Identification of Diverse Sources of Multiple Disease Resistance in Wheat

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Wheat germplasm, numbering 6, 319 available with NBPGR, New Delhi, was evaluated at multilocations during 2004-05 to 2008-09 (five crop seasons) against major diseases of wheat under hot spot and artificially epiphytotic conditions. The diseases were: the three rusts, foliar blight and Karnal bunt. Based on this, the accessions of germplasm were identified as having multiple disease resistance. These diverse sources are available in National Genebank of NBPGR, New Delhi, and can be utilized in the breeding programme for providing durable or sustainable resistance.

Key Words: Diverse sources of resistance, Foliar blight, Karnal bunt, Multiple disease resistance, Rusts of wheat, *Triticum aestivum*, Wheat

Introduction

Wheat (*Triticum* spp.) is the second most important cereal crop after rice in India and a key crop of green revolution and the post-green revolution era. The wheat production touched its peak during 2010-11 crop season, with an all time high production of 85.93 mt (Anonymous, 2011) in comparison to 12.3 mt during 1964-65 (Tandon and Rao, 1986). The backbone of the Indian wheat programme is the breeding for disease resistance, especially for rusts. Cultivation of resistant varieties is the most eco-friendly and economically viable method for combating the diseases or the pests. New and diverse sources of resistance are very important for inclusion in the breeding programme. Hence, there is always a search for such sources of resistance against the major diseases and pests.

The major diseases of wheat in India are rusts, namely, leaf or brown rust, stripe or yellow rust and stem or black rust, Karnal bunt and leaf blight. Other diseases, like powdery mildew, head scab, foot rot, flag smut and hill bunt are the diseases of limited importance, due to their distribution in some limited areas (Joshi *et al.* 1988). Sources of resistance to various diseases in wheat, have been identified and enlisted in various publications (Sharma *et al.* 2002; Singh, *et al.,* 2001, 2004). The National Bureau of Plant Genetic Resources (NBPGR), New Delhi, has about 30,000 germplasm of wheat and its wild species in National Genebank, local land races, indigenous and exotic materials with diverse backgrounds. It was decided to evaluate this germplasm at multilocations with the purpose of enlisting their disease level as well as to identify the sources of resistance against the major diseases to utilize them in the wheat breeding programme. With this objective, genotypes were evaluated at multilocations under hot spot and inoculated conditions against the three rusts (black, brown and yellow), Karnal bunt and foliar blight.

Material and Methods

Germplasm supplied by the NBPGR, New Delhi, which was censerved in National genebank, was planted at

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multilocations for evaluation against the three rusts, viz., leaf or brown rust (*Puccinia triticina* Eriks. & Henn.), stripe or yellow rust (*Puccinia striiformis* West.), stem of black rust (*Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn); Foliar blight or spot blotch (*Bipolaris sorokiniana* (Sacc.) Shoem) and Karnal bunt (*Tilletia indica* Mitra, syn. *Neovossia indica* (Mitra) Mundkur). In all, 6319 germplasm lines were evaluated during four crop seasons (2004-05 to 2008-09) at multilocations. The seeds of the accession numbers given here, are available in the genebank at NBPGR, New Delhi.

The germplasm was planted at the following locations during 2004-05 (1500 entries), 2005-06 (1660 entries), 2006-07 (1041 entries), 2007-08 (1018 entries) and 2008-09 (1100 entries).

For yellow or stripe rust	Ludhiana, Pantnagar, Karnal
For brown or leaf rust	Ludhiana, Pantnagar, Varanasi, Faizabad, Vijapur, Powarkheda, Pune, Dharwad, Karnal
For black or stem rust	Vijapur, Powarkheda, Pune and Dharwad
For Karnal bunt	Ludhiana
For Foliar blight	Varanasi, Faizabad

The wheat germplasm was subjected to artificial inoculations of virulent pathotypes/strains or isolates of the pathogens at their respective hot spot locations for ensuring that there are no escapes while identifying the resistant genotypes (Sharma *et al.,* 2002). The procedure followed for each of the diseases is as follows:

Rusts

The inoculum of virulent and predominant pathotypes maintained under controlled conditions at DWR, Regional Research Station, Flowerdale, Shimla, H. P. and also at Rust Laboratory, Mahabaleshwar (Maharashtra) were used for inoculation. Following are the important pathotypes of three rusts used for artificial inoculation:

Stem rust: 11(79G31), 40 A (62G29), 42 (19G35), 122(7G11), 117-6 (37G19)

Leaf rust: 12-2(1R5), 77-2 (109R31-1), 77-5(121R63-1), 104-2(21R55)

Stripe rust: K (47S102), P (46S103), L (70S69), 13 (67S8), 46S119 and 78S84

Inoculation procedure: The initial inoculum in the form of uredospores of the most virulent and prevalent pathotypes of a rust was inoculated on 30 days old wheat seedlings of susceptible cultivars, like Agra Local, Sonalika or Mahabaleshwar?, HD 2329, Kharchia 65, WL 711, PBW 343, grown under polythene tunnels in the month of October for inoculum multiplication. The inoculation was done by rubbing the inoculum on leaves, sprays and syringe inoculation in the afternoon. Proper humidity and temperature conditions are provided to make inoculation successful and further multiplication of uredospores. The fresh uredospores collected with the help of spore collector from these plants were used for inoculation in the fields. Inoculation in the field was done by spraying of suspension of uredospores prepared in water by using TWEEN 80 spreader. Generally a knapsack sprayer was used for inoculation. Syringe inoculation was also done on border rows of susceptible varieties in the screening block. A line of susceptible check varieties was planted after every 20 lines of test entries in field as an infector besides planting on borders of each sub block in field to create maximum disease pressure of rusts. The pots having rust infected wheat plants were also kept in the field during the month of December and January. To help maximum sporulation and multiplication of the rusts, fields were irrigated after the inoculations.

Disease scoring: The scoring of rusts was done after dough stage by taking both severity of disease on plant parts denoted by per cent area covered as well as kind of host response (R, MR, MS, S, X) as per modified Peterson scale (Joshi *et al*., 1986). The coefficient of infection (CI) was calculated by multiplying the severity with the standard value of host response which is as follows:

Response	Numerical value
Resistant (R)	0.2
Moderately Resistant (MR)	0.4
Intermediate (X)	0.6
Moderately Susceptible (MS)	0.8
Susceptible (S)	1.0

Once CI of a location is calculated, an average CI (ACI) of multilocation data is computed. The highest rust score amongst locations along with ACI represents the rust reaction of a test entry. A variety is considered resistant if its ACI for a rust is less than 10.00.

Karnal bunt

Each entry was sown in one meter row. Recommended cultural practices were followed to grow the crop till

harvest. To determine the response of genotypes to Karnal bunt, earheads were injected with hypodermic syringe with adequate amount of inoculum (10,000 allantoids/ml water) at Zadok's crop growth stage 43-49 (Zadoks, *et al.*1974). Five earheads were inoculated in each entry during evening hours. After inoculation, high humidity was maintained for proper development of disease. The disease incidence in the earheads was recorded at crop maturity and was calculated by reckoning the infected and the total number of grains (both diseased and healthy) of 5 earheads per entry. On the basis of the data, the entries showing response of upto 5 per cent infection were rated as resistant.

Leaf blight

One row of 1m length of each entry was planted and a row of a highly susceptible entry RAJ 4015 was repeat planted after every 20 test entries. The inoculations of pathogens were done right from the month of January at 15 days intervals till development of disease. The built up of disease was ensured by using regular irrigations. The recording of disease was done in 0-9 double digit scale. The right hand side digit of score represents the per cent blighted area of flag-1 leaf, whereas the left side digit indicates the score of blight on flag leaf. The score (0-9) was as follows:

0:-No blight, **1:**-Up to 10% leaf area blighted, **2:**-11-20% leaf area blighted, **3:**-21-30% leaf area blighted, **4:**-31-40% leaf area blighted, **5**-41:-50% leaf area blighted, **6:**-51-60% leaf area blighted, **7:**-61-70% leaf area blighted, **8:**-71-80% leaf area blighted, **9:**->80% leaf area blighted.

Categorization of entries

Following range of scores (average) were used to identify the resistant and moderately resistant entries at dough stage:

Highly resistant: Av. score range 00-13, Highest score up to 35; *Resistant:* Av. Score range 14-35 (With highest score up to 57).

Results and Discussion

Based on the multilocation data over the years, the following multiple disease resistant genotypes were identified.

Stem, leaf and stripe rusts: IC128654, IC128649, IC128638, IC128639, IC128642, IC128656, IC128555, IC128592, IC128619, IC279333, IC128647, IC128520, IC128643, IC310106, IC128521, IC128179, IC128524, IC128590, IC128624, IC310124, IC128631, IC128652, IC128587, IC145276, IC128564, IC145811, IC128525, IC128594, IC128692, IC128650, IC128553, IC128637, IC145636, IC128507, IC145780, IC128629, IC321153, IC145602, IC128457, IC128526, IC145808, IC145331, IC63954, IC63955, IC111659, IC111667, IC111668, IC111670, IC111686, IC111687, IC111688, IC111691, IC111692, IC111693, IC111694, IC111701, IC111731, IC111771, IC111783, IC111787, IC111888, IC111892, IC111905, IC111912, IC111918, IC 111919, IC31982, IC47044, IC73591, IC73593, IC75313, IC75314, IC82194, IC260877, IC321981, IC416080, IC416082, IC416083, IC416084, IC416087, IC416088, IC416089, IC416092, IC416094, IC416098, IC416102, IC416106, IC416107, IC416108, IC416112, IC416113, IC416281, IC427210, IC138364, IC138426, IC138432, IC138438, IC138477, IC138478, IC138479, IC138504, IC138521, IC138524, IC138618, IC138625, IC138626, IC145882, IC145884, IC145916, IC145951, IC145977, IC252370, IC252392, IC252407, IC252420, IC252423, IC252430, C252431, IC252432, IC252433, IC252438, IC252439, IC252441, IC252443, IC252444, IC252445, IC252448, IC252450, IC252453, IC252455, IC252456, IC252457, IC252458, IC252459, IC252469, IC252472, IC252477, IC252490, IC252497, IC252499, IC252520, C252541, IC252542, IC252547, IC252591, IC252611, IC252629, IC252641, IC252650, IC252673, IC252676, IC252678, IC252686, IC252694, IC252706, IC252710, IC252723, IC252725, IC252767, IC252818, IC252819, IC252892, IC252983, IC335670, IC335671, IC335683, IC335704, IC335707, IC335716, IC335717, IC335737, IC335742, IC335746, IC335750, IC24177, IC260849, IC260877, IC279320, IC279321, IC279875, IC281566, IC290022, IC290025, IC290039, IC290046, IC290057, IC290058, IC290065, IC290070, IC290087, IC290095, IC290096, IC290098, IC290150, IC290154, IC290157, IC290162, IC290168, IC290173, IC290175, IC290176, IC290177, IC290178, IC290182, IC290184, IC290186, IC290191, IC290196, IC290197, IC290208, IC290215, IC290217, IC290221, IC290222, IC290226, IC290227, IC290231, IC290238, IC290241, IC290242, IC290243, IC290244, IC290258, IC290261, IC290262, IC290264, IC290280, IC290281, IC290298, IC290299, IC290302, IC290305, IC290309, IC290311, IC290314, IC290316, IC290325, IC290326, IC290326, IC290327, IC290329, IC290342, IC310120, IC310124, IC316100, IC36901 and IC535341.

Stem and leaf rusts: IC128561, IC145810, IC145808, IC128654, IC145806, IC145769, IC128649, IC128638, IC128456, IC310117, IC128639, IC128642, IC128656, IC310124, IC128552, IC145253, IC128594, IC128566, IC128692, IC145748, IC128614, IC128624, IC128496, IC128555, IC128650, IC145809, IC145801, IC128592, IC145696, IC128689, IC145797, IC128553, IC128201, IC128250, IC145828, IC145692, IC128619, IC128617, IC128663, IC145275, IC279333, IC128631, IC128209, IC128196, IC128570, IC128647, IC128652, IC321157, IC145541, IC128263, IC128610, IC128565, IC145501, IC128536, IC128190, IC128541, IC128678, IC145638, IC128645, IC128549, IC128637, IC128520, IC128693, IC128195, IC128567, IC279314, IC145813, IC128643, IC128568, IC145635, IC145341, IC128558, IC145636, IC145778, IC128202, IC128595, IC145416, IC128551, IC128616, IC145538, IC128697, IC128560, IC128554 and IC145768, IC128197, IC128185, IC145822, IC145415, IC128564, IC145816, IC145257, IC128694, IC128525, IC310106, IC128587, IC128167, IC128181, IC128507, IC128547, IC128538, IC128495, IC128640, IC128171, IC128526, IC145780, IC128521, IC145804, IC279229, IC128247, IC128696, IC145262, IC145335, IC128569, IC128179, IC145334, IC128588, IC145286, IC128524, IC145796, IC128457, IC145642, IC128609, IC145798, IC145276, IC145683, IC321160, IC128571, IC128157, IC145781, IC128550, IC128528, IC128458, IC128497, IC145331, IC128590, IC128625, IC145784, IC145703, IC128629, IC128682, IC145753, IC145293, IC128186, IC145281, IC145282, IC128466, IC128464, IC145800, IC128193, IC145285, IC145682, IC321154, IC128499, IC145602,IC128557, IC145811, IC279335, IC128546, IC145825, IC321153, IC128662, IC145436, IC111954, IC111930, IC111944, IC111828, IC111736, IC111807, IC75356, IC73589, IC111767, IC73578, IC73582, IC111735, IC111884, IC75340, IC75352, IC75354, IC75348, IC73585, IC75343, IC111715, IC82404, IC75251, IC111714, IC75334, IC111883, IC111779, IC73581, IC111708, IC111939, IC111785, IC75346, IC73498, IC73588, IC111941, IC111763, IC29049, IC75250, IC75316, IC111860, IC111786, IC82394, IC75336, IC111893, IC111882, IC75355, IC28960, IC111876, IC111794, IC111688, IC111717, IC26740, IC29000, IC82355A, IC111784, IC47517, IC253015, IC35125, IC35117, IC36854, IC111916, IC111864, IC111719, IC111886, IC111705, IC75358, IC111940, IC73576, IC111915, IC118713, IC262365, IC279314, IC279321, IC279327, IC279335, IC279480, IC279604, IC279642, IC279709, IC279864, IC279866, IC279871, IC279876, IC279879, IC279883, IC281558, IC319810, IC321871, IC322026, IC361695, IC372646, IC372657, IC372660, IC372666, IC397523, IC397922, IC415839, IC415945, IC415948, IC415950, IC415954, IC415967, IC415974, IC415975, IC415977, IC415979, IC415981, IC415983, IC415985, IC415986, IC415991, IC415993, IC415998, IC416001, IC416004, IC416007, IC416017, IC416018, IC416019, IC416029, IC416033, IC416036, IC416055, IC416064, IC416091, IC416093, IC416097, IC416099, IC416100, IC416101, IC416103, IC416104, IC416105, IC416109, IC416110, IC416111, IC416117, IC416122, IC416124, IC416125, IC416126, IC416127, IC416129, IC416130, IC416131, IC416133, IC416134, IC416138, IC416139, IC416140, IC416141, IC416142, IC416143, IC416144, IC416145, IC416146, IC416147, IC416148, IC416150, IC416151, IC416152, IC416153, IC416156, IC416163, IC416164, IC416166, IC416167, IC416171, IC416172, IC416173, IC416174, IC416179, IC416181, IC416182, IC416184, IC416186, IC416187, IC416188, IC416190, IC416191, IC416197, IC416198, IC416201, IC416205, IC416207, IC416208, IC416209, IC416216, IC416232, IC416235, IC416236, IC416237, IC416238, IC416254, IC416274, IC416276, IC416277, IC416279, IC416280, IC416284, IC416286, IC138395, IC138397, IC138401, IC138404, IC138406, IC138407, IC138408, IC138410, IC138422, IC138424, IC138427, IC138428, IC138429, IC138433, IC138434, IC138437, IC138440, IC138441, IC138444, IC138486, IC138487, IC138488, IC138556, IC138609, IC138616, IC138637, IC138639, IC138641, IC145950, IC145956, IC145957, IC145958, IC145966, IC145971, IC145972, IC145980, IC252348, IC252351, IC252352, IC252353, IC252369, IC252374, IC252381, IC252382, IC252385, IC252396, IC252400, IC252408, IC252409, IC252414, IC252419, IC252424, IC252434, IC252435, IC252436, IC252437, IC252440, IC252442, IC252446, IC252447, IC252449, IC252451, IC252452, IC252454, IC252460, IC252461, IC252467, IC252470, IC252471, IC252473, IC252488, IC252491, IC252493, IC252498, IC252506, IC252508, IC252512, IC252516, IC252526, IC252532, IC252536, IC252540, IC252550, IC252551, IC252554, IC252565, IC252571, IC252593, IC252608, IC252610, IC252618, IC252620, IC252621, IC252623, IC252626, IC252628, IC252632, IC252635, IC252640, IC252643, IC252645, IC252648, IC252654, IC252660, IC252663, IC252665, IC252666, IC252668, IC252679, IC252680, IC252681, IC252682, IC252684, IC252687, IC252688,

IC252692, IC252695, IC252699, IC252702, IC252704, IC252708, IC252718, IC252726, IC252727, IC252731, IC252753, IC252755, IC252768, IC252775, IC252806, IC252834, IC252836, IC252854, IC252861, IC252886, IC252888, IC252893, IC252927, IC252947, IC252948, IC252951, IC252952, IC252953, IC252961, IC252973, IC252974, IC253014, IC335697, IC335706, IC335709, IC260878, IC279688, IC279864, IC290037, IC290040, IC290041, IC290043, IC290051, IC290055, IC290056, IC290072, IC290081, IC290082, IC290084, IC290086, IC290091, IC290153, IC290156, IC290165, IC290169, IC290179, IC290180, IC290181, IC290183, IC290188, IC290192, IC290194, IC290195, IC290199, IC290205, IC290211, IC290212, IC290214, IC290216, IC290225, IC290228, IC290233, IC290245, IC290272, IC290279, IC290296, IC290297, IC290300, IC290303, IC290304, IC290310, IC290318, IC290322, IC290324, IC290327, IC290332, IC290334, IC290336, IC290337, IC290338, IC290339, IC290340, IC310106, IC310127, IC313156, IC313157, IC315921, IC316086, IC316088, IC317422, IC321875, IC535212, IC535305 and IC535459.

Stem and stripe rusts: IC128654, IC128649, IC128638, IC128639, IC128642, IC128656, IC128555, IC128592, IC128619, IC279333, IC128647, IC128520, IC128643, IC310106, IC128521, IC128179, IC128524, IC128590, IC128657, IC145305, IC128644, IC145479, IC128648, IC145478, IC311078, IC279866, IC145587, IC128624, IC128545, IC128634, IC145304, IC128579, IC310124, IC128631, IC128652, IC128587, IC145349, IC145452, IC145330, IC145313, IC79037, IC145705, IC82195, IC145571, IC128573, IC145306, IC145706, IC128591, IC145563,IC208901, IC145567, IC145595, IC145593, IC145565, IC145568, IC145276, IC145564, IC145569, IC128564, IC128523, IC145431, IC145811, IC128525, IC128594, IC128692, IC128650, IC128553, IC128637, IC145636, IC128507, IC145780, IC128629, IC321153, IC145453, IC145779, IC128636, IC128461, IC128574, IC128172, IC145265, IC128575, IC145299, IC381144, IC128589, IC279886, IC145294, IC145248, IC128641, IC145612, IC313151, IC145425, IC145594, IC145540, IC381179, IC145602, IC128457, IC145329, IC145704, IC145443, IC145442, IC128526, IC145808, IC145331, IC128251, IC145570, IC128448, IC145685, IC145473, IC145430, IC145591, IC145417, IC128462, IC145312, IC128174, IC128384, IC145787, IC145302, IC145562, IC128440, IC111648, IC111652, IC111660, IC111664, IC111669, IC111683, IC111689, IC111690, IC111695, IC111697, IC111698, IC111699, IC111700, IC111702, IC111737, IC111759, IC111788, IC111831, IC111833, IC111834, IC111835, IC111836, IC111837, IC111838, IC111848, IC111849, IC111857, IC111889, IC111894, IC111901, IC111906, IC111914, IC111996, IC112000, IC112031, IC112037, IC112039, IC112041, IC112042, IC112048, IC112049, IC112051, IC112052, IC112063, IC112064, IC112065, IC112074, IC112077, IC112080, IC112081, IC112091, IC118715, IC118717, IC28936, IC28963, IC30306, IC35161, IC35176, IC36702, IC36703, IC36705, IC36761, IC47348, IC63954, IC63955, IC63956, IC64224, IC64230, IC73494, IC75224, IC75249, IC75326, IC75330, IC75350, IC75351, IC75359, IC75394, IC78696, IC78989A, IC78990, IC78991, IC79062, IC79087, IC79091, IC79108, IC79109, IC79111, IC82151, IC82173, IC82182, IC82193, IC82301, IC82323, IC82324, IC82326, IC82333, IC82339, IC26048, IC279886, IC281560, IC315871, IC321953, IC321985, IC381144, IC382720, IC397830, IC397983, IC397986, IC397999, IC398067, IC398115, IC415951, IC415970, IC415973, IC416068, IC416069, IC416072, IC416074, IC416075, IC416076, IC416118, IC416161, IC416162, IC416219, IC416247, IC416258, IC416273, IC427134, IC427231, IC138357, IC138361, IC138362, IC138363, IC138392, IC138393, IC138412, IC138423, IC138425, IC138480, IC138481, IC138482, IC138498, IC138499, IC138500, IC138505, IC138506, IC138508, IC138518, IC138520, IC138522, IC138523, IC138525, IC138529, IC138530, IC138531, IC138532, IC138533, IC138534, IC138535, IC138536, IC138537, IC138538, IC138542, IC138543, IC138546, IC138547, IC138548, IC138559, IC138615, IC138617, IC138621, IC138623, IC138624, IC145842, IC145845, IC145852, IC145854, IC145858, IC145859, IC145861, IC145862, IC145863, IC145864, IC145865, IC145866, IC145868, IC145869, IC145870, IC145871, IC145872, IC145873, IC145875, IC145876, IC145877, IC145878, IC145879, IC145880, IC145881, IC145885, IC145886, IC145887, IC145888, IC145889, IC145895, IC145896, IC145914, IC145917, IC145918, IC145919, IC145922, IC145923, IC145924, IC145925, IC145926, IC145932, IC145934, IC145937, IC145938, IC145939, IC145940, IC145945, IC145961, IC252411, IC252412, IC252474, IC252475, IC252478, IC252484, IC252517, IC252518, IC252595, IC252612, IC252619, IC252642, IC252652, IC252672, IC252675, IC252690, IC252700, IC252714, IC252716, IC252737, IC252738, IC252740, IC252746, IC252761, IC252770, IC252772, IC252785, IC252793, IC252794, IC252798, IC252799, IC252801,

IC252803, IC252807, IC252813, IC252833, IC252837, IC252843, IC252846, IC252847, IC252858, IC252859, IC252874, IC252883, IC252887, IC252894, IC252897, IC252912, IC252916, IC252917, IC252919, IC252920, IC252949, IC252955, IC252958, IC252976, IC252977, IC252978, IC252979, IC252982, IC252984, IC252989, IC252995, IC252996, IC252998, IC253001, IC253016, IC335665, IC335667, IC335668, IC335669, IC335672, IC335674, IC335675, IC335676, IC335682, IC335684, IC335685, IC335686, IC335689, IC335691, IC335692, IC335695, IC335696, IC335702, IC335703, IC335705, IC335708, IC335710, IC335729, IC335730, IC335732, IC335733, IC335734, IC335738, IC335740, IC335743, IC335744, IC335745, IC335747, IC335748, IC24175, IC24548, IC255632, IC258214, IC258215, IC260845, IC260857, IC260858, IC260867, IC260868, IC260870, IC260875, IC260876, IC260883, IC260895, IC260901, IC260902, IC260903, IC260904, IC260905, IC260912, IC260918, IC260919, IC260930, IC260938, IC260939, IC260940, IC260941, IC260942, IC260960, IC260963, IC260967, IC260970, IC260972, IC260974, IC260977, IC262042, IC266789, IC266791, IC266831, IC266847, IC266852, IC266872, IC266884, IC266921, IC266977, IC279317, IC279324, IC279480, IC279537, IC279617, IC279707, IC279766, IC279825, IC279871, IC279876, IC279883, IC279884, IC279886, IC279887, IC279888, IC279889, IC279890, IC28086, IC281542, IC281544, IC281545, IC281546, IC281547, IC281548, IC281550, IC281551, IC281553, IC281555, IC281561, IC281562, IC281563, IC281565, IC281567, IC28518, IC28544, IC290014, IC290015, IC290018, IC290027, IC290030, IC290033, IC290036, IC290042, IC290052, IC290053, IC290060, IC290062, IC290063, IC290068, IC290074, IC290075, IC290085, IC290089, IC290090, IC290092, IC290093, IC290166, IC290172, IC290206, IC290220, IC290230, IC290275, IC290290, IC290301, IC290313, IC290317, IC290319, IC290330, IC30253, IC30275, IC30289, IC30291, IC30297, IC31278, IC31529, IC316087, IC316089, IC316091, IC316092, IC316096, IC316098, IC316099, IC316105, IC317632, IC319812, IC321152, IC321153, IC321154, IC321160, IC321161, IC321162, IC321847, IC321864, IC36875, IC535193, IC535196, IC535312, IC535332, IC535334, IC535335, IC535337, IC535338, IC535339, IC535437, IC535473, IC535476, IC535478, IC535480, IC535483, IC535493, IC535504, IC535505, IC535508, IC535509, IC535553, IC535556, IC535559, IC535566, IC535572, IC535573, IC535589 and IC535591.

Leaf and stripe rusts: IC128654, IC128649, IC128638, IC128639, IC128642, IC128656, IC128555, IC128592, IC128619, IC279333, IC128647, IC128520, IC128643, IC310106, IC361692, IC128521, IC128179, IC128524, IC145528, IC128590, IC128624, IC145820, IC310124, IC128631, IC128652, IC128593, IC128587, IC145812, IC145276, IC128564, IC145811, IC128525, IC128594, IC128692, IC145818, IC128650, IC128553, IC128637, IC145636, IC279877, IC128507, IC145780, IC279324, IC128629, IC321153, IC145602, IC128457, IC128526, IC145808, IC128453, IC128527, IC145331,

Leaf and Stripe rusts: IC41589, IC36751, IC36747, IC36723, IC112006, IC111921, IC111757 and IC111713, IC138507, IC138511, IC145909, IC252402, IC252425, IC252427, IC252428, IC252537, IC252796, IC321977, IC321982, IC415940, IC415966, IC416081, IC416085 and IC416095, IC260935, IC266764, IC279564, IC279877, IC281564, IC290038, IC290050, IC290076, IC290088, IC290094, IC290097, IC290146, IC290163, IC290185, IC290190, IC290193, IC290204, IC290213, IC290256, IC290259, IC290312 and IC316085.

Leaf Blight, Stem Rust, Leaf Rust and Stripe Rust: IC145780, IC82194, IC111692, IC260849, IC279320, IC290261, IC290262, IC290264, IC290299, IC290309, IC290314, IC290316 and IC316100.

Leaf blight, stem rust and stripe rust: IC145780, IC145779, IC82194, IC111692, IC260849, IC260919, IC260930, IC260967, IC260972, IC266831, IC279320, IC290018, IC290075, IC290089, IC290261, IC290262, IC290264, IC290299, IC290309, IC290313, IC290314, IC290316, IC290317, IC316100 and IC321162.

Leaf blight, leaf rust and stripe Rust: IC145780, IC82194 and IC111692, IC260849, IC279320, IC290076, IC290088, IC290185, IC290261, IC290262, IC290264, IC290299, IC290309, IC290312, IC290314, IC290316 and IC316100.

Leaf blight, stem rust and leaf rust: IC145798, 145780, IC82194, IC28960, IC111692,

IC138404, IC138408, IC138429, IC260849, IC279320, IC290084, IC290261, IC290262, IC290264, IC290299, IC290309, IC290310, IC290314, IC290316, IC290318, IC290322, IC290337, IC310106 and IC316100.

Karnal bunt, stem rust, leaf rust and stripe rust: IC128619, IC128642, IC128647, IC128643, IC128624, IC128507, IC128564, IC128637, IC128592, IC128654, IC128639, IC128521, IC128590, IC128525, IC128587,

IC128652, IC128638, IC128656, IC128555, IC128526, IC128631, IC279333, IC310124, IC47044, IC63954, IC63955, IC75314, IC111670, IC111771, IC111783. IC321981, IC416082, IC416083, IC416084, IC416089, IC416092, IC416102, IC416112, IC416113, IC427210 IC24177, IC260849, IC279321, IC290065, IC290096 and IC290196.

Stem Rust, Leaf Rust and Karnal Bunt: IC128181, IC128186, IC128197, IC128201, IC128202, IC128250, IC128496, IC128499, IC128507, IC128521, IC128525, IC128526, IC128538, IC128546, IC128547, IC128554, IC128555, IC128561, IC128564, IC128566, IC128567, IC128568, IC128570, IC128571, IC128587, IC128590, IC--128592, IC128619,

IC128624, IC128625, IC128631, IC128637, IC128638, IC128639, IC128642, IC128643, IC128647, IC128652, IC128654, IC128656, IC128662, IC128663, IC128697, IC145257, IC145275, IC145334, IC145341, IC145501, IC145538, IC145642, IC145683, IC145748, IC145769, IC145781, IC145796, IC145797, IC145798, IC145801, IC145809, IC145810, IC145816, IC279229, IC279314, IC279333, IC310117, IC310124, IC321157 and IC321160. IC111670, IC82394, IC75356, IC75352, IC75348, IC75343, IC75340, IC75336, C 75316, IC75314, IC75251, IC75250, IC73589, IC73588, IC73582, IC73581, IC73578, IC73576, IC73498, IC63955, IC63954, IC47044, IC35117, IC111954, IC111940, IC111893, IC111882, IC111794, IC111785, IC111784, IC111783, IC111779, IC111771, IC111670, IC111767, IC111735, IC111708 and IC111705, IC279864, IC279879, IC372646, IC397922, IC415945, IC415954, IC415977, IC415981, IC415983, IC415985, IC415986, IC415993, IC416018, IC416019, IC416029, IC416033, IC416093, IC416099, IC416103, IC416104, IC416122, IC416124, IC416133, IC416147, IC416148, IC416151, IC416156, IC416163, IC416164, IC416174, IC416179, IC416184, IC416186, IC416190, IC416191, IC416197, IC416198, IC416232, IC416236, IC416237, IC416274, IC416276, IC416279, IC416286, IC279688, IC290086, IC290156, IC290205, IC290297, IC290322, IC290334 and IC535459.

Stem rust, stripe rust and Karnal bunt: IC128172, IC128507, IC128521, IC128525, IC128526, IC128545, IC128555, IC128564, IC128574, IC128579, IC128587, IC128590, IC128592, IC128619, IC128624, IC128631, IC128634, IC128637, IC128638, IC128639, IC128641, IC128642, IC128643, IC128647, IC128652, IC128654, IC128656, IC128657,IC145304, IC145306, IC145430, IC145442, IC145443, IC145452, IC145453, IC145479, IC145564, IC145568, IC145569, IC145612, IC145706, IC145779,IC145787, IC279333, IC310124, IC313151, IC381179, IC82195, IC128654, IC128638, IC128642, IC128656, IC128592, IC128619, IC128590, IC128631, IC128652, IC128587, IC128564, IC128525, IC128637, IC310124, IC279333, IC361692, IC128624, IC128555, IC128643, IC279324, IC128526, IC128647, IC145812, IC128507, IC128521, IC128593, IC128527, IC28936, IC35161, IC36705, IC36761, IC47044, IC63954, IC63955, IC63956, IC64224, IC64230, IC75224, IC75249, IC75314, IC75394, IC78991, IC79062, IC79087, IC79091, IC79111, IC82193, IC82323, IC82333, IC111669, IC111670, IC111683, IC111702, IC111771, IC111776, IC111783, IC112000, IC112037, IC112039, IC112041, IC112049, IC112051, IC112064, IC78989A. IC321985, IC416074, IC416072, IC427231, IC416075, IC416258, IC398115, IC398067, IC416161, IC397999, IC416273, IC416247, IC397830, IC416162, IC416219, IC397986, IC36747, IC41589, IC47044, IC63954, IC63955, IC75314, IC111670, IC111757, IC111771, IC111783 and IC112006. IC24175, IC24548, IC255632, IC260875, IC260876, IC260912, IC260942, IC266791, IC279317, IC279324, IC279480, IC279617, IC28086, IC28518, IC28544, IC290062, IC290319, IC30253, IC30275, IC30289, IC30291, IC30297, IC31278, IC317632, IC321152, IC36875, IC535193, IC535334, IC535335, IC535337, IC535339, IC535437, IC535473, IC535476, IC535478, IC535480, IC535504, IC535553, IC535556 and IC535559.

Karnal bunt, leaf rust and stripe rust: IC416081, IC416095 IC290038 and IC290322.

Leaf blight and Karnal bunt: IC145797, IC145779, IC145798, IC31979, IC36737, IC36739, IC73647, IC78981, IC82246, IC355872and IC82190A.

Leaf blight and stem rust: IC138411, IC138419, IC138538, IC138551, IC138557, IC138587, IC138595, IC145871, IC145888 and IC252785.

Leaf blight and stripe rust: IC138512, IC138538, IC145871, IC145888 and IC252785.

Leaf blight: IC138458, IC138516, IC138591 and IC252784.

The germplasm, thus, identified as resistant contains a wide range of material, like those of exotic and indigenous origin, the local landraces, the Indian germplasm, etc. Thus, these are the diverse sources of resistance for the diseases in wheat. Most of these have not been utilized

for incorporating the disease resistance in the wheat breeding programme. These resistance sources carry resistance to more than one disease and hence are very useful for use in the breeding programme. Though, rust resistance gene postulation has not been done so far in these lines, it is expected that these diverse sources of resistance can provide durable or sustainable resistance over a period of time. It is recommended that these sources be utilized in the wheat breeding programme.

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