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Adult plant resistance to leaf rust (*Puccinia triticina*) in some Indian bread wheat (*Triticum aestivum*) accessions bearing leaf tip necrosis

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ABSTRACT

Of the 2200 germplasm accessions of *Triticum aestivum* L. screened under field condition against leaf rust (*Puccinia triticina*), 1526 exhibited symptom of leaf tip necrosis (LTN). Ninety eight per cent of accessions showing LTN revealed reduced leaf rust severities from traces to 40 compared to 80 - 100 in susceptible infector rows. LTN reduced leaf rust severities independent of its low, medium and high expressions across the accessions. Likely presence of durable resistance gene *Lr*34 associated with the trait of LTN, either singly or in complementation with other genes is discussed.

Key words : Leaf rust, Leaf tip necrosis (LTN), *Lr* 34, Wheat

Leaf rust caused by the fungal pathogen *Puccinia triticina* Eriks. is one of the most common diseases of bread wheat (*Triticum aestivum* L.) in India. The disease develops rapidly at temperatures between 10° and 30°C. Uredopustules of leaf rust are of bright orange colour, gathered in irregular small clusters on entire or portion of leaf, and burst on the upper surface. It reduces foliage, root growth and yield principally by reducing the rate of photosynthesis but losses depend principally on the plant growth stage at the time of its incidence. Early establishment of the disease significantly reduces the yield. Cultivation of resistant varieties is the most economical and environment friendly approach to curtail the losses. Many varieties with different resistant genes have been developed and deployed to reduce the effect of leaf rust on wheat yield (Roelfs 1988 and Mc Intosh 1995). However, most of these varieties carrying major seedling resistant genes have followed boom and bust cycle and for durable solution the breeders are putting more emphasis of adult plant resistant genes. One of such genes is *Lr34* which has been widely used as a buffer in case of immediate breakdown of other major genes. *Lr34*, is recognised by the presence of leaf tip necrosis, a trait associated with it and Dyck (1991) has associated this trait with gene *Lr*34. Presently, *Lr34* is present in large number of varieties either singly or in combination and is providing effective and durable resistance against leaf rust (Kolmer *et al.* 2008). This paper reports the status of leaf rust resistance in certain wheat lines bearing the trait of leaf tip necrosis and possibly carrying gene *Lr34*. It is hoped that wheat lines identified with leaf tip necrosis as well as resistance to leaf rust may become useful sources of resistance in the future breeding programmes.

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MATERIALS AND METHODS

A total 2200 germplasm accessions of *Triticum aestivum* (bread wheat) planted by National Bureau of Plant Genetic Resources (NBPGR), New Delhi, a constituent organisation of Indian Council of Agricultural Research (ICAR), New Delhi at IARI, Regional Station, Wellington, Tamil Nadu (11°22' N 76°46' E, elevation 1817 m, rainfall 1500 mm) during summer (May to September) of 2011. Genotypes were sown in single rows of 1 m length with 23 cm spacing maintaining one infector/spreader line after every 20th genotype along with border rows of universally susceptible bread wheat cultivar Agra Local. Recommended cultural practices were followed till crop harvest (Singh *et al*. 2006). Leaf rust survives at Wellington around the year through the agencies of self sown/stray plants, breeding materials planted regularly by Indian wheat breeders for resistance evaluation and green bridge maintained at the station for regular supply of rust inoculum to the breeding materials. The leaf rust

pathotypes 77A(109R31), 77-5(121R63-1), 77-7(121R127), 77-8(253R31) and 17(61R24) were identified from the random leaf rust samples collected from fields planted with accessions and analysed following glass house procedures of Nayar *et al.* (1997). Rust severity was recorded following the modified Cobb scale (Peterson *et al*. 1948) after accessions had completed the growth stage 87 (Zadoks *et al*. 1974). Simultaneous observations were also made on the presence of leaf tip necrosis on flag leaf. The scores of 40 and below were considered as resistant and those above 40 as susceptible. Three types of LTN symptoms designated as low, medium and high (Fig 1) were categorised to find out their individual effect on the terminal severity of leaf rust in the accessions. These categories of LTN are distinguished following an earlier description that symptoms of leaf tip necrosis include 2 to 3 cm of necrosis at the end of the leaves, which extend an additional 2 to 4 cm on the edge of the leaves (Singh 1992). Effect of three different categories of LTN (Fig 1) on terminal severity of leaf rust was visualised by counting accessions showing various severities under each category of LTN and the data were subjected to the analysis of standard deviation about mean.

RESULTS AND DISCUSSION

Natural leaf rust incidence initiated on spreader/infector and border rows by the 52nd day of sowing. Leaf rust incidence to the extent of 80-100S on spreader/infectors, border rows and susceptible accessions developed by the plant growth stage 71 – 87 on Zadoks scale (Zadoks *et al*. 1974). Variable levels of expression (Fig 1) for LTN was observed in different entries, however, 1526 accessions out of 2200 showed the symptoms. Genotypes categorised in different classes of LTN are presented in Table 1. It was observed that genotypes with even moderate level of LTN expression were having significantly reduced brown rust severity. Among the lines with LTN, 98% were showing reduced severity between a range of T–40 compared to 80–100 in infectors or susceptible entries without LTN. Remaining 88% accessions (2% showing high score of 60 excluded) showing reduced severities T- 20 can be treated as partially resistant or slow rusters which are likely to confer durable resistance to leaf rust as has been observed in cultivar Frontana (Roelfs 1988) and its derivatives Penjamo 62, Torim73, Kalyan/Bluebird etc. (Singh and Rajaram 1992). Moreover, the partial resistance has been advocated to be more durable (Singh *et al*. 1991). It can be assumed that all accessions listed in Table 1 with severity of 40 may possess gene *Lr34* alone while others showing lesser severities in the range of T -20 may be possessing additional 2, 3 or more number of minor genes. This assumption is based on the hypothesis of Singh and Rajaram (1992) based on the observation that gene *Lr34* alone reduces severity of leaf rust to 40% but respectively to 10-15% and 1-5% with combination of two and three additional genes. Very few accessions irrespective of the category of LTN permitted high terminal severity of 60 which can be attributed to the genetical background of the genotypes which might be rendering gene *Lr*34 ineffective since the expression of *Lr34* is dependent on the presence of

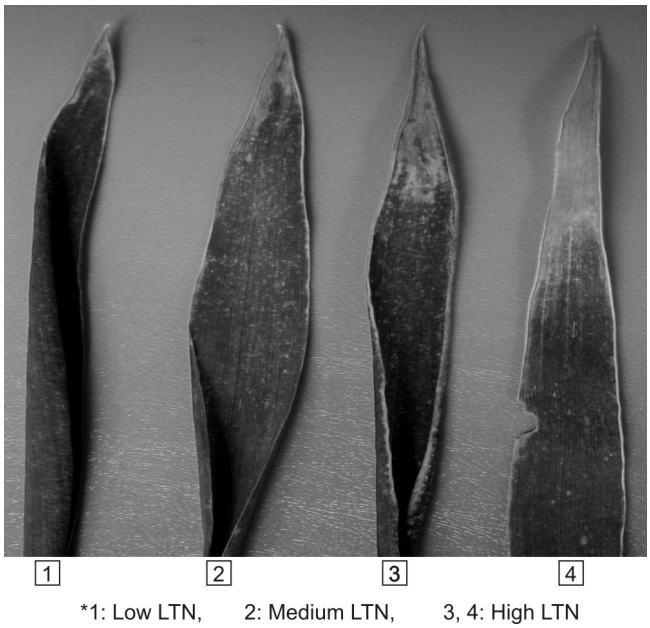


Fig 1 Three categories of leaf tip necrosis (LTN)* observed in the accessions

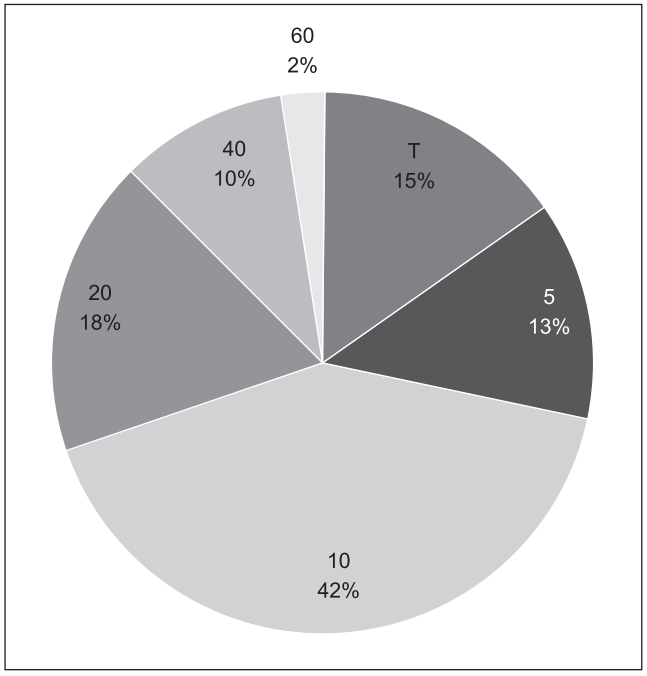


Fig 2 Leaf rust intensity* observed on wheat accessions** expressing leaf tip necrosis

Table 1 Accessions grouped according to LTN types and their reaction to leaf rust

LTN type	Rust reaction*	No.	Name of accessions
Low	T	150	IC542566, IC542567, IC536168, IC536188, EC573567, EC573571, EC573575, EC573576, EC573577, EC573579, EC573582, EC573583, EC573584, EC573587, EC573589, EC573599, EC573606, EC573629, EC573640, EC573641, EC573644, EC573645, EC573647, EC573649, IC536236, IC536238, IC536256, IC536259, EC573762, EC573766, EC573767, EC573768, EC573777, EC573779, EC573780, EC573783, EC573784, EC573785, EC573787, EC573788, EC573792, EC573820, EC573831, EC573833, EC573834, EC573837, EC573838, EC573841, EC573842, EC573843, EC573844, EC573845, EC573847, EC573853, EC573863, EC573864, EC573868, EC573888, EC573895, EC573896, EC573903, EC573905, EC573907, EC573920, EC573924, EC573925, EC573926, EC573927, EC573960, EC573970, EC573971, EC573974, EC573983, EC573994, EC574016, EC574017, EC574019, EC574020, EC574027, EC574028, EC574037, EC574047, EC574068, EC574069, EC574074, EC574077, EC574078, EC574079, EC574082, EC574086, EC574087, EC574088, EC574091, EC574092, EC574093, EC574094, EC574096, EC574097, EC574104, EC574106, EC574107, EC574108, EC574109, EC574120, EC574121, EC574122, IC536348, IC536364, IC536365, IC536366, IC536394, IC536403, IC536406, IC536510, IC536511, IC536512, IC536521, IC536524, IC535353, IC542418, IC542429, IC542430, IC542432, IC542438, EC574277, EC574313, EC574339, EC574340, EC574341, EC574347, EC574348, EC574384, EC574395, EC574396, EC574436, EC574626, EC574634, EC574749, EC574756, EC574760, EC574762, EC574763, EC577429, EC577431, EC577437, EC577440, EC577443, EC577464, EC577465, EC577486
	5	75	IC542570, IC542573, IC536131, IC536156, EC573586, EC573607, EC573626, EC573632, EC573642, EC573652, IC536246, EC573800, EC573803, EC573852, EC573859, EC573875, EC573910, EC573930, EC573942, EC573957, EC574075, EC574081, EC574102, EC574113, IC536398, IC536401, IC536405, IC536409, IC542395, IC542438, EC574193, EC574231, EC574234, EC574279, EC574283, EC574289, EC574294, EC574300, EC574302, EC574305, EC574306, EC574337, EC574344, EC574345, EC574365, EC574366, EC574391, EC574394, EC574400, EC574402, EC574405, EC574406, EC574419, EC574433, EC574434, EC574480, EC574481, EC574482, EC574483, EC574502, EC574579, EC574625, EC574662, EC574667, EC574668, EC574748, EC574853, EC574854, EC574934, EC574989, EC575077, EC575079, EC575081, EC575082, EC575090
	10	321	IC542568, IC542569, IC542572, IC542574, IC536125, IC536128, IC536129, IC536130, IC536136, IC536140, IC536142, IC536147, IC536158, IC536192, IC536199, IC536201, IC536202, EC573553, EC573555, EC573556, EC573557, EC573563, EC573564, EC573573, EC573574, EC573588, EC573594, IC536205, IC536208, IC536209, IC536212, IC536215, IC536226, IC536227, EC573604, EC573608, EC573609, EC573610, EC573612, EC573616, EC573617, EC573618, EC573619, EC573620, EC573622, EC573623, EC573625, EC573627, EC573646, EC573650, EC573651, EC573655, IC536237, IC536241, IC536250, EC573781, EC573790, EC573791, EC573796, EC573797, EC573798, EC573802, EC573804, EC573805, EC573806, EC573812, EC573814, EC573815, EC573824, EC573825, EC573826, EC573851, EC573854, EC573855, C573860, EC573866, EC573867, EC577530, EC577531, EC573871, EC573877, EC573878, EC573879, EC573880, EC573884, EC573886, EC573887, EC573894, EC573897, EC573899, EC573900, EC573901, EC573902, EC573908, EC573917, EC573918, EC573921, EC573938, EC573939, EC573952, EC573955, EC573956, EC573958, EC573972, EC573979, EC573980, EC573992, EC573993, EC574012, EC574018, EC574023, EC574024, EC574025, EC574026, EC574031, EC574032, EC574033, EC574041, EC574042, EC574053, EC574061, EC574062, EC574063, EC574064, EC574083, EC574099, EC574103, EC574119, EC574125, EC574126, EC574127, EC574128, EC574177, IC536349, IC536350, IC536352, IC536392, IC536523, IC535518, IC536321, IC536322, IC536324, IC536334, IC536336, IC536337, IC536338, IC536346, IC542386, IC542392, IC542397, IC542398, IC542411, IC542412, IC542416, IC542420, IC542421, IC542422, IC542423, IC542426, IC542427, IC542431, IC542433, IC542434, IC542436, EC574194, EC574195, EC574203, EC574204, EC574209, EC574230, EC574241, EC574246, EC574258, EC574278, EC574280, EC574285, EC574288, EC574292, EC574301, EC574307, EC574308, EC574309, EC574311, EC574322, EC574338, EC574343, EC574350, EC574351, EC574352, EC574356, EC574358, EC574362, EC574363, EC574369, EC574370, EC574372, EC574373, EC574374, EC574384, EC574392, EC574401, EC574404, EC574405, EC574406, EC574407, EC574408, EC574418,

Contd.

Table 1 *Continued*

LTN type	Rust reaction*	No.	Name of accessions
			EC576116, EC574431, EC574432, EC574435, EC574477, EC574576, EC574577, EC574582, EC574592, EC574596, EC574612, EC574613, EC574614, EC574628, EC574629, EC574630, EC574633, EC574634, EC574637, EC574647, EC574648, EC574649, EC574650, EC574651, EC574652, EC574653 ,EC574656, EC574657, EC574658, EC574661, EC574669, EC574671, EC574711, EC574720, EC574721, EC574723, EC574737, EC574738, EC574743, EC574744, EC574745, EC574746, EC574778, EC574786, EC574793, EC574793, EC574795, EC574805, EC574809, EC574838, EC574839, EC574849, ,EC574851, EC574852, EC574856, EC574857, EC574863, EC574877, EC574879, EC574883, EC574884, EC574885, EC574886, EC574887, EC574895, EC574914, EC574915, EC574916, EC574917, EC574918,EC574919, EC574921, EC574987, EC574988, EC574992, EC574993, EC574997, EC574998, EC575001, EC575013, EC575015, EC575016, EC575028, EC575029, EC575032, EC575033, EC575036, EC575039, EC575049, EC575050, EC575058, EC575063, EC575066, EC575067, EC575068, EC575069, EC575070, EC575071, EC575072, EC575074, EC575075, EC575084, EC575085, EC575086, EC575087, EC575088, EC575089, EC575091, EC575092, EC575093, EC575094, EC575095, EC577490, EC575364
	20	169	IC542575, IC536118, IC536126, IC536132, IC536133, IC536149, IC536154, EC573545, EC573546, EC573552, EC573565, EC573570, EC573581, EC573590, EC573591, EC573593, EC573597, IC536213, IC536224, IC536225, EC573618, EC573621, EC573624, EC573635, IC536245, IC536254, IC536255, EC573793, EC573807, EC573810, EC573822, EC573823, EC573848, EC573869, EC573870, EC573873, EC573874, EC573883, EC573885, EC573889, EC573890, EC573891, EC573909, EC573923, EC573934, EC573940, EC573947, EC573949, EC573953, EC573961, EC573963, EC573964, EC573965, EC573966, EC573967, EC573969, EC573982, EC573991, EC574001, EC574002, EC574004, EC574005, EC574006, EC574011, EC574013, EC574015, EC574021, EC574045, EC574049, EC574060, EC574070, IC536359, IC536516, IC536517, IC536518, IC535487, IC535488, IC535499, IC536311, IC536339, IC536340, IC536341, IC536342, IC536347, IC542380, IC542396, IC542399, IC542408, IC542415, IC542424, IC542425, IC542428, EC574202, EC574226, EC574227, EC574240, EC574247, EC574248, EC574286, EC574287, EC574303, EC574371, EC574403, EC574479, EC574571, EC574573, EC574574, EC574578, EC574581, EC574584, EC574588, EC574591, EC574597, EC574598, EC574599, EC574613, EC574617, EC574632, EC574635, EC574636, EC574646, EC574696,EC574717, EC574719, EC574757, EC574774, EC574777, EC574791, EC574796, EC574798, EC574800, EC574806, EC574815, EC574816, EC574836, EC574837, EC574842, EC574843, EC574850, EC574855, EC574858, EC574859, EC574861, EC574878, EC574980, EC574981, EC574983, EC574985, EC574986, ,EC574991, EC574994, EC574995, EC575002, EC575007, EC575010, EC575037, EC575053, EC575164, EC575287, EC577430, EC577432, EC577433, EC577434, EC577488, EC577489, EC577492, EC575409, EC575503, EC575504
	40	101	IC536121, IC536127, IC536145, IC536148, IC536150, IC536153, IC536157, EC573542, EC573544, EC573596, EC573598, IC536206, IC536207, IC536214, EC573614, EC573630, EC573638, EC573643, EC573799, EC573809, EC573817, EC573827, EC573828, EC573850, EC573892, EC573893, EC573935, EC573946, EC573950, EC573951, EC573959, EC573962, EC573995, EC573996, EC574003, EC574007, EC574009, EC574035, EC574036, EC574039, EC574055, EC574056, EC574059, IC536360, IC536361, IC536362, IC536363, IC536384, IC535356, IC535358, IC535556, IC536323, IC536345, IC542381, IC542382, IC542383, IC542384, IC542388, IC542400, IC542401, IC542407, IC542413, IC542414, EC574585, EC574589, EC574595, EC574602, EC574779, EC574841, EC574898, EC574913, EC574969, EC574975, EC574976, EC574977, EC574978, EC574979, EC575000, EC575003, EC575004, EC575005, EC575006, EC575009, EC575011, EC575018, EC575019, EC577441, EC577466, EC575391, EC575400, EC575413,EC575423, EC575426, EC575449, EC575456, EC575457, EC575466, EC575490, EC575491, EC575496, EC575505
	60	23	IC536116, IC536152, EC573543, EC573914, EC574038, EC574043, EC574044, IC535273, IC535289, IC535484, IC536317, IC542385, EC574563, EC577436, EC577442, EC577444, EC577445, EC577446, EC577487, EC575487, EC575510, EC575511, EC575512
Medium	T	62	EC573540, EC573541, EC573560, EC573568, EC573580, EC573611, EC573636, EC573648, EC573653, IC536231, IC536233, IC536234, IC536235, IC536239, EC573769, EC573856, EC573904,

Contd.

Table 1 *Continued*

LTN type	Rust reaction*	No.	Name of accessions
			EC573922, EC574072, EC574100, EC574123, IC536356, IC536399, IC536408, IC536412, IC536453, IC536496, IC536506, IC542391, IC542439, EC574199, EC574200, EC574201, EC574210, EC574211, EC574212, EC574213, EC574214, EC574215, EC574216, EC574218, EC574219, EC574221, EC574229, EC574233, EC574244, EC574245, EC574257, EC574265, EC574266, EC574274, EC574282, EC574290, EC574326, EC574327, EC574413, EC574623, EC574756, EC577427, EC577428, EC577435, EC577438
	5	86	IC536123, IC536159, IC536185, IC536200, IC536219, IC536221, EC573603, EC573613, EC573633, EC573654, IC536230, IC536240, IC536247, IC536257, IC536260, EC573906, EC573929, EC573937, IC542451, IC536351, IC536371, IC536377, IC536380, IC536386, IC536444, IC536467, IC536474, IC536477, IC536483, IC536311, IC542386, IC542440, IC542441, IC542442, EC574196, EC574197, EC574205, EC574222, EC574223, EC574224, EC574235, EC574238, EC574259, EC574260, EC574264, EC574267, EC574281, EC574312, EC574316, EC574317, EC574319, EC574321, EC574325, EC574328, EC574336, EC574354, EC574355, EC574361, EC574383, EC574417, EC574441, EC574442, EC574451, EC574452, EC574580, EC574624, EC574643, EC574644, EC574663, EC574664, EC574665, EC574666, EC574698, EC574794, EC574845, EC574846, EC574847, EC574889, EC575044, EC575045, EC575046, EC575047, EC575064, EC575078, EC575080, EC575083
	10	213	IC536124, IC536141, IC536144, IC536155, IC536180, IC536186, IC536195, IC536198, IC536203, EC573550, EC573561, EC573562, EC573566, IC536206, IC536210, IC536211, IC536217, IC536223, EC573601, EC573628, EC573634, IC536229, IC536232, IC536242, IC536252, EC573786, EC573789, EC573794, EC573801, EC573813, EC573816, EC573821, EC573830, EC573913, EC573916, EC573931, EC573932, EC573954, EC573973, EC573978, EC573986, EC573990, EC574029, EC574030, EC574064, EC574067, EC574101, EC574177, IC536358, IC536369, IC536373, IC536376, IC536400, IC536407, IC536413, IC536440, IC536465, IC536473, IC536497, IC536505, IC536516, IC535289, IC535518, IC542379, IC542380, IC542383, IC542384, IC542388, IC542389, IC542402, IC542415, IC542422, IC542423, IC542435, IC542437, EC574208, EC574225, EC574236, EC574237, EC574239, EC574242, EC574249, EC574251, EC574252, EC574253, EC574254, EC574255, EC574261, EC574262, EC574293, EC574298, EC574310, EC574314, EC574318, EC574320, EC574323, EC574324, EC574329, EC574330, EC574331, EC574332, EC574333, EC574334, EC574335, EC574342, EC574359, EC574393, EC574430, EC576115, EC574439, EC574440, EC574466, EC574467, EC574490, EC574541, EC574583, EC574611, EC574615, EC574616, EC574618, EC574619, EC574622, EC574640, EC574645, EC574654, EC574655, EC574659, EC574660, EC574670, EC574673, EC574674 EC574675, EC574676, EC574677, EC574678, EC574679, EC574680, EC574681, EC574682, EC574683, EC574684, EC574685, EC574686, EC574695, EC574697, EC574708, EC574709, EC574710, EC574722, EC574731, EC574732, EC574733, EC574734, EC574739, EC574740, EC574741, EC574742, EC574747, EC574751, EC574758, EC574772, EC574788, EC574797, EC574801, EC574802, EC574803, EC574804, EC574811, EC574812, EC574813, EC574840, EC574844, EC574848, EC574852, EC574862, EC574863, EC574864, EC574867, EC574871, EC574875, EC574880, EC574881, EC574882, EC574888, EC574890, EC574891, EC574900, EC574901, EC574902, EC574903, EC574904, EC574905, EC574910, EC574911, EC574912, EC574920, EC574990, EC574996, EC575034, EC575035, EC575042, EC575043, EC575059, EC575060, EC575061, EC575062, EC575065, EC575076, EC575288, EC575289, EC577456, EC575365, EC575411
	20	86	IC536122, IC536138, IC536162, IC536170, IC536182, IC536191, IC536193, EC573547, IC536228, EC573639, IC536243, IC536249, EC573808, EC573829, EC573876, EC573936, EC573941, EC573984, EC574000, EC574014, EC574022, IC536357, IC536368, IC536370, IC536378, IC536385, IC536404, IC536454, IC536475, IC536482, IC536502, IC536515, IC535358, IC536322, IC536323, IC536324, IC542396, IC542408, EC574206, EC574207, EC574220, EC574228, EC574346, EC574386, EC574493, EC574537, EC574557, EC574558, EC574586, EC574587, EC574590, EC574593, EC574601, EC574610, EC574621, EC574687, EC574688, EC574689, EC574718, EC574759, EC574782, EC574783, EC574784, EC574785, EC574810, EC574814, EC574833, EC574834, EC574835, EC574868, EC574869, EC574870, EC574873, EC574874, EC574876, EC574892, EC574897, EC574999, EC575017, EC575051, EC575052, EC575495, EC575497, EC575498, EC575501, EC575502

Contd.

Table 1 *Continued*

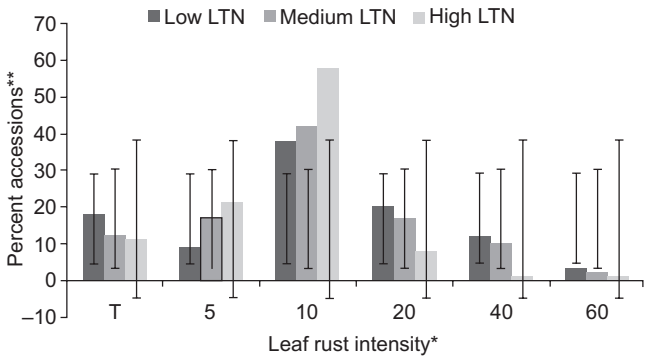
LTN type	Rust reaction*	No.	Name of accessions
	40	50	IC536190, EC573551, EC573631, EC573881, EC573882, EC573943, EC573944, EC573945, EC573948, EC573968, EC574008, EC574034, EC574057, EC574058, EC574084, IC536375, IC536387, IC536471, IC536484, EC574776, EC574865, EC574866, EC574893, EC574894, EC574982, EC575008, EC577460, EC577483, EC575363, EC575401, EC575419, EC575429, EC575438, EC575442, EC575446, EC575447, EC575448, EC575452, EC575462, EC575464, EC575465, EC575488, EC575492, EC575493, EC575494, EC575499, EC575500, EC575521, EC575522, EC575523
	60	13	IC536164, EC573549, EC573559, EC574494, EC574781, EC577475, EC575404, EC575514, EC575515, EC575516, EC575517, EC575520, EC575527
High	T	20	IC536139, IC536168, EC573572, IC536220, EC573975, EC573976, EC573977, EC574115, IC536433, EC574273, EC574390, EC574426, EC574427, EC574437, EC574438, EC574444, EC574445, EC574446, EC574454, EC574627
	5	37	EC573569, IC536222, IC536431, EC574291, EC574412, EC574421, EC574428, EC574450, EC574458, EC574459, EC574460, EC574461, EC574462, EC574463, EC574475, EC574476, EC574478, EC574484, EC574485, EC574503, EC574504, EC574642,EC574690, EC574691, EC574700, EC574701, EC574702, EC574704, EC574705, EC574706, EC574707, EC574789, EC574828, EC574829, EC574830, EC574831, EC574847
	10	102	IC536161, IC536167, IC536174, IC536176, IC536178, IC536181, IC536183, IC536187, IC536196, IC536197, IC536204, IC536216, EC573911, EC573912, EC573987, EC573988, EC573989, EC573999, IC536475, IC536503, IC536508, EC574217, EC574268, EC574271, EC574367, EC574368, EC574387, EC574397, EC574398, EC574399, EC574409, EC574410, EC574411, EC574414, EC574415, EC574422, EC574423, EC574424, EC574429, EC574447, EC574448, EC574453, EC574455, EC574456, EC574457, EC574459, EC574460, EC574464, EC574465, EC574469, EC574470, EC574471, EC574473, EC574474, EC574487, EC574488, EC574489, EC574491, EC574492, EC574495, EC574496, EC574498, EC574570, EC574594, EC574603, EC574639, EC574642, EC574690, EC574691, EC574693, EC574694, EC574712, EC574713, EC574714, EC574715, EC574716, EC574724, EC574725, EC574726, EC574727, EC574728, EC574729, EC574730, EC574735, EC574736, EC574790 , EC574817, EC574818, EC574819, EC574820, EC574821, EC574822, EC574823, EC574824, EC574825, EC574832, EC574906, EC574907, EC574908, EC574909, EC575040, EC575041
	20	15	IC536218, EC574387, EC574443, EC574468, EC574476, EC574497, EC574499, EC574501, EC574567, EC574568, EC574620, EC574826, EC574827, EC574899, EC575048
	40	2	EC573997, IC536383
	60	1	EC574569

*T = trace severity, 5, 10, 20, 40, 60 = % severity (Peterson *et al*. 1948)

other resistance genes complementing it (Dyck and Samborski 1982 and Kumar *et al*. 1999).

Effect of three different categories of LTN demonstrated in Fig 1 on terminal severity of leaf rust was also visualised by correlating the extent of LTN expression with disease severity and it was found to have no impact on final reduction (Fig 3). Three different types of LTN do not behave differently for their effect on terminal severity of leaf rust supporting the earlier findings of Singh (1992), wherein a range of leaf tip necrosis was observed but without any individual effect on terminal severity in breeding populations.

Present observations lead to a conclusion that accessions bearing LTN suffered less from leaf rust infection as compared to those without this trait. Since leaf tip necrosis has been proved to be genetically linked with gene *Lr34* (Singh 1992a and Dyck 1991), hence accessions of Indian wheat germplasm studied here can be assumed to possess this useful gene of



*T = trace severity, 5, 10, 20, 40, 60 = % severity
** Vertical bars represent standard deviation about mean of the accessions counted under each category of LTN

Fig 3 Leaf rust intensity*of accessions belonging to low, medium and high categories of LTN

resistance for leaf rust. These accessions may find their utility as genetic stocks for breeding varieties with durable resistance to leaf rust. Many of these accessions besides having *Lr34* also possess many other desirable traits like plant type, yield components and yellow rust as well as powdery mildew resistance and therefore can act as an important reservoir of genetic stocks for wheat improvement. Since LTN is also associated with the presence of *Yr*18 (Singh 1992b) and lower incidence of stem rust (Bansal *et al*. 2008), the involvement of these lines in breeding programmes improves the frequency of desirable gene or traits in the population significantly. Presence of *Lr34* which is linked with LTN may carry slight yield penalty. However, the grain yield reduces approximately 15% in the presence of *Lr34* and the reductions in the absence of *Lr34* are substantially higher and range between 42.5 – 84% (Singh and Huerto-Espano 1997).

The difficulty in the selection of *Lr34* on the basis of host – pathogen interaction at the seedling stage due to non-availability of differentiating pathotypes (Dyck and Samborski 1982) and easy scorability further enhance the value of LTN as a selection criterion for wheat improvement. However, confirmation of presence of *Lr34* in the plant progenies selected on the basis of LTN with the available molecular markers will significantly reduce the cost of breeding programme. It will be worthwhile to verify presence of *Lr34* in the presently reported accessions by molecular innovations such as those described by Lagudah *et al.* (2009).

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