15. RELATIVE DISEASE REACTION OF MAIZE VARIETIES TO DOWNY MILDEWS OVER VARIED ENVIRONMENTS (BASED ON INTERNATIONAL DOWNY MILDEW NURSERY 1969–1973)

Joginder SINGH*

Downy mildew of maize are an important disease complex not only in Asia but in several other tropical and sub-tropical maize growing countries of the world. A number of fungal species are known to incite the disease and cause severe damage to the plant foliage and developing ear. More than one species of downy mildew have been reported from an individual country. For instance in India, Philippines downy mildew (*Sclerospora philippinensis* Weston), Sorghum downy mildew (*S. sorghi* Weston and Uppal), Sugarcane downy mildew (*S. sacchari* Miyake) and brown stripe downy mildew (*Sclerophthora rayssiae* var. *zeae*, Payak and Renfro), are of economic importance. Likewise, brown stripe downy mildew and Philippine downy mildew are important in Nepal.

Information relating to chief disease symptom (on susceptible host varieties, under favourable weather conditions), geographic distribution and causal organisms of various downy mildews of maize is embodied in Table 1. Downy mildews are characterized by various types of chloratic streaks and presence of white downy growth on the lower leaf surface. Various species of downy mildew attacking maize, however, differ in their disease symptoms in minor details. The precise expression of disease symptoms is dependent on the age of the plant at infection, inoculum load as well as the macro- and micro-plant environment. Accordingly, under natural field condition, disease symptoms alone cannot be exclusively used in the correct identification of the specific downy mildew. Moreover, the information on the races as well as biotypes is entirely lacking, except for sorghum downy mildew wherein presence of two distinct races, namely, oriental and occidental (Futrell, 1972) and maize and sorghum (Payak, 1974) have been suggested. This complex situation throws a challange to the pathologists and breeders for devicing control measures so as to realize high stable production.

Various control measures have been suggested. Chemical control schedules have been developed in Philippines, Taiwan and India. Control of downy mildew through the use of Dueter and Dithane M22 or M45, Chloroneb, aureofungin etc. have been reported (Dalmacio and Exconde 1971, Schultz 1971, Payak in personal communication). Chemical control measures are not only laborious and expensive but these schedules cannot be rigidly practised particularly in wet season sowings. Proper crop management practices like earlier sowing, early roguing of infected seedlings and destroying collateral host under field help to reduce the disease incidence but cannot completely control the disease. Obviously, the incorporation of resistance into the commercial maize varieties and hybrids should help in ensuring stabilized production in disease prone regions.

Breeding for disease resistance basically requires (i) identification of sources of resistance to the prevailing pathotypes and (ii) knowledge about the mode of inheri-

* Project Coordinator (Maize), All India Coordinated Maize Improvement Project, Cummings Laboratory, Indian Agricultural Research Institute, New Delhi-110012, India.

Table 1. Downy mildews of maize, geographic distribution and chief symptoms

Downy mildew Pathotype	Caused by	Distribution	Symptoms and collateral host
Philipine downy mildew	*Sclerospora philippinensis* Weston	Philippines, India and Nepal	Extensive chlorsis assorciated with white downy mass on the ventral leaf surface. Ear development is retarded or poorly developed. Also attacks *Saccharumspontaneum; S. officinarum, Sorghum bicolor, S. halepense and S. propinquum.*
Sugarcane downy mildew	*Screlospra sacchari* Miyake	Taiwan, India, Australia, Fiji, Islands, Philippines and New Guinae	Yellow to whitish stripes or streaks develop at the base of 3rd to 6th leaf with marked chlorosis on the younger leaves. Leaf shreading not recorded on maize. Ears become small with poor grain filling and malformation. Increase in number of ears per plant is frequent. It is also known to attack *Tripsacum dactyloides* sugarcane and broom grass.
Sorghum downy mildew	*Sclerospra sorghi* Weston and Uppal	USA, Mexico, India, Thailand Nepal and Israel	Long, light-green to cream coloured parallel streaks. Ear development is retarded. Frequently plant terminates into a fan of small leaves. It also attacks Sudan grass, Sudan grass×Sorghum hydrids and *Heteropogon contortus*
Jawa downy mildew	*Sclerospora maydis* (Rec) Butler	Indonesia, Congo and Somaliland	Infected leaves show slight colorosis in case of localized symptoms. Seedlings from infected seeds show severe chlorosis right from the first leaf. It can also infect *Euchlaena mexicana*
Graminicola downy mildew	*Sclerospora graminicola* (Sacc) Schroet		Symptoms are similar to crazy top.
Crazy top	*Sclerophthora macrospora* (Sacc) Thirumalachar, Shaw and Nanashimahan	USA. Mexico, Eastern and Western Europe	Excessive tillering, rolling and twisting of upper leaves, chlorotic striping are less pronounced than philippine downy mildew. Phyllody or replacement of tassel with leaves is not infrequent.
Brown stripe downy mildew	*Schlerophthora rayssiae* var. *zeae* Payak and Renfro	India, Nepal, Sikkim and Bhutan	Narrow chlorotic or yellow stripes, of variable length and are delimited by veins. These stripes become necrotic and present a brown burnt appearance.

tance. Considerable data, on the first aspect, have been accumulated by the International Downy Mildew Nursery conducted during the period 1969 to 1973 (Renfro, 1973) while the information on the nature of inheritance for resistance is rather limited to the few efforts of individual breeders.

Our present knowledge about downy mildew poses two basic questions:

1) What are the most desirable downy mildew resistant varieties that will show stable performance under varied levels of disease incidence, and 2) possible location which have similar or dissimilar pathotypes.

Using the data accumulated under the Downy Mildew Nursery (Renfro, 1973) an attempt has been made in the present study to gather information on the above two aspects.

Identification of Maize Varieties Resistant to Downy Mildews

For this study data collected under the International Downy Mildew Nursery for the period 1969 to 1973 were subjected to regression analysis, using the methodology outlined by Eberhart and Russel (1966). All disease incidence data, originally recorded

as per cent, were transformed (angular transformation) in order to reduce the wide variation as well as to eliminate zero values. Data only from those locations for which error variance was available, were included in the study. After analysis the mean values were retransformed to per cent. Since most of the varieties tested over the five year period were not common, data for each year were analysed separately. Moreover, combined analysis was also carried out for five of the common varieties.

Analysis of variance and data relating to stability parameters viz. mean, regression b and deviation from regression S^2d, for 1969 to 1973 are presented in Table 2 to 11. The relationship between the regression b and mean values, and between mean value and environmental index is presented in Figures 1 to 8. The stability analysis for 1969 and 1970 (Tables 3 and 5) suggested that the correlation estimates for most of the varieties were rather low, thereby indicating poor fit to the linear model, hence

Table 2. Analysis of variance 1DMN 1869

Source	D. F.	M. S.
V	16	11.84×10^{2}**
E(L)	1	11.09×10^{2}**
V×E(L)	16	54.93
Pooled devs.	34	118.76
Pooled error	192	141.96

Table 3. Stability parameters for downy mildew: IDMN 1969

Pedigree	Mean %	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2d	F
Tx 325	80.0	1	1.97	0.6363	44	1.31
Tx 601	9.8	10	1.82	0.4879	204	2.44
Tx 441	47.7	3	2.79	0.8034	0	0.98
Antigua 2D	38.7	7	0.55	0.2705	0	0.88
Ganga 5	38.9	5	1.18	0.5939	0	0.58
Ganga 2	27.0	8	1.38	0.8233	0	0.20
Philippine DMR 2	3.8	12	0.14	0.1330	0	0.26
Philippine DMR 1	3.7	13	0.40	0.2876	0	0.41
A 206	2.0	17	0.27	0.3729	0	0.10
Ph 9DMR	2.6	15	−0.69	−0.4817	0	0.37
Mimies	2.3	16	−0.18	−0.1552	0	0.31
Aromin white flint	2.6	14	1.25	0.9190	0	0.06
Phil. Hyb 801	38.8	6	0.95	0.5782	0	0.42
DMR 131	7.1	11	0.66	0.2486	76	1.54
Tainan No. 5	52.8	2	2.35	0.7793	0	0.82
DMR comp. 1	13.9	9	1.45	0.8345	0	0.21
Check (Local)	47.6	4	0.65	0.1713	320	3.25
C. D. at 5%	9.5		0.39			

Location Mean	Pantnagar	Potzu (Aug.)	Los Banos (4 weeks)	Musuan (4 weeks)
	16.3	27.1	14.2	25.8
General Mean	20.5			

Table 4. Analysis of Variance IDMN 1970

Source	D. F.	M. S.
V	18	$24.13 \times 10^{2**}$
E(L)	1	$67.28 \times 10^{2**}$
V×E(L)	18	299.69*
Pooled devs.	114	84.22
Pooled error	432	104.05

Table 5. Stability parameters for downy mildew: IDMN 1970

Pedigree	Mean %	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
CM 105	41.0	5	1.88	0.7947	18	1.17
Taiwan DMR comp. 1	8.8	10	0.63	0.8090	0	0.12
Taiwan DMR comp. 2	3.7	15	−0.11	−0.1658	0	0.28
Taiwan DMR comp. 3	12.5	9	0.91	0.8085	0	0.25
Phil. DMR 1	4.6	14	0.27	0.3894	0	0.22
Chain DMR syn.	3.0	16	0.06	0.1524	0	0.10
Phil. DMR 2	6.9	11	0.57	0.5879	0	0.35
Ph 9 DMR	2.2	18	−0.06	−0.0845	0	0.32
Phil. DMR 3	2.6	17	0.52	0.6793	0	0.17
Bogor Syn 2	4.8	13	0.57	0.8255	0	0.08
Peer Rehovot	71.8	1	2.27	0.6158	393	4.78
Tx 441	23.8	8	2.10	0.8091	33	1.32
Tx 601	6.8	12	−0.36	−0.3392	0	0.58
Caribbean comp.	44.6	4	1.97	0.9515	0	0.23
CM 110	40.7	6	2.15	0.9186	0	0.48
Taiwan #5	65.2	3	2.18	0.8970	0	0.65
La Granja yel. pop	66.3	2	1.97	0.8047	21	1.21
Local variety	29.2	7	1.19	0.4998	150	2.44
Sorghum	1.3	19	0.24	0.2398	0	0.56
C. D. at 5%	2.9		1.38			

Location Means	Potzu (April) 22.1	Thailand I 23.4	Pantnagar 37.3	Texas 25.0	Thailand II 10.5
	Thailand III 10.1	Thailand IV 8.4	Udaipur 20.7		
General Mean	18.9				

stability estimates for these two years should be viewed more cautiously.

The most desirable varieties should have lowest mean and regression b, while the S^2d should be lowest. Such varieties will be positioned in the left hand lower quadrant in the 'mean-regression b' graphs. The most promising varieties selected on the basis of stability analysis of individual year are as follows:

1969: Ph 9 DMR, Mimies, Phil. DMR 2, A 206, Phil. DMR 1, DMR 131.
1970: Tx 601, Taiwan DMR Comp 2, Ph 9 DMR, Chain cross DMR syn.
1971: Phil. DMR 4, Phil. DMR 1*, Phil. DMR 6* Phil. DMR 2*

Table 6. Analysis of variance IDMN 1971

Source	D. F.	M. S.
V	16	21.15×10^{2}**
E(L)	1	29.38×10^{3}**
V×E(L)	16	280.93*
Pooled devs.	85	89.46
Pooled error	336	108.96

Table 7. Stability parameters for downy mildew: IDMN 1971

Pedigree	Mean %	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
CM 105	85.5	4	0.66	0.7280	26	1.24
Tx 441	76.7	6	1.22	0.8729	53	1.49
Tx 601	76.4	7	1.33	0.9288	0	0.94
Caribbean comp. (III)	93.5	2	0.58	0.9612	0	0.09
Tainan DRM 1	65.8	8	1.22	0.8864	33	1.30
Bogor syn. 1	50.6	9	1.48	0.9646	0	0.52
Bogor syn. 2	40.0	12	1.31	0.9245	0	0.92
Ph 9 DMR	42.0	11	1.49	0.9512	0	0.74
Philippine DMR 1	35.9	16	1.05	0.9385	0	0.47
Philippine DMR 2	39.1	14	1.09	0.9698	0	0.24
Philippine DMR 4	42.6	10	0.92	0.9767	0	0.13
Philippine DMR 6	37.8	15	1.09	0.9751	0	0.19
Tuxpantiqua-MIT DMR	39.3	13	1.33	0.9599	0	0.48
UPCA sweet syn. 1	82.7	5	0.92	0.9688	0	0.17
La Granja yel. pop	94.7	1	0.50	0.8907	0	0.21
Local check	85.9	3	−0.01	−0.0137	166	2.52
Sorghum (check)	4.0	17	0.69	0.6392	134	2.23
C. D. at 5%	3.7		0.65			

Location Mean	Farm Suwan 44.6	Chaibadan 49.4	Nakorn Sawan 72.2	Potzu 18.8	Musuan (4 weeks) 18.2
	Ilagan (4 weeks) 84.0	Bogor (4 weeks) 44.0			
General Mean	59.6				

1972: Taiwan DMR 2, Chain cross DMR, Phil. DMR 5, Phil. DMR 1*
1973: Phil. DMR 3, Tainan DMR 2, Phil. DMR 1, Ph 9 DMR*, Phil. DMR 4*
* Regression (b) more than 1

Stability analysis, of five varieties tested over the five years, representing 26 environments, was also carried out and is presented in Tables 12 and 13, and Figures 9 and 10. The variety Phil. DMR 1 recorded the lowest mean and regression b, with zero estimates of S^2d. The variety Ph 9 DMR which had the second lowest mean value had the highest regression and is likely to be less stable. Phil. DMR 2 was comparable with regard to mean and regression b (0.93) to Phil. DMR 1. Thus, Phil. DMR 1 and

Table 8. Analysis of variance IDMN 1972

Source	D. F.	M. S.
V	15	442.56**
E(L)	1	19.61×10^3**
V×E(L)	15	25.96*
Pooled devs.	16	62.59
Pooled error	135	90.79

Table 9. Stability parameters for downy mildew IDMN 1972

Pedigree	Mean %	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
Tainan DMR 1	37.3	5	0.99	0.9998	0	0.00
Tainan DMR 2	20.4	15	0.88	0.9978	0	0.04
2027-3-5×Ly 22-4	46.4	3	1.29	0.9541	111	2.22
Ph 9 DMR×Amr III	45.0	4	0.94	0.9987	0	0.03
Bogor syn. 2	35.8	6	1.04	0.9892	0	0.32
Chain Cross DMR	22.2	14	0.89	0.9857	0	0.31
Phil. DMR 1	26.0	13	1.03	0.9986	0	0.03
Phil. DMR 2	32.8	8	1.03	0.9999	0	0.00
Phil. DMR 4	33.4	7	0.99	0.9971	0	0.07
Phil. DMR 5	17.1	16	0.96	0.9975	0	0.06
Phil. DMR 6	31.1	9	1.12	0.9997	0	0.00
Tuxpantiqua×MIT	28.3	11	1.03	0.9994	0	0.01
Taiwan CIMMYT DMR 13	26.3	12	1.19	0.9973	0	0.10
Ph 9 DMR	28.9	10	1.07	0.9653	11	1.13
La Granja pop corn	84.0	1	0.69	0.9810	0	0.25
Local check	82.8	2	0.78	0.7505	489	6.39
C. D. at 5%	7.6		0.65			

Location Mean	Farm Suwan 12.9	Potzu 18.8	Bogor 83.5
General Mean	37.2		

Phil. DMR 2 were the most desirable varieties which deserve priority in their utilization in breeding programmes.

Data on grain yield collected under the International Downy Mildew Yield Trial for 1971 and 1972 were also subjected to regression analysis. Stability analyses for 1971 and 1972 and combined over the two years, are presented in Tables 14 to 19 and Figures 11 to 16. For grain yield, varieties with high mean yield and regression b of 1.0 and above 1.0 respectively would be most desirable for average to above average environments. The local check variety had the highest mean with a regression of 1.16. Next best to the check was Taiwan DMR 10 which had the highest value of regression b (1.25). The most promising variety Phil. DMR 1, from disease resistance view point, was unfortunately low yielder. The other variety Phil. DMR 2 ranked fourth and gave higher yield than grand mean, with a regression of 1.15.

From above data no attempt should be made to establish any logical association

Table 10. Analysis of variance IDMN 1973

Source	D. F.	M. S.
V	14	$12.46 \times 10^{2**}$
E(L)	1	$93.28 \times 10^{2**}$
V×E(L)	14	136.92
Pooled devs.	30	18.36
Pooled error	168	87.34

Table 11. Stability parameters for downy mildew: IDMN 1973

Pedigree	Mean %	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
Bogor syn. 2	32.8	7	1.39	0.9814	0	0.26
Ph 9 DMR	19.1	12	1.07	0.9822	0	0.15
Phil. DMR 1	19.2	11	0.85	0.9931	0	0.03
Phil. DMR 2	21.2	9	1.16	0.9789	0	0.21
Phil. DMR 3	12.5	14	0.48	0.9551	0	0.08
Phil. DMR 4	20.0	10	1.04	0.9340	0	0.57
Thai. DMR comp. 3	36.3	5	1.49	0.9967	0	0.05
Tainan DMR 2	12.8	13	0.78	0.9692	0	0.14
Tainan DMR 4	35.4	6	1.38	0.9911	0	0.12
Tainan DMR 10	46.6	4	1.02	0.9968	0	0.02
Tainan (CIMMYT) DMR 11	52.3	3	1.36	0.9921	0	0.10
Tainan (CIMMYT) DMR 13	26.7	8	1.21	0.9898	0	0.10
Hawaiin Super Sweet (SUSC)	92.7	1	1.53	0.9530	0	0.84
Local variety (check)	83.2	2	0.16	0.4218	0	0.44
Sorghum TSS 18-8	0.5	15	0.00	—	0	0.00
C. D. at 5%	1.5		0.49			

Location Mean	Nakon Sawan 35.6	Chaibadan 43.1	Farm Suwan 53.9	Potzu 6.0
General Mean	32.5			

between yield and disease incidence. It is important to remember that the Downy Mildew Yield Trials were conducted under varied levels of disease incidence. Evaluation of isogenic lines under high levels of disease incidence should provide the necessary answer.

Association Between Different Pathotypes of Maize

Information on this aspect was attempt by running all possible rank correlations between various locations within each year data of International Downy Mildew Nursery. Data on rank correlations (ρ) and (ρ^2) for each year are presented in Table 20. The ρ^2 values obtained in individual year were classified on the basis of their magnitude (Table 21). The ρ values for most of the comparisions were significant, but ρ^2 estimates of above 60% shall have practical predictive value.

No clear pattern emerged from Table 21 which summarized data over the five year period. This was partly due to lack of uniformity in the choice of test locations over the five years. Some of specific points of interest are:

Table 12. Analysis of variance IDMN 1969–1973

Source	D. F.	M. S.
V	4	$41.42 \times 10^{2**}$
E(L)	1	$39.96 \times 10^{3**}$
V×E(L)	4	86.72
Pooled devs.	120	81.79
Pooled error	312	83.47

Table 13. Stability parameters for downy mildew IDMN 1969–1973

Pedigree	Mean %	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
Phil. DMR 1	14.7	5	0.93	0.9664	0	0.24
Phil. DMR 2	18.3	3	0.93	0.9476	0	0.39
Bogor Syn. 2	18.8	2	1.09	0.9530	0	0.48
Ph 9 DMR	15.7	4	1.12	0.9491	0	0.55
Local	62.6	1	0.90	0.7096	184	3.21
C. D. at 5%	0.9		0.31			

Location Mean	Taiwan Potzu (Aug.) 12.2	Los Banos (2 weeks) 10.7	Los Banos (4 weeks) 13.4	Taiwan, Potzu April 2.6	Taiwan, Potzu Sept. 1.9
	Thailand, Nakorn Sawan I 19.3	Thailand, Nakorn Sawan II 5.0	Thailand, Nakorn Sawan III 5.3	Thailand, Nakorn Sawan IV 3.3	India Pantnagar 12.0 / India Udaipur 8.1
	Texas Berclair 13.7	Farm Suwan 29.9	Thailand Chaibadan 45.6	Nakorn Sawan 55.1	Taiwan Potzu 12.5
	Philippines Musuan (4 weeks) 91.3	Philippines Ilagan (4 weeks) 72.2	Indonesia Bogor (4 weeks) 36.4	Thailand Farm Suwan 13.3	Taiwan Potzu 26.2
	Indonesia Bogor 86.1	Nakorn Sawan 33.9	Thailand Chaibadan 44.0	Farm Suwan 58.0	Taiwan Potzu 9.3
General Mean	24.8				

1. The association between two locations of Philippines, Los Banos and Musuain 1969, Musuain and Ilagan in 1971 was low. The ρ^2 estimates for Musuan—Los Banos during 1970 were very high. Could this disparity be due tao presence of two different biotypes of downy mildew during 1969 and 1971?

2. Low values of Potzu-Musuan, Potzu-Ilagan were rather unexpected since relative resistance to Philippine and sugarcane downy mildews have frequently been recorded.

3. Close association in relative ranking of varieties at three environments of Thailand was recorded. Probably, only one testing site would be enough for future evaluations.

Table 14. Analysis of Variance IDMYT 1971 & 1972

Source	D. F.	M. S.
V	11	$19.76\times10^{5**}$
E(L)	1	$16.65\times10^{7**}$
V×E(L)	11	$65.89\times10^{4**}$
Pooled devs.	108	19.60×10^{4}
Pooled error	363	28.51×10^{4}

Table 15. Stability parameters for grain yield: IDMYT, 1971 and 1972

Pedigree	Variety Mean (kg/ha)	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
Philippine DMR 1	3,212	8	0.88	0.9199	0	0.76
Philippine DMR 2	3,584	4	1.15	0.9424	0	0.90
Philippine DMR 3	3,576	5	1.01	0.9509	0	0.58
Philippine DMR 4	3,854	3	1.21	0.9802	0	0.32
Philippine DMR 5	3,323	7	1.02	0.9723	0	0.32
Philippine DMR 6	3.572	6	1.21	0.9900	0	0.16
Taiwan DMR comp. #1	3,161	9	0.90	0.9376	0	0.60
Taiwan DMR comp. #2	3,035	11	0.91	0.9750	0	0.23
Taiwan DMR comp #4	3,140	10	0.60	0.7311	210,491	1.73
Taiwan DMR comp. #10	4,004	2	1.25	0.9473	0	0.97
Taiwan DMR comp. #12	2,597	12	0.64	0.8136	42,194	1.14
Local check	4,009	1	1.16	0.9692	0	0.47
C. D. at 5%	404		0.34			

Location Mean	Bogor 1,817	Udaipur 3,834	Ludhiana 4,892	Farm Suwan 3,914	Catabato 2,235
	Farm Suwan 4,418	UPCA 4,132	Pantnagar 3,244	Udaipur 2,333	Ludhiana 1,898
	Bogor 4,932				
General Mean	3,423				

4. Relationship between locations of Philippines (Philippine downy mildew) and Indonesia (Jawa Downy mildew), was very poor suggesting poor relationship in pathogenicity.

5. Relative ranking of varieties for reaction to downy mildew in Indonesia and Thailand was fairly close, suggesting comparable pathogenicity to sorghum and jawa downy mildews.

The above information based on rank correlation provides only an indirect evidence, more precise confirmatory information based on inheritance studies to various downy mildew would provide the definite answer.

Table 16. Analysis of Variance IDMYT 1971

Source	D. F.	M. S.
V	11	$16.7\times10^{5**}$
E)L)	1	$78.3\times10^{6**}$
V×E(L)	11	38.0×10^{4}
Pooled devs.	36	14.1×10^{4}
Pooled error	165	39.5×10^{4}

Table 17. Stability parameters for grain yield, IDMYT 1971

Pedigree	Variety Mean (kg/ha)	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
Philippine DMR 1	2,848	10	0.62	0.9810	0	0.08
Philippine DMR 2	3,547	4	0.90	0.9698	0	0.28
Philippine DMR 3	3,524	6	0.92	0.9223	0	0.81
Philippine DMR 4	4,009	2	1.18	0.9980	0	0.03
Philippine DMR 5	3,240	7	0.93	0.9642	0	0.36
Philippine DMR 6	3,537	5	1.14	0.9898	0	0.14
Taiwan DMR comp. #1	3,200	8	1.05	0.9661	0	0.44
Taiwan DMR comp. #2	3,077	9	1.04	0.9953	0	0.05
Taiwan DMR comp. #4	2,641	11	0.83	0.8974	0	0.92
Taiwan DMR comp. #10	4,168	1	1.43	0.9715	0	0.66
Taiwan DMR comp. #12	2,256	12	0.63	0.9231	0	0.37
Check	3,983	3	1.27	0.9954	0	0.08
C. D. at 5%	543		0.43			

Location Mean	Bogor 1,817	Udaipur 3,834	Ludhiana 4,892	Farm Suwan 3,914	Cotabato 2,235
General Mean	3,338				

Table 18. Analysis of Variance IDMYT 1972

Source	D. F.	M. S.
V	11	$70.24 \times 10^{4**}$
E(L)	1	$87.46 \times 10^{6**}$
V×E(L)	11	$66.17 \times 10^{4}{}_{*}$
Pooled devs.	48	15.59×10^{4}
Pooled error	198	19.31×10^{4}

Table 19. Stability parameters for grain yield, IDMYT 1972

Pedigree	Variety Mean (kg/ha)	Rank	Reg. coeff. (b)	Corr. coeff. (r)	S^2D	F
Philippine DMR 1	3,516	8	1.08	0.9778	0	0.50
Philippine DMR 2	3,593	6	1.38	0.9620	89,096	1.46
Philippine DMR 3	3,620	4	1.10	0.9771	0	0.56
Philippine DMR 4	3,724	3	1.27	0.9932	0	0.20
Philippine DMR 5	3,392	9	1.10	0.9830	0	0.40
Philippine DMR 6	3,602	5	1.28	0.9948	0	0.16
Taiwan DMR comp. #1	3,128	10	0.77	0.9357	0	0.79
Taiwan DMR comp. #2	3,000	11	0.80	0.9782	0	0.27
Taiwan DMR comp. #4	3,555	7	0.35	0.7481	0	0.93
Taiwan DMR comp. #10	3,867	2	1.12	0.9637	0	0.91
Taiwan DMR comp. #12	2,880	12	0.62	0.7888	242,057	2.25
Check	4,032	1	1.08	0.9486	43,087	1.22
C. D. at 5%	510		0.42			

Location Mean	Farm Suwan 4,418	UPCA 4,132	Pantnagar 3,244	Udaipur 2,333	Ludhiana 1,898
	Bogor 4,932				
General Mean	3,493				

Table 20. Rank correlation (ρ) among various locations, International Downy Mildew Nursery, 1969–1973

	Taiwan (Potzu) August	L. Banos 4 weeks	Musuan 4 weeks
India (Pantnagar)	0.839** (70.30)	0.784** (61.51)	0.755** (56.92)
Taiwan (Potzu) August		0.888** (78.88)	0.733 (53.77)
L. Banos (4 weeks)			0.625 (39.00)

Table 20 (contd.)

(1970)

	Thailand 1 (N.S.)	India P'Nagar	Texas Berclair	Thailand 2 (N.S.)	Thailand 3 (N.S.)	Thailand 4 (N.S.)	India Udaipur	Philippines	
								Musuan	L. Banos
Taiwan (Potzu)	0.738** (54.52)	0.900** (81.03)	0.767** (58.79)	0.888** (78.80)	0.838** (70.25)	0.818** (66.84)	0.892** (79.47)	0.844** (71.16)	0.922** (85.04)
Thailand 1 (Nakorn Sawan)		0.756** (57.09)	0.606** (36.72)	0.802** (64.28)	0.828** (68.50)	0.774** (59.92)	0.720** (51.78)	0.686** (47.00)	0.779** (60.69)
India (Pantnagar)			0.785** (61.54)	0.858** (73.56)	0.834** (69.50)	0.864** (74.61)	0.876** (76.65)	0.817** (66.71)	0.866** (75.03)
Texas (Berclair)				0.773** (59.79)	0.732** (63.50)	0.797** (63.56)	0.724** (52.38)	0.559** (31.29)	0.692** (47.81)
Thailand 2 (Nakorn Sawan)					0.915** (83.79)	0.901** (81.21)	0.921** (84.82)	0.780** (60.91)	0.880** (77.42)
Thailand 3 (Nakorn Sawan)						0.930**	0.894** (79.88)	0.812** (65.98)	0.898** (80.62)
Thailand 4 (Nakorn Sawan)							0.901** (81.19)	0.819** (67.09)	0.874** (76.45)
India (Udaipur)								0.939** (88.13)	0.942** (88.47)
Philippines (Musuan)									0.933** (87.10)

Table 20 (contd.)

(1971)

	Thailand		Taiwan Potzu	Philippines		Indonesia Bogor
	Cahibadan	Nakorn Sawan		Musuan	Ilagan	
Thailand (Farm Suwan)	0.830** (68.82)	0.826** (68.24)	0.819** (67.04)	0.327 (10.69)	0.545* (29.07)	0.672** (45.18)
Thailand (Chaibadan)		0.718** (51.48)	0.745** (55.47)	0.496* (24.57)	0.396 (15.68)	0.784** (61.41)
Thailand (Nakorn Sawan)			0.837** (70.04)	0.505* (25.47)	0.633** (40.08)	0.838** (70.15)
Taiwan, Potzu				0.473* (22.34)	0.524* (27.43)	0.723** (52.33)
Philippines, Musuan					0.729** (53.18)	0.615** (37.82)
Philippines, Ilagan						0.573* (32.85)

Table 20 (contd.)

(1972)

	Taiwan (Potzu)	Indonesia (Bogor)	Thailand (Nakorn Sawan)
Thailand (Farm Suwan)	0.567* (32.16)	0.790** (62.33)	0.506* (25.58)
Taiwan (Potzu)		0.752** (56.52)	0.802** (64.27)
Indonesia (Bogor)			0.337 (11.38)

Table 20 (contd.)

(1973)

	Thaliand		Taiwan Potzu	Philippines Musuan	Indonesia Bogor
	Chaibadan	Farm Suwan			
Thailand (Nakorn Sawan)	0.943** (88.88)	0.956** (91.29)	0.747* (55.75)	0.616** (37.99)	0.890** (79.26)
Thailand (Chaibadan)		0.896** (80.26)	0.666** (44.34)	0.537** (28.83)	0.861** (74.09)
Thailand (Farm Suwan)			0.705** (40.68)	0.607** (36.85)	0.892** (79.60)
Taiwan (Potzu)				0.348 (12.08)	0.723** (52.22)
Philippines (Musuan)					0.721** (52.02)

Values in parentheses relate to ρ^2

Table 21. Rank correlations among various locations of IDMN

	1967	1970	1971	1972	1973
ρ^2 over 80%		Potzu–Pantnagar Potzu–Los Banos NS II–NS III NS II–NS IV NS II–Udaipur NS III–NS IV NS III–Los Banos NS IV–Udaipur Udaipur–Musuan Udaipur–Los Banos Musuan–Los Banos			NS–Chaibadan NS–Farm Suwan Chaibadan–Farm Suwan
ρ^2 between 60–80%	P'Nagar–Potzu P'Nagar–L. Banos Potzu–L. Banos	Potzu–NS II Potzu–NS III Potzu–NS IV Potzu–Udaipur Potzu–Musuan NS I–NS II NS I–NS III NS I–L. Banos P'Nagar–Texas P'Nagar–NS II P'Nagar–NS III P'Nagar–NS IV P'Nagar–Udaipur P'Nagar–Musuan P'Nagar–L. Banos	Farm Suwan–Chaibadan Farm Suwan–Nakorn Sawan Farm Suwan–Potzu Chaibadan–Bogor Nakorn Sawan–Potzu Nakorn Sawan–Bogor	Farm Suwan–Bogor Potzu–NS	NS–Bogor Chaibadan–Bogor Farm Suwan–Bogor

Tabl 21 (contd.)

	1969	1970	1971	1972	1973
ρ^2 between 60–80%		Texas–NS IV NS II–Musuan NS II–L. Bogor NS III–Udaipur NS III–Musuan NS IV–Musuan NS IV–L. Banos			
ρ^2 between 40–60%	P'Nagar–Musuan Potzu–Musuan	Potzu–NS I Potzu–Texas NS I–Pantnagar NS I–NS IV NS I–Udaipur NS I–Musuan Texas–NS II Texas–NS III Texas–Udaipur Texas–L. Banos	Farm Suwan–Bogor Chaibadan–NS Chaibadan–Ilagan Potzu–Bogor Musuan–Ilagan	Potzu–Bogor	N. S–Potzu Chaibadan–Potzu Farm Suwan–Potzu Potzu–Bogor Musuan–Bogor
ρ^2 below 40%	L. Banos–Musuan	NS I–Texas Texas–Musuan	Farm Suwan–Musuan Farm Suwan–Ilagan Chaibadan–Musuan Chaibadan–Ilagan Nakorn Sawan–Musuan Potzu–Musuan Potzu–Ilagan Musuan–Bogor Ilagan–Bogor	Farm Suwan–Potzu Farm Suwan–N. S. Bogor–N. S.	N. S.–Musuan Chaibadan–Musuan Farm Suwan–Musuan Potzu–Musuan

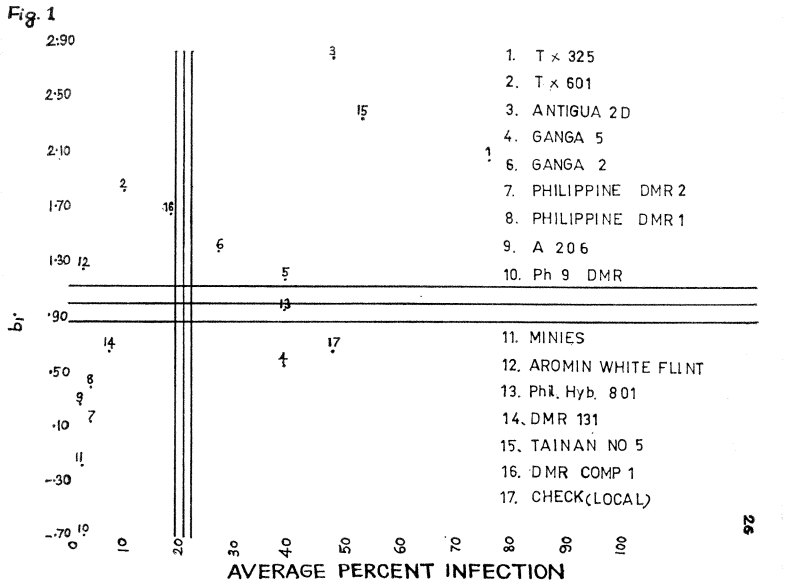

Fig. 1. Relation of downy mildew infection and stability —International downy mildew nursery—1969

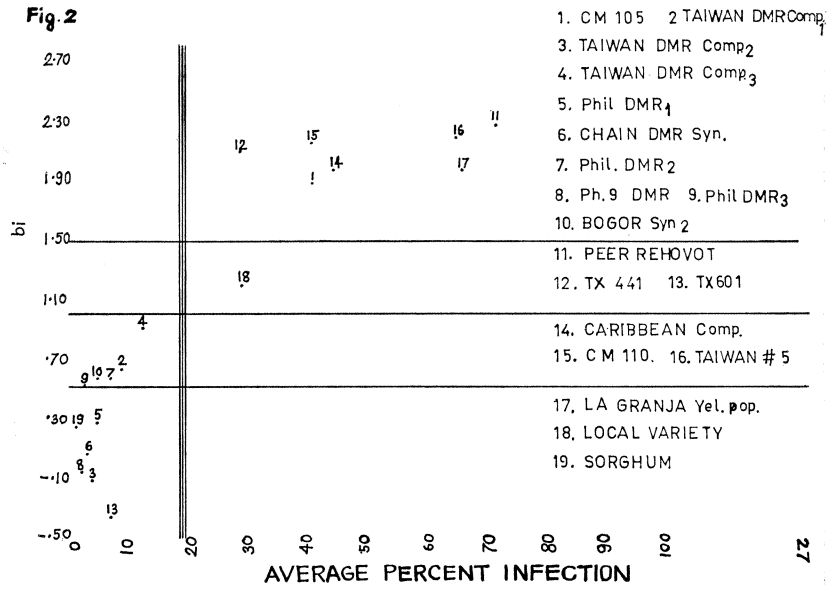

Fig. 2. Relation of downy mildew infection and stability —International downy mildew nursery—1970

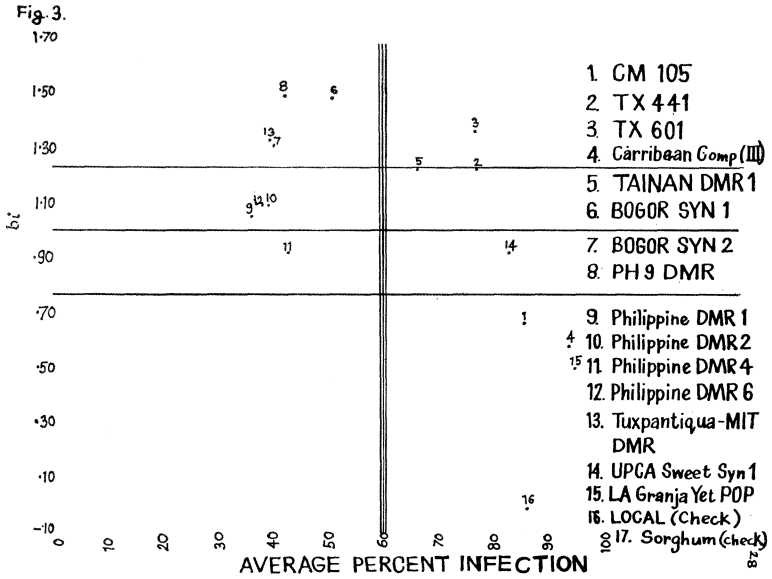

Fig. 3. Relation of downy mildew infection and stability —International downy mildew nursery—1971

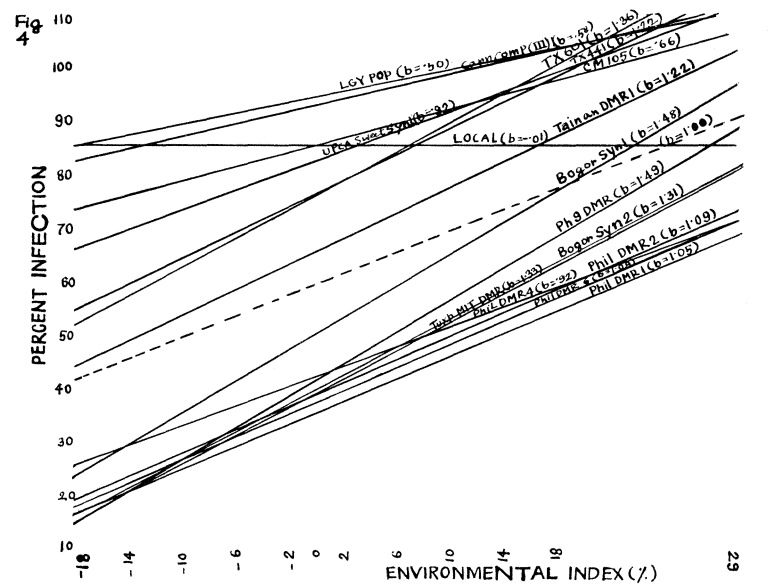

Fig. 4. Response of maize varieties to varying environments —International downy mildew nursery—1971

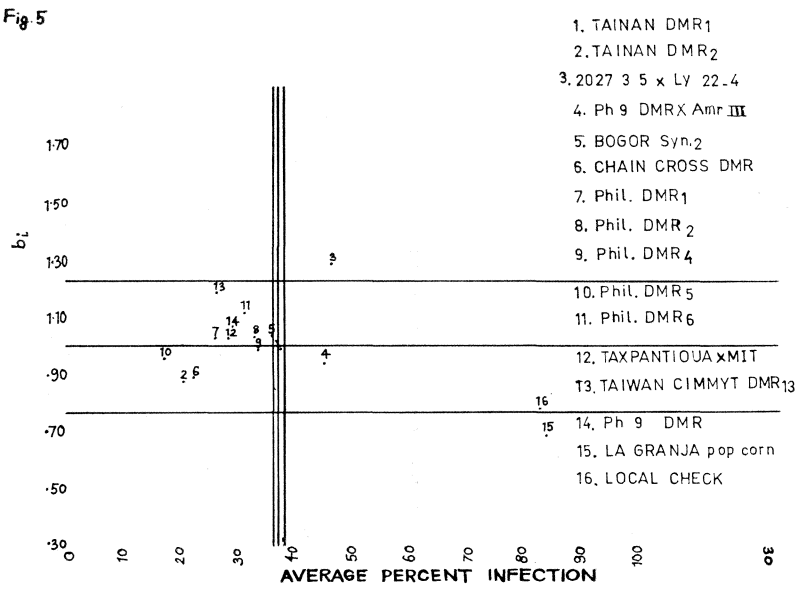

Fig. 5. Relation of downy mildew infection and stability —International downy mildew nursery—1972

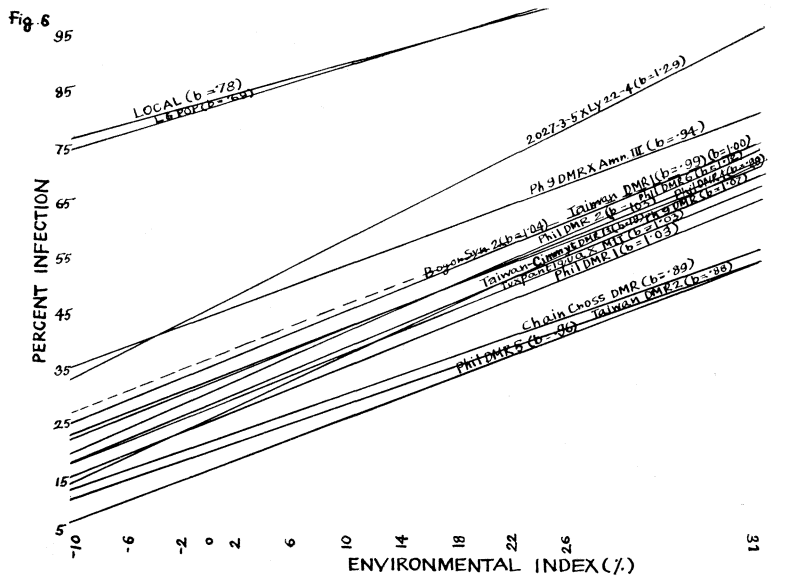

Fig. 6. Response of maize varieties to varying environments —International downy mildew nursery—1972

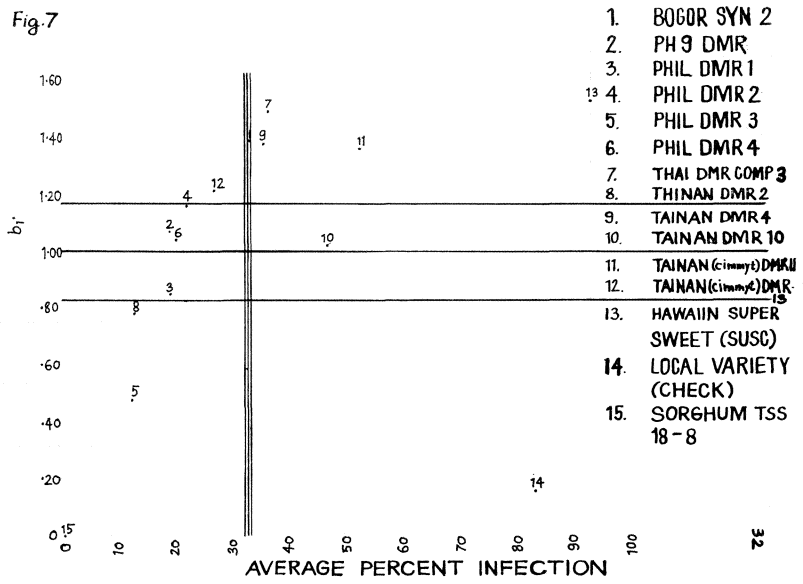

Fig. 7. Relation of downy mildew infection and stability —International downy mildew nursery—1973

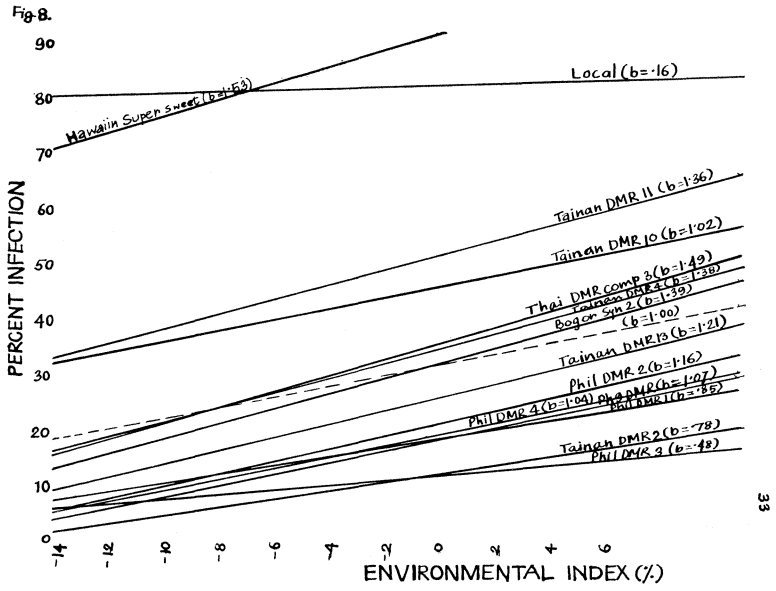

Fig. 8. Response of maize varieties to varying environments —International downy mildew nursery—1973

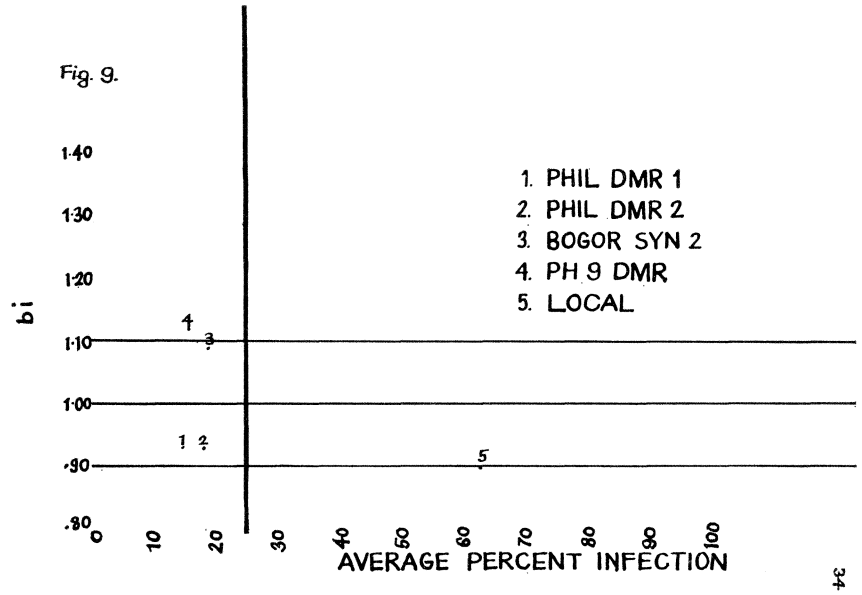

Fig. 9. Relation of downy mildew infection and stability —International downy mildew nursery—1969–73

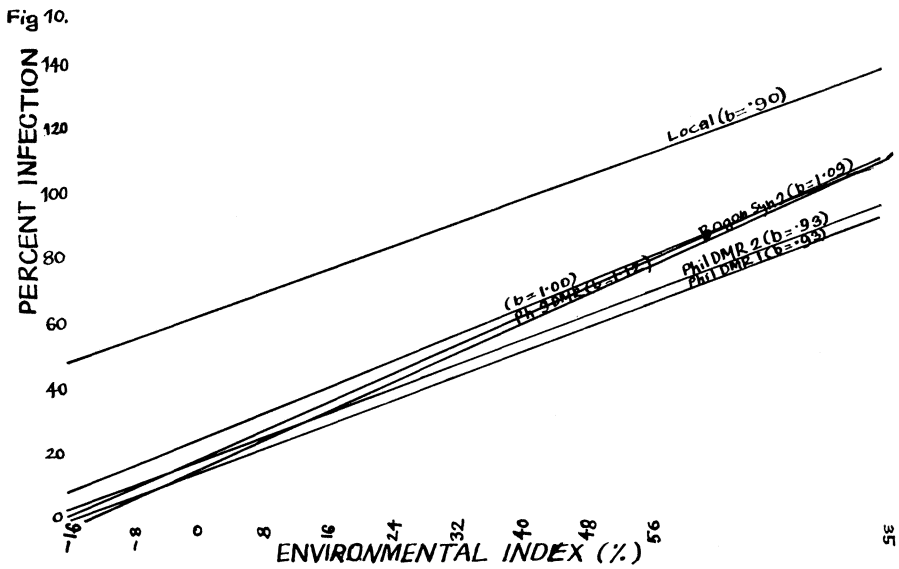

Fig. 10. Response of maize varieties to varying environments —International downy mildew nursery—1969–73

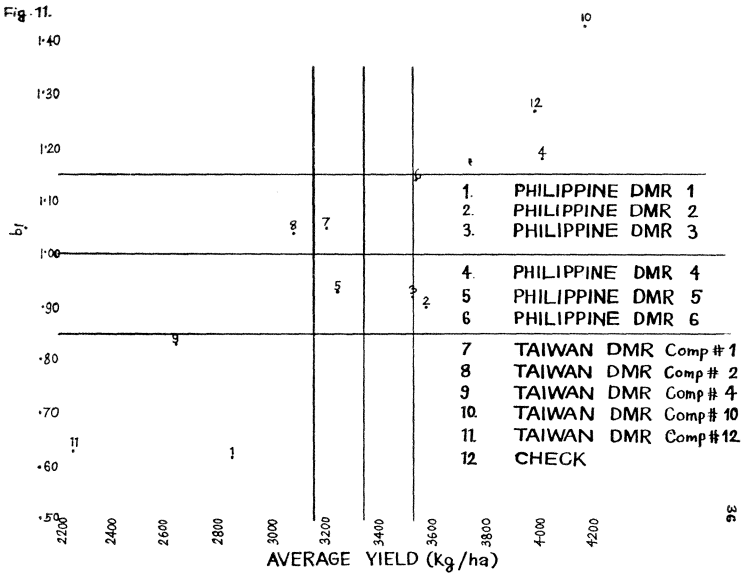

Fig. 11. Relation of yield and stability —Downy mildew yield trial—1971

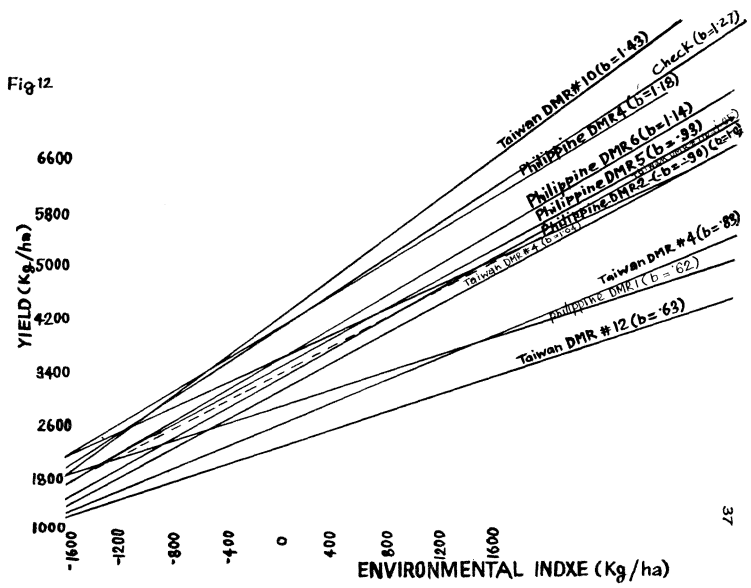

Fig. 12. Response of maize varieties to varying environments —Downy mildew yield trial—1971

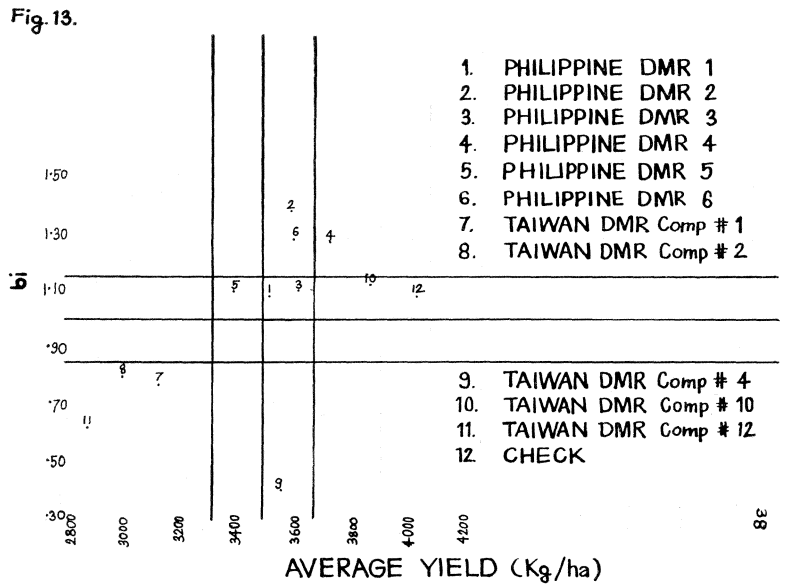

Fig. 13. Relation of yield and stability —Downy mildew yield trial—1972

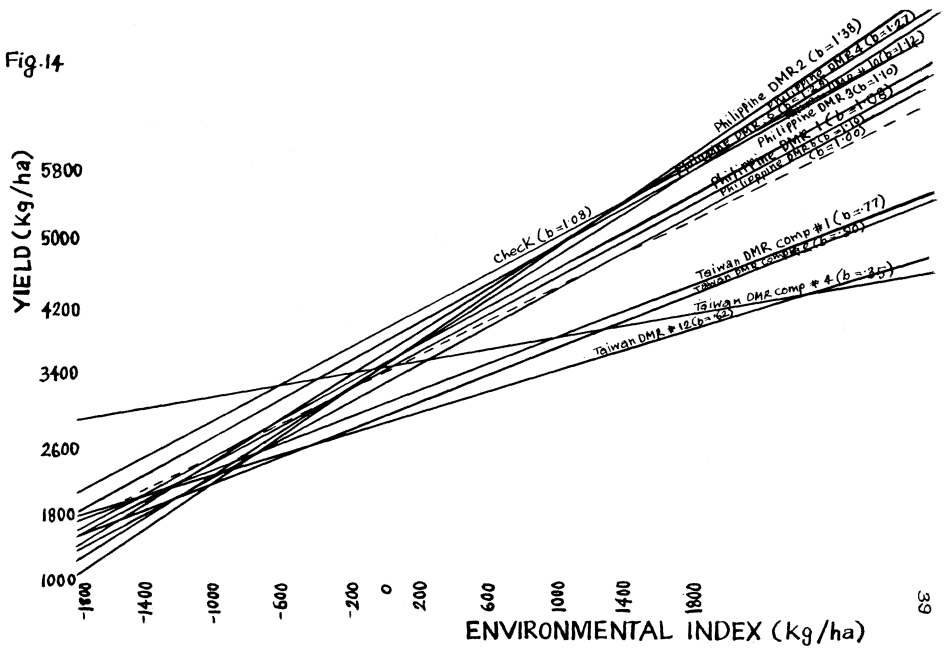

Fig. 14. Response of maize varieties to varying environments —Downy mildew yield trial—1972

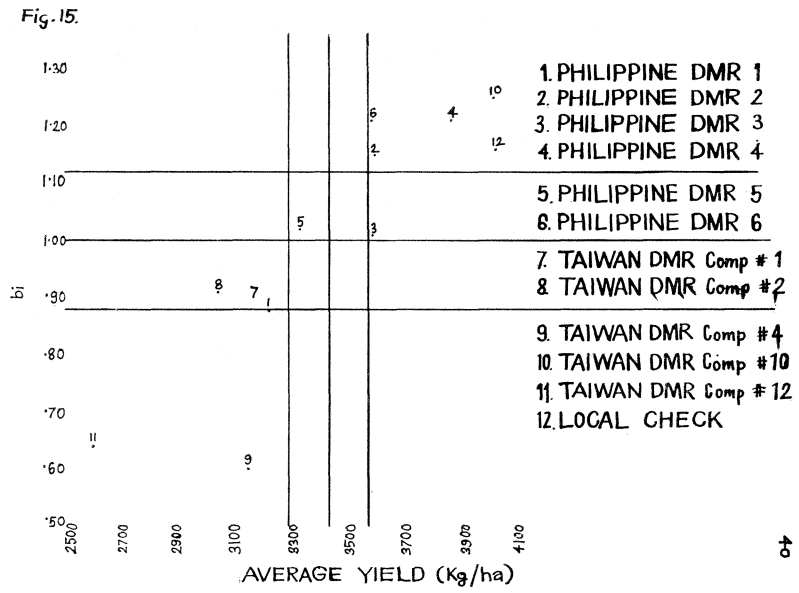

Fig. 15. Relation of yield and stability —Downy mildew yield trial—1971–72

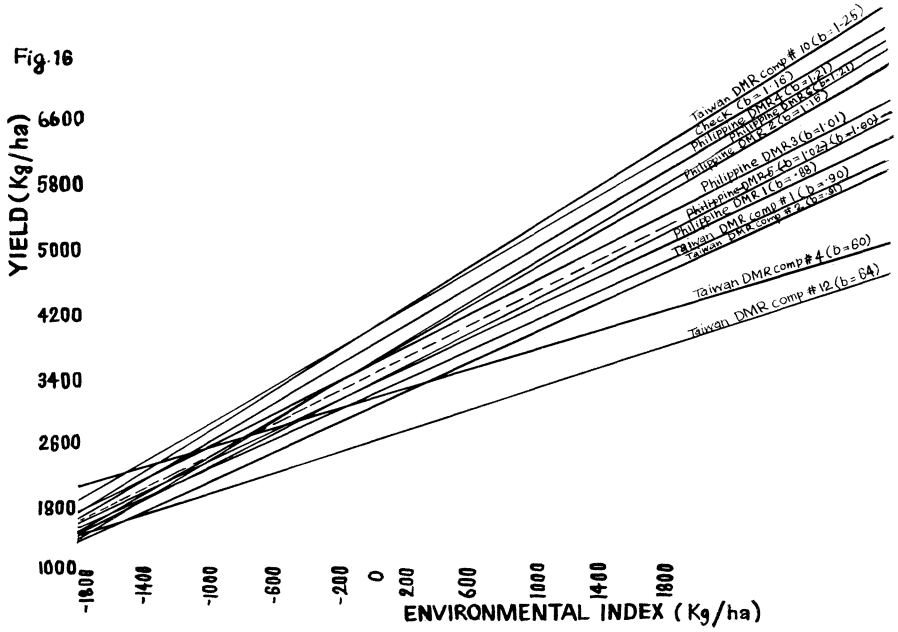

Fig. 16. Response of maize varieties to varying environments —Downy mildew yield trial—1971–72

References

Dalmacio, S. C. and O. R. Exconde (1971). Chemical control of downy mildew I. The use of protectant fungicides. Proceed. VII IACP Workshop, Los Banos 108–110.

Eberhart, S. A. and W. A. Russel (1966). Stability parameters for comparing varieties. Crop Sci., **6**: 36–40.

Futrell, M. C. (1972). The potential danger of downy mildew and Fusarium to sorghum and corn: 27th Annual Corn & Sorghum Res. Conf. 36–42.

Payak, M. M. (1974). Epidemiology of maize downy mildews with special reference to those occurring in India (in press)

Renfro, B. L. (1973). Introductory remarks and five year summary of International Downy Mildew Nursery. Proceed. 9th IACP Workshop, Malaysia 1–13.

Schultz, C. E. (1971). Evaluation of seed treatment with chloroneb for control of Philippine Downy Mildew of Corn. Proceed. VII IACP Workshop, Los Banos 104–107.