Annals of Plant and Soil Research 20(1): 52–57 (2018)

Screening for resistance against turcicum leaf blight under natural and artificial epiphytotic conditions in maize (*Zea mays* L.)

SMARIKA THAKUR[1], S.K. GULERIA[2] AND RAKESH DEVLASH[3]

CSK Himachal Pradesh Krishi Vishvidyalaya, Hill Agriculture Research Centre (HAREC) Bajaura, Himachal Pradesh

Received: November, 2017; Revised accepted: January, 2018

ABSTRACT

Maize is widely known for its highest genetic potential among cereal crops and like any other economically significant and extensively cultivated crop, maize also suffers from various diseases resulting in considerable losses in yield. Among them Turcicum leaf blight (TLB) caused by Exserohilum turcicum is gaining considerable economic importance. Maize grain yield loss varies from 25 to 90 per cent in different parts of India depending upon the severity of TLB epiphytotics. This makes identification of disease resistant germplasm, the primary and essential management practice for this crop. The present study involving 27 inbred lines and 2 testers in a line × tester design was conducted at HAREC, Bajaura, Himachal Pradesh. The parents and crosses were screened against TLB under natural and artificial epiphytotic conditions. These were phenotyped for TLB incidence at dough stage using standard 1-5 disease rating scale. The study resulted in identification of 5 lines viz. L_3, L_6, L_{21}, L_{22}, L_{26} and 31 cross combinations viz. $L_1\times T_1$, $L_1\times T_2$, $L_3\times T_1$, $L_3\times T_2$, $L_4\times T_1$, $L_4\times T_2$, $L_6\times T_2$, $L_7\times T_1$, $L_7\times T_2$, , $L_9\times T_1$, $L_9\times T_2$, $L_{11}\times T_1$, $L_{11}\times T_2$, $L_{12}\times T_1$, , $L_{14}\times T_2$, $L_{15}\times T_1$, $L_{15}\times T_2$, $L_{16}\times T_2$, $L_{17}\times T_1$, $L_{17}\times T_2$, $L_{18}\times T_1$, $L_{18}\times T_2$, $L_{19}\times T_1$, $L_{19}\times T_2$, , $L_{20}\times T_2$, $L_{22}\times T_1$, $L_{22}\times T_2$, $L_{23}\times T_2$, $L_{26}\times T_2$, $L_{27}\times T_1$, $L_{27}\times T_2$ which exhibited resistant reaction under both natural and artificial ephiphytotic conditions. Tester T_1 was observed to be resistant and moderately resistant under natural and artificial epiphytotic conditions, respectively whereas T_2 was found susceptible under both the conditions. The new sources of TLB resistance and their combinations identified in the present study will be helpful for their deployment in the breeding programmes.

Keywords: Maize, TLB, natural, artificial, epiphytotic conditions

INTRODUCTION

Maize (*Zea mays* L.) is cultivated in all agricultural areas around the world and is an economically significant crop for the human population. It is grown from 58^0L north to 40^0L south and extends from the sea level up to an altitude of above 3,800m; covering regions with rainfall varying from 250 to 10,000 mm (Hallauer and Miranda 1988). Maize is widely known for its highest genetic potential among cereal crops and like any other economically significant and extensively cultivated crop, maize also suffers from various diseases resulting in considerable losses in yield. Among them Turcicum leaf blight (TLB) caused by *Exserohilum turcicum* is gaining considerable economic importance. TLB also known as northern corn leaf blight is a major constraint to maize production in many maize growing regions around the globe. A growing season characterized by high humidity and moderate temperatures (17 ˚C to 27 ˚C) is favourable for the development of this disease. TLB is characterized by long elliptical, greyish green or tan leaf lesions that first appear on the lower leaves and increase in size and number until very little living tissue is left. The pathogen causes the loss of chlorophyll from the leaves, in turn leading to reduction in photosynthesis, accumulation of carbohydrates in grains and ultimately loss of grain yield (Paliwal et al, 2000). Maize grain yield loss varies from 25 to 90 per cent in different parts of India depending upon the severity of TLB epiphytotics (Chenulu and Hora, 1962). Therefore, identification of disease resistant germplasm is the primary and essential management practice not only for maize but for any crop.

MATERIAL AND METHODS

The material for the present study comprised of 27 (early maturing) inbred lines of maize and 2 diverse testers V341 and V346 in a line × tester design resulting in 54 crosses. Three checks *viz.,* Bajaura makka, PMH 2 and Vivek 21 were used. The detail of maize inbred lines, testers and checks studied is presented in the Table 1. The present study was carried out at the experimental farm of HAREC Bajaura (Kullu) situated at 31°08´ N latitude and 77° E longitude and at 1090 m above mean sea level,

**Corresponding author E-mail: smarikasthakur92@gmail.com*

representing mid-hill, sub-humid zone (Zone 21) of Himachal Pradesh endowed with mild summers and cool winters with low monsoon rains (1036.9 mm) having sandy loam soil. The parents and crosses were screened against TLB under artificial and natural epiphytotic conditions. These were phenotyped for TLB incidence at dough stage using standard 1-5 disease rating scale.

Table 1: Description of the lines, testers and checks used in the study

S.No.	Material	Pedigree	S.No.	Material	Pedigree	S.No.	Material	Pedigree
A) Lines								
L_1	9043	DMR WNC NY 1708	L_{10}	CM400	Tenn 29	L_{19}	BAJIM13-1	Sel HPAU-2013
L_2	1156-4	DMR QPM 60	L_{11}	CML439	SA-C2HC(26 × 21)-4-3-7-5-B-B-B-B-B	L_{20}	V334	TZI 19
L_3	BAJIM 02-1	Sel. from HYD/95R-3083	L_{12}	CML40	Pob 36 C5HC144-2-2-B-#-#	L_{21}	V335	TZ1-25
L_4	9363-3	WNC DMR 19R YDWS2002	L_{13}	BAJIM13-2	Sel. From DKI9276	L_{22}	V336	CM145, P63.CoH-C-181
L_5	9366-1	WNC DMR 19R YDWS2017	L_{14}	BAJIM13-3	Sel from DKI9501	L_{23}	V340	CM128 × CM129
L_6	CML121	P1218191/P1209135//P1226685/P1317328	L_{15}	BAJIM13-4	Sel from DKI9554	L_{24}	V348	Pop -31
L_7	CML423	G18C19MH100#-4-1-1-BBBBBBB	L_{16}	BAJIM08-104	HAREC pool k-90-1-6-1	L_{25}	V351	Shakti (S0) HE 25
L_8	BAJIM 08-8	HAREC 95 pool-90-1	L_{17}	BAJIM13-5	Sel. From LYPSARA	L_{26}	V372	Pro 337-OP+⊗-6-4-1-3-⊗-B+#+#+#-⊗-#
L_9	CM112	Desc 2-229-1-1-f-f-	L_{18}	BAJIM13-6	Sel. from PANT 12K1793	L_{27}	V373	JKMH-1754-OP-⊗-16-7-12-1-⊗+B- #
B) Testers								
T_1	V341	BIO-45010 OP	T_2	V346	Mexico Acc No. 3136 @3-2-3-8-1			
C) Checks								
1.	Bajaura makka	PS 62/ FH 3209/ FH 3198/ FH 3202/ Early Composite/ 10 half sibs progenies of Hill early yellow pool and Kullu local	2.	PMH 2	LM15 × LM16	3.	Vivek 21	CM 212 × V 341

Screening of the disease

(a) Screening of the material for the disease under natural epiphytotic condition was done in the main experimental trial. Fifty four crosses along with parents (27 lines and 2 testers) and three checks *viz.,* Bajaura makka, PMH 2 and Vivek 21 were evaluated in randomized complete block design (RCBD) with two replications in a plot size of 3.0 × 1.2m (3.6 m^2) at a spacing of 60 × 20 cm during *kharif,* 2015.

(b) For the screening of material against TLB under the artificial conditions, a separate single row trial in RCBD with two replications in a plot size of 2.0 × 0.60 m (1.2 m^2) at a spacing of 60 × 20 cm was conducted during *kharif*, 2015. The inoculation was done by dropping a pinch of

inoculum by hand inside the whorl of the leaves when the crop was around 35 to 45 days old. A spray of water followed this from a knapsack sprayer directed in the whorl. The inoculation was done in the late afternoon and was done three times at a weekly interval. The inoculum was prepared using heavily infected leaves collected in the previous year. This was done before the leaves became fully mature. Infected leaves were stored in large gunny bags in dry conditions. To prepare the inoculum, the dry leaves were ground into a meal about the coarseness of wheat bran.

RESULTS AND DISCUSSION

The material was phenotyped for TLB incidence at dough stage using standard 1-5 disease rating scale. Based on this rating scale, the maize lines were classified into four groups namely, resistant (R) genotypes with a score ≤ 2.0; moderately resistant (MR) 2.1-3.0; susceptible (S) 3.1- 4.0 and highly susceptible (HS) 4.1-5.0. The mean values of disease scores of parents, crosses and checks for TLB were obtained (Table 2).

Table 2: Mean values of disease scores of parents, crosses and checks for TLB

Entry	TLB		Entry	TLB		Entry	TLB	
Crosses	Natural	Artificial	Crosses	Natural	Artificial	Crosses	Natural	Artificial
L_1XT_1	1.00	1.50	$L_{10}XT_1$	1.50	2.25	$L_{19}XT_1$	1.25	1.75
L_1XT_2	1.00	1.50	$L_{10}XT_2$	1.75	2.25	$L_{19}XT_2$	1.00	1.50
L_2XT_1	2.00	2.50	$L_{11}XT_1$	1.00	1.50	$L_{20}XT_1$	1.75	2.75
L_2XT_2	1.75	2.75	$L_{11}XT_2$	1.00	2.00	$L_{20}XT_2$	1.00	1.50
L_3XT_1	1.00	1.50	$L_{12}XT_1$	1.00	1.50	$L_{21}XT_1$	2.25	2.75
L_3XT_2	1.00	2.00	$L_{12}XT_2$	1.50	2.25	$L_{21}XT_2$	2.25	2.75
L_4XT_1	1.00	1.50	$L_{13}XT_1$	2.00	2.75	$L_{22}XT_1$	1.00	1.50
L_4XT_2	1.25	1.75	$L_{13}XT_2$	2.75	3.25	$L_{22}XT_2$	1.25	1.75
L_5XT_1	1.25	2.25	$L_{14}XT_1$	1.50	2.25	$L_{23}XT_1$	1.75	2.50
L_5XT_2	2.50	3.00	$L_{14}XT_2$	1.00	1.50	$L_{23}XT_2$	1.25	1.75
L_6XT_1	1.25	2.25	$L_{15}XT_1$	1.25	1.75	$L_{24}XT_1$	1.50	2.25
L_6XT_2	1.00	1.50	$L_{15}XT_2$	1.25	2.00	$L_{24}XT_2$	1.00	2.25
L_7XT_1	1.00	1.50	$L_{16}XT_1$	2.25	2.75	$L_{25}XT_1$	2.00	2.75
L_7XT_2	1.00	1.50	$L_{16}XT_2$	1.25	2.00	$L_{25}XT_2$	1.25	2.25
L_8XT_1	2.25	2.75	$L_{17}XT_1$	1.00	1.50	$L_{26}XT_1$	1.25	2.25
L_8XT_2	1.75	2.25	$L_{17}XT_2$	1.00	1.50	$L_{26}XT_2$	1.00	1.50
L_9XT_1	1.25	1.75	$L_{18}XT_1$	1.25	1.75	$L_{27}XT_1$	1.00	1.50
L_9XT_2	1.00	1.50	$L_{18}XT_2$	1.00	1.50	$L_{27}XT_2$	1.25	1.50
Lines								
L_1	2.25	2.75	L_{10}	3.00	3.75	L_{19}	1.75	2.50
L_2	3.25	3.75	L_{11}	2.50	3.00	L_{20}	1.50	2.25
L_3	1.25	1.75	L_{12}	2.25	3.25	L_{21}	1.50	1.75
L_4	2.50	3.00	L_{13}	3.00	4.25	L_{22}	1.25	1.75
L_5	1.75	4.50	L_{14}	2.00	2.50	L_{23}	2.00	3.50
L_6	1.25	1.75	L_{15}	2.50	3.25	L_{24}	2.25	3.25
L_7	1.75	3.25	L_{16}	3.00	3.50	L_{25}	2.75	4.00
L_8	3.25	4.25	L_{17}	2.75	3.25	L_{26}	1.25	2.00
L_9	2.00	2.75	L_{18}	2.50	3.00	L_{27}	1.75	2.25
Tester								
T_1	2.00	2.75	T_2	3.25	3.75			
Check								
Bajaura makka	2.00	2.75	PMH 2	2.25	3.00	Vivek 21	1.75	3.25

Under natural conditions 13 lines *viz.* L_3, L_5, L_6, L_7, L_9, L_{14}, L_{19}, L_{20}, L_{21}, L_{22}, L_{23}, L_{26} and L_{27} were observed to be resistant whereas from amongst these lines only 5 lines *viz.* L_3, L_6, L_{21}, L_{22} and L_{26} were recorded to be resistant under artificial epiphytotic condition; 12 lines *viz.* L_1, L_4, L_{10}, L_{11}, L_{12}, L_{13}, L_{15}, L_{16}, L_{17}, L_{18}, L_{24} and L_{25} exhibited moderately resistant reaction under natural conditions whereas from amongst these 12 lines only 4 lines *viz.* L_1, L_4, L_{11}, L_{18} and 5

lines viz. L_9, L_{14}, L_{19}, L_{20} and L_{27} which recorded resistant reaction under natural conditions exhibited moderately resistant reaction under artificial condition. Only 2 lines *viz*. L_2 and L_8 were found to be susceptible under natural conditions while 10 lines *viz.* L_2, L_7, L_{10}, L_{12}, L_{15}, L_{16}, L_{17}, L_{23}, L_{24} and L_{25} were observed to be susceptible under artificial condition and 3 lines *viz.* L_5, L_8 and L_{13} were observed to be highly susceptible whereas no line was recorded to be highly susceptible under natural condition. Tester T_1 was recorded resistant under natural condition but was recorded to be moderately resistant under artificial condition and T_2 was found to be susceptible under both natural and artificial conditions. Among crosses 46 crosses exhibited resistant reaction under natural condition out of these only 31 crosses *viz.* $L_1\times T_1$, $L_1\times T_2$, $L_3\times T_1$, $L_3\times T_2$, $L_4\times T_1$, $L_4\times T_2$, $L_6\times T_2$, $L_7\times T_1$, $L_7\times T_2$, , $L_9\times T_1$, $L_9\times T_2$, $L_{11}\times T_1$, $L_{11}\times T_2$, $L_{12}\times T_1$, , $L_{14}\times T_2$, $L_{15}\times T_1$, $L_{15}\times T_2$, $L_{16}\times T_2$ $L_{17}\times T_1$, $L_{17}\times T_2$, $L_{18}\times T_1$, $L_{18}\times T_2$, $L_{19}\times T_1$, $L_{19}\times T_2$, , $L_{20}\times T_2$, $L_{22}\times T_1$, $L_{22}\times T_2$, $L_{23}\times T_2$, $L_{26}\times T_2$, $L_{27}\times T_1$ and $L_{27}\times T_2$ recorded resistant reactions under artificial condition.Moderately resistant reaction under natural condition was recorded for 6 crosses *viz.* $L_5\times T_2$, $L_8\times T_1$, $L_{13}\times T_2$, $L_{16}\times T_1$, $L_{21}\times T_1$ and $L_{21}\times T_2$ and no cross was observed to be susceptible/ highly susceptible under natural condition whereas the cross $L_{13}\times T_2$ was recorded to be susceptible under artificial condition, 22 crosses *viz.* $L_2\times T_1$, $L_2\times T_2$, $L_5\times T_1$, $L_5\times T_2$, $L_6\times T_1$, $L_8\times T_1$, $L_8\times T_2$, $L_{10}\times T_1$, $L_{10}\times T_2$, $L_{12}\times T_2$, $L_{13}\times T_1$, $L_{14}\times T_1$, $L_{16}\times T_1$, $L_{20}\times T_1$, $L_{21}\times T_1$, $L_{21}\times T_2$, $L_{23}\times T_1$ $L_{24}\times T_1$, $L_{24}\times T_2$, $L_{25}\times T_1$, $L_{25}\times T_2$ and $L_{26}\times T_1$ recorded moderately resistant reaction and no cross was observed to be highly susceptible under artificial epiphytotic condition. Checks Bajaura makka and Vivek 21 were observed to be resistant whereas PMH 2 was found to be moderately resistant under natural condition while under artificial condition checks Bajaura makka and PMH 2 were observed to be moderately resistant whereas Vivek 21 was found to be susceptible under artificial epiphytotic conditions (Table 3, Table 4). The difference in the recorded observations on the disease reactions under natural and artificial epiphytotic conditions can be attributed to non-uniformity of disease occurrence in the field and lesser inoculum load under natural conditions.

Table 3: Disease reaction to Turcicum leaf blight under natural epiphytotic conditions

Disease Reaction Type	Crosses	Line/s	Tester/s	Check/s
Resistant	$L_1\times T_1$, $L_1\times T_2$, $L_2\times T_1$, $L_2\times T_2$, $L_3\times T_1$, $L_3\times T_2$, $L_4\times T_1$, $L_4\times T_2$, $L_5\times T_1$, $L_6\times T_1$, $L_6\times T_2$, $L_7\times T_1$, $L_7\times T_2$, $L_8\times T_2$, $L_9\times T_1$, $L_9\times T_2$, $L_{10}\times T_1$, $L_{10}\times T_2$, $L_{11}\times T_1$, $L_{11}\times T_2$, $L_{12}\times T_1$, $L_{12}\times T_2$, $L_{13}\times T_1$, $L_{14}\times T_1$, $L_{14}\times T_2$, $L_{15}\times T_1$, $L_{15}\times T_2$, $L_{16}\times T_2$, $L_{17}\times T_1$, $L_{17}\times T_2$, $L_{18}\times T_1$, $L_{18}\times T_2$, $L_{19}\times T_1$, $L_{19}\times T_2$, $L_{20}\times T_1$, $L_{20}\times T_2$, $L_{22}\times T_1$, $L_{22}\times T_2$, $L_{23}\times T_1$,$L_{23}\times T_2$, $L_{24}\times T_1$, $L_{24}\times T_2$, $L_{25}\times T_1$, $L_{25}\times T_2$, $L_{26}\times T_1$, $L_{26}\times T_2$, $L_{27}\times T_1$, $L_{27}\times T_2$ (48)	L_3, L_5, L_6, L_7, L_9, L_{14}, L_{19}, L_{20}, L_{21}, L_{22}, L_{23}, L_{26}, L_{27} (13)	T_1	Bajaura makka, Vivek 21 (2)
Moderately Resistant	$L_5\times T_2$, $L_8\times T_1$, $L_{13}\times T_2$, $L_{16}\times T_1$, $L_{21}\times T_1$, $L_{21}\times T_2$ (6)	L_1, L_4, L_{10}, L_{11}, L_{12}, L_{13}, L_{15}, L_{16}, L_{17}, L_{18}, L_{24}, L_{25} (12)	-	PMH 2 (1)
Susceptible	-	L_2, L_8 (2)	T_2	-
Highly Susceptible	-	-	-	-

Studies for the identification of genotypes resistant against TLB have been carried out by several workers. Rijal *et al.* (2016) evalulated 30 maize genotypes in 2014-2015 at Dumarwana, Nijgadh, Keureni and Rampur and 10 genotypes in 2015-2016 at Anandpur, Shitalnagar, Dumarwana, Nijgadh and Rampur for resistance to Turcicum leaf blight (Exserohilum turcicum) under farmers field conditions and identified 20 genotypes that exhibited resistant reaction in

both the years as promising sources of resistance against E. turcicum. Chandrashekara *et al.* (2014) screened 35 short-duration maize inbred lines against TLB under artificial inoculation and identified 12 inbred lines resistant against TLB. Singh *et al.* (2014) carried out a study, involving 118 maize genotypes to identify, the new sources of resistance to TLB under artificial epiphytotic condition which led to the identification of 26 resistant, 56 moderately resistant, 26 susceptible and 10 highly susceptible maize genotypes. Meena *et al.* (2009) also conducted an experiment for evaluation of 60 indigenous and exotic inbred lines under artificial epiphytotic conditions for evaluation of Turcicum Leaf Blight (TLB) and identified 20 inbred lines as sources of resistance to TLB.

Table 4: Disease reaction to Turcicum leaf blight under artificial epiphytotic conditions

Disease Reaction Type	Crosses	Line/s	Tester/s	Check/s
Resistant	$L_1 \times T_1$, $L_1 \times T_2$, $L_3 \times T_1$, $L_3 \times T_2$, $L_4 \times T_1$, $L_4 \times T_2$, $L_6 \times T_2$, $L_7 \times T_1$, $L_7 \times T_2$, , $L_9 \times T_1$, $L_9 \times T_2$, $L_{11} \times T_1$, $L_{11} \times T_2$, $L_{12} \times T_1$, , $L_{14} \times T_2$, $L_{15} \times T_1$, $L_{15} \times T_2$, $L_{16} \times T_2$ $L_{17} \times T_1$, $L_{17} \times T_2$, $L_{18} \times T_1$, $L_{18} \times T_2$, $L_{19} \times T_1$, $L_{19} \times T_2$, , $L_{20} \times T_2$, $L_{22} \times T_1$, $L_{22} \times T_2$, $L_{23} \times T_2$, $L_{26} \times T_2$, $L_{27} \times T_1$, $L_{27} \times T_2$ (31)	L_3, L_6, L_{21}, L_{22}, L_{26} (5)	-	-
Moderately Resistant	$L_2 \times T_1$, $L_2 \times T_2$, $L_5 \times T_1$, $L_5 \times T_2$, $L_6 \times T_1$, $L_8 \times T_1$, $L_8 \times T_2$, $L_{10} \times T_1$, $L_{10} \times T_2$, $L_{12} \times T_2$, $L_{13} \times T_1$, $L_{14} \times T_1$, $L_{16} \times T_1$, $L_{20} \times T_1$, $L_{21} \times T_1$, $L_{21} \times T_2$, $L_{23} \times T_1$ $L_{24} \times T_1$, $L_{24} \times T_2$, $L_{25} \times T_1$, $L_{25} \times T_2$, $L_{26} \times T_1$ (22)	L_1, L_4, L_9, L_{11}, L_{14}, L_{18}, L_{19}, L_{20}, L_{27} (9)	T_1	Bajaura makka, PMH 2 (2)
Susceptible	$L_{13} \times T_2$ (1)	L_2, L_7, L_{10}, L_{12}, L_{15}, L_{16}, L_{17}, L_{23}, L_{24}, L_{25}, (10)	T_2	Vivek 21 (1)
Highly Susceptible	-	L_5, L_8, L_{13} (3)	-	-

The present study resulted in the identification of 5 lines *viz.* L_3, L_6, L_{21}, L_{22}, L_{26} and 31 cross combinations *viz.* $L_1 \times T_1$, $L_1 \times T_2$, $L_3 \times T_1$, $L_3 \times T_2$, $L_4 \times T_1$, $L_4 \times T_2$, $L_6 \times T_2$, $L_7 \times T_1$, $L_7 \times T_2$, , $L_9 \times T_1$, $L_9 \times T_2$, $L_{11} \times T_1$, $L_{11} \times T_2$, $L_{12} \times T_1$, $L_{14} \times T_2$, $L_{15} \times T_1$, $L_{15} \times T_2$, $L_{16} \times T_2$ $L_{17} \times T_1$, $L_{17} \times T_2$, $L_{18} \times T_1$, $L_{18} \times T_2$, $L_{19} \times T_1$, $L_{19} \times T_2$, $L_{20} \times T_2$, $L_{22} \times T_1$, $L_{22} \times T_2$, $L_{23} \times T_2$, $L_{26} \times T_2$, $L_{27} \times T_1$ and $L_{27} \times T_2$ which exhibited resistant reaction under both natural and artificial epiphytotic conditions. The maize germplasm with resistance to E. turcicum has also previously been reported (Muriithi and Mutinda, 2001; Pandurangegowda *et al.*, 2002; Dharanendraswamy, 2003; Harlapur, 2005). Tester T_1 was observed to be resistant and moderately resistant under natural and artificial epiphytotic conditions respectively whereas T_2 was found susceptible under both the conditions. The lines so identified to be resistant to TLB are a valuable source of resistance and can be utilized in resistance breeding programmes. The cross combinations can be further evaluated for yield and other characters and can be released as promising hybrid varieties resistant to TLB.

REFERENCES

Chandrasekhara, C., Jha, S.K., Arunkumar, R. and Agrawal, P.K. (2014) Identification of new sources of resistance to turcicum leaf blight and maydis leaf blight in maize (*Zea mays* L.). *SABRAO Journal of Breeding and Genetics* **46** (1): 44-55.

Chenulu, V. V. and Hora, T. S. (1962) Studies on losses due to Helminthosporium blight of maize, *Indian Phytopathology* **15**: 235-237.

Dharanendraswamy, S. (2003) Studies on turcicum leaf blight of maize caused by

Exserohilum turcicum. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad.

Hallauer, A.R. and Miranda, J.B. (1988)Quantitative genetics in maize breeding. 2nd ed. Iowa State University, Press, Ames. pp 64-71.

Harlapur, S. I. (2005) Epidemiology and management of turcicum Leaf blight of maize caused by Exserohilum turcicium (pass.) Leonard and suggs. Ph.D. (Plant Pathology). Thesis, University of Agricultural Sciences, Dharwad.

Meena, S., Kumar, S., Pardurange, G. K. T., Pant, S.K., Kumar, B., Kaur, B., Hettiara Chchi, K., Singh, O. N. and Parsanna, B. H.(2009) Sources of resistance to Exserohilum turcicum (Pass.) and Puccinia polysora (Underw.) incitant of Turcicum leaf blight and polysora rust of maize. *Phytopathology and Plant Protection* **73**: 528-536.

Muriithi LM., & Mutinda, C.J.M. (2001) Genetic variability of maize genotypes for resistance to Exerohilum turcicum in Kenya. In: 7th Eastern and South Africa Regional Maize Conference February, pp. 11 -15.

Paliwal, R.L., Granodos, G., Latiffe, R.H. and Violic, A.D. (2000) Tropical maize Improvement and Production, (FAO: Rome).

Pandurangegowda, K.T., Naik, P., Shetty, T.A.S., Hattappa, S., Naik, N.P., & Juna, M. (2002) High yielding maize composite NAC 6004 resistant to turcicum leaf blight and downy mildew. *Environmental Ecology* **20**: 920-923.

Rijal, T.R, Govind, K.C., Koirala, K.B. and Shrestha, J. (2016) Evaluation of maize genotypes for Turcicum leaf blight (*Exserohilum turcicum*) in Terai and inner terai of Nepal. *Journal of Maize Research and Development* **2**(1): 109-116.

Singh, R., Srivastava, R.P., Mani, V.P., Khandelwal, R.S. and Ram, L. (2014). Screening of maize genotypes against northern corn leaf blight. *The Bioscan* **9**(4): 1689-1693.