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Introgression of Banded Leaf and Sheath Blight (BLSB) Resistance from Teosinte to Maize Cultivar

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***Abstract*:** Maize (*Zea mays L.*) is a member of the *Poaceae* family and is targeted as the world's most important strategic cereal food crop. This study was planned to screen the maize-Teosinte RILs population for banded leaf and sheath blight and agronomic traits. A total of 338 maize-Teosinte recombinant inbred lines (RILs), derived from cross between the high popping volume (HPV) Canadian popcorn inbred line (susceptible) as the female parent and Teosinte (wild relative) as the male parent (resistant).The data were recorded for agronomic traits and disease score for banded leaf and sheath blight . The mean sum of squares due to genotypes were observed highly significant (p<0.01) for all the trait studied. The 100 seed weight, an important trait showed highly significant positive correlation with number of seed rows per cob and cobs length. Path coefficient analysis revealed direct positive effect of cob length, number of seed rows per cob and plant height on grain yield. The first two Principal component values used to construct biplot graphs explained 39.70% of the total variation. The four maize-Teosinte RIL lines viz.; RIL-210, RIL-272, RIL-314 and RIL473 were screened resistant to banded leaf and sheath blight, which is a good source of BLSB resistance and would be utilized in breeding for maize improvement program. The recombinant inbred lines viz., RIL-6, RIL-26 and RIL-419 were identified as a better-performing line for multiple agronomic traits which, would also utilized to improve agronomic performance of maize.

Keywords: Recombinant inbred lines, Banded Leaf and sheath blight, *Rhizoctonia solani*, Popcorn, *Zea mays* L.

Maize (*Zea mays* L.) is a member of the *Poaceae* family and is the third most important cereal grain worldwide, after wheat and rice (Farrell and Hodges 2004) and targeted as the world's most significant strategic cereal food crop (Tefera 2020). It is a staple food crop for many countries of the world, including Latin America, Asia and Africa. Maize is grown on 197 million (M) hectares, with 32% grown in lower capacity income countries (Erenstein et al., 2021). Banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani* f. sp. *Sasakii* (Khunn) is a soil-borne pathogen having wide-ranging outbreaks in several portions of India (Singh et al., 2014). The banded leaf and sheath blight (BLSB) pathogen was first reported by Bertus in Sri Lanka in 1927 and is name sclerotial disease (Singh and Shahi 2012). Disease losses are especially severe when the relative humidity is high and the plant population density is high. This disease primarily affects the first and second leaf sheaths above ground and then progresses upward to the ear leading to serious crop losses and is spreading to new areas due to intensive farming techniques. It has been gaining epiphytotic proportions in the previous decades due to its rising severity. In currently produced cultivars, BLSB has the capacity to yield losses of up to 40–70% (Singh et al. 2018). The pathogen can cause 7.6 to 64.8% grain yield loss, while in the ear rot stage of BLSB, grain loss might reach 100% in continuous rain condition (Kumar et al., 2021).

Maize originated from wild grass (*Zea mays* ssp. *parviglumis*) around 9000 years back in the Balsas region of southwest Mexico. Teosinteis very closely related to maize are classified as *Z. mays* ssp. *Mexicana* (Schrader) Iltis, *Z. mays* ssp. *huehuetenangensis*, which cultivate in northern and central Mexico. Teosinte has certain superiority as insect resistance, disease resistance, saline–alkaline resistance, drought resistance, reproductive ability and multiple tillers and has been successfully used in maize breeding as an important source of favorable alleles (Wang et al., 2020). The abiotic stress tolerance, pest and disease resistance, quality, yield and fertility restoration and male sterility is an important for all crops and have been improved with crop wild relatives (Hajjar and Hodgkin 2007). The introgression lines can be used to incorporate the BLSB resistance to maize cultivars while also improving their morphological and yield performance of maize. Additional breeding initiatives can make advantage of these introgression lines in further breeding programmes.

MATERIAL AND METHODS

The experimental material includes the total of 338 maize-Teosinte recombinant inbred lines (RILs) F_4, derived from cross between the high popping volume (HPV) Canadian popcorn inbred line (susceptible) as the female parent and Teosinte (wild relative) as the male parent (resistant) were sown during *kharif* season, 2021 along with parents in the last week of May at the Eternal University experimental field, Machher, Baru Sahib, Himachal Pradesh, India.Each genotype was represented by a plot of two rows of 1m and row to row spacing was maintained at 40 cm. The observations were recorded for agro-morphological traits and disease reaction. The recorded data were statistically analyzed to performed following standard procedures for the estimation of components of genetic variation, with the help of the SAS software, version 9.1.SAS Institute, Inc. SAS user's guide (Clark and Kempthorne 1958).

Banded leaf sheath blight Inoculum: The pathogen of banded leaf sheath blight (BLSB) was isolated from sclerotia collected from infected plants in previous year's research field. These sclerotia were cultured on potato dextrose agar (PDA) medium, purified and stored in laboratory for subsequent use in preparing artificial disease inoculation for field experiments. Unhulled sorghum grains were soaked in potable water for 24 hours, dispense 50g in 250ml Erlenmeyer flask after drained of excess water, and autoclaved at a 121°C (15 psi pressure) for 30 minutes. Fresh culture was prepared in petri dish using the stored BLSB culture and pathogen started growing on culture plate. The sterilized cork borer was used to aseptically homogenize a 5-6 days old pathogen growth collected from potato dextrose agar in 10 ml sterile water, and 5 ml of homogenized culture was utilized to seed each flask and incubated at 27 °C for 10-14 days. Grains were shaken at 3-4 days interval for identical growth of fungal on sorghum grains. After approximately two weeks of incubation, the inoculum was ready for use and stored, dried, at 15°C for future applications.

Artificial inoculation for banded leaf sheath blight: In addition to various method of artificial disease inoculation, maize plants were subjected to BLSB pathogen under field conditions following the standard procedure outlined by Yadav et al. (2023). Inoculation was done on 30-45 days old plants after sowing of maize. Inserting four to five grains coated with fungal growth and sclerotia bodies gently between the stalk's rind and inoculating leaf sheath of three leaves in each plant at the second, third, and fifth internode from the base of the plant stem. Regular irrigation was applied to sustain high humidity levels (>90%) during the disease's progression. Inoculation was replicated again after 10 days to avoid chances of failure of disease growth. After 35 days of inoculation, each maize line was scored for disease and classified into groups depending on their reactivity.

Disease score: A disease rating scale of 0 to 5 was used to assess symptoms such as sheath damage, early plant death, stem breakage, rotten ears and stalk lesions (Jiang et al., 2020).

Morphological observations: During the *kharif* season 2021,observations were recorded on morphological traits viz; emergence to flowering (days), days to maturity (days), plant height (m), number of cobs per plant (numbers), number of tillers per plant (numbers), number of branches per plant, number of seed rows per cob, cob length (cm) and hundred-grain seed weight (g).

Statistical analysis: The recorded data was subjected to statistically analyzed, following standard procedures for the estimation of components of genetic variation, correlations among yield-related traits and principal component analysis through SAS software, version 9.1.SAS Institute, Inc. SAS.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among these RILs for all the traits indicates that the genotypes employed in this study differ with regard to the characters that opened a way to proceed for further improvement through simple selection and these genotypes can used for selection in maize improvement program (Table 1). The results were also supported by Singh et al. (2017), Adhikari et al. (2019) and Sahoo et al. (2021).

Performance of RILs for agronomic traits: Days to flowering emergence ranged from 54 to 101 days. The early flowering was recorded for the five lines viz. RIL-6, RIL-27, RIL-104, RIL-323, and RIL-378 with their parent Canadian popcorn and Teosinte. Days to maturity ranged from 99 to 150 days. The early maturity was observed in five lines viz.; RIL-23, RIL-28, RIL-46, RIL-47 and RIL-143 as compared to the parents. The plant height ranged from 1.20 to 3.63 (m). The short height was recorded for the five lines viz.; RIL-51, RIL-125, RIL-304, RIL-392 and RIL-443 with respect to parents. The numbers of tillers per plant ranged from 1 to 4 tilers. The high numbers of tillers per plant were recorded for RIL-68, RIL-228, RIL-308, RIL397 and RIL-479 with the parents. The number of branches per plant ranged from 0 to 5. The high number of branches per plant were observed in RILs viz.; RIL-272, RIL-428, RIL-429, RIL-272 and RIL-429 with respect to parents. Numbers of cobs per plant ranged from 1 to 22. The lines were having high number of cobs per plant were RIL-46, RIL-272, RIL-428, RIL-429 and RIL-482 with the parents. The number of seed rows per cob ranged from 2 to 8. The lines with more seed rows per cob were observed for RIL302, RIL-358, RIL-403, RIL-419 and RIL-441 as compared to parents. Cob length ranged from 4. to 23.67cm. The RILs were observed with high cob length was RIL-9, RIL-26, RIL-109, RIL-358, RIL-382 as compared to parents. The 100 seed weight was ranged from 4.5 to 21.37

g. The RILs were observed the high seed weight viz; RIL-6, RIL-37, RIL-188, RIL-231 and RIL-358 (Table 1). The high variance values indicate that the genes played a significant role in this variance, and selection can be very effective. The observed ranges of different morphological and yield traits in study are in general accordance with similar studies in maize (Chaurasia et al., 2020 , Kumawat et al., 2020, Pranay et al., 2022, Reddy et al., 2022, Al-Rawi et al., 2024).

Correlations among agronomic traits in maize-Teosinte RIL population: Phenotypic correlations are observed that for the maize RIL population, a total of 17 correlations were found significant, 14 correlation coefficients were to be highly significant and 3 to be significant (Table 2). The emergence to flowering days had a highly positively significant correlation with days to maturity, number of tillers per plant and highly negative significant correlation with number of rows per cob, 100 seed weight, while, negative significant correlation with cob length. Plant height was a highly positively significant correlation with number of branches per plant and number of cobs per plant. Similar findings were also observed earlier workers (Malik et al., 2005, Rafiq et al., 2010, Bekele et al., 2014). Number of tillers per plant had a highly positive significant correlation with number of branches per plant and the number of cobs per plant whereas, number of tillers per plant had a highly significant negative correlation with the number of seed rows per cob. Number of branches per plant was highly positively associated with number of cobs per plant, while, a highly negative correlation with number of seed rows per cob and a significant negative correlation with cob length. Number of cobs per plant also have a significant negative correlation with number of seed rows per cob. The number of seed rows per cob recorded a highly significant positive correlation with cob length, and 100seed weight. Cob length was also showed that a highly significant correlation with 100 seed weight (Table 2). Some researchers reported similar observations (Hengu et al., 2017, Izzam et al., 2017, Chaurasia et al., 2020, Pranay et al., 2022), The researchers observed that plant height, ear height, ear length, ear diameter, grains per row, 100-seed weight, cob yield per plant and seed vigour index were significant and positively significantly inter-correlated with the grain yield per plant and these traits possess high yield potential in maize crop.

Path coefficient analysis for maize-Teosinte RILs for

Table 1. Analysis of variance and morphological parameters for various agronomic traits of maize-Teosinte RIL population

Source of Variation	DF	Days to Tassel initiation (Days)	Days to maturity (Days)	Plant height (m)	No. of tillers per plant (Number)	No. of branches per plant (Number)	No. of cobs per plant (Number)	No. of Seed rows per cob (Number)	Cob length (cm)	100 seed weight (g)
Replication	2	83.962	96.862	0.2535	0.98	2.344	27.5335	2.2515	4.3985	10.8625
Treatment	339	167.924**	193.724**	0.507**	1.96**	4.688**	55.067**	4.503**	8.797**	21.725**
Error	678	6.544	6.301	0.009	0.075	0.105	0.563	0.751	3.813	0.992
Mean		78.00	125.00	2.37	1.54	1.00	8.14	4.20	7.31	10.09
Minimum		54.00	99.00	1.20	1.00	0.00	1.00	2.00	4.33	4.50
Maximum		101.00	150.00	3.63	4.00	5.00	22.00	8.00	23.67	21.37

*, ** - significant at 5 % and 1 % level respectively

Table 2. Correlation among the different agronomic traits in maize-Teosinte RIL population

Parameter	Days to maturity (Days)	Plant height (m)	No. of tillers per plant (Number)	No. of branch per plant (Number)	No. of cobs per plant (Number)	No. of seed rows per cob (Number)	Cob length (cm)	100 seed weight (g)
Emergence to flowering (days)	0.242**	0.054	0.145**	0.009	-0.009	-0.220**	-0.120*	-0.186**
Days to maturity		-0.044	0.050	-0.038	-0.031	-0.069	-0.020	-0.032
Plant height (m)			0.010	0.171**	0.147**	-0.064	0.004	0.019
Number of tillers per plant				0.157**	0.382**	-0.160**	-0.059	-0.030
Number. of branch per plant					0.580**	-0.163**	-0.125*	-0.004
Numberof cobs per plant						-0.119*	-0.089	0.011
Numberof seed rows per cob							0.324**	0.196**
Cobs length (cm)								0.217**

*, ** - significant at 5 % and 1 % level respectively

agro morphological traits: The maximum positive direct effects of cob length, number of seed rows per cob and plant height were observed on 100 seed weight (Table 3). The negative direct effect of emergence to flowering was observed on 100 seed weight. The number of seed rows per cob and cob length had indirect effect on 100 seed weight. Jakhar et al. (2017), Chaurasia et al. (2020) and Pranay et al. (2022) had also observed same results working on maize. Aman et al. (2020) reported significant positive direct effects of ear height on yield per hectare in maize.

Principal Component Analysis (PCA) for agronomic traits: The PCA was performed for 9 agronomic traits of the maize-Teosinte RIL population. The correlation matrix reported 9 major components, which correlate to the number of traits. The variability of PCA concentrate is explained by the first five principal components. The first four PCs explained 63.3 % of the total variation, in which the contribution of PC1 was 22.50%, PC2 17.20, PC3, 12.50 and PC4 11.20 in the total divergence of the studied population. Significant PCs had Eigen values ranging from 2.027 (PC1) to 1.004 (PC4) (Table 4). PCAs displayed that the total genetic diversity was clearly distributed throughout the agromorphological traits. Murtadha et al. (2018), observed the genetic variation of maize genotypes was significantly influenced by variables such as days to maturity, ear height, ear diameter, ear length, grain rows per ear, grains per row, and yield per plant. The utility of PCA in selecting maize genotypes through the selection of features that significantly contribute to the genetic variation of maize germplasms was also highlighted by Mustafa et al. (2015). Based on the factor loading graph (Fig. 1), 100 seed weight is strongly correlated with cob length and number of rows per cob. The 100 seed weight is negatively correlated with the emergence of flowering, and days to maturity (Fig. 1). The plant height is also strongly correlated with number of cobs per plant, number of branches per plant, number of tiller per plant and negatively correlated with days to flowering initiation or days to maturity. Similar findings have been also observed by other reports Malik et al. (2005), Rafiq et al. (2010), Bekele et al. (2014). Aman et al. (2020) reported that PCA had a significant and positive correlation with days to 50% tasselling, plant height, ear height, and 100-grain weight in maize.

Screening of maize-Teosinte RIL population for banded leaf and sheath blight: After 45 days of inoculation, data pertaining to BLSB adopting a disease scale of 0-5 scale. There are three types of ear rot, (i) infection before ear initiation, the ear cannot be developed and it is rudimentary, (ii)infection after ear initiation; the stalk fiber at the tip darkens, becomes caked-up, and hardens, resulting in poor grain filling, (iii) infection after grain filling; the kernels become light in weight, chaffy, and lusterless. The presence of light brown cottony mycelium on the plant ear, the presence of tiny and round black sclerotial, premature drying of ears, and caking of the ear sheath are characterized signs

Table 4. Eigen values (latent roots) and rotated component loadings (principal component traits of maize-Teosinte RILs)

Component	Eigen value	Proportion (%)	Cumulative (%)
PC1	2.03	22.50	22.50
PC2	1.54	17.20	39.70
PC3	1.12	12.50	52.10
PC4	1.00	11.20	63.30
PC5	0.84	9.30	72.60
PC6	0.79	8.80	81.40
PC7	0.67	7.40	88.80
PC8	0.64	7.10	96.00
PC9	0.36	4.00	100.00

Table 3. Path coefficient analysis for various agronomic traits in maize-Teosinte RIL population

Parameter	Emergence to flowering (Days)	Days to maturity (Days)	Plant height (m)	No. of tillers per plant (Number)	No. of branch per plant (Number)	No. of cobs per plant (Number)	No. of seed rows per cob (Number)	Cobs length (cm)	r value with 100 seed weight
Emergence to flowering (days)	-0.146	0.004	0.002	0.001	0.000	0.000	-0.027	-0.020	-0.186**
Days to maturity	-0.035	0.017	-0.001	0.000	-0.001	-0.001	-0.008	-0.003	-0.032
Plant height (m)	-0.008	-0.001	0.028	0.000	0.003	0.003	-0.008	0.001	0.019
Number of tillers per plant	-0.021	0.001	0.000	0.008	0.003	0.008	-0.019	-0.010	-0.030
Number. of branch per plant	-0.001	-0.001	0.005	0.001	0.020	0.012	-0.020	-0.021	-0.004
Number of cobs per plant	0.001	-0.001	0.004	0.003	0.012	0.020	-0.014	-0.015	0.011
Number of seed rows per cob	0.032	-0.001	-0.002	-0.001	-0.003	-0.002	0.120	0.053	0.196**
Cobs length (cm)	0.018	0.000	0.000	-0.001	-0.002	-0.002	0.039	0.165	0.217**

*Significant at 5% level; **Significant at 1% level; Bold figure indicates direct effect; Residual effect=0.91360 of ear rot that are also observed in the maize-Teosite RIL population. Later on the infection was visible on the lower sheath that manifested spreads to the upper leaf sheaths, resulting in leaf sheath rot and whole leaf drying in the maize-Teosite RILs population. The disease occurs on 40-45 days old plants during the pre-flowering stage of the plant, resulting in blighting and the death of the apical region of growing plant in the maize-Teosite RIL population. Lesions and blotches cover the majority of the leaves, making alternating narrow purple or brown zones more visible has been recorded in the maize-Teosite RILs population, which is a characteristic symptom of BLSB.

Disease reactions in maize-Teosinte recombinant inbred lines: The parent line Canadian popcorn (HPV) was highly susceptible having the disease score 5 while the Teosinte was immune with 0 disease score (Table 5). The disease reaction of the 338 recombinant inbred lines is presented in Table 5. Banded leaf sheath blight disease scores ranged from 0.0 to 5.0. There was no immune line observed while, four RILs viz.; RIL-210, RIL-272, RIL-314 and RIL473 were observed resistant with a disease score 1. Forty-seven RILs were recorded as a moderately resistant to BLSB with a disease score of 2. Sixty-three RILs were observed with moderate susceptible reaction to this disease having the disease score 3, 166 lines recorded susceptible as having disease score 4 and 58 lines showed high susceptibility for BLSB with the highest disease score 5 (Table 5). The BLSB was observed in Indian farming systems, affecting grain yield economic losses by 40-100% (Malik et al. 2018). The symptoms of maize leaf and sheath blight are very similar to those described by Rijal et al. (2007) and (Sagar and Bhusal 2019). Chen et al. (2013) observed the same results in the 282 maize inbred lines of disease resistance to BLSB, four moderately resistant inbred lines were found and there was no immune line was recorded. Another study involved twenty-eight maize genotypes were tested for the BLSB

Table 5. BLSB reaction in maize-Teosinte RIL population

Disease scoring	Disease rating scale	Reaction	No. of lines	RILs ID
0	0	I	-	-
1-10%	1.0	R	4	RIL-210, RIL-272, RIL-314, RIL-473
11-25%	2.0	MR	47	RIL-1, RIL-3, RIL-9, RIL-11, RIL-14, RIL-20, RIL-23, RIL-24, RIL-39, RIL-48, RIL-55, RIL-59, RIL-62, RIL-72, RIL-83, RIL-108, RIL-109, RIL-126, RIL-142, RIL-185, RIL-192, RIL-203, RIL-205, RIL-207, RIL-220, RIL-223, RIL-230, RIL-257, RIL-283, RIL-290, RIL-300, RIL-302, RIL-312, RIL-322, RIL-336, RIL-398, RIL-418, RIL-428, RIL-429, RIL-436, RIL-439, RIL-442, RIL-453, RIL-478, RIL-479, RIL-480, RIL-486
26-50%	3.0	MS	63	RIL-5, RIL-8, RIL-12, RIL-15, RIL-19, RIL-22, RIL-25, RIL-26, RIL-36, RIL-40, RIL-47, RIL-49, RIL-50, RIL-53, RIL-57, RIL-75, RIL-76, RIL-104, RIL-135, RIL-149, RIL-175, RIL-196, RIL-208, RIL-226, RIL-227, RIL-228, RIL-233, RIL-238, RIL-239, RIL-240, RIL-241, RIL-267, RIL-299, RIL-303, RIL-304, RIL-308, RIL-309, RIL-342, RIL-350, RIL-355, RIL-374, RIL-395, RIL-401, RIL-404, RIL-407, RIL-411, RIL-413, RIL-414, RIL-415, RIL-426, RIL-432, RIL-434, RIL-443, RIL-446, RIL-448, RIL-455, RIL-456, RIL-457, RIL-459, RIL-462, RIL-463, RIL-474, RIL-476
51-75%	4.0	S	166	RIL-10, RIL-16, RIL-17, RIL-18, RIL-21, RIL-28, RIL-31, RIL-32, RIL-33, RIL-34, RIL-37, RIL-42, RIL-43, RIL-44, RIL-45, RIL-46, RIL-51, RIL-52, RIL-63, RIL-64, RIL-68, RIL-73, RIL-82, RIL-84, RIL-88, RIL-91, RIL-92, RIL-103, RIL-105, RIL-111, RIL-115, RIL-116, RIL-117, RIL-119, RIL-121, RIL-125, RIL-127, RIL-137, RIL-140, RIL-141, RIL-143, RIL-146, RIL-151, RIL-155, RIL-158, RIL-159, RIL-169, RIL-170, RIL-171, RIL-173, RIL-174, RIL-178, RIL-179, RIL-180, RIL-184, RIL-186, RIL-188, RIL-189, RIL-194, RIL-197, RIL-201, RIL-204, RIL-209, RIL-212, RIL-213, RIL-214, RIL-215, RIL-216, RIL-225, RIL-231, RIL-236, RIL-237, RIL-242, RIL-243, RIL-244, RIL-247, RIL-249, RIL-250, RIL-251, RIL-253, RIL-255, RIL-256, RIL-266, RIL-270, RIL-273, RIL-275, RIL-279, RIL-280, RIL-281, RIL-282, RIL-284, RIL-285, RIL-288, RIL-289, RIL-298, RIL-301, RIL-306, RIL-307, RIL-313, RIL-315, RIL-318, RIL-319, RIL-321, RIL-323, RIL-328, RIL-329, RIL-330, RIL-333, RIL-338, RIL-339, RIL-340, RIL-343, RIL-344, RIL-345, RIL-346, RIL-347, RIL-352, RIL-356, RIL-357, RIL-358, RIL-364, RIL-365, RIL-366, RIL-371, RIL-372, RIL-373, RIL-375, RIL-377, RIL-378, RIL-379, RIL-380, RIL-381, RIL-382, RIL-383, RIL-387, RIL-388, RIL-389, RIL-391, RIL-397, RIL-400, RIL-402, RIL-405, RIL-417, RIL-422, RIL-423, RIL-424, RIL-425, RIL-430, RIL-435, RIL-438, RIL-440, RIL-441, RIL-444, RIL-450, RIL-451, RIL-454, RIL-458, RIL-464, RIL-465, RIL-467, RIL-470, RIL-477, RIL-481, RIL-483, RIL-484, RIL-485
75-100%	5	HS	58	RIL-2, RIL-6, RIL-27, RIL-54, RIL-60, RIL-61, RIL-74, RIL-101, RIL-112, RIL-114, RIL-122, RIL-123, RIL-134, RIL-139, RIL-147, RIL-156, RIL-160, RIL-162, RIL-168, RIL-181, RIL-182, RIL-187, RIL-190, RIL-193, RIL-211, RIL-217, RIL-221, RIL-222, RIL-254, RIL-311, RIL-337, RIL-341, RIL-367, RIL-369, RIL-370, RIL-392, RIL-393, RIL-394, RIL-396, RIL-399, RIL-403, RIL-408, RIL-412, RIL-416, RIL-419, RIL-420, RIL-421, RIL-437, RIL-445, RIL-447, RIL-449, RIL-461, RIL-468, RIL-469, RIL-482, RIL-487, RIL-488

I=Immune, R=resistant, MR=moderatelyresistant, MS=moderatelysusceptible, S=susceptible, HS=highlysusceptible under artificial inoculations out of which four accessions were found to be resistant, three were to be highly susceptible, and the remaining twenty-one were found to be susceptible and none was found to be highly resistant (Asif and Mall 2017, Devi et al., 2018).

CONCLUSIONS

The disease score of the 338 recombinant inbred lines showed that four lines viz., RIL-210, RIL- 272, RIL-314 and RIL-473 were resistant and forty-seven RILs showed moderately resistant to BLSB. The recombinant inbred lines viz., RIL-6, RIL-26 and RIL-419 were recorded as better genotypes for multiple traits. These RILs would also utilized to improve agronomic performance and disease resistance of maize.

AUTHOR CONTRIBUTIONS

Conceptualized by Harcharan Singh Dhaliwal and Vikrant Tyagi; Nidhi Devi and Vaishali Sharma performed the experiments. Vikrant Tyagi supervised Nidhi Devi and Vaishali Sharma. Vikrant Tyagi, Imran Sheikh, and Nidhi Devi wrote the original draft. Vikrant Tyagi, Priti Sharma, Praneet Chauhan, and Imran Sheikh reviewed and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

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