Response of maize genotypes to gray leaf spot disease (*Cercospora zeae-maydis*) in the hills of Nepal

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Abstract

Gray leaf spot (GLS) is an important and destructive disease of maize in the hills of Nepal. The occurrence of this disease is recorded for the first time in the country in 2006. Several genotypes of maize supposed to be resistant to gray leaf spot in SARMP Zimbabwe and CIAT Colombia were evaluated together with other varieties in observation nursery conducted at farmer's fields as well as at Khumaltar (NARC research station in the Kathmandu Valley) during 2008 and 2009. Ten out of 28 genotypes of maize were identified as resistant to moderately resistant to GLS. The disease incidence was higher on the open pollinated varieties of maize. The severity of GLS on genotypes of maize observed as 3.0 and 2.2, respectively at Baluwapati and Dhungkharka in Kavrepalanchwok and 2.0 at Khumaltar in Lalitpur during 2008. The severity of GLS was observed as high as 2.4 at Pakhribas in Dhankuta and 1.7 at Khumaltar in 2009.

Key words: Maize, Nepal. Gray leaf spot, *Cercospora zeae-maydis*, resistant

Introduction

Gray leaf spot (GLS) disease caused by *Cercospora zeae maydis* Tehon & Daniels is a serious threat to farmers and has caused serious losses in grain yield of maize in 2006. The disease was first identified from the state of Illinois, USA in 1925 (Tehon & Daniels, 1925). Its occurrence was recorded in the Kavrepalanchowk district of Nepal (Manandhar, G. 2007). Grain yield losses of maize of up to 19 percent and 18 percent, respectively, on the local variety and on the improved OPV (Ganesh -1) were observed in field experiments (Manandhar and Baidya, 2010). The severity of GLS was high in the high hill region affecting adversely farmers who live with limited resources. The disease has been observed spreading over the years in 17 districts in the eastern, central and mid western regions of the country (Manandhar *et al*., 2009). GLS is evident on plants as small spots first on lower leaves of plants at tassel initiation. The disease moves upwards and spots change into long characteristics lesions within a month turning plants into a diseased field. The disease is significant since it rapidly destroys foliage when the plant is near at grain maturity. With objective to observe and measure reactions of maize to GLS, a nursery was grown in

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coordination with the District Agriculture Development Office (DADO). Seeds of maize cultivars with resistance to GLS in SARMP/CIAT/CIMMYT/Zimbabwe/Colombia were provided by HMRP/CIMMYT/N based in Kathmandu.

Methodology

Gray leaf spot nursery was planted at two different farmer's fields in Dhungkharka VDC-8 (2,040 masl) and Baluwapati VDC-7 (1,865 masl) in Kavrepalanchowk in 2008 and at Pakhribas VDC-7 (1,720 masl) in Dhankuta during 2009. The fields had the history of GLS epidemic in previous years. Sixteen to twenty eight genotypes of maize including OPVs, inbred line and other genotypes from CIMMYT's maize regional programs in Colombia and Zimbabwe were evaluated in two replications in RCBD with chemical fertilizer applied at 120:60:40 kg of NPK/ha. Other agronomical practices were followed as usual. The plot size for each genotype was 2-row of 3 m long at Baluwapati, and 2-row of 4 m long at Dhungkharka. Seeds of maize were sown at Baluwapati on 26th of March and at Dhungkharka on 17th of April in 2008. Twenty seven genotypes of maize was sown each in 2-row of 5 m long plot on 15 May in the observation nursery at Khumaltar (1,320 masl) in 2008. In the following year 13 genotypes of maize were sown each in 2-row of 4 m long on 2nd of June at Khumaltar and 18 in 2-row of 3 m long on 8th of April at Pakhribas. Due to long drought, seeds were re-sown for the second time on 9th of June at Khumaltar. Ganesh-2 variety of maize being very susceptible to GLS was used as spreader and border rows to provide a congenial environment to GLS development at Khumaltar in 2009.

All genotypes of maize were scored for GLS at scale of 1-5, on one to three different dates at two weeks interval starting from the occurrence of lesions on leaves (i.e. on 10th, 25th of August and 1st of September at Dhungkharka; 28th of July, 12th and 31st of August at Baluwapati; 16th of August and 5th of September at Khumaltar in 2008; and during 30th of August and 13th of September at Khumaltar; and 13th August at Pakhribas in 2009). The number of infected leaf was also recorded for the incidence of GLS. Agronomic characters such as days to tasseling, silking, plant height and ear height were recorded at Khumaltar. The weight of ears and moisture content of kernels were also recorded at Khumaltar on 9th of September and on 1st of October at Dhungkharka in 2008.

Gray leaf spot severity was rated according to Saghai Maroof *et al*., 1993, using following 1-5 scales:

1 = no symptoms;
2 = moderate lesion development below the leaf subtending the ear;
3 = heavy lesion development on and below the leaf subtending the ear with a few lesions above it;
4 = severe lesion development on all but the uppermost leaves, which may have a few lesions; and
5 = all leaves dead;

Results and discussion

The disease began to appear on plants in mid July earlier on the local variety of maize at farmer's fields then in the nursery at higher elevation (1,720 to 2,040 masl) while at Khumaltar (1,320 masl) it appeared in mid to late August. The incidence of GLS was higher as 71 and 87 percent at severity of 2.7 and 2.8 on OPVs, respectively in the two years, while in Colombian material, it reached up to 67 percent at severity of 2.3 in 2008 and in the following year as 1.8 only on selected genotypes (Table 1). The reaction of disease on Zimbabwean maize was 2.2 and 1.8, respectively in two years. The incidence of GLS was highest as 75 percent at severity of 2.1 at Pakhribas in 2009. Ganesh-1, Deuti, Manakamana-1, Manakamana-3 and Sitala were identified as moderately resistant OPVs, and Ganesh-2, local, S99TLWQ-HG-AB (Poshilo Makai-1), Manakamana-4, Manakamana-6 as susceptible OPVs. An inbred genotype of maize (source: CIMMYT/NMRP); TL 03A-S2 ElitexElite F2 1101-83 was found resistant to GLS with the lowest disease as 1.0 at Khumaltar and 1.4 at farmer's fields. GLS was lowest on Ganesh-1 and Manakamana -1 at Baluwapati; Manakamana-3, Manakamana-1, Sitala, Ganesh-1 and Deuti at Dhungkharka; Sitala, Ganesh-1 and Deuti at Pakhribas and Ganesh-1, Manakamana-1, Manakamana-3 and Deuti at Khumaltar. Three genotypes of maize including Manakamana -3, Deuti and an inbred were observed as free of lesion in a preliminary field test in small plot of five plants of each for GLS at Khumaltar in 2007. This inbred also showed resistant reaction to GLS at farmer's field under epidemic condition at Kaleswor-9 VDC, Lalitpur in 2007 (Tiwari and Ferrara, 2007; PPD Annual report 2009). The inbred genotype of maize was possessing resistant reaction to northern leaf blight at NMRP and Khumal;tar since 2006. Similarly, Manakamana-1 and Ganesh-1 have been reported to have higher resistance over local at Panchthar and Solukhumbu, Terathum and Kavrepalanchowk (personal communication). Manakamana-3 and Deuti among distributed seven OPVs in relief program through DADO/NARC by MoA (Arun-2, Manakamana-1, Ganesh-2, Rampur Composite for mid hills and Ganesh-1, Manakamana-3 and Deuti for high hills) were observed moderately resistant to disease at Dhungkharka in 2007. Ganesh-1 (pool 9A), Manakamana-3 (Population 22) varieties were originally derived from population and pools of CIMMYT origin and that could be one of the major reason for being more resistant reaction over local in farmer's fields. Ganesh-1 was released for high hill region and other OPVs; Manakamana-3 (Pop. 22), Sitala (Pop. 44), Manakamana-4 (Pop. 45) and Deuti (ZM 621) for mid hill conditions.

CLA87/CLA91 and Corpoica H-112 genotypes introduced from Colombia were showing resistant reaction with the lowest severity level of GLS. Similarly, 05SADVI, ZM 525, ZM 627, 07SADVI genotypes were also resistant to GLS. A moderately resistant reaction with earliness in maturity was observed in ZM 501, ZM 305, ZM 309 and ZM 307. The mean days to produce tassel and silk were observed lowest as 74 and 77 on maize from Zimbabwe and highest as 77 and 81 on Colombian maize, while the mean of OPVs was intermediate as 75 and 77 at Khumaltar. Grain yield was highest in Manakamana-3 (4.050 t/h),

CML451/CLO2450 (4.300 t/h) and ZM 305 (4.250 t/h) and ZM 501 at Khumaltar. Similarly, ZM 525 (5.564 t/h), ZM627, 07SADVI and ZM401 and Corpoica H-112 (4.058 t/h) among the new genotypes of maize produced the higher yield under disease epidemic conditions at Pakhribas (Table 2). Ganesh-1 (5.463 t/h) yielded highest at Pakhribas. The weight of ears from five randomly selected plants used for GLS score was highest in Manakamana-3, ZM 627 and Corpoica H-112 at Dhungkharka. Ear rot was remarkable at Baluwapati.

CML451/CLO2450 and ZM 305 among maize from SARMP, and Manakamana-6 and S99TLWQ-HG-AB (Poshilo Makai-1) among OPVs seemed to be tolerant to GLS. The short plant height, most preferred in hills was shortest on genotypes from Zimbabwe than that of the others. The local exhibited the tallest plant height and ear height as 271 cm and 157 cm among all maize. Host resistance for this worldwide important disease of maize has been reported on several hybrids and inbred lines (Hilty *et al*, 1979; Ward *et al*., 1999; Compendium of corn diseases 3rd edt., 1999). Details are given in Appendix 1 & 2.

Conclusion

Genotypes of maize resistant to moderately resistant to GLS was identified. The OPVs like Ganesh-1, Deuti, Manakamana-1 and Manakamana-3 (Ganesh-1 for high hills), can reduce yield loss in GLS prone environments of the hills. Several resistant genotypes and inbred maize can be useful for source of disease resistance in the national maize breeding program. Genotypes of maize including Corpoica H-112, CLA 87/CLA 91 from Colombia, and ZM 627, ZM 525, 05 SADVI, 07 SADVI, ZM 401 and ZM 501 from Zimbabwe were identified as resistant to GLS. Awareness to GLS, monitoring, crop improvement for GLS resistance and use of GLS resistant sources in the national maize breeding program should be emphasized.

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Appendix 1. Gray leaf spot disease reaction on genotypes of maize from SARMP/ CIMMYT/Colombia/ Zimbabwe/NMRP at Dhungkharka, Baluwapati, Pakhribas and Khumaltar in 2008 and 2009

1. a) OPVs

S N	Maize Genotype	Incidence, %				Severity, 1-5					
		D/rka	B/pti	**Mn.**	P/bas	D/rka	B/pti	K/mal	**Mn.**	K/mal	P/bas
		'08	**'08**	**'08**	**'09**	**'08**	**'08**	**'08**	**'08**	**'09**	**'09**
1.	Mana-3	**42**	80	61	88	**1.8**	3.0	2.0	2.3	-	3.0
2.	Sitala	45	78	62	75	1.9	3.1	2.7	2.6	-	**2.1**
3.	Mana-1	47	**61**	54	98	1.9	**2.8**	1.9	**2.2**	-	3.1
4.	Deuti	56	78	67	**73**	2.1	3.0	1.9	2.3	-	2.4

S N	Maize Genotype	Incidence, %				Severity, 1-5					
		D/rka	B/pti	**Mn.**	P/bas	D/rka	B/pti	K/mal	**Mn.**	K/mal	P/bas
		'08	**'08**	**'08**	**'09**	**'08**	**'08**	**'08**	**'08**	**'09**	**'09**
5.	Ganesh-1	54	81	68	77	2.1	**2.8**	**1.7**	**2.2**	-	2.4
6.	Mana-6	79	87	83	100	3.0	3.5	2.7	3.1	-	2.8
7.	Local	74	84	79	100	2.9	3.5	3.3	3.2	2.2	2.8
8.	Ganesh-2	85	97	91	-	3.2	3.8	3.0	3.3	2.7	-
9.	Mana-4	-	-	-	79	-	-	-	-	-	2.9
10.	S99TLWQ-HG-AB	-	-	-	81	-	-	-	-	-	3.2
11.	S99TLYQ-HG-AB	-	-	-	96	-	-	-	-	-	2.8
	Mean	**60**	**81**	**71**	**87**	**2.4**	**3.2**	**2.4**	**2.7**	**2.5**	**2.8**

1. b) Maize genotype

S N	From Colombia	Incidence, %				Severity, 1-5					
		D/rka	B/pti	**Mn.**	P/bas	D/rka	B/pti	K/mal	**Mn.**	K/mal	P/bas
		'08	**'08**	**'08**	**'09**	**'08**	**'08**	**'08**	**'08**	**'09**	**'09**
1.	Corpoica H-112	46	64	55	36	1.8	2.4	**1.3**	1.8	**1.0**	**1.7**
2.	CLA 87/CLA 91	**38**	**47**	**43**	**32**	**1.7**	**1.8**	**1.3**	**1.6**	1.7	1.9
3.	FNC 3056	51	83	77	-	2.1	3.3	**1.3**	2.2	-	-
4.	ICA V-305	49	76	63	-	1.9	3.1	1.8	2.3	-	-
5.	S03 TLYQ AB 05	66	69	68	-	2.6	2.9	1.5	2.3	-	-
6.	CML 451/CLO2450	63	95	79	-	2.3	3.5	2.2	2.7	2.3	-
7.	Cimcali 05B roya 1	80	82	81	-	3.1	3.2	2.4	2.9	-	-
	Mean	**56**	**74**	**67**	**34**	**2.2**	**2.9**	**1.7**	**2.3**	**1.7**	**1.8**

1. c) Maize genotype

S N	From Zimbabwe	Incidence, %		Severity, 1-5					
		D/rka	P/bas	D/rka	K/mal	**Mn.**	K/mal	P/bas	**Mn.**
		'08	**'09**	**'08**	**'08**	**'08**	**'09**	**'09**	**'09**
1.	05SADVI	26	**57**	**1.5**	**1.0**	1.2	1.2	2.0	**1.6**
2.	ZM 525	35	71	1.7	**1.0**	1.4	1.4	**1.9**	1.7
3.	ZM 627	26	61	1.6	1.7	1.7	**1.1**	2.0	**1.6**
4.	07SADVI	**24**	80	1.6	1.7	**1.7**	1.7	2.0	1.9
5.	ZM 401	27	78	1.7	2.1	**1.9**	1.2	2.2	1.7
6.	07SADVE	40	-	2.0	1.9	2.0	-	-	-

S N	From Zimbabwe	Incidence, %		Severity, 1-5					
		D/rka	P/bas	D/rka	K/mal	**Mn.**	K/mal	P/bas	**Mn.**
		'08	**'09**	**'08**	**'08**	**'08**	**'09**	**'09**	**'09**
7.	ZM 501	43	100	2.0	2.2	2.1	1.9	2.3	2.1
8.	ZM 421	53	-	2.3	2.2	**2.3**	-	-	-
9.	ZM 307	70	-	2.5	2.0	**2.3**	-	-	-
10.	ZM 523	55	-	2.3	2.5	**2.4**	-	-	-
11.	ZM 305	58	-	2.7	2.2	2.5	2.6	-	-
12.	ZM 309	69	-	2.6	2.5	2.6	-	-	-
	Mean	**44**	**75**	**2.0**	**1.9**	**2.2**	**1.6**	**2.1**	**1.8**

1. d) Maize inbred line from CIMMYT/NMRP

S N		Incidence, %		Severity, 1-5				
		D/rka	B/pti	**Mn.**	D/rka	B/pti	**Mn.**	K/maL
		'08	**'08**	**'08**	**'08**	**'08**	**'08**	**'09**
1.	TL 03A-S2 ElitexElite F2 1101-83	14	30	**22**	1.3	1.5	1.4	1.0

GLE	Incidence, %			Severity, 1-5				
	B/pti	D/rka	P/bas	B/pti	D/rka	K/maL	P/bas K/mal	
	'08	**'08**	**'09**	**'08**	**'08**	**'08**	**'09**	**'09**
Over all Mean	**75**	**51**	**77**	**3.0**	**2.2**	**2.0**	**2.4**	**1.7**

Appendix 2. Grain yields, days to 50 percent flowering, plant and ear height of genotypes of maize in gray leaf spot observation nursery at Khumaltar, Pakhribas and Dhungkharka in 2008 to 2009

2. a) Open Pollinated Varieties

SN	Maize Genotypes	Days to Tassal	50% Silk	Plant ht.cm	ear ht.cm	MC % K/mal	GY.t/h K/mal	Fwt g D/kra	GY.t/h K/mal	GY.t/h P/bas
		2008	2008	2008	2008	2008	2008	2008	2009	2009
1.	Mana-3	78	81	241	137	32.5	4.050	900	-	4.226
2.	Sitala white	74	76	213	109	30.6	3.550	650	-	4.242
3.	Mana-1	78	80	235	111	31.7	3.900	450	-	4.468
4.	Deuti	75	78	198	88	30.9	3.450	250	-	4.562
5.	Ganesh-1	76	80	254	147	29.9	2.750	500	-	5.463
6.	Ganesh-2	70	73	230	125	23.5	3.750	450	2.012	-

SN	Maize Genotypes	Days to Tassal	50% Silk	Plant ht.cm	ear ht.cm	MC % K/mal	GY.t/h K/mal	Fwt g D/kra	GY.t/h K/mal	GY.t/h P/bas
		2008	2008	2008	2008	2008	2008	2008	2009	2009
7.	Mana-6	72	74	222	112	25.9	3.500	730	-	3.986
8.	Local	74	77	271	157	28.8	3.900	750	1.990	3.390
9.	S99TLWQ-HG-AB	-	-	-		-	-	-	-	4.468
10.	S99TLYQ-AB	-	-	-		-	-	-	-	4.240
11.	Mana-4	-	-	-	-	-	-	-	-	3.390
		75	**77**	**233**	**123**	**29.2**	**3.606**	**585**	**2.001**	**4.244**

2. b) Genotypes of maize from Colombia

1.	CLA87/CLA91	76	78	222	122	31.9	3.800	550	2.663	3.003
2.	FNC3056	80	82	198	99	32.8	3.250	450	-	-
3.	CorpoicaH-112	78	80	216	111	30.2	3.900	700	1.874	4.058
4.	ICAV-305	79	81	225	117	30.8	2.200	550	-	-
5.	S03TLYQAB05	76	79	201	87	31.4	2.900	400	-	-
6.	CML451/CLO2450	77	90	202	95	30.7	4.300	600	1.979	-
7.	Cimcali05Broya1	74	77	180	87	30.0	3.050	600	-	-
		77	**81**	**206**	**103**	**31.1**	**3.343**	**550**	**2.172**	**3.531**

2. c) Genotypes of maize from Zimbabwe

1.	07SADVI	75	78	203	109	29.1	3.950	550	2.905	4.913
2.	ZM 501	70	73	201	92	28.0	3.550	530	3.194	4.240
3.	05SADVI	76	78	218	111	31.6	4.150	750	2.622	3.780
4.	ZM 627	77	80	212	107	31.6	3.600	900	2.762	5.536
5.	ZM 525	76	79	179	79	30.8	3.100	800	2.214	5.564
6.	ZM 305	70	73	195	89	28.8	4.250	430	1.691	-
7.	07SADVE	75	77	177	75	30.7	3.250	750	-	-
8.	ZM 309	69	72	174	78	26.9	2.800	300	-	-
9.	ZM 523	76	79	216	114	30.8	3.000	680	-	-
10.	ZM 421	78	80	221	111	29.3	3.200	500	-	-
11.	ZM 401	73	76	205	97	28.8	4.000	500	1.993	4.258
12.	ZM 307	70	73	190	82	27.1	3.050	700	-	-
		74	**77**	**199**	**95**	**29.5**	**3.492**	**616**	**2.483**	**4.715**

2. d) Maize inbred genotype of maize from CIMMYT/NMRP

TL 03A-S2 ElitexElite F2	**1101**	**8**	-	-	-	-	-	2.199
Over all Mean	**75**	**78**	**211**	**105**	**29.8**	**3.487**	**569**	**2.315**

Abbreviations: '-' : not included; Mana : Manakamana; S99TLWQ-HG-AB: Poshili Makai-1 D/rka : Dhungkharka; B/pti : Baluwapati; P/bas: Pakhribas; K/mal: Khumaltar; ht.: height; cm: centimeter; Days to 50% : days required to tassel/silk in 50 % of plants; MC: moisture content of kernels; g: gram; t/h: ton per hectare; GY: grain yield adjusted at 14 percent mc; Fwt : Fresh weight of ears from five plants; '08 : 2008; '09: 2009; Mn.: Mean; masl: meter above sea level; SARMP: South American Regional Maize Program; CIMMYT: International Maize and Wheat Improvement Center; NMRP: National Maize Research Program.