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Genetic analysis of resistance to Turcicum Leaf Blight in semi-temperate early maturing genotypes of maize (*Zea mays*)

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Abstract

Turcicum leaf blight (*Exserohilum turcicum*) is the most common and chronic disease of maize, especially in Himalayan hilly region. Studies on inheritance of the disease were conducted using six generations derived from 4 susceptible (CM 128, V 327, V 128 and V 17) and 2 resistant inbred lines (V 335 and V 13) having early maturity suited to hilly region. The 6 parents and their 15 F_1's, 15 F_2's, 15 BC_1's and 15 BC_2's, were studied for reaction to turcicum leaf blight at 2 locations namely, Hawalbagh Research Farm of Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora during *kharif* 2000 and at Sihora Farm, Rudrapur during *rabi,* 2000-01. Significant additive and dominance variances were observed in most of the crosses in the two environments mentioned above. The study suggested that both additive and dominance components were important in the inheritance of turcicum leaf blight, the magnitude of additive component being relatively higher than non-additive component. Gene interactions and environment were also found to be important. The resistant lines V 335 and V 13 were found to be the best general combiners. Highly significant SCA effects were observed in both environments in 3 crosses, viz. V 327 x V 335, V 335 x V 17 and V 13 x V 128, which involved one disease resistant parent. Significant GCA and SCA variance also indicated that the additive and non-additive components were important in the inheritance of resistance to turcicum leaf blight in maize. Low to high H_{ns} estimates were observed with good genetic advance, especially at Hawalbagh during *kharif* 2000. The higher estimates of additive component of variance, heritability and genetic advance during *kharif* 2000 indicated that selection for turcicum leaf blight resistance was likely to be more effective at Hawalbagh during *kharif* than at Rudrapur during *rabi*. Population improvement approach, preferably, reciprocal recurrent selection may be followed for the development of early maturing and turcicum leaf blight resistant cultivars of maize, especially for the Himalayan hilly region.

Key words: Combining ability, *Exserohilum turcicum*, Generation mean, Heritability, Inheritance, Turcicum leaf blight

Introduction

Turcicum leaf blight (*Helminthosporium turcicum* pass or *Exserohilum turcicum*), also known as northern corn leaf blight is a major foliar disease of maize in the plains of India and in the Himalayan region, especially Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Meghalaya, Tripura and Assam. Production and productivity of maize in hilly areas is low as compared to the other areas of the country. High yield losses (28-91%) caused by turcicum leaf blight is one of the major causes of low yield [1, 2]. Most of the maize cultivars, particularly early maturing cultivars, are highly susceptible to this disease. It can be managed to some extent by chemicals and cultural methods. Nonetheless utilization of host resistance is the most cost effective and environmentally sound method for its control [3]. Several researchers have studied the inheritance of resistance to turcicum leaf blight in maize. Both additive and non-additive gene effects contributed to resistance to the disease although additive gene effects were more important [4-6]. Nonetheless, the involvement of early maturing germplasm which dominate the maize cultivation in the hills is very scanty in such studies. The present investigation was, therefore, undertaken to study inheritance, combining ability effects, heritability and genetic advance for resistance to turcicum leaf blight in the early maturing semi temperate genotypes of maize.

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Materials and methods

The material comprised of 4 susceptible (CM 128, V 327, V 17 and V 128) and 2 resistant (V 335 and V 13) maize inbred lines evolved under hilly environment and, were selected on the basis of their disease reaction and early maturity. These 6 inbred lines were crossed in all possible combinations (excluding reciprocals) at Winter Maize Nursery, Directorate of Maize Research, Amberpet, Hyderabad during *rabi,* 1998-99 to obtain 15 F_1's. These 15 F_1's were advanced by bulk pollinations to obtain 15 F_2's and back crosses were made to obtain 15 BC_1's and 15 BC_2's at Hawalbagh during *kharif* 1999. The 15 F_1's, 15 F_2's, 15 BC_1's, 15 BC_2's, and 6 parents were evaluated in a randomized block design during *kharif* 2000 at Hawalbagh Research Farm of Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora (E_1) and during *rabi* 2000-01 at Sihora Farm, Rudrapur (E_2). The material was planted in two replications with row-to-row spacing of 60 cm and plant-to-plant spacing of 25cm. Recommended fertilizer dose @ of 160 Kg N, 60 Kg P_2O_5 and 40 Kg K_2O was applied to raise a good crop.

Screening for Turcicum leaf blight

Screening was done using infectors and artificial inoculation. Two rows of infectors Dihari Local and VL Amber Popcorn were planted after every six plots. Artificial epiphytotic conditions were created as follows:

1. Spores obtained from fresh leaves in water were cultured on sorghum grains and on artificial medium like potato dextrose agar.
2. Mature leaves heavily infected with leaf blight collected in the previous season, were sun dried and grounded to get coarse powder which was used as inoculum.

A pinch of leaf powder was dropped into the leaf whorl of each plant, commencing from 20th day after planting. To ensure better disease development, spore suspension was also sprayed on plants at 5-7 days interval from 20th day after planting to pre-tasseling stage. Inoculation was preferably done late in the afternoon. The incidence of disease was recorded at flowering and dry silk stage following 1.0 to 5.0 rating scale [7]. Estimates for components of generation means were worked out [8] and combining ability analysis was carried out following Model- I, Method II [9].

Results and discussion

Components of variance based on 6 generation means

The estimates for different components and interactions in 15 crosses during *kharif* 2000 at Hawalbagh, during *rabi* 2000-01at Rudrapur and the pooled data are presented in Table 1. At Hawalbagh during *kharif* 2000, all the crosses showed significant additive and dominance variance except CM 128 x V 17 in which dominance variance was non-significant. The magnitude of additive component was relatively higher than non-additive component in 12 crosses, suggesting that resistance to turcicum leaf blight was largely governed by additive gene action. In most of the crosses 'h' and 'l' components had opposite signs indicating duplicate epistasis. The negative values of 'd' and 'h' indicated resistance, while positive values indicated susceptibility to disease. On the other hand during *rabi* 2000 at Rudrapur, significant additive variance was observed in all the 15 crosses. Significant dominance variance was observed in 8 crosses, while it was non significant in the remaining 7 crosses. Seven crosses showed relatively higher additive component and the remaining 8 crosses showed higher dominance component. The data suggested that both additive and dominance components were important in the inheritance of the disease during *rabi* season at Rudrapur. All crosses except one each showed significant additive and dominance components in pooled analysis. Furthermore, the pooled analysis also showed that additive component was higher in 8 crosses, while dominance component was higher in 7 crosses. The study suggested that additive component was more important, especially at Hawalbagh. Epistasis was also significant in the inheritance for resistance to turcicum leaf blight.

General combining ability (GCA) and specific combining ability (SCA) effects

Analysis of variance for combining ability under two environments, i.e. Hawalbagh (E_1) and Rudrapur (E_2) and also on the basis of pooled data showed that differences due to GCA and SCA effects were significant in both environments and also on the basis of pooled data. The GCA and SCA effects for parents and crosses in two environments as well as on the basis of pooled data are given in Table 2. The GCA effects for all the 6 parents were significant in both environments and pooled data, except non significant value for parent V 17 in E_1. The resistant parents V 335 and V 13 showed highest significant negative GCA effects in both

Table 1. Estimates of gene effects in fifteen crosses for turcicum leaf blight at Hawalbagh (*kharif* 2000), Rudrapur (*rabi* 2000-01) and on the basis of pooled data

Sl.No.	Crosses	m	d	h	i	j	l
	Hawalbagh						
1	CM 128 × V 327	4.1844**	-0.1220**	-1.3360**	-0.2500**	0.2937**	1.0138**
2	CM 128 × V 335	3.8312**	0.9313**	-5.4088**	-0.9500**	-0.8525**	4.2525**
3	CM 128 × V 13	3.0981**	0.9344**	-1.5094**	0.2200**	-1.7088**	1.1863**
4	CM 128 × V 128	4.3531**	-0.1406**	-1.1669**	-0.4000*	0.1013**	1.0013**
5	CM 128 × V 17	4.2331**	-0.3406**	0.1381**	-0.0800	0.0521**	-0.3088*
6	V 327 × V 335	3.1131**	1.0531**	0.2131	-0.1100**	-2.1363**	0.1613*
7	V 327 × V 13	2.4900**	1.0563**	1.5150**	0.5100**	-2.1225**	0.6300**
8	V 327 × V 128	3.3650**	-0.0188**	1.2725**	0.7100**	-0.0325	-0.3250**
9	V 327 × V 17	4.5450**	-0.2188**	-1.3050**	-0.2700**	0.5275**	1.0100**
10	V 335 × V 13	1.8669**	0.0031*	0.8994**	0.0800	-0.0063	-0.4663**
11	V 335 × V 128	3.0919**	-1.0719**	-1.1506**	-0.0700**	2.0738**	0.7338**
12	V 335 × V 17	2.9919**	-1.2719**	-1.4131**	0.2300**	2.4938**	1.1588**
13	V 13 × V 128	2.6688**	-1.0750**	-1.6538**	0.3500**	2.2000**	3.0725**
14	V 13 × V 17	3.3388**	-1.2750**	-3.5638**	-0.1200**	2.5900**	4.3125**
15	V 128 × V 17	3.8238**	-0.2000**	0.9663**	0.4700**	0.6900**	-0.2275
	Rudrapur						
1	CM 128 × V 327	3.2206**	0.0469**	1.5056**	0.2450**	-0.2940**	-1.3140**
2	CM 128 × V 335	3.2813**	0.9563**	-1.3688**	-0.7250**	-1.8125**	0.9125**
3	CM 128 × V 13	2.6863**	0.8563**	0.2838**	-0.0300	-1.7125**	-0.1325**
4	CM 128 × V 128	3.6469**	-0.1469**	0.0469	0.0125	0.1813**	0.1188*
5	CM 128 × V 17	3.7075**	-0.1375**	-0.2525	-0.0575**	0.3375**	0.3950**
6	V 327 × V 335	2.6619**	0.9094**	0.4044*	-0.1525**	-1.8063**	-0.1163
7	V 327 × V 13	2.9744**	0.8094**	0.5419	-0.3650**	-1.4938*	-0.2413
8	V 327 × V 128	3.8325**	-0.1938**	-0.3400	-0.2200**	0.4375**	0.2700**
9	V 327 × V 17	3.5506**	-0.1844**	0.7331**	0.0525*	0.3563**	-0.5099**
10	V 335 × V 13	1.6850**	-0.1000**	0.3800	0.0150	0.2750**	-0.2400
11	V 335 × V 128	2.6156**	-1.1031**	-0.4469**	0.0875**	2.1688**	0.6313**
12	V 335 × V 17	2.4913**	-1.0938**	-0.4138	0.2025**	1.9000**	0.5225**
13	V 13 × V 128	2.1081**	-1.0031**	0.6556*	0.6950**	1.7813**	0.1363
14	V 13 × V 17	1.7388**	-0.9938**	1.5413**	1.0550**	1.8625**	-0.4175*
15	V 128 × V 17	3.7919**	0.0094**	0.0694	0.0050	0.0313	-0.0863
	Pooled						
1	CM 128 × V 327	3.7007**	-0.0375**	0.0903	-0.0007	-0.0207	-0.1536**
2	CM 128 × V 335	3.4925**	0.9438**	-3.1975**	-0.7738**	-1.3688**	2.4550**
3	CM 128 × V 13	2.5222**	0.8953**	3.6010**	0.2450**	-1.9906**	02.7106**
4	CM 128 × V 128	3.5613**	-0.1438**	0.4838**	0.2450**	0.0875**	-0.6325**
5	CM 128 × V 17	3.6566**	-0.2391**	0.1978	0.2450**	0.2781**	-0.4419**
6	V 327 × V 335	2.7650**	0.9813**	0.6763**	-0.0088	-2.0188**	-0.2225**
7	V 327 × V 13	2.8047**	0.9328**	0.8109**	0.0000	-1.7906**	-0.2906**
8	V 327 × V 128	3.5875**	-0.1063**	0.5000**	0.2563**	0.1813**	-0.0500
9	V 327 × V 17	4.0153**	-0.2016**	-0.1884**	-0.0763**	0.4594**	0.1856**
10	V 335 × V 13	1.7909**	-0.0484**	0.5947**	0.0325	0.0719**	-0.3231**
11	V 335 × V 128	2.8938**	-1.0875**	-0.9188**	-0.0313**	2.1188**	-0.3231**
12	V 335 × V 17	2.7066**	-1.1828**	-0.8084**	0.2513**	2.1844**	0.7706**
13	V 13 × V 128	2.3959**	-1.0391**	-0.5216**	0.5150**	1.9906**	1.6194**
14	V 13 × V 17	2.5675**	-1.1344**	-1.0975**	0.4388**	2.2125**	2.005**
15	V 128 × V 17	3.7928**	-0.0953	0.5628**	0.2525**	0.2906**	-0.1869**

m = mean, d = additive, h = dominance, i = additive × additive, j = additive × dominance and l = dominance × dominance
*,**Significant at 5% and 1% level of significance, respectively.

Table 2. Estimates of GCA effects for turcicum leaf blight at Hawalbagh (E_1) in *kharif* 2000, at Rudrapur in *rabi* 2000-01 and pooled data (E_1 and E_2)

S.No.	Parents	Hawalbagh *Kharif* 2000 (E_1)	Rudrapur *Rabi* 2000-01 (E_2)	Pooled
GCA effects				
1	CM 128	0.0740**	0.3203**	0.1616**
2	V 327	0.3505**	0.2719**	0.3260**
3	V 335	-0.8526**	-0.6250**	-0.7638**
4	V 13	-0.5104**	-0.6063**	-0.5435**
5	V 128	0.4271**	0.3141**	0.3866**
6	V 17	0.0173	0.325**	0.433**
	SE gi	± 0.0173	± 0.0112	± 0.0089
	CD at 1% level	0.0492	0.0319	0.0254
	CD at 5% level	0.0361	0.0234	0.0186
SCA effects				
	Crosses			
1	CM 128 × V 327	-0.0757	-0.2993**	-0.1499**
2	CM 128 × V 335	-0.0600	0.6475**	0.0525*
3	CM 128 × V 13	-03022	0.0038	-0.1116**
4	CM 128 × V 128	0.1728**	0.0585	0.0682**
5	CM 128 × V 17	-0.0366	0.085*	0.0618**
6	V 327 × V 335	0.4759**	0.1835**	0.3568**
7	V 327 × V 13	0.0212	0.4897**	0.2427**
8	V 327 × V 128	0.0212	-0.5692**	0.0251
9	V 327 × V 17	-0.1257	0.0585	-0.0463
10	V 335 × V 13	0.1493**	-0.0634	0.0701**
11	V 335 × V 128	-0.4132**	-0.0087	-0.1850**
12	V 335 × V 17	-0.435**	-0.2196**	-0.3002**
13	V 13 × V 128	0.6571**	-0.24**	0.1946**
14	V 13 × V 17	0.5728**	0.0241	0.2857**
15	V 128 × V 17	0.1103**	0.0163	0.0493
	SE sij	±0.0475	0.135	0.0911
	CD at 1% level	±0.0308	0.135	0.0642
	CD at 5% level	± 0.0245	0.0697	0.0511

*, ** Significant at 5% and 1% level of significance, respectively

environments and also in pooled data and were the best general combiners for resistance to turcicum leaf blight. The 4 susceptible parents showed highly significant positive values suggesting that they were also good general combiners for the disease. The ranking of GCA effects of the parents was in accordance with their respective mean disease ratings. Therefore, their *per se* performance for disease reaction indicated their ability to transmit resistance.

Highly significant SCA effects were observed in both environments and on the basis of pooled data in 3 crosses, *viz*., V 327 x V 335, V 335 x V 17 and V 13 x V 128. All these 3 crosses involved one disease resistant parent. However, out of these 3, the cross V 335 x V 17 showed significant negative SCA effects in E_1 and E_2 as well as pooled data, suggesting that this cross could be utilized for developing disease resistant breeding material. Four crosses CM 128 x V 327, CM 128 x V 335, CM 128 x V 17 and V 327 x V 13 showed significant SCA effects in environment E_2 and pooled data. Another set of 4 crosses CM 128 x V 128, V 335 x V 13, V 335 x V 128 and V 13 x V 17 showed significant SCA effects in environment E_1 and pooled data. Significant SCA effects were observed only in one environment or only in pooled data in one cross each and one cross did not show significant SCA in E_1, E_2 as well as in pooled data. Significant GCA and SCA variance indicated that the additive as well as non-additive components were important in the inheritance of resistance to turcicum leaf blight in maize. However, the GCA effects were higher showing preponderance of additive component as also reported in other studies [3, 10]. Both additive and non additive gene effects contributed to resistance to turcicum leaf blight although additive gene effects were more important [11] Another study involving 6 generations also showed that additive, non additive and epistatic gene effects were important in 4 different crosses and predominance of additive genetic component was the general tendency [6, 12]. In the present study also different gene effects were observed in different crosses suggesting that nature of inheritance of turcicum leaf blight resistance could be population specific. Inbreds V 13 and V 335 were good general combiners for resistance to turcicum leaf blight and showed better ability to produce combinations with reduced incidence of turcicum leaf blight. In general, *per se* performance of the inbreds for disease incidence appeared to be a good indicator of their ability to transmit resistance.

Heritability and genetic advance

Estimates of heritability broad sense (H_{bs}), heritability narrow sense (H_{ns}) and genetic advance for turcicum leaf blight in 15 crosses in two environments, i.e. Hawalbagh and Rudrapur are given in Table 3. The estimates differed in two environments and also in different crosses. The H_{bs} in 15 crosses ranged from

Table 3. Estimates of heritability and genetic advance for reaction to turcicum leaf blight Hawalbagh(E_1), at Rudrapur (E_2) and on the basis of pooled data

Sl. No.		Heritability broad sense (h_{bs})			Heritability narrow sense (h_{ns})			Genetic Advance (GA)		
		E_1	E_2	Pooled	E_1	E_2	Pooled	E_1	E_2	Pooled
1	CM 128 × V 327	56.43	48.37	49.67	19.33	18.34	16.30	10.14	08.85	05.70
2	CM 128 × V 335	50.11	55.26	55.60	07.10	46.80	03.40	04.90	19.90	01.41
3	CM 128 × V 13	47.69	44.69	59.66	12.20	11.70	22.62	05.50	04.10	10.92
4	CM 128 × V 128	84.44	52.03	60.12	31.07	39.10	22.79	16.81	16.30	11.00
5	CM 128 × V 17	65.85	60.18	62.22	12.20	10.78	23.59	08.49	00.37	11.39
6	V 327 × V 335	39.74	52.81	48.34	27.00	01.91	17.31	12.70	00.88	05.80
7	V 327 × V 13	54.42	73.38	50.22	19.20	37.60	48.40	11.90	27.90	18.80
8	V 327 × V 128	64.81	50.46	57.32	31.16	27.40	07.69	24.51	12.50	03.57
9	V 327 × V 17	44.2	46.23	48.01	21.90	09.94	35.40	11.40	04.35	12.00
10	V 335 × V 13	50.89	64.71	64.99	09.36	08.71	26.02	05.98	05.70	12.41
11	V 335 × V 128	37.57	45.48	39.03	09.89	02.69	06.60	04.69	01.02	01.70
12	V 335 × V 17	35.42	49.16	52.08	07.20	34.80	02.22	03.00	18.00	00.79
13	V 13 ×V 128	56.82	52.52	56.65	50.00	40.40	68.60	32.40	06.00	26.80
14	V 13 × V 17	55.15	48.28	54.49	4.00	13.40	08.12	02.20	73.10	32.90
15	V 128 × V 17	70.23	44.71	61.02	26.46	07.10	18.40	19.79	02.60	06.80

35.42% to 84.44% during *kharif* at Hawalbagh (E_1), 44.69% to 73.38% during *rabi* at Rudrapur (E_2) and 39.03% to 64.99% in pooled data. The estimates of H_{bs} were higher in 8 crosses in E_1 and in 7 crosses in E_2. The H_{ns} ranged from 4.0% to 50.0% in E_1, 1.91% to 46.80% in E_2 and 3.40% to 68.60% in pooled data. Estimates of H_{ns} were higher in E_1 than in E_2 in 10 crosses. The H_{bs} estimates were high to very high in both the environments, while H_{ns} estimates ranged from very low to high in 2 environments. Furthermore, the estimates of both H_{bs} and H_{ns} varied in most of the crosses. Such variation was, however, more for H_{ns} as compared to H_{bs}. The heritability of a character may vary from one cross to another due to the extent of genetic variance present in the parents [13] and high heritability was also reported in the study for resistance to turcicum leaf blight [3]. The genetic advance ranged from 2.20% to 32.40% in E_1, 1.02% to 73.10% in E_2 and 0.79% to 32.90% in pooled analysis. The genetic advance was relatively higher in E_1 in 11 out of 15 crosses. The broad and narrow sense heritability estimates were higher in more number of crosses at Hawalbagh (E_1) than at Rudrapur (E_2). The higher estimates of additive component of variance, heritability and genetic advance in E_1 environment indicated that selection for turcicum leaf blight resistance was likely to be more effective at Hawalbagh than at Rudrapur. Reciprocal recurrent selection method may be followed for development of early maturing and turcicum leaf blight resistant cultivars of maize, especially for Himalayan hilly region.

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