79//PF70354/MUS/3/PASTOR/4/ BAV92	350.00
5793111	TILHI/PALMERIN F2004	352.88
5793110	TILHI/PALMERIN F2004	355.76
5793395	CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/4/TROST	360.08

1st CSISA Spot Blotch Trial. This nursery consisted of 258 entries replicated four times of which three were inoculated with pathogen and the fourth replicate was protected by multiple application of fungicide Opus (epoxiconazole). Spot blotch development in the nursery was good and consistent throughout the nursery. The check Sonalika (three entries) was only early maturing and had heading less than 63 days. Normal heading was noted in 86 entries and 169 lines had late maturity. The AUDPC scores of this nursery ranged from 204.53 to 1,271.81 with a mean score of 520.46. In this nursery, the resistant check Chirya had a mean score of 278.34 and the susceptible check Sonalika had the score of 1,231.00. There was negative correlation (–0.56) between spot blotch AUPDC scores and days-to-heading. Based on the rigorous selection criteria from the CSISA nursery. 50 breeding lines have been selected to be send across different location worldwide and evaluated in 2012. Presently, the selected lines are being increased at Mexicali to be forming the 2nd CSISA Spot Blotch Nursery. The most promising ten lines from this nursery are given in Table 5 (pp. 48-49).

Septoria tritici blotch research.

Field screening of germ plasm for resistance to *Septoria tritici* blotch. A total of 243 genotypes from the Bread Wheat-Irrigated (BWIR: 115 entries) and the Bread Wheat Rainfed (BWR: 128 entries) Program were evaluated for reaction to *Septoria tritici* blotch at two locations, Toluca and Boximo. At each location there was a randomized block design with two replicates. The disease assessment utilized a double-digit scale and multiple evaluations were conducted, which were later used to develop AUPDC score.

The development of *Septoria tritici* blotch at both the locations was similar. For the BWIR nursery, the range of *Septoria tritici* blotch AUDPC scores (mean of all reps/location) was between 201.81 and 993.43 with a mean score of 397.97. From this nursery, 50 lines were selected based on AUDPC scores and pedigree information, which may be part of the ISEPTON nursery. The most promising genotypes identified from this nursery are listed in Table 6 (p. 50). For the BWR nursery, the range of *Septoria tritici* blotch AUDPC scores (mean of all reps/location) was between 168.52 and 358.64 with a mean score of 291.13. From this nursery, 40 lines were selected that may be part of the ISEPTON nursery. The most promising genotypes identified from this nursery are listed in Table 6 (p. 50).

20th International Septoria Observation Nursery. The 20th International Septoria Observation Nursery (20th ISEPTON) comprised of 53 entries of genetically diverse genotypes was distributed to Ethiopia, Iran, Mexico, Morrocco, Syria, Tunisia, and Uruguay (20 sets). The genotypes were selected based on low *Septoria tritici* blotch scores and availability of seed.

Greenhouse screening protocol for *Septoria tritici* blotch. Two experiments were conducted to develop protocols for induction of *Septoria tritici* blotch under greenhouse conditions. Each experiment was conducted as a randomized block design with two replicates. Each replicate consisted of five genotypes with known reaction to *Septoria tritici* blotch (Table 7, p. 50). The experimental unit consisted of five plants/entry that were planted in big pots. The planting was done on 24 August.

Inoculation for the first experiment was on 8 October. Inoculum was made from isolate P8. Spore inoculum from isolate P8 was made by culturing the fungus on medium of agar, malt, and levadura (4 g extract of levadura, 4 g extract of malt, 4 g sacarosa, 15 g agar, and 1,000 mL distilled water). The prepared medium with isolate P8 was left for

Table 6. Disease reaction of the ten most promising breeding lines from Bread Wheat-Irrigated (BWIR) and the Bread Wheat Rainfed (BWR) Programs to Septoria tritici blotch under field tests at Boximo and Toluca, Mexico.

GID	Genotype	AUPDC score
Resistant BWIR lines.		
5849246	CHEN/*Ae. tauschii* (TAUS)//BCN/3/BAV92/4/INQALAB 91*2/KUKUNA	201.81
5995732	WBLL1*2/VIVITSI/4/D67.2/P66.270//*Ae. tauschii* (320)/3/CUNNINGHAM	217.17
5996488	BABAX/LR43//BABAX/6/MOR/VEE#5//DUCULA/3/DUCULA/4/MILAN/5/BAU/ MILAN/7/SKAUZ/BAV92	217.81
5995748	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/CROC_1/*Ae. tauschii* (205)// KAUZ/3/2*KAUZ*2/YACO//KAUZ	218.45
5996074	MILAN/PASTOR/3/C80.1/3*BATAVIA//2*WBLL1	224.93
5996189	THB/KEA//PF85487/3/DUCULA/4/WBLL1*2/TUKURU	244.88
5995992	CNDO/R143//ENTE/MEXI_2/3/*Ae. tauschii* (TAUS)/4/WEAVER/5/2*KAUZ/6/TIMBA	245.46
5996796	UP2338/3/HE1/3*CNO79//2*SERI/4/RABE/2*MO88	257.58
5994285	PBW343*2/KUKUNA*2//YANAC	264.26
5996195	THB/KEA//PF85487/3/DUCULA/4/WBLL1*2/TUKURU	266.22
Resistant BWR lines.		
5999769	BABAX/LR42//BABAX/3/VORB	168.52
5999771	BABAX/LR42//BABAX/3/VORB	172.84
5999774	BABAX/LR42//BABAX/3/VORB	183.64
5999775	BABAX/LR42//BABAX/3/VORB	183.64
5999807	VORB/4/D67.2/P66.270//*Ae. tauschii* (320)/3/CUNNINGHAM	199.85
5999926	PROINTA SUPERIOR/4/RL6043/4*NAC//PASTOR/3/BAV92/5/KLEIN SAGITARIO	207.41
5999956	POTCH 92/2*ROLF07	209.57
5999957	POTCH 92/2*ROLF07	225.77
5999970	POTCH 93/4/MILAN/KAUZ//PRINIA/3/BAV92/5/MILAN/KAUZ//PRINIA/3/BAV92	231.17
5999972	ACHTAR*3//KANZ/KS85-8-5/4/MILAN/KAUZ//PRINIA/3/BAV92/5/MILAN/KAUZ// PRINIA/3/BAV92	235.49

3 days for incubation at room temperature (18–22ºC). The spores were harvested and a spore suspension prepared at a concentration of 10^7 conidia/mL. The plants were spray inoculated until run-off. Inoculated plants were left in a mist-chamber for 48 hours with continuous misting. Subsequently, the humidifiers were turned off, plants were left to dry, and then the plants were put in GH8 at a temperature of 18ºC min and 28ºC max. In the second experiment inoculation was on 29 October with isolate ST2. The rest of the protocol was similar to that in the first experiment. Disease evaluation was based on percentage of *Septoria tritici* blotch infection.

Murga, a known source of resistance gave no disease symptoms in both the experiments, whereas the other lines with moderate to high susceptibility to *Septoria tritici* blotch gave disease symptoms as expected (Table 7). More disease was observed in first experiment then the second experiment, indicating that plant age may play role in disease development. Additionally, differences in the development of disease in the two experiments can be attributed to the two isolates used and the greenhouse temperature; temperatures were a bit lower in the second experiment. However, we were able to induce *Septoria tritici* blotch under greenhouse conditions for the first time at the Main Station. The challenge now lies in optimizing and further reducing the time taken in evaluating the disease in greenhouse conditions.

Table 7. Percent infection of *Septoria tritici* blotch on the five lines evaluated under greenhouse conditions at El Batan, Mexico, in 2010.

Line	First experiment		Second experiment	
	1 November	8 November	16 November	22 November
HPO/TAN/VEE/3/2*PGO/4/Milan/5/5Seri 1	20	50	10	40
SAAR//PBW343*2/Kukuna/3/PBW343*2/Kukuna	50	70	10	50
Kauz//Altar 84/Aus/3/Milan/Kauz/4/Avites	20	50	20	50
Catbird	40	50	10	40

Fusarium head blight research.

High-throughput field screening operations at El Batan, Mexico. A total of 1.8 ha was planted at El Batan, Mexico, in mid-May 2010 to screen wheat and barley material under artificial field inoculation for FHB. Plots were inoculated with the help of precision CO_2 backpack sprayers equipped with a flat fan nozzle for liquid inoculum (50,000 conidia/mL) at a pressure of 40 psi and a rate of 39 mL of inoculum/m. The inoculum was of a mixture of five different *F. graminearum* isolates collected during the preceding year in naturally infected fields. Ten spikes/plot were tagged and spray inoculated at anthesis. The inoculation is repeated 2 days later. A programmable misting system maintains a humid microclimate, which is favorable for the disease development.

For preliminary material screened for the first time, only the absolute number of infected spikelets/spike was evaluated, and the average number of infected spikelets for all ten spikes calculated. For advanced material in replicated trials in the second and third year of screening, the percent of infected spikelets/spike was evaluated by counting the number of infected spikelets and the total number of spikelets for each spike. Subsequently, the FHB index was calculated using the following formula:

$$\text{FHB index (\%)} = \frac{\text{Severity}}{\text{Incidence}}$$

where severity = the average severity of all spikes that show infection (totally healthy spikes are not considered for calculation of severity) and incidence = the percent of spikes that show infection.

The difference in evaluation methods between the preliminary and advanced material is due to the fact that the number of preliminary materials is much higher than the number of advanced materials. Assessing FHB resistance for the preliminary materials would be too labor- and time-intensive. On the other hand, a difference only between 'resistant' and 'susceptible' for first year material proved not to be valuable, because it does not take into account that resistance to FHB is a quantitative trait. The evaluation of the absolute number of infected spikelets/spike (regardless the total number of spikelets) was found to be the middle ground between these two approaches.

In addition to the candidates and entries of the international nurseries and mapping populations, F_3- and F_4-derived head rows also were planted, which had been spaced planted in Obregón to select for agronomic type. This research is a significant contribution of the Fusarium program in resistance breeding efforts for FHB and how the information generated in former years aids the development of new promising lines.

Bread wheat lines for irrigated areas: Results of PCFusarium White and Red Grain Nursery. A total of 290 entries from the PCFusarium White Grain (1,076 entries) and PCFusarium Red Grain (246 entries) nurseries planted in 2009 were selected, assembled in the PCFusarium White and Red Grain Nursery (PCFusWGyRG), and tested again in the summer of 2010 at El Batan in replicated trials. Entries with FHB indices below 11 % are shown in Table 8 (pp. 51-54).

Interestingly, despite the normally lower levels of resistance for white-grained material, relatively high levels of resistance in terms of disease symptoms (FHB index) and mycotoxin contamination were observed for these types in this trial. This demonstrates that white-grained bread wheats with levels of resistance similar to that of red-grained materials are available, which is a breakthrough in bread wheat breeding.

Table 8. White- (W) and red-grained (R) bread wheat genotypes for irrigated areas in the PC Fusarium White and Red Grain Nursery tested for the 2nd year in the summer of 2010 and results of FHB index and DON contamination.

CID	GID	Cross	Grain color	FHB index (%)	DON (ppm)
4965	10004	Sumai #3 (resistant check)		1.7	0.5
520956	6123270	FN/2*mazar 99//GONDO/TNMU/3/FRANCOLIN #1	W	3.0	0.9
516901	6123192	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	3.6	2.3
516852	6122669	PFAU/WEAVER*2//BRAMBLING/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/PFAU/WEAVER//BRAMBLING	R	3.9	1.9
516093	6121931	HPO/TAN//VEE/3/2*PGO/4/MILAN/5/SSERI1/6/GONDO	W	4.1	1.3

Table 8. White- (W) and red-grained (R) bread wheat genotypes for irrigated areas in the PC Fusarium White and Red Grain Nursery tested for the 2nd year in the summer of 2010 and results of FHB index and DON contamination.

CID	GID	Cross	Grain color	FHB index (%)	DON (ppm)
520950	6123240	SHA3/CBRD//TNMU/5/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	W	4.1	4.4
516901	6123199	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	4.4	2.0
516068	6123620	CBRD/FILIN	R	4.9	1.8
520950	6123246	SHA3/CBRD//TNMU/5/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	R	5.0	1.4
516900	6123179	PBW343/mazar 99*2/6/TURACO/5/CHIR3/4/SIREN//ALTAR 84/AE.SQUARROSA (205)/3/3*BUC	W	5.0	2.3
120634	2589783	Heilo (moderate resistant check)		5.4	1.7
516775	6122143	CAL/NH//H567.71/3/SERI/4/CAL/NH//H567.71/5/2*KAUZ/6/mazar99/7/CHUM18/BORL95//CBRD/8/CAL/NH//H567.71/3/SERI/4/CAL/NH//H567.71/5/2*KAUZ/6/mazar 99	W	5.5	6.0
516068	6123635	CBRD/FILIN	R	5.7	0.8
516068	6123623	CBRD/FILIN	R	6.3	1.3
516772	6122128	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES/5/CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/6/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	W	6.4	7.0
516852	6122665	PFAU/WEAVER*2//BRAMBLING/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/PFAU/WEAVER//BRAMBLING	R	6.7	1.5
516852	6122662	PFAU/WEAVER*2//BRAMBLING/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/PFAU/WEAVER//BRAMBLING	R	6.8	2.3
516852	6122658	PFAU/WEAVER*2//BRAMBLING/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/PFAU/WEAVER//BRAMBLING	W	6.8	1.8
516104	6122002	WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ/5/GONDO	W	6.8	3.4
516901	6123187	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	6.9	1.3
516874	6122758	KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/HUITES/5/SHA3/SERI//SHA4/LIRA/6/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	R	7.0	0.8
516844	6122610	WBLL1/FRET2//mazar 99/3/SHA3/SERI//SHA4/LIRA/4/WBLL1/TACUPETO F2001//mazar 99	R	7.0	2.8
520950	6123245	SHA3/CBRD//TNMU/5/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	R	7.1	2.8
520964	6123343	HEILO/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/AE.SQUARROSA (190)/8/VORB/FISCAL	R	7.2	1.7
516772	6122127	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES/5/CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/6/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	W	7.3	5.9
516901	6123188	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	7.3	1.9
516901	6123191	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	7.4	3.1
516068	6123629	CBRD/FILIN	R	7.7	1.0
516068	6123617	CBRD/FILIN	R	7.8	0.7
520950	6123242	SHA3/CBRD//TNMU/5/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	R	7.9	2.7
516775	6122145	CAL/NH//H567.71/3/SERI/4/CAL/NH//H567.71/5/2*KAUZ/6/mazar99/7/CHUM18/BORL95//CBRD/8/CAL/NH//H567.71/3/SERI/4/CAL/NH//H567.71/5/2*KAUZ/6/mazar 99	W	8.0	3.8

Table 8. White- (W) and red-grained (R) bread wheat genotypes for irrigated areas in the PC Fusarium White and Red Grain Nursery tested for the 2nd year in the summer of 2010 and results of FHB index and DON contamination.

CID	GID	Cross	Grain color	FHB index (%)	DON (ppm)
520949	6123236	NG8675/CBRD/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/WBLL1*2/CHAPIO	R	8.1	1.0
516068	6123625	CBRD/FILIN	R	8.1	1.6
516772	6122129	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES/5/CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/6/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	W	8.1	2.5
516901	6123186	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	8.3	1.5
516871	6122748	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES*2/5/CHIL/CHUM18	W	8.3	9.8
516068	6123628	CBRD/FILIN	R	8.3	1.4
516843	6122590	WBLL1/FRET2//mazar 99*2/3/GONDO	W	8.4	1.7
516070	6123660	CHIL/CHUM18//GONDO	R	8.6	1.5
516871	6122741	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES*2/5/CHIL/CHUM18	W	8.6	9.5
516901	6123193	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	8.7	1.0
516901	6123195	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	8.7	1.7
516901	6123189	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	8.7	0.7
516901	6123196	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	8.9	0.8
520950	6123247	SHA3/CBRD//TNMU/5/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	R	8.9	2.0
516772	6122123	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES/5/CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/6/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	W	8.9	2.0
520949	6123231	NG8675/CBRD/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/WBLL1*2/CHAPIO	R	9.0	2.3
516900	6123185	PBW343/mazar 99*2/6/TURACO/5/CHIR3/4/SIREN//ALTAR 84/*Ae. tauschii* (205)/3/3*BUC	R	9.0	1.4
516776	6122173	CAL/NH//H567.71/3/SERI/4/CAL/NH//H567.71/5/2*KAUZ/6/mazar99*2/7/CNDO/R143//ENTE/MEXI_2/3/*Ae. tauschii* (TAUS)/4/WEAVER/5/2*mazar 99	W	9.1	4.3
516852	6122654	PFAU/WEAVER*2//BRAMBLING/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/PFAU/WEAVER//BRAMBLING	W	9.2	3.6
516070	6123661	CHIL/CHUM18//GONDO	R	9.2	2.7
520949	6123235	NG8675/CBRD/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/WBLL1*2/CHAPIO	R	9.3	0.9
516107	6122040	WBLL1*2/KURUKU//HEILO	W	9.4	2.5
516772	6122104	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES/5/CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/6/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	W	9.5	7.9
516901	6123200	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	R	9.6	0.9
516068	6123630	CBRD/FILIN	R	9.6	1.6
516901	6123198	PBW343/mazar 99*2/3/WUH1/VEE#5//CBRD	W	9.6	1.4
516789	6122272	WAXWING/KIRITATI*2/3/SHA3/SERI//SHA4/LIRA	R	9.6	4.0
516068	6123634	CBRD/FILIN	R	9.9	1.4
520948	6123221	CHIL/CHUM18//GONDO/3/WBLL1*2/KURUKU	R	10.0	2.1
520956	6123283	FN/2*mazar 99//GONDO/TNMU/3/FRANCOLIN #1	R	10.0	2.3
520947	6123209	CHIL/CHUM18//FN/2*mazar 99/3/PRL/2*mazar 99	R	10.1	2.5

Table 8. White- (W) and red-grained (R) bread wheat genotypes for irrigated areas in the PC Fusarium White and Red Grain Nursery tested for the 2nd year in the summer of 2010 and results of FHB index and DON contamination.

CID	GID	Cross	Grain color	FHB index (%)	DON (ppm)
516852	6122657	PFAU/WEAVER*2//BRAMBLING/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/AE.SQUARROSA (190)/8/PFAU/WEAVER//BRAMBLING	W	10.1	3.3
516107	6122042	WBLL1*2/KURUKU//HEILO	W	10.1	2.7
516068	6123616	CBRD/FILIN	R	10.2	1.1
516883	6123013	PRINIA/PASTOR//CHIL/CHUM18/3/PRINIA/PASTOR	R	10.4	1.2
516772	6122097	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES/5/CROC_1/*Ae. tauschii* (205)//KAUZ/3/SASIA/6/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	W	10.4	3.8
520974	6123365	KAUZ/mazar 99//PBW343*2/3/HEILO	W	10.4	1.8
520950	6123243	SHA3/CBRD//TNMU/5/KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES	R	10.5	2.9
516871	6122746	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES*2/5/CHIL/CHUM18	W	10.7	4.8
520949	6123229	NG8675/CBRD/7/IVAN/6/SABUF/5/BCN/4/RABI//GS/CRA/3/*Ae. tauschii* (190)/8/WBLL1*2/CHAPIO	W	10.7	3.3
516883	6123007	PRINIA/PASTOR//CHIL/CHUM18/3/PRINIA/PASTOR	W	10.7	2.5
516098	6121958	KAUZ/mazar 99//PBW343/3/HEILO	W	10.7	2.9
516093	6121935	HPO/TAN//VEE/3/2*PGO/4/MILAN/5/SSERI1/6/GONDO	W	10.8	2.4
516070	6121915	CHIL/CHUM18//GONDO	W	10.9	2.5
516068	6123631	CBRD/FILIN	R	10.9	2.9
1860	5536	GAMENYA (susceptible check)		92.5	8.1

Bread wheat for marginal areas: Results of the 27th Semi-Arid Wheat Screening Nursery (SAWSN) and 20th High Rainfall Wheat Screening Nursery (HRWSN). The 27th SAWSN and the 20th HRWSN were tested again in the 2010 summer cycle in El Batan. Entries with an FHB index less than 20% (27th SAWSN) and 18% (20th HRWSN) also were tested for DON contamination (Table 9, continued on p. 55, and Table 10, pp. 55-56).

Table 9. Bread wheat genotypes for marginal areas from the 27th Semi-Arid Wheat Screening Nursery tested for the 2nd year in the summer of 2010 and results of Fusarium head blight (FHB) index and DON contamination.

CID	GID	Cross	FHB index (%)	DON (ppm)
4965	10004	SUMAI #3	0.5	2.8
120634	2589783	HEILO	5.3	2.7
450346	5427852	SW94.2690/SUNCO	11.5	2.2
279807	3855011	VOROBEY	12.9	4.2
450346	5427842	SW94.2690/SUNCO	13.1	3.7
450352	5427939	VEE/MJI//2*TUI/3/mazar 99/4/BERKUT	13.2	3.1
473247	5435908	PASTOR//HXL7573/2*BAU/3/SOKOLL/WBLL1	13.3	2.1
450346	5427849	SW94.2690/SUNCO	13.5	2.8
437257	5423751	OASIS//TC14/2*SPER/3/ATTILA/10/ATTILA*2/9/KT/BAGE//FN/U/3/BZA/4/TRM/5/ALDAN/6/SERI/7/VEE#10/8/OPATA	13.5	3.7
452364	5428200	PASTOR/4/WEAVER/TSC//WEAVER/3/WEAVER/5/URES/PRL//BAV92	13.9	3.6
454534	5428538	*T. dicoccon* PI94625/*Ae. tauschii* (372)//3*PASTOR	14.3	3.1
450346	5427856	SW94.2690/SUNCO	14.6	3.9
450352	5427940	VEE/MJI//2*TUI/3/mazar 99/4/BERKUT	14.7	2.0

Table 9. Bread wheat genotypes for marginal areas from the 27th Semi-Arid Wheat Screening Nursery tested for the 2nd year in the summer of 2010 and results of Fusarium head blight (FHB) index and DON contamination.

CID	GID	Cross	FHB index (%)	DON (ppm)
427650	5422808	OASIS//TC14/2*SPER/3/ATTILA/4/WBLL4	15.0	2.7
437245	5423717	A93324S.7197.29/4/KAUZ//ALTAR 84/AOS/3/KAUZ/5/PASTOR	16.2	4.3
450356	5427957	FILIN/3/CROC_1/*Ae. tauschii* (205)//KAUZ/4/FILIN/5/VEE/MJI//2*TUI/3/mazar 99	16.5	3.7
450355	5427955	BERKUT/3/ATTILA*2//CHIL/BUC	16.7	3.2
437240	5423682	TAN//TEMPORALERA M 87/AGR/3/FRET2/4/URES/PRL//BAV92	17.1	4.9
435275	5423325	BABAX/LR42//BABAX/3/ER2000	17.3	4.8
473281	5436044	MEX94.27.1.20/3/SOKOLL//ATTILA/3*BCN	17.9	5.8
472868	5435731	SOKOLL/3/PASTOR//HXL7573/2*BAU	18.2	4.5
452470	5428491	PASTOR//HXL7573/2*BAU/3/CMH82.575/CMH82.801	18.3	3.5
437257	5423741	OASIS//TC14/2*SPER/3/ATTILA/10/ATTILA*2/9/KT/BAGE//FN/U/3/BZA/4/TRM/5/ALDAN/6/SERI/7/VEE#10/8/OPATA	18.4	2.2
454534	5428531	*T. dicoccon* PI94625/*Ae. tauschii* (372)//3*PASTOR	18.4	3.2
460356	5429403	PASTOR//HXL7573/2*BAU/3/WBLL1	19.1	5.8
435388	5423482	MILAN/10/ATTILA*2/9/KT/BAGE//FN/U/3/BZA/4/TRM/5/ALDAN/6/SERI/7/VEE#10/8/OPATA	19.5	1.4
1860	5536	GAMENYA	60.3	0.2

Table 10. Bread wheat genotypes for marginal areas from the 20th High Rainfall Wheat Screening Nursery tested for the 2nd year in the summer of 2010 and results of Fusarium head blight (FHB) index and DON contamination.

CID	GID	Cross	FHB index (%)	DON (ppm)
4965	10004	Sumai #3 (resistant check)	0.5	0.3
4749	9774	Shanghai #8	4.1	0.9
451641	5685994	NING MAI 96035/FINSI//HEILO	5.3	2.8
120634	2589783	Heilo (moderate resistant check)	6.2	1.6
442354	5686022	ATTILA/HEILO	6.9	1.1
451641	5685999	NING MAI 96035/FINSI//HEILO	7.3	2.5
442354	5686027	ATTILA/HEILO	9.0	0.9
475170	5685928	CPI8/GEDIZ/3/GOO//ALB/CRA/4/*Ae. tauschii* (208)/5/HAHN/2*WEAVER/6/SKAUZ/BAV92	9.7	2.6
444320	5686059	BURI/JARU//METSO	9.8	2.4
442354	5686023	ATTILA/HEILO	10.4	2.3
480883	5551988	WAXWING//PFAU/WEAVER	12.6	3.0
451641	5685998	NING MAI 96035/FINSI//HEILO	12.6	3.3
279807	3855011	VOROBEY	13.2	3.1
442354	5686025	ATTILA/HEILO	13.3	2.1
451641	5686001	NING MAI 96035/FINSI//HEILO	13.6	2.1
475170	5685929	CPI8/GEDIZ/3/GOO//ALB/CRA/4/*Ae. tauschii* (208)/5/HAHN/2*WEAVER/6/SKAUZ/BAV92	16.1	2.6
476919	5535312	ND643//2*PRL/2*mazar 99	16.4	3.0
448397	5398611	BABAX/LR42//BABAX*2/3/KURUKU	17.3	3.5
444913	3826276	FUNDACEP 30	17.4	1.2

Table 10. Bread wheat genotypes for marginal areas from the 20th High Rainfall Wheat Screening Nursery tested for the 2nd year in the summer of 2010 and results of Fusarium head blight (FHB) index and DON contamination.

CID	GID	Cross	FHB index (%)	DON (ppm)
451809	5685991	IAS58/4/KAL/BB//CJ71/3/ALD/5/CNR/6/THB/CEP7780/7/TNMU/8/METSO	17.5	3.0
475170	5685927	CPI8/GEDIZ/3/GOO//ALB/CRA/4/*Ae. tauschii* (208)/5/HAHN/2*WEAVER/6/SKAUZ/BAV92	17.9	2.4
451641	5685996	NING MAI 96035/FINSI//HEILO	17.9	2.9
1860	5536	GAMENYA (susceptible check)	64.2	4.9

Wheat blast caused by Magnaporthe grisea.

Defining disease prone climatic conditions and wheat blast risk assessment. Wheat blast or 'brusone', induced by *Magnaporthe grisea*, infects the spikes of wheat grown in subtropical climates. The disease has been recorded in the wheat cropping areas of Brazil since the mid 1980s and occurs in similar climatic conditions in Paraguay and Bolivia. No reports exist on the occurrence of wheat blast outside South America. Damage potential is high and can account for 10 to 100% crop losses. Control of the disease is limited by lack of effective fungicide spray schemes and resistant cultivars. This study estimated the potential risk of wheat blast to occur in other wheat-growing areas in the world based on a climate similarity approach. The assessment was based on categorizing blast sites in South America for moderate and high disease severity levels and their corresponding climate profiles. Climate similarity with wheat production areas in nontraditional, warmer areas on other continents was derived from the Worldclim database considering the coolest quarter in which wheat is grown and similarity comparisons with the areas of cultivation in the northern hemisphere were drawn from the warmest quarter of the year.

Our preliminary analysis revealed areas of wheat blast risk in significant parts of central India, Bangladesh, and parts of Ethiopia. The wheat-growing regions in South Africa or Australia did not match with the blast climate profile. Similarity also was identified with large areas of wheat production in the northern hemisphere, Eurasia, and North America. However, determining the similarity of sites using the Homologue software showed that northern Eurasia and North America did not match a year-round climate comparison with areas in South America where brusone is known to occur. Areas generally at the border of wheat-growing areas in the Indian subcontinent and in parts of Africa show a 40–60% to 60–80% similarity with affected areas in South America underlining that risk of wheat blast pathogen survival exists. From the limited knowledge available from the wheat blast pathogen, its survival in the cool or cold season is unlikely, diminishing the current risk of wheat blast in production zones of the northern hemisphere.

The first international workshop on wheat blast held in Passo Fundo, Brazil.

To address wheat blast or 'brusone', which is responsible for 5–100% of wheat yield losses in regions of South America and has the potential to spread to other countries, the 'Wheat blast: A potential threat to global wheat production" workshop was held in Passo Fundo, Brazil, 3-5 May, 2010, followed by a field visit to the Brasilia region. The workshop was organized by Embrapa Wheat, Embrapa Cerrados, and CIMMYT with the support of the project to ensure a participation of scientists from national programs besides Brazil. The workshop was attended by representatives from 11 countries. Wheat blast was identified for the first time in 1985 in the State of Paraná in southern Brazil, from where it quickly spread to neighboring countries. Four years later, blast caused serious damage (40–100%) in the wheat fields of Paraguay. In the lowlands of Bolivia, it was responsible for a loss of 90,000 ha of wheat between 1997 and 2000. In 2007, the disease was seen in summer-sown experimental wheat trials in Chaco, Argentina, and although researchers in Uruguay have not observed the disease in wheat, they have found the fungus on barley. The 2009 outbreak cut Brazilian wheat production by up to 30%.

Of great concern is that chemical control of wheat blast may not be working. Some farmers are using four fungicide applications with no results, which suggests the current chemicals are not effective against the fungus or are not properly applied. To date, resistant cultivars are unavailable and only limited tolerance can be found. Climate change is adding to the problem. 'A more hot and humid climate favors fungal diseases such as wheat blast, which needs high temperatures of about 24–28°C and long periods of rain to occur,' explained researcher Gisele Torres of Embrapa Wheat. Changes in rainfall may create environmental conditions favorable to wheat blast in other parts of the world such as South Asia or Africa and was the main reason for inviting researchers from different wheat-producing countries on several continents to discuss wheat blast in Brazil.

The most important diseases that affect wheat production worldwide are leaf rust (5×10^6 ha), tan spot (4.5×10^6 ha), and Fusarium (4×10^6 ha). 'So far, new diseases like wheat blast in South America have been limited to a few countries,' said Man Mohan Kohli, ex-CIMMYT researcher once posted in South America. 'Similarly, the distribution of the stem rust Ug99 in Africa has been limited, but has been the object of studies by several research institutes around the world.' Efforts to improve wheat resistance to Ug99 and to reduce the risk of its spread to other countries show how international collaborative research and investment facilitates scientific response to new virulent pathotypes, or races of pathogens, that could become potentially devastating. Researchers from the following institutions participated in the workshop, which was supported by EMBRAPA and BMZ (Germany): Göttingen University (Germany), Kansas State University (United States), CIRAD (France), CIAT (Bolivia), INTA (Argentina), INIA (Uruguay), CIMMYT (Mexico), USDA/ARS (United States), MAG/ DIA (Paraguay), and Wageningen University (Netherlands), as well as Brazil Embrapa Cerrados, Embrapa Wheat, Embrapa Labex Europa, BIOTRIGO, COODETEC, FUNDACEP, UPF, UNESP, and Fapa/Agrária.

Safe movement of germ plasm.

The project 'Safe movement of germ plasm' was concluded in March 2010. Recommendations for 15 crops under the CGIAR mandate were published on line as part of the SGRP GPG2 Knowledge Portal. We corresponded with all CGIAR centers scientists working on seed crops to obtain the technical information on import/export permits, technical guidelines, and best practices in seed health for all CGIAR mandate seed crops. We revised and edited the materials receive from other centers. Please consult http://cropgenebank.sgrp.cgiar.org.

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Identification of genes of agricultural importance in bread wheats for the state of Sonora, Mexico.

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Introduction. Southern Sonora is characterized by having a large area sown with irrigated wheat every year. Farmers, through their economic contributions to agricultural research, demand wheats with high yield potential, quality, and