J. Farm Sci., 38(1): (11-15) 2025

RESEARCH PAPER

Identification of *Turcicum* leaf blight resistant and drought tolerant inbred lines in maize

*S. C. TALEKAR[1], S. I. HARLAPURI[2], G. U. PREMA[2] S. R. SALAKINKOP[4], M. VANIPRAVEENA[1], R. M. KACHAPUR[1], S. B. PATIL[1], S. B. KANDAKOOR[3], S. S. NOOLI[4], N. SHASHIDHAR[1], G. K. NAIDU[1] AND BHARATKUMAR CHITTI[1]

[1]Department of Genetics and Plant Breeding, [2]Department of Plant Pathology, [3]Department of Agricultural Entomology
[4]Department of Agronomy, College of Agriculture, Dharwad- 580 005
University of Agricultural Sciences, Dharwad - 580 005, India
*E mail: talekarsc@uasd.in

(Received: February, 2025 ; Accepted: March, 2025)

DOI: doi.org/10.61475/JFS.2025.v38i1.03

Abstract: Maize is one of the important food crops in the world after rice and wheat. *Turcicum* leaf blight (TLB) and moisture stress are the major biotic and abiotic stresses in southern India that can devastate maize production. Therefore, to develop maize hybrids resistant to *Turcicum* leaf blight and tolerance to drought stress, identifying parental lines possessing durable resistance to TLB besides showing tolerance to moisture stress is essential. To address this, we screened a set of 24 inbred lines for four years from 2019 to 2023 under artificial epiphytotic condition for *Turcicum* leaf blight resistance and a set 20 inbreds under moisture stress and non-stress conditions at four locations in *rabi* 2022-23. Two lines GI707 and GI751 manifested consistent resistance against *Turcicum* leaf blight in all four environments (years) compared with resistant check CI 4 and hence identified as resistant inbred lines. Similarly, we identified two lines GI 755 and GI 722 as drought tolerant as they performed exceptionally well in all four locations with higher mean grain yield under severe moisture stress condition with minimum yield reduction compared to that of drought tolerant check CML 580. These lines could potentially serve as parents in development of new maize hybrids suitable for rainfed ecosystem and also as donors for *Turcicum* leaf blight resistance.

Key words: Drought, Maize, Moisture stress, *Turcicum* leaf blight

Introduction

India is the fourth country in world in maize cultivable area, ranks 5th in production (FAO, 2024). However, the productivity of maize in India (3209 kg/ha) is far less than other countries, which can be attributed to various biotic and abiotic factors that affect its production (https://iimr.icar.gov.in). The changing climate affecting the frequency and intensity of moisture stress due to reduced rainfall in some regions and in others it is affecting the intensity of biotic stresses due to enhanced rainfall (Tesfaye *et al.,* 2015; Vanipraveena *et al.,* 2021). High precipitation, lower temperatures with high humidity pave the way for higher incidence of *Turcicum* leaf blight (TLB), which can cause significant yield loss up to 50% (Ferguson and Carson, 2004).

On the contrary, drought is one of the most important abiotic stresses and predominant production constraint in rainfed maize. Moisture stress starting from vegetative stage to reproductive stages influences maize yield and flowering is the most sensitive stage . The yield loss ranging 30-90% was noticed depending on the stage and duration of moisture stress (Ranganatha *et al.,* 2021). The severity of TLB incidence goes hand in hand based on the amount of rainfall. Therefore, due attention is required to breed for TLB resistance and drought tolerance in maize for realizing higher yields. The use of fungicides for managing TLB enhances cultivation cost to farmers and chemicals are also not eco-friendly (Rossi *et al*., 2015). Thus, growing TLB resistant hybrids is the better option (Welz and Geiger, 2000; Chen *et al*., 2016). However, identification of TLB resistant parental lines for development of hybrids is the pre-requisite. Similarly, identifying drought tolerant lines is also important for developing hybrids that can tolerate moisture stress conditions. Since the genotype performance varies due to the interaction of genotypes with seasons/years, it is important to screen the genotypes in multi-environments either in different locations or seasons/years for identifying stable genotypes (Carson *et al*. 2002). In this context, an attempt was made to identify TLB resistant lines and drought tolerant lines by screening diverse inbred lines under appropriate conditions for their utilization in hybrid maize breeding programme.

Material and methods

A set of newly developed inbred lines at AICRP on Maize, Dharwad were used for experiments. Twenty-four inbred lines including resistant and susceptible checks were screened under artificial epiphytotic condition for four years at Dharwad during *kharif* seasons from 2019 to 2023 except 2020 against TLB disease. The susceptible check CM 202 was grown as an infector genotype after every 10 rows of test lines and two rows around the experiment plot. Seedlings were inoculated with pathogen at 30 and 45 days after planting following standard procedures (Hooda *et al*., 2017), and disease intensity was scored using 1–9 scale (Hooda *et al*., 2017). For drought tolerance study, a set of 20 inbred lines that are common with TLB experiment were evaluated along with checks at four locations Dharwad, Bailhongal, Sankeshwar and Arabhavi in Karnataka during *rabi* 2022-23 under moisture-stress and non-stress conditions separately. Moisture-stress was induced simultaneously in all four locations when the crop attained 680 growing degree days by with-holding irrigation . The important thing to note here is that the irrigation was not resumed up to harvest of the crop indicating the severity of the drought condition that was created to identify only true drought tolerant inbreds. Both the experiments were conducted using randomized block design with two replications following standard cultivation practices.

The analysis of variance and variability parameters were worked out for both experiments using R 4.3.0 programme. Ward's technique was adopted to establish the relationship between genotypes and environments and represented using a hierarchical cluster for the drought related experiment. We have worked out the per cent reduction in the grain yield in moisture stress compared with that of non-stress condition instead of drought susceptibility index (DSI), because we induced severe moisture stress condition very well before the flowering, irrigation was not given up to the harvest of the crop. Therefore, the estimation of DSI will not be appropriate because the yield of inbred lines under such severe moisture stress condition is very low in comparison with normal conditions.

Results and discussion

High GCV (25.09) and PCV (33.36) were noticed with lower difference between the GCV and PCV suggesting lesser influence of the environment on the expression of genotypes (Fig 1). The heritability in broad sense (56.0%) was modeate with high genetic advance as per cent of mean (GAM) indicating that the disease resistance was reliable. Previously, several workers reported the presence of high GCV, PCV, heritability and GAM for TLB response (Bartaula *et al*., 2019; Neupane *et al*., 2020).

Among the 22 test genotypes, the pooled data of four years (environments) revealed that two inbred lines *viz.,* GI 707 (3.0) and GI 751 (3.0) displayed high stability for the disease reaction by recording resistant reaction (Table 1), which were on par with resistant inbred check, CI-4 (2.9). On the contrary, the inbred line GI 717 (3.1) that was almost resistant based on the mean, but showed moderate resistant reaction during 2022 and 2023. Based on the performance across four years, a total of 16 lines were moderately resistant, while 3 genotypes were moderately susceptible. The susceptible check genotype CM 202 recorded a mean score of 8.5 indicating high disease pressure in all the screening environments. Therefore, it was clear that the inbred lines GI 707 and GI 751 were identified as

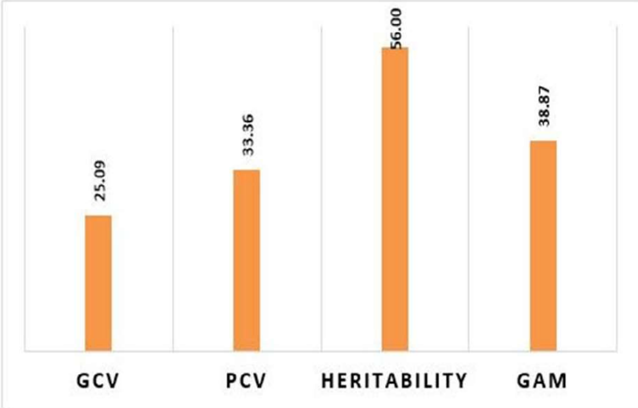


Fig 1. Genetic variability parameters for *Turcicum* leaf blight resistance in maize inbred lines

Table 1. Disease score and reaction of maize inbred lines against TLB disease across four years (environments)

Genotypes	2019		2021		2022		2023		Mean	
	Score	Reaction	Score	Reaction	Score	Reaction	Score	Reaction	Score	Reaction
GI 701	3.0	R	5.0	MR	3.5	MR	6.5	MS	4.5	MR
GI 702	3.5	MR	4.5	MR	2.5	R	4.5	MR	3.8	MR
GI 704	4.0	MR	5.0	MR	4.5	MR	3.0	R	4.1	MR
GI 707	2.5	R	3.0	R	3.0	R	3.5	MR	3.0	R
GI 711	4.0	MR	4.0	MR	3.5	MR	3.0	R	3.6	MR
GI 712	4.5	MR	4.0	MR	2.5	R	4.0	MR	3.8	MR
GI 713	7.0	MS	4.0	MR	3.5	MR	5.5	MS	5.0	MR
GI 717	2.0	R	2.5	R	3.5	MR	4.5	MR	3.1	MR
GI 719	4.0	MR	5.0	MR	4.0	MR	3.0	R	4.0	MR
GI 720	8.0	S	5.0	MR	7.0	MS	4.5	MR	6.1	MS
GI 721	4.0	MR	5.5	MS	6.5	MS	4.0	MR	5.0	MR
GI 722	6.0	MS	4.0	MR	6.0	MS	3.5	MR	4.9	MR
GI 724	5.0	MR	5.0	MR	4.0	MR	2.5	R	4.1	MR
GI 729	7.0	MS	5.5	MS	5.5	MS	3.5	MR	5.4	MS
GI 736	5.5	MS	6.0	MS	5.5	MS	3.5	MR	5.1	MS
GI 743	6.5	MS	6.0	MS	6.5	MS	5.0	MR	6.0	MS
GI 744	4.0	MR	4.0	MR	5.5	MS	3.5	MR	4.3	MR
GI 751	3.0	R	3.0	R	3.0	R	3.0	R	3.0	R
GI 752	4.0	MR	3.5	MR	5.5	MS	3.5	MR	4.1	MR
GI 755	5.0	MR	4.0	MR	3.0	R	4.5	MR	4.1	MR
GI 756	5.0	MR	4.5	MR	4.5	MR	3.5	MR	4.4	MR
GI 759	5.5	MS	4.0	MR	4.5	MR	4.0	MR	4.5	MR
I-4 (RC)	3.0	R	2.5	R	3.0	R	3.0	R	2.9	R
CM-202 (SC)	8.5	S	8.0	S	9.0	S	8.5	S	8.5	S

Note: RC-Resistant check for *Turcicum* leaf blight, SC-Susceptible check for TLB, TLB reaction: R-Resistant, MR-Moderately resistant, MS-Moderatley susceptible, S-Susceptible

Table 2. Grain yield of inbred lines under moisture stress and optimum moisture conditions in four different environments

Inbred lines	Moisture Stress					Optimum Moisture				
	DWD	BLH	SNK	ARB	Mean	DWD	BLH	SNK	ARB	Mean
GI 704	6.07	3.44	1.76	7.75	4.76	15.09	11.28	12.46	28.00	16.71
GI 722	9.67	3.84	1.67	9.56	6.19	22.55	23.53	26.67	34.76	26.88
GI 724	2.46	1.34	0.00	2.79	1.65	17.86	34.72	15.00	12.81	20.10
GI 755	8.03	5.09	4.02	10.72	6.97	30.54	21.34	16.53	35.07	25.87
GI 758	2.76	1.89	0.00	1.87	1.63	2.12	9.36	11.77	5.93	7.30
GI 2109	2.60	0.25	1.39	4.72	2.24	25.02	18.17	8.89	24.90	19.25
GI 2120	1.59	2.11	0.00	8.37	3.02	15.33	13.46	8.45	22.42	14.92
GI 2121	7.68	5.25	0.00	10.58	5.88	32.71	24.33	17.78	34.18	27.25
VL 108727	5.03	1.67	1.39	1.10	2.30	16.27	15.64	11.81	16.51	15.06
VL 143906	2.12	3.59	0.00	6.59	3.08	16.65	20.11	9.85	26.81	18.36
VL 162291	6.10	5.67	3.61	1.97	4.34	23.97	12.62	12.75	38.32	21.92
VL 175873	5.47	2.39	0.00	4.53	3.10	16.58	17.09	10.00	19.96	15.91
VL 18265	2.08	4.89	3.36	6.03	4.09	20.58	15.20	11.58	23.96	17.83
VL 183150	5.50	1.36	1.95	4.04	3.21	25.65	15.70	5.30	15.41	15.52
VL 184811	5.50	7.75	1.79	8.34	5.85	34.90	25.58	31.10	35.13	31.68
VL 18789	4.80	1.03	0.56	2.00	2.10	23.17	17.06	12.78	20.52	18.38
VL 20174	6.17	5.23	0.84	9.47	5.43	15.45	19.61	13.29	21.63	17.50
CML 582	0.45	0.40	1.03	1.03	0.73	17.62	17.06	6.67	15.42	14.19
CML 580 (DTC)	8.00	2.86	3.61	8.40	5.72	33.75	33.11	23.68	27.96	29.63
GI 756 (DSC)	0.24	0.44	0.00	3.20	0.97	5.26	9.48	16.67	12.63	11.01
S.Em±	0.69	0.37	0.35	0.92		1.86	1.32	1.22	2.37	
C.V. (%)	2.02	1.08	1.02	2.70		5.48	3.90	3.59	6.98	
C.D. (p=0.05)	24.91	20.59	22.02	27.09		15.73	12.30	15.04	17.36	
h^2_{bs} (%)	83.35	91.01	83.89	81.12		86.62	89.43	89.82	80.21	

Note: DWD-Dharwad; BLH-Bailhongal; SNK-Sankeshwar, ARB-Arabhavi; SEm±: Standard error of means; CV- coefficient of variation (%); CD- critical difference; h^2_{bs}–heritability in broad sense (%); DTC-drought tolerant check; DSC-drought susceptible check

stable true resistant genotypes, which could be used further as donor parents for development of TLB resistant hybrids. Numerous studies in Ethiopia, Kenya, United States and China identified many resistant genotypes (Muiru *et al*., 2007; Abebe *et al*., 2008) for *Turcicum* leaf blight in maize and other important diseases in other crops (Badu-Apraku *et al*., 2021; Galiano-Carneiro *et al*., 2021).

In drought experiments, the difference between GCV (43.39%) and PCV (66.23%) was more under moisture stress conditions (Fig 2) indicating higher influence of environment due to moisture stress as compared to PCV (38.51%) and GCV (27.14%) in optimal irrigation conditions. Such differences have been noticed previously by Nusrat *et al*., 2019 and Naidu *et al*., 2023. Under stress conditions, moderate heritability (42.0%) with high GAM (58.56%) was observed for the grain yield while moderate heritability (49.0%) with moderate GAM (39.41%) was observed under non-stress conditions suggesting greater environmental influence on the phenotype and selection for superior inbred lines under stress conditions might result in the improvement of grain yield. The results are in corroborative with the findings of Gazal *et al.* (2021) and Hugar (2022).

The pooled analysis of all the four locations (Table 2) indicated that the inbred lines *viz.,* GI 755 (6.97 q/ha), GI 722 (6.19 q/ha), GI 2121 (5.88 q/ha) performed very good for grain yield under moisture-stress condition compared with drought tolerant check CML 580 (5.72 q/ha). Furthermore, these inbred lines also manifested good performance in the optimum condition. The susceptible check GI 756 (-91.89%) recorded higher yield reductions indicating the severity of the moisture stress induced in the crop growth at all the four locations. Although, inbred line VL 184811 (31.68 q/ha) produced highest grain yield in non-stress, the yield reduction in the stress condition was -81.53% (Table 3). Nevertheless, the inbred lines GI 755 and GI 722 that ranked top two positions in the drought condition showed lower per cent yield reduction of -73.09% and 76.07% compared with the drought tolerant check CML 580 (-80.68%). On the contrary, lines GI 704 (-71.51%) and VL 20174 (-68.98%) registered lowest yield reduction, but yielding potentiality of these lines is almost 40-50% less in non-stress condition compared to high yielding inbred lines. Because drought is a random event, the lines should be able to produce

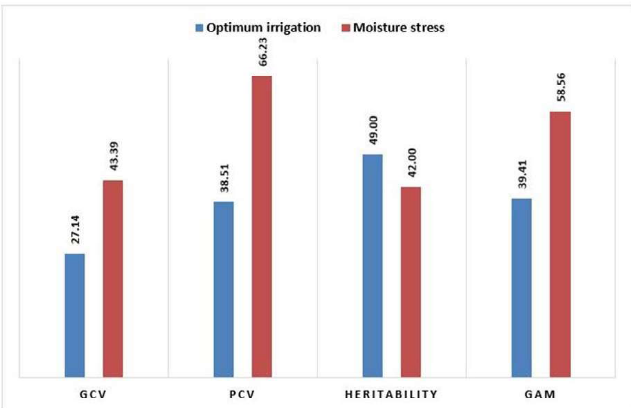


Fig 2. Genetic variability parameters for grain yield under optimum irrigation and stress conditions in maize

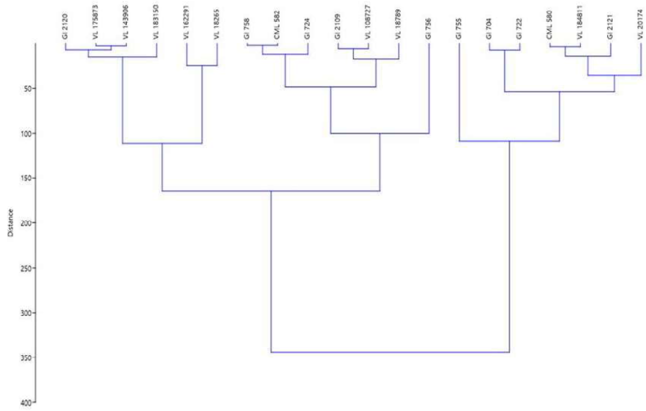
Table 3. Mean grain yield of maize inbred lines under moisture stress and optimum irrigation conditions over four environments

Inbred lines	Moisture stress condition		Optimum moisture condition		Per cent reduction in yield
	Grain yield (q/ha)	Rank	Grain yield (q/ha)	Rank	
GI 704	4.76	7	16.71	15	-71.51
GI 722	6.19	2	26.88	4	-76.97
GI 724	1.65	17	20.10	7	-91.79
GI 755	6.96	1	25.87	5	-73.09
GI 758	1.63	18	7.30	20	-77.67
GI 2109	2.24	15	19.25	8	-88.36
GI 2120	3.02	13	14.91	16	-79.78
GI 2121	5.88	3	27.25	3	-78.42
VL 108727	2.30	14	15.06	19	-84.72
VL 143906	3.07	12	18.35	10	-83.26
VL 162291	4.34	8	21.91	6	-80.21
VL 175873	3.10	11	15.91	13	-80.52
VL 18265	4.09	9	17.83	11	-77.06
VL 183150	3.21	10	15.51	14	-79.29
VL 184811	5.85	4	31.68	1	-81.53
VL 18789	2.10	16	18.38	9	-88.57
VL 20174	5.43	6	17.49	12	-68.98
CML 582	0.73	20	14.19	17	-94.85
CML 580(DTC)	5.72	5	29.62	2	-80.68
GI 756 (DSC)	0.97	19	11.01	18	-91.89

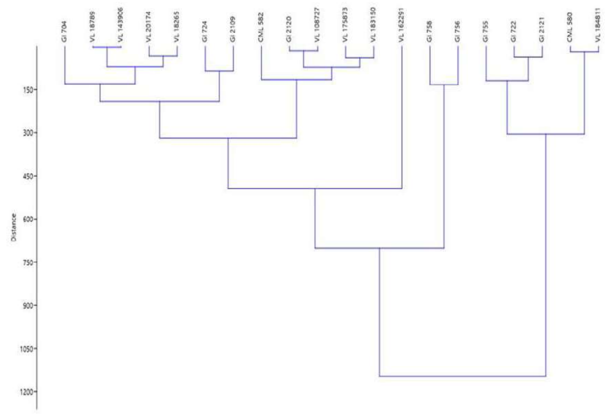
Note: DTC-drought tolerant check; DSC-drought susceptible check

higher yield if drought do not occur. In this context, the two lines GI 755 and GI 722 are regarded as stable drought tolerant lines because they have performed better in all the four locations with minimum reduction under moisture stress condition. Similar results were observed by Hugar (2022) and Naidu *et al* (2023) in maize under both the conditions.

Clustering analysis grouped 20 inbred lines into three clusters under moisture stress and four under clusters under non-stress conditions, respectively (Fig 3). In stress, lines GI 755 and GI 722 with higher grain yield were positioned into same cluster as that of tolerant check CML 580 (Fig 3a). Interestingly, all the tolerant and moderately tolerant lines (GI 755, GI 722, GI 704, CML 580, VL 184811, GI 2121 and VL 20174) were grouped into the same cluster III, while other genotypes were grouped into cluster I and II. Similarly in optimum irrigated condition, lines GI 755, GI 722, GI 2121 and VL 184811 categorized into same cluster as that of tolerant check CML 580 (Fig 3b). Several workers have studied the diversity pattern of maize inbreds under moisture stress and optimum irrigation conditions (Gazal *et al*., 2021; Hugar, 2022).



a) Moisture stress condition



b) Optimum moisture condition

Fig3(a&b). Dendrogram showing the grouping of maize inbred lines based on cluster analysis

Conclusion

From our study, it can be concluded that the identified stable *Turcicum* leaf blight (TLB) resistant inbred lines, GI 707 and GI 751 across four years could be utilized in developing TLB resistant maize hybrids and stable moisture stress tolerant inbreds, GI 722 and GI 755 could be used as potential parents/ donors for developing maize hybrids suitable for rainfed ecosystems.

Acknowledgment

The authors acknowledge International Center for Wheat and Maize Improvement, Hyderabad for sharing the germplasm for the study through IMIC-Asia programme.

References

Abebe D, Singburaudom N Sangchote S and Sarobol E, 2008, Evaluation of maize varieties for resistance to northern corn leaf blight under field conditions in Ethiopia. *Kasetasrt Journal*, 42: 1-10.

Badu Apraku B, Bankole F A, Fakorede M A, Ayinde O and Ortega Beltran A, 2021, Genetic analysis of grain yield and resistance of extra early maturing maize inbreds to northern corn leaf blight. *Crop Science*, 61(3): 1864-1880.

Bartaula S, Panthi U, Timilsena K, Acharya S S and Shrestha J, 2019, Variability, heritability and genetic advance of maize (*Zea mays* L.) genotypes. *Agriculture Livestock and Fisheries*, 6(2): 163-169.

Carson M L, Goodman M M and Williamson S M, 2002, Variation in aggressiveness among isolates of *Cercospora* from maize as a potential cause of genotype-environment interaction in gray leaf spot trials. *Plant Disease,* 86: 1089-1093.

Chen G, Wang X, Long S, Jaqueth J Li B and Yan J, 2016, Mapping of QTL conferring resistance to northern corn leaf blight using high-density SNPs in maize. *Molecular Breeding*, 36: 1-9. doi: 10.1007/s11032-015-0421-3.

Food and agricultural organization of the United Nations. (FAO) FAOSTAT. Available at http://www.fao.org/faostat/en (2023).

Ferguson L M and Carson M L, 2004, Spatial diversity of *Setosphaeria turcica* sampled from the Eastern United States. *Phytopathology*, 94, 892–900. doi: 10.1094/ PHYTO.2004.94.8.892.

Galiano-Carneiro A L, Kessel B, Presterl T and Miedaner T, 2021, Intercontinental trials reveal stable QTL for Northern corn leaf blight resistance in Europe and in Brazil. *Theoretical and Applied Genetics*, 134: 63-79.

Gazal A, Nehvi F A, Lone A A and Za Dar, 2021, Studies on drought tolerance in maize inbred lines using morphological and molecular approaches. *Maydica*, 65(3): 1-9.

Naidu G K, Hugar R, Kachapur R M, Jayant B, Talekar S C and Chimmad V P, 2023, Simulated drought stress unravels differential response and different mechanisms of drought tolerance in newly developed tropical field corn inbreds. *PLoS ONE*, 18(3): e0283528. https://doi. org/10.1371/ journal.pone.0283528.

Nusrat I U, Ali G, Dar Z A, Maqbool S, Khulbe R K and Bhat A, 2019, Effect of PEG induced drought stress on maize (*Zea mays* L.) inbreds. *Plant Archives*,19:1677–1681.

Hooda K S, Khokhar M K, Shekhar M, Karjagi, C G, Kumar B and Mallikarjuna N, 2017, *Turcicum* leaf blight - sustainable management of a re-emerging maize disease. *Journal of Plant Disease and Protection*, 124: 101-113. doi: 10.1007/ s41348-016-0054-8.

Hugar R, 2022, Studies on genetic variability of root traits for drought tolerance in maize (*Zea mays* L.). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka.

Indian Institute of Maize Research, Ludhiana, available at https:// iimr.icar.gov.in (2024)

Muiru W M , Koopmann B, Tiedemann A V, Mutitu E W and Kimenju J W, 2010, Race typing and evaluation of aggressiveness of *Exserohilum turcicum* isolates of Kenyan, German and Austrian origin. *World Journal of Agricultural Sciences*, 6: 277-284.

Neupane B, Poudel A and Wagle P, 2020, Varietal evaluation of promising maize genotypes in mid hills of Nepal. *Journal of Agriculture and Natural Resources* , 3(2): 127–139.

Ranganatha H M , Lohithaswa H Cand Pandravada A, 2021, Mapping and validation of major quantitative trait loci for resistance to northern corn leaf blight along with the determination of the relationship between resistances to multiple foliar pathogens of maize (*Zea mays* L.). *Frontiers in Genetics*, 11, 548407.doi: 10.3389/fgene.2020.548407.

Rossi R L, Reis E M and Brustolin R, 2015, Fungicide baseline for mycelial sensitivity of *Exserohilum turcicum*, causal agent of northern corn leaf blight. *Summa Phytopathologica,* 41: 25–30. doi: 10.1590/0100-5405/1931.

Tesfaye K, Gbegbelegbe S, Cairns J E, Shiferaw B, Prasanna B M, Sonder K, Boote K, Makumbi D and Robertson R, 2015, Maize systems under climate change in sub-Saharan Africa: Potential impacts on production and food security. *International Journal of Climate Change Strategies and Manag*ement, 7(3): 247-271.

Vanipraveena M, Talekar S C, Kachapur R M and Harlapur S I, 2021, Elite general and specific combiners for high sugar content and green ear yield in sweet corn (*Zea mays* L. *saccharata*). *Journal of Farm Sciences*, 34(1): 10-14.

Welz H G and Geiger H H, 2000, Genes for resistance to northern corn leaf blight in diverse maize populations. *Plant Breeding*,119, 1–14. doi: 10.1046/j.1439- 0523.2000.00462.x.