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Short Communication

Genetic and anatomical characterization of land races of maize (*Zea mays* L.) for lodging and yield related traits

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One of the major constraints to realization of high yields of maize especially under hilly conditions is lodging of the crop. Most of the local maize cultivars of the state are highly susceptible to root and stem lodging causing extensive damage to the crop during adverse agro-climatic conditions which are of a common occurrence during *kharif* season in hills. Susceptibility to lodging in local cultivars of maize may be due to morphological characters such as tallness, high cob placement, excessive biomass, longer inter nodal distance and weak stem and root system. Anatomical characters such as density of pith, distribution of sclerenchymatous cells, hypodermic thickness and vascular bundle number have been also reported to be correlated with lodging resistance. Keeping all these factors in view, the present study was aimed at characterization and evaluation of local germplasm of maize for lodging and grain yield.

One hundred local cultivars/germplasm of maize collected from different areas (31 from Chamba, 36 from Kangra and rest from Mandi districts) of Himachal Pradesh lying between 600 and 1500 m. above mean sea level, along with four checks comprising two composites- Girija and Parvati and two hybrids, PSCL 3438 and KH 517 were evaluated in an augmented randomized block design following the standard package of practices. The data were recorded on five randomly taken plants on days to brace root emergence, plant height, cob placement, number of nodes, inter nodal distance, thickness of stem, number of leaves, leaf area, number of roots, root length, root volume, plant fresh weight, days to maturity, number of nodes bearing effective brace root-emergence, stem lodging, root lodging, length of cobs, width of cobs, number of grain rows, number of grains per row, 1000-grain weight, grain yield, lodging score and incidence of leaf and sheath banded blight as well stem borer. Banded leaf and sheath bight was recorded using 0-9 scale [1]. The study on anatomical characters *viz.*, distribution of sclerenchymatous tissues and vascular bundles in the stem was done in the laboratory following the standard procedures [2, 3]. The material comprising one hundred germplasm lines was categorized into two groups i.e. resistant and susceptible stem lodged. The transverse sections of the different groups were observed for variation in the distribution of sclerenchymatous tissues and vascular bundles in the plant cells in each group. The data obtained with respect to different characters was analyzed following the model suggested by Khatun *et al.*, [4].

The study revealed the presence of sufficient variation among the germplasm material for majority of the traits studied (Table 1). The high phenotypic and genotypic coefficients of variation for characters stem lodging, root lodging, stem borer infestation, plant fresh weight, number of nodes bearing effective brace roots and grain yield indicated the presence of wide genotypic variability among the genotypes for these characters providing thus greater scope for their improvement, as has been earlier also reported by Tariq and Ahmad [5]. The germplasm lines PMG-3, PMG-8, PMG-11, PMG-23, PMG-25, PMG-34, PMG-42, PMG-44, PMG-46, PMG-78, PMG-80, PMG-82, PMG-87 and PMG-91 were some of the lines which showed superiority for more than one trait which can be exploited in future maize improvement programme.

Heritability (broad sense) estimates were moderate to high for majority of the traits however, with some exceptions. High heritability coupled with high genetic advance was observed for cob placement, 1000-grain weight and plant fresh weight suggesting thereby the additive gene effects to be mainly responsible for their inheritance. Correlation and path studies revealed the significance of number of grains per row followed by 1000-grain weight, number of grain rows, cob width, cob length and cob placement towards their direct contribution towards grain yield. A number of other characters also contributed indirectly towards grain yield via number of grains per row and 1000-grain weight, thereby further emphasizing the importance of these two characters in the selection programme aimed at high yielding maize types.

Regarding reaction of maize germplasm lines to banded leaf and sheath blight under natural (field) conditions, data recorded on a 0-9 scale revealed that

Table 1. Estimates of parameters of variability, heritability and genetic advance for different traits in maize germplasm

Traits	Range	Mean	GCV(%)	PCV(%)	h^2bs(%)	GA(%)
Grain yield (g)	156.0-1075.9	550.7	22.3	27.0	68.3	38.0
Plant height (cm)	218.9-391.7	320.1	11.4	12.0	91.1	22.5
Cob placement (cm)	85.7-233.2	156.9	19.1	20.3	88.9	37.1
Number of leaves	9.9-17.8	13.6	7.1	9.7	52.9	10.6
Cob length (cm)	8.7-21.6	15.9	14.0	15.6	80.7	25.9
Cob width (cm)	1.7-2.7	2.2	7.5	8.9	75.0	13.8
Number of grain rows	8.4-18.2	13.2	9.6	12.3	61.5	15.5
Number of grains/row	15.2-41.6	30.9	16.1	18.0	80.3	29.8
1000-grain weight (g)	143.3-405.9	293.0	18.4	20.3	82.4	34.4
Number of nodes	12.1-19.1	28.4	6.9	8.6	66.7	11.8
Inter nodal distance (cm)	12.0-22.7	18.0	6.8	9.3	53.8	10.3
Days to maturity	57.7-124.5	107.5	9.2	9.7	89.9	18.1
Days to tasselling	53.6-71.9	61.1	5.5	6.0	83.1	10.3
Days to brace root emergence	27.4-39.9	33.0	6.7	7.7	76.2	12.1
Number of nodes bearing effective brace roots	0.7-3.6	2.1	21.7	27.7	59.4	33.8
Thickness of stem (cm)	0.8-1.5	1.1	4.0	10.6	14.3	3.2
Thickness of rind (cm)	0.1-0.2	0.2	20.8	29.4	50.0	30.3
Plant fresh weight	2.1-9.9	4.1	24.5	27.1	81.9	46.7
Leaf area (cm^2)	3316.0-5344.0	4452.5	6.6	8.5	60.9	10.7
Number of roots	19.9-55.5	35.2	12.4	16.6	56.5	19.3
Root length (cm)	14.3-26.7	20.9	-	12.0	-	-
Root volume (ml)	25.2-99.5	57.4	12.5	26.6	22.1	12.1
Stem lodging (%)	-3.4-38.7	11.2	96.2	119.2	65.1	159.9
Root lodging (%)	-3.1-48.3	13.4	97.8	110.5	78.3	178.3
Stem borer (%)	-9.8-43.6	15.0	58.3	87.7	44.3	79.9
Specific gravity	0.9-1.0	0.9	-	3.3	-	-

- negligible values

Table 2. Reaction of different genotypes of maize to banded leaf and sheath blight and lodging

Score	Reaction	Genotypes
A. Banded leaf and sheath blight		
0	Immune	PMG-47,89,90,91,94,95,96,98,99,100,69
1-10%	Resistant	PMG-6,8,13,41,87,88,92,93,97
11-20%	Moderately resistant	PMG-1,3,4,5,7,9,10,11,14,16,13,21,26,22,35,42,43,49,27,29,38,39,50,54,57,61,63,67
B. Lodging		
0-1	No lodging (Resistant)	PMG-2,PMG-3,PMG-6,PMG-15,PMG-16,PMG-26,PMG-27,PMG-28,PMG-29,PMG-34,PMG-37,PMG-38,PMG-42,PMG-47,PMG-48,PMG-49,PMG-50,PMG-51,PMG-52,PMG-53,PMG-58,PMG-53,PMG-58,PMG-59,PMG-60,PMG-61,PMG-62,PMG-63,PMG-66,PMG-67,PMG-68,PMG-69,PMG-81,PMG-82,PMG-83,PMG-84,PMG-87,PMG-88,PMG-91,PMG-92,PMG-98,PMG-99,PMG-100
3	Low susceptibility	PMG-4,PMG-5,PMG-7,PMG-8,PMG-9,PMG-10,PMG-12,PMG-18,PMG-19,PMG-25,PMG-45,PMG-46,PMG-70,PMG-74,PMG-75,PMG-76,PMG-77,PMG-78,PMG-79,PMG-93,PMG-94,PMG-96,PMG-97

PMG-47, PMG-89, PMG-90, PMG-91, PMG-94, PMG-95, PMG-96, PMG-98, PMG-99, PMG-100 and PMG-69 were immune and PMG-6, PMG-8, PMG-13, PMG-41, PMG-87, PMG-88, PMG-92, PMG-93 and PMG-97 were resistant (Table 2). Since banded leaf and sheath blight is one of the important diseases of maize, the lines so identified as immune to resistant can be exploited as resistance donors in future maize breeding programmes. The scoring on lodging under natural conditions on a 0-7 scale revealed that PMG-2, PMG-3, PMG-6, PMG-15, PMG-16, PMG-26, PMG-83, PMG-84, PMG-87, PMG-88, PMG-91, PMG-92, PMG-98, PMG-99 and PMG-100 were resistant to lodging (Table 2). The resistant lines revealed well defined and developed sclerenchymatous tissues along with more number of smaller vascular bundles towards the periphery than the susceptible ones. The more number of smaller vascular bundles at the periphery and sclerenchymatous cells which are smaller in size and compact appear to be responsible for adding strength to the stem as reported by by the earlier workers [6, 7].

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