Electronic Journal of Plant Breeding, 3(2): 788-793 (June 2012)
ISSN 0975-928X

Research Note

Screening and source of resistance to downy mildew (*Peronosclerospora sorghi*) in Maize (*Zea Mays* L.)

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(Received: 26 Aug 2011; Accepted: 19 Apr 2012)

Abstract
Host plant resistance is an effective and economical means of controlling downy mildew disease in maize (*Zea mays* L.). The present study was initiated with screening of 100 maize inbreds against downy mildew. The parents UMI 57 and UMI 743 showed resistance to downy mildew. Among 56 hybrids, two hybrids *viz.*, CM 500 x UMI 39 and CM 500 x UMI 57 were found to be highly resistant (100 %) to downy mildew with higher grain yield. The disease reaction of the progenies ranged from zero to 100 per cent. The maximum disease incidence was registered in CM 500. The incidence was recorded nil in UMI 57. All downy mildew resistant hybrids were found to possess significantly higher concentration of total phenols, soluble protein (mg/g), peroxidase and polyphenol oxidase. Hence these biochemical substances could have a possible role in the resistance behaviour of the genotypes against downy mildew.

Key words
*Zea mays L.***,** downy mildew**,** resistance**,** screening

Maize (*Zea mays* L.) holds an unique position in world agriculture as a food, feed and industrial crop *par excellence*. In India, maize has emerged as third most important grain crop next to rice and wheat. Cultivation of high yielding hybrids is threatened by a fungal disease called 'downy mildew', particularly in South India. Downy mildew causes considerable damage to maize, some times up to 100 per cent, so there exists enough scope to improve the production and productivity of maize through breeding for high yielding single cross maize hybrids with resistance to downy mildew.

Downy mildews in maize, belonging to the genera *Peronosclerospora* and *Sclerophthora*, are the most destructive diseases of this crop in tropical Asian countries. The major downy mildew diseases occurring in Asia include sorghum downy mildew (*Peronosclerospora sorghi* (Weston & Uppal C.G.Shaw), Philippine downy mildew (*Peronosclerospora philippinis* Weston C.G.Shaw), Java downy mildew [(*Peronosclerospora maydis* (Raciborski)], Sugarcane downy mildew *[Peronosclerospora sacchari* (T. Miyake) C.G.Shaw] and Brown stripe downy mildew [*Scleropthora rayssiae var. zeae* (Payak and Renfro)]. The downy mildews are the 'old world' diseases causing enormous losses in various crop plants, including maize. Twenty-one species of downy mildew fungal pathogens have been reported to attack members of the family Poaceae, of which 10 species in three genera of fungi have been reported to cause different types of downy mildews in maize (De Leon, 1991; Smith and Renfro, 1999; Spencer and Dick, 2002).

In South India, the first report of downy mildew on maize appeared in 1975. Olanya and Fajemisin (1993) revealed that the disease in the South India does not seem to infect sorghum, even when susceptible varieties were exposed to *Peronosclerospora sorghi* conidia from infected maize. The sorghum downy mildew (SDM) is particularly prevalent in the peninsular India (Tamil Nadu, Karnataka , Andhra Pradesh) causing losses of 30 per cent and higher (Krishnappa *et al.*, 1995). The disease is known by two names, "downy mildew" and "crazy top" based on two types of symptoms in maize that develop as a result of systemic infection.
Yellowing develops from the basal regions of the leaves towards their tips in plants systemically infected by *Peronosclerospora sorghi*. The infected plants produce smaller cobs and malformed tassels. Thakur and Mathur (2002) reported that, in sorghum, pearl millet and maize, symptoms of downy mildew infection develop at 25°c, but incidence was reduced below 20°c and above 35°c. Crazy top

of maize was first described in Italy in 1902. This symptom was caused by *Sclerospora macrospora* in maize. They reported that the leaves of severely infected plants were narrow, strap like and leathery in texture. Stunting of infected plant was a common symptom, but the most pronounced symptom was the replacement of normal tassels by leaves. Thus the name "crazy top" of this downy mildew was given due to these symptoms. The most efficient, effective and economic long term control of downy mildews of maize is exploitation of host resistance.

A set of 100 maize germplasm accessions formed the basic material for downy mildew resistance. The selfed seeds were obtained from the Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore.

<u>Screening of germplasm for downy mildew resistance</u>: Screening of germplasm lines for downy mildew resistance in order to select parents for further studies. During *Kharif* 2003 (July – August), 100 germplasm accessions were raised in sick plot conditions adopting randomized block design with two replications. The CM 500, a genotype highly susceptible to downy mildew was grown at every ten rows, which formed the infector rows and source of inoculum. Infector rows were sown 20 days prior to the sowing of test entries. Inoculation of infector row was done by adopting the artificial inoculation procedure.

Diseased sorghum plants from which inoculum were to be drawn was sprayed with water at 6 p.m. on the previous day, so that leaves will have thin film of water for good sporulation. The next morning around 2.30 a.m. the leaves with good sporulation were collected and washed in the water at the rate of 15 leaves per litre of water. The spore suspension was thoroughly mixed and sprayed on the infector rows around 4 a.m. with hand compression sprayer. Water spray was given twice, in the morning and evening to create the required humidity artificially. This procedure was followed at 2 leaves and 3 leaves stages i.e. on 7 th and 10 th day after sowing. Test entries were sown 20 days after sowing of infector rows. .Disease incidence in test entries was recorded on 40th day after sowing and the mean percentage of incidence in each test entry under each replication was worked out to classify the entries as highly resistant (0 % disease incidence), resistant (0-10 % disease incidence), moderately resistant (11–25 % disease incidence) susceptible (26–50% disease incidence) and highly susceptible (above 50 % disease incidence) as suggested by Pandurangegowda *et al.* (1986).

$$\text{Incidence (\%)} = \frac{\text{No. of infected plants}}{\text{Total number of plants}} \times 100$$

Out of hundred germplasm accessions screened for downy mildew under sick plot, UMI 39, UMI 57 and UMI 743 exhibited resistance to downy mildew, while UMI 62 and UMI 97 showed moderate resistance and all other accessions were susceptible (Table 1). The analysis of variance revealed that the differences among the genotypes were highly significant for this trait and the combining ability analysis suggested the presence of significant gca and sca effects. The GCA variances were of greater magnitude than SCA variances indicating the preponderance of additive gene action. This observation is in confirmity with the reports of Craig (1982), Lima *et al.* (1982), Yen *et al.* (2001) and Nair (2003). The contribution of both additive and non-additive gene effects, in the inheritance of downy mildew was observed. The parents, UMI 57, UMI 62, UMI 39 and UMI 743 recorded positive *gca* effects, of which the effects of UMI 57 and UMI 743 were significant. Among the hybrids, UMI 57 x CM 500, UMI 13 x CM 500 and UMI 62 x UMI 118 recorded significant and positive *sca* effects. The hybrids UMI 743 x CM 500, UMI 13 x UMI 57 and UMI 13 x UMI 97 recorded significant positive reciprocal sca effects. Two hybrids *viz.*, CM 500 x UMI 39, CM 500 x UMI 57 were found to be highly resistant (100%) to downy mildew (Table 2) with high grain yield per plant of 155.93 and 153.93 g respectively. The hybrids CM 500 x UMI 97 (143.09 g), UMI 13 x UMI 57 (139.81 g) and CM 500 x UMI 39 (130.98 g) were also with high yield per plant and with resistant reaction to downy mildew. In this study, the susceptible x highly susceptible combination hybrids UMI 13 x UMI 118 and UMI 13 x CM 500 showed highly susceptible reaction. Moderately resistant x resistant combination UMI 62 x UMI 743 recorded moderate reaction. The susceptible x highly resistant combination hybrid CM 500 x UMI 57 showed highly resistant reaction. The results indicate that the downy mildew resistance is conditioned by both additive and dominant genes. The variations observed for resistance also indicated the possible role of polygenes.

One of the important objectives of the present study was to understand the genetic architecture of the selected parents and to assess their performance, reaction to downy mildew disease and to utilize them effectively in breeding for exploitation of heterosis and in recombination breeding programme. Three parents *viz.*, CM 500, UMI 57 and UMI 743 recorded positive and significant *gca* effects for grain yield per plant. The parents UMI 743 and UMI 57 also exhibited positive and significant *gca* effects for ear height, ear weight and number of grains per row, while UMI 743 and CM 500 recorded significant and positive *gca* effects for ear length and 100-grain weight. For downy mildew resistance, the parents, UMI 57, UMI 62, UMI 39 and UMI 743 recorded positive *gca* effects, of which the effects of UMI 57 and UMI 743 were significant. In the present study, the cross combinations UMI 13 x UMI 39, UMI 13 x UMI 57, UMI 57 x UMI 97, UMI 57 x UMI 743, UMI 57 x CM 500, UMI 62 x UMI 118 and UMI 97 x CM 500 were observed to be best with regard to grain yield per plant . Among these, UMI 57 x CM 500 and UMI 13 x UMI 57 were found to be moderately resistant to downy mildew.

The diallel analysis of hybrids for downy mildew resistance showed the preponderance of additive gene action and this findings is in accordance with Lima *et al.* (1982), Craig, (1982), Yen *et al.* (2001) and Nair *et al.* use additive gene action (2004). Recurrent selection procedures use additive gene action and very effective screening procedures can be used to improve upon the levels of downy mildew resistance. Recurrent selection involves the identification and intermating of superior genotype in a population to form a new and improved population from which further selection can be practiced and is an efficient method for increasing the frequency of desirable genes. The association between biochemical components and grain yield per plant with downy mildew resistance is given in Table 3 and 4. To understand the relation of total phenols, soluble protein, peroxidase, polyphenol oxidase, grain protein and grain yield per plant with downy mildew resistance, correlation analysis was carried out. This revealed that total phenols, soluble protein, peroxidase and polyphenol oxidase had significant and positive correlation with downy mildew resistance.

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Table 1. Screening of germplasm accessions for downy mildew resistance

S.No.	Entries	Downy mildew incidence (%)	Grade	S.No.	Entries	Downy mildew incidence (%)	Grade
1	UMI 39	8.00	R	51	UMI 85	64.10	HS
2	UMI 57	6.66	R	52	UMI 86	57.14	HS
3	UMI 743	8.33	R	53	UMI 87	64.28	HS
4	UMI 62	20.00	MR	54	UMI 88	72.41	HS
5	UMI 97	16.66	MR	55	UMI 90	75.00	HS
6	UMI 178	46.00	S	56	UMI 92	87.50	HS
7	UMI 89	48.42	S	57	UMI 96	83.33	HS
8	UMI 2	77.41	HS	58	UMI 99	94.73	HS
9	UMI 4	83.33	HS	59	UMI 101	82.75	HS
10	UMI 8	75.00	HS	60	UMI 102	78.12	HS
11	UMI 9	84.00	HS	61	UMI 109	73.68	HS
12	UMI 10	80.00	HS	62	UMI 112	87.50	HS
13	UMI 12	78.12	HS	63	UMI 113	57.14	HS
14	UMI 13	96.15	HS	64	UMI 114	85.00	HS
15	UMI 14	80.00	HS	65	UMI 116	82.75	HS
16	UMI 16	73.68	HS	66	UMI 118	88.46	HS
17	UMI 17	87.50	HS	67	UMI 120	80.00	HS
18	UMI 18	82.75	HS	68	UMI 122	100.00	HS
19	UMI 19	85.71	HS	69	UMI 123	72.00	HS
20	UMI 27	93.33	HS	70	UMI 124	82.75	HS
21	UMI 28	85.00	HS	71	UMI 127	64.51	HS
22	UMI 29	90.00	HS	72	UMI 131	82.35	HS
23	UMI 30	70.83	HS	73	UMI 132	57.14	HS
24	UMI 34	56.00	HS	74	UMI 133	75.00	HS
25	UMI 35	70.00	HS	75	UMI I34	63.15	HS
26	UMI 37	80.95	HS	76	UMI 135	78.94	HS
27	UMI 38	69.44	HS	77	UMI 136	96.00	HS
28	UMI 40	88.00	HS	78	UMI 138	100.00	HS
29	UMI 42	96.00	HS	79	UMI 140	87.09	HS
30	UMI 44	100.00	HS	80	UMI 141	80.00	HS
31	UMI 46	61.53	HS	81	UMI 143	78.98	HS
32	UMI 48	90.00	HS	82	UMI 152	87.50	HS
33	UMI 50	64.28	HS	83	UMI 154	92.30	HS
34	UMI 51	66.66	HS	84	UMI 156	55.55	HS
35	UMI 54	75.00	HS	85	UMI 158	75.00	HS
36	UMI 58	56.00	HS	86	UMI 161	85.71	HS
37	UMI 59	70.00	HS	87	UMI 164	68.57	HS
38	UMI 60	80.95	HS	88	UMI 168	80.00	HS
39	UMI 61	69.44	HS	89	UMI 173	55.55	HS
40	UMI 64	63.15	HS	90	UMI 176	70.83	HS
41	UMI 66	73.68	HS	91	UMI 180	70.00	HS
42	UMI 67	83.33	HS	92	UMI 182	80.95	HS
43	UMI 70	78.94	HS	93	UMI 187	69.44	HS
44	UMI 75	75.00	HS	94	UMI 188	91.30	HS
45	UMI 76	77.41	HS	95	UMI 189	96.00	HS
46	UMI 78	78.94	HS	96	UMI 190	73.68	HS
47	UMI 79	64.00	HS	97	UMI 193	78.94	HS
48	UMI 80	82.75	HS	98	UMI 196	83.33	HS
49	UMI 81	85.71	HS	99	UMI 197	57.14	HS
50	UMI 83	72.41	HS	100	UMI 198	64.51	HS
				CM 500 (Susceptible donor)		**100.00**	**HS**

Table 2. Resistance performance of hybrids (%) against downy mildew (Figures in parenthesis are arcsin transformed values)

Crosses	Downy mildew resistance percentage	
	Direct crosses	Reciprocal crosses
UMI 13 x UMI 39	12.15 (20.39)	73.90 (59.29)
UMI 13 x UMI 57	79.06 (62.77)	32.84 (34.97)
UMI 13 x UMI 62	13.00 (21.10)	29.25 (32.74)
UMI 13 x UMI 97	30.25 (33.37)	4.40 (12.02)
UMI 13 x UMI 118	25.90 (30.59)	10.71 (19.10)
UMI 13 x UMI 743	13.55 (21.59)	11.80 (20.09)
UMI 13 x CM 500	71.25 (57.58)	62.34 (52.15)
UMI 39 x UMI 57	15.80 (23.46)	36.65 (37.25)
UMI 39 x UMI 62	29.40 (32.83)	16.15 (23.67)
UMI 39 x UMI 97	0.00 (25.13)	50.40 (45.23)
UMI 39 x UMI 118	0.00 (25.13)	15.55 (23.22)
UMI 39 x UMI 743	5.75 (13.83)	85.64 (67.75)
UMI 39 x CM 500	11.66 (19.96)	100.00 (89.75)
UMI 57 x UMI 62	15.67 (23.31)	21.30 (27.48)
UMI 57 x UMI 97	17.20 (24.49)	34.15 (35.76)
UMI 57 x UMI 118	0.00 (25.13)	35.95 (36.84)
UMI 57 x UMI 743	32.05 (34.48)	85.64 (67.75)
UMI 57 x CM 500	88.76 (70.42)	100.00 (89.75)
UMI 62 x UMI 97	37.85 (37.97)	28.65 (32.36)
UMI 62 x UMI 118	52.00 (46.15)	45.65 (42.51)
UMI 62 x UMI 743	40.55 (39.55)	84.91 (67.15)
UMI 62 x CM 500	37.85 (37.97)	92.70 (74.35)
UMI 97 x UMI 118	52.00 (46.15)	10.80 (19.18)
UMI 97 x UMI 743	40.55 (39.55)	80.75 (63.99)
UMI 97 x CM 500	37.85 (37.97)	93.15 (74.84)
UMI 118 x UMI 743	26.25 (30.81)	27.59 (31.68)
UMI 118 x CM 500	32.50 (34.76)	32.84 (34.97)
UMI 743 x CM 500	65.67 (54.14)	15.67 (23.31)
Hybrid mean	39.33	
SE	0.905	
CD at 5%	1.814	
CD at 1%	2.415	

Table 3. Biochemical estimates of parents and their downy mildew resistance

Parents	Phenols (mg/g)	Soluble protein (mg/g)	Peroxidase (ΔA/mg protein/min)	Polyphenol oxidase ΔA/mg protein/min)	Downy mildew resistance (%)
UMI 13	4.27	4.63	4.13	3.71	40.00
UMI 39	4.92*	6.36*	5.38*	5.93*	96.34
UMI 57	5.43*	6.30*	5.88*	6.03*	100.00
UMI 62	4.90*	5.38	4.89*	4.42	86.20
UMI 97	4.42	5.34	4.43	3.64	76.00
UMI 118	4.10	4.31	3.98	4.12	12.00
UMI 743	4.45	5.42*	4.72	5.48*	96.25
CM 500	3.23	4.51	4.19	4.63	11.63
Mean	**4.46**	**5.28**	**4.70**	**4.74**	**56.98**
S.E	**0.066**	**0.133**	**0.119**	**0.128**	**0.470**
C.D (5%)	**0.220**	**0.445**	**0.398**	**0.429**	**1.111**

* significant

Table 4. Correlation between biochemical parameters and downy mildew resistance

Biochemical parameters	Correlation coefficient with downy mildew resistance
Phenols	0.8723 **
Soluble protein	0.9397 **
Peroxidase	0.7055 **
Polyphenol oxidase	0.5474 *
Yield	0.2662