

24. BREEDING FOR DOWNY MILDEW RESISTANCE IN OPAQUE-2 MAIZE

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The major emphasis of the protein quality maize improvement program is to combine the improve kernel vitreosity of the opaque-2 converted materials with downy mildew resistance. The reaction of this high quality protein maize to downy mildew diseases is the same as normal maize varieties; no resistant varieties have been developed. Efforts have been made in this breeding program to transfer downy mildew resistant characters from normal resistant varieties to opaque-2 varieties.

The Development of an Opaque-2 Composite with Downy Mildew Resistance

Seven elite normal maize populations, namely Thai Composite #1, Caripeno, Puerto Rico Gr. 1, Guatemala PB 5, Cupurico-Flint Comp., Caribbean Comp., and Cuba 40-Cuba Gr. 1 were crossed to Philippine DMR 1 and DMR 5, the downy mildew resistant sources. These 14 downy mildew incorporated populations were then crossed to Thai Opaque-2 Composite #1, an elite opaque-2 variety. The F₁ crosses were advanced to F₂ and only opaque phenotypes were selected in each cross. No attempt had been made to screen for downy mildew in these advanced generations; selections were made only when natural infection occurred.

Table 1. Grain yield and percen downy mildew infection of varieties grown in the Uniform Station Opaque-2 Yield Trial at Farm Suwan and Kampangsaen, Thailand in 1973

Entry	Downy Mildew Infection (%)		Grain Yield (kg/ha)	
	Farm Suwan	Kampangsaen	Farm Suwan	Kampangsaen
Ver. 181-Ant. Gr. 2 (Opaque)	87	84	1,184	387
Caribbean Mixed Comp. (O ₂ O ₂)	88	77	1,223	572
Thai Opaque-2 Comp. #1	88	91	1,564	594
Flint Comp. Amar. (O ₂ O ₂)	84	70	1,504	654
Cuba Gr. 1 (O ₂ O ₂)	84	76	1,604	440
Thai Opaque-2 Comp. #2	86	83	1,492	662
Thai Opaque-2 Comp. #3	70	64	2,792	1,197
Veratigua × Ver. 1 Opaco-2	90	93	1,072	358
Composite K	80	89	1,640	641
Yellow Hard Endosperm Comp.	88	80	1,339	586
White Hard Endosperm Comp.	84	73	1,391	1,290
Thai Composite #1 (S)C ₃ (Normal Check)	76	74	3,328	1,210
L. S. D. (0.05)			560	195
C. V. (%)			23.20	53.37

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In the F₄ generation full-sib families were generated in each population. Only good hard endosperm families from each population were selected and bulked to form Thai Opaque-2 Composite #3. This composite was planted in the downy mildew nursery in 1973 early season. Reciprocal full-sibs were again generated from the plants free of systemic downy mildew infection. At harvest only ears with good, hard endosperm kernels were saved. These full-sibbed ears were shelled separately and planted in both the downy mildew nursery and the crossing block in the following 1973 rainy season. Unfortunately, downy mildew infection failed to occur in either block, so selection was based only on hard endosperm character. However, progress can be evaluated from the results of 3 yield trials. In the Uniform Station Opaque-2 Yield Trials (Table 1) Thai Opaque-2 Composite #3 had a lower yield than other opaque-2 varieties in the trial. The result in the International Opaque-2 Maize Trial (Table 2) showed the same trend, i.e., Thai Opaque-2 Composite #3 had only 50 percent infected plants compared to as high as 90 percent infected plants in other varieties. In SEARCA Yield Trials (Table 3) few varieties, including Thai Composite #1 (DMR) × Thai Opaque-2 Composite #1 (F₃),

Table 2. Grain yield and percent downy mildew infection of varieties grown in the CIMMYT International Maize Testing Program IV, International Opaque-2 Maize Trial (IMOT) at Farm Suwan, Thailand in 1973

Entry	Origin	Downy Mildew Infection (%)	Grain Yield (kg/ha)
Agroceres 504	Brazil	91	542
Protina	India	80	1,590
Peru-1	Peru	85	668
Peru-2	Peru	80	1,531
Desarrural 02 CIII	Honduras	81	1,363
Shankii	India	80	966
INIAP Comp. Tropical	Ecuador	79	1,384
INIAP C515 × Comp. Tropical	Ecuador	68	2,328
INIA H-412	Mexico	69	1,732
INIA H-230	Mexico	86	717
INIA H-386	Mexico	71	2,230
INIA H-352	Mexico	72	1,519
Rattan	India	80	1,401
INIA H-309	Mexico	71	1,632
CIMMYT 02 Comp.	CIMMYT	81	1,398
Composite K (H. End.)	CIMMYT	83	1,229
(Ver. 181 × Ant. Gpo. 2) × (Ven. 1)	CIMMYT	81	1,338
Composite L (ME) ₂	CIMMYT	63	2,089
Flint Comp. Amarillo	CIMMYT	70	1,784
(Compo. K × La Posta)	CIMMYT	80	1,524
Thai 02 Comp. #1	Thailand	87	1,148
La Posta	CIMMYT	77	1,626
Comp. Grano Duro	CIMMYT	54	2,722
Thai Opaque-2 Comp. #3 (Local Opaque-2)	4007 73D	50	3,411
Thai Composite #1 (Local Normal)		64	3,215
L. S. D. (0.05)			723
C. V. (%)			26.8

Table 3. Grain Yield and percent downy mildew of varieties grown in the SEARCA High Lysine Trial at Farm Suwan and Kampangsaen, Thailand in 1973

Entry	Origin	Downy Mildew Infection (%)		Grain Yield (kg/ha)	
		Farm Suwan	Kampangsaen	Farm Suwan	Kampangsaen
College Composite O ₂ O ₂ (Yellow)	Philippines	93	85	1,072	396
[(Mimies WF Cuba GPO. 1×Tuxp.)#3×O ₂ O ₂]#2	Philippines	54	43	2,599	825
Ver. 181-Ant. Gpo. 2×Ven. 1 Opaco-2	Mexico	91	73	1,192	670
Comp. Amarillo Duro	Mexico	93	70	1,464	1,076
White Hard Endosperm Comp.	Mexico	78	75	1,847	894
Car. Mixed Comp. O ₂ O ₂	Thailand	88	64	1,488	741
Thai Opaque-2 Comp. #1	Thailand	85	61	1,882	1,409
Bogor Syn. 2 O ₂ O ₂	Indonesia	49	32	3,245	941
Bogor Comp. 2 O ₂ O ₂	Indonesia	66	62	1,712	1,121
Thai Comp. #1 (DMR)×Thai Opaque-2 Comp #1 (F ₃)	Thailand	52	40	3,170	1,556
Thai Comp. #1 (S)C ₃ (Local Check)	Thailand	77	59	2,593	1,884
L. S. D. (0.05)				762	729
C. V. (%)				22.10	40.89

one of 7 populations that formed Thai Opaque-2 Composite #3, showed relatively low percent infection among plants.

In the same rainy season 80 full-sib families of Thai Opaque-2 Composite (Hard Endosperm) from CIMMYT and 205 full-sib families of Thai Opaque-2 Composite #3 were planted in the nursery. Under the heavy natural epiphytotic condition the families from CIMMYT were almost wiped out while the families from the Thai Opaque-2 Composite #3 showed high frequency of resistant families (Table 4). The downy mildew

Table 4. Distribution of downy mildew reaction among full-sib families of the Thai Opaque-2 Composite

Class of % infected plants	No. of families	
	Thai Opaque-2 Comp. ¹⁾	Thai Opaque-2 Comp. #3 ²⁾
0- 10	—	8
11- 20	—	8
21- 30	—	20
31- 40	1	27
41- 50	—	30
51- 60	2	30
61- 70	9	25
71- 80	16	30
81- 90	19	23
91-100	33	4

1) 80 Full-sib families from CIMMYT

2) Full-sib families generated from downy mildew incorporated populations at Farm Suwan

Table 5. Downy Mildew reaction in some opaque-2 corn varieties at Farm Suwan, 1973 L

	Variety	Origin	Downy mildew infection (%)
1.	Veratigua × Ven. 1 Opaco-2	CIMMYT	91
2.	Thai Opaque-2 Comp. #3	F. S.	63
3.	Composite K	CIMMYT	74
4.	Yellow Hard End. Comp.	CIMMYT	88
5.	White hard Endo. Comp.	CIMMYT	75
6.	PD (MS) 6-ETO-Cuba Pob. Crist	CIMMYT	35
7.	PD (MS) 6-Gr. Amar.	CIMMYT	88
8.	PD (MS) 6-ETO-Cuba Pob. Crist × PD (MS) 6-Gr. Amar.	CIMMYT	93
9.	Nicarillo	CIMMYT	75
10.	DMR 3	Philippines	4
11.	DMR 5	Philippines	5
12.	Thai Comp. BC ₂ F ₃ (DMR)	F. S.	4
13.	Cuprico-Flint Comp. (DMR)	F. S.	56

reaction in some of the opaque-2 corn varieties planted in the same nursery was shown in Table 5. All varieties except PD(MS)₆-Eto-Cuba Pob. Crist from CIMMYT had high disease reaction comparing to the normal resistant varieties. The disease reaction in the Thai Opaque-2 Composite #3 was relatively low.

The Development of Backup Populations

It is anticipated that Thai Opaque-2 Composite #3 will be a core, hard endosperm opaque-2 population with downy mildew resistance. Further improvement is being made using the parallel breeding scheme proposed by CIMMYT, i.e., inter-population selection using an improved normal population and an improved opaque-2 population. Concurrently, backup populations are being developed. A few hard endosperm opaque-2 populations from CIMMYT, namely Composite K, Veracruz 181-Antigua Gr. 2 × Venezuela I Opaco-2, Yellow Hard Endosperm Composite, White Hard Endosperm Composite, etc., were crossed to normal DMR varieties and to Thai Opaque-2 Composite #3. The F₁'s from these crosses are being advanced and screened for downy mildew resistance.