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GENOTYPE BY ENVIRONMENT INTERACTIONS IN MAIZE IN EASTERN AFRICA

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Maize (*Zea mays* L.) is the staple food crop for many of the inhabitants of Eastern Africa [9]. With the continual increase in population, food production must be increased to keep pace with the population growth. Maize is not an indigenous crop in Africa and early introductions were probably not the varieties with the greatest potential [10]. Recent introductions have given considerably higher yields in Kenya [6] and in Tanzania [1, 2, 3]. As Kenya farmers are gradually accepting the hybrid varieties and the improved maize agronomy package, they are doubling their yields [8, 10]. Eastern African Maize Variety Trials were initiated in 1966 to obtain information on the general adaptation of the new hybrid and composite varieties.

Breeders at the first Eastern African Cereals Workshop Conference held at Kitale, Kenya, and Serere, Uganda, in 1965 planned a more extensive trial to obtain information on genotype by environment interactions as well as on the performance of both released and experimental varieties and hybrids. This paper summarizes the results of these trials.

Materials and Methods

Fifteen hybrids and eight open-pollinated varieties were submitted for the 1968-69 Eastern African Maize Variety Trials by breeders from four countries. The entry list and sources of materials are shown in Table I.

Table I—Entry List and Sources of Materials in the 1968-69 Eastern Africa Maize Variety Trial

Entry	Type of entry*	Source of germplasm	Source of entry
H611 (R) C1 ..	VC	Kenya and Ecuador	Kenya
H613B	TC	Kenya and Ecuador	Kenya
KCB × KCE ..	VC	KCB, KCE	Kenya
KCB × KCC ..	VC	KCB, KCC	Kenya
KCC	V	Mexico, Ecuador, Costa Rica	Kenya
KCE	V	East Africa and Central and South America ..	Kenya
H632	TWC	Kenya	Kenya
KCB × UCA ..	VC	KCB, UCA	Kenya
UCA × UCB-W ..	VC	UCA, UCB-W	Tanzania
KCC × ZCA ..	VC	KCC, ZCA	Kenya
KCB	V	Kenya and Ecuador	Kenya
UCA	V	East Africa and Central and South America ..	Tanzania
KWNA	V	East Africa and Central and South America ..	Uganda
SR52	SC	Rhodesia	Zambia
SR52 × 63J 347† ..	TWC	Rhodesia and Zambia	Zambia
SR52 × 63J 96 ..	TWC	Rhodesia and Zambia	Zambia
H511	VC	East Africa and Mexico	Kenya
UCA × ZCA ..	VC	UCA, ZCA	Kenya
KCB × IC	VC	KCB, IC	Kenya
ZCA × IC	VC	ZCA, IC	Kenya
UCB-W	V	East Africa and Central and South America ..	Tanzania
ZCA	V	Zambia	Zambia
IC	V	East Africa and Central and South America ..	Tanzania

*Types are single-cross (SC), three-way-cross (TWC), topcross (TC), and variety-cross (VC) hybrid and open-pollinated varieties (V). H613B is a topcross with a single cross as female and a variety as male parent.

†This hybrid variety has been released recently by Zambia as ZH1.

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TABLE II—LOCATION, ALTITUDE, MEAN YIELD AND COEFFICIENT OF VARIATION (CV) FOR THE 37 ENVIRONMENTS OF THE 1968–69 EASTERN AFRICAN MAIZE VARIETY TRIAL

Location	Altitude* km.	Yield	
		Mean q/ha	CV %
Ethiopia:			
Kulumsa	2·20 (H)	80·4	9
Alemaya	2·05 (H)	47·1	14
Areko	1·78 (H)	50·6	22
Awassa	1·70 (H)	77·4	17
Jimma	1·70 (H)	56·2	24
Chilalo	1·65 (H)	78·1	13
Bako	1·65 (H)	30·4	41
Kenya:			
Chorlim	2·13 (H)	69·9	26
Endebess	1·92 (H)	73·8	11
Kitale—1	1·89 (H)	70·0	14
Kitale—2	1·89 (H)	68·6	14
Kakamega	1·58 (M)	46·5	39
Embu	1·46 (M)	33·9	12
Busia	1·22 (M)	44·7	25
Tanzania:			
Igeri	2·29 (H)	16·4	40
Njombe	1·98 (H)	58·2	18
Buhemba	1·46 (M)	42·5	16
Ismani	1·22 (M)	23·1	28
Bwanga	1·22 (M)	24·3	39
Mwanza	1·19 (M)	22·6	34
Korogwe	·61 (L)	31·2	25
Morogoro	·61 (L)	37·5	16
Ilonga	·50 (L)	35·7	34
Wami	·46 (L)	22·6	25
Obwari	·18 (L)	40·6	20
Uganda:			
Namulonge	1·20 (M)	28·5	21
Bukalasa	1·19 (M)	31·5	20
Serere	1·10 (M)	46·8	16
Abi	1·07 (M)	56·8	24
Aduku	·91 (M)	24·0	30
Malawi:			
Bvumbwe	1·16 (M)	38·0	23
Chitedze	1·15 (M)	58·8	12
Chitala	·60 (L)	29·3	24
Zambia:			
Lusaka	1·28 (M)	24·8	39
Misamfu	1·28 (M)	34·3	33
Chilanga—1	1·21 (M)	78·0	17
Chilanga—2	1·21 (M)	61·9	15
Mean	1·35	45·8	—

*(L), (M) and (H) indicated the arbitrary groupings into low (0 to 0·65 km.), medium (0·90 to 1·60 km.) and high (1·65 to 2·30 km.) altitudinal zones, respectively.

"H611(R)C1" is the product of one cycle of reciprocal recurrent selection with "Kitale II" and "Ecuador 573" [4]. "H613B" is the top-cross (F x G) x Ecuador 573; and "H632" is (A x F) x G, where A, F, and G are inbred lines developed from the Kenya Flat White complex [10]. "SR52" was developed in Rhodesia from the "Salisbury Flat White" variety and is grown extensively in Rhodesia and Zambia; the lines 63J 347 and 63J 96 were developed from similar material and SR52 x 63J 347 has been released recently by Zambia as ZH1. "H511" is the variety-cross hybrid between Embu 11 and 12, where Embu 11 and 12 were each developed by crossing an early-maturing variety with a late-maturing variety. The other variety-cross hybrids are crosses between the current Eastern African breeding populations. These breeding populations are broadly based composites developed from diverse local and introduced germplasm.

Each co-operator entered a local variety and a sample collected from farmers near the trial site as checks to provide the 25 entries for the trial. The experiment was conducted as a 5 x 5 triple lattice with four rows per plot. Each row was overplanted and thinned to ten single-plant hills, and data were recorded on only the two centre rows. The suggested spacings of 75 cm. between rows and 30 cm. within a row were used at most locations. Data were obtained from the 37 locations listed in Table II. The altitude mean yield (excluding checks), and coefficient of variation for yield are presented for each location. Data were obtained at some of the locations for percentage lodging (plants leaning more than 45° or broken below the ear); ears per 100 plants; ear height (height of top ear node in cm.); percentage bare tips (ears with inadequate husk extension); days to tassel; blight score (*Helminthosporium turcicum* Pass.) on a 1 to 6 scale with 1 indicating resistance; and rust score (*Puccinia sorghi* Schw.), also on a 1 to 6 scale.

Yield per plot was adjusted to a uniform stand within each location with the randomized block covariance analysis, and the lattice analysis was then used to obtain adjusted mean yields and the average effective error at each environment. The combined analysis for each country and an overall combined analysis were computed with these adjusted means. The procedure as outlined by Eberhart and Russell [7] was extended to include response to altitude (b_A) in addition to the response to environments (b_I). Two models were fit sequentially as follows:

$$(1)\ Y_{ij} = m_i + b_{A_i} A_j + e_{ij}$$

$$(2)\ Y_{ij} = m_i + b'_{A_i} A_j + b'_{I_i} I_j + e_{ij},$$

where Y_{ij} is the observed yield of the *ith* variety ($i = 1, 23$) grown in the *jth* environment ($j = 1, 37$); m_i is the mean of the *ith* variety; b_{A_i} is the linear response to a change in altitude per km. for the *ith* variety; A_j is the altitude of the *jth* location minus the average altitude of all locations (expressed in km.); b_{I_i} is the linear response to a change of the environmental index; I_j is the environmental index (mean yield of all varieties in the *jth* environment minus the grand mean); and e_{ij} is the deviation from regression for the *ith* variety grown in the *jth* environment.

The environments were arbitrarily grouped into low (0 to 0.65 km.), medium (0.90 to 1.60 km.), and high (1.65 to 2.30 km.) altitudinal zones; and the yield analyses were computed for these zones, including the response to environments in addition to the overall analysis.

Results and Discussion

The genotype by environment interaction was large for yield from this regional trial, but the differential linear responses of varieties to altitude (V x A) and to the environmental index (V x I, adjusted for A) removed a significant amount of this interaction (Table III). Because the analysis failed to detect V x A (quadratic) or V x AI interactions, these terms were not included in the model. Removing the variation due to V x A and V x I reduced the estimate of genotype x environmental variance component, s^2_{ge}, from 59 to 34. Days to tassel showed a large linear response to altitude, and the varieties responded differently to changes in altitude as indicated by the significant V x A interaction. Because the altitude quadratic response and the V x A (quadratic) interaction were not significant for days to tassel, only the linear term for altitude was used in the model.

The performances of the 23 varieties are shown in Table IV. Average yields increased 17 q/ha. for each km. increase in altitude. The

TABLE III—ANALYSES OF VARIANCE FOR YIELD AND DAYS TO TASSEL OF 23 VARIETIES GROWN IN 37 ENVIRONMENTS FOR THE 1968-69 EASTERN AFRICAN MAIZE VARIETY TRIAL

Source†	Yield, q/ha		Days to tassel	
	Degrees of freedom	Mean square	Degrees of freedom	Mean square
Environments	36	8,432·29	24	3,616·24
A (linear)	1	68,192·01**	1	69,353·07**
A (quadratic)	1	501·17	1	952·59
Residual	34	6,907·84**	22	749·28**
Varieties (V)	22	591·27**	22	281·20**
V × Environments	792	91·35**	528	5·92**
V × A (linear)	22	774·48**	22	14·42**
V × I (adj. A)§	22	275·42**	—	—
Deviation	748	65·84**	506	5·55**
V × A (quadratic)	22	96·90	22	5·91
V × AI..	22	88·60	—	—
Residual	704	63·16**	484	5·53**
Pooled error‡	1,332	32·29	900	1·62

† A and I indicate altitude and the environmental index.
** Indicate significance at the ·01 probability level.
§ The sums of squares were adjusted for the interaction with altitude because the altitude and environmental indexes are not orthogonal.
‡ Because the analysis has been presented on a mean basis (over replications), the expected mean square for pooled error is σ^2_e/r.

TABLE IV—PERFORMANCE OF VARIETIES IN THE EASTERN AFRICAN MAIZE VARIETY TRIAL GROWN IN 1968-1969

Variety	Yield, q/ha					Days to tassel	
	Mean	Model 1	Model 2				
		b_A	b'_A	b'_I	Deviation mean square	Mean	b_A*
H611 (R) C1 ..	53·8	31·5	9·7	1·26	126	83	23·2
KCB × KCE..	46·4	29·7	10·0	1·13	79	81	23·2
H613B.. ..	48·0	29·5	9·8	1·14	128	83	23·6
KCC	43·1	28·3	10·5	1·02	43	85	23·6
KCB × KCC..	45·1	27·2	8·9	1·05	68	82	22·8
KCE	41·3	23·4	4·8	1·07	65	84	23·7
KCC × ZCA..	46·6	21·5	3·2	1·05	71	80	22·8
UCA	47·7	21·5	1·1	1·17	43	81	22·4
H632	51·3	20·9	1·5	1·12	44	80	23·7
KCB × UCA..	48·1	20·5	1·5	1·10	43	80	22·8
KCB	43·8	18·8	0·5	1·05	25	80	22·4
KWN A ..	46·2	16·3	−0·8	·98	33	77	21·1
UCA × UCB-W	48·1	15·3	−1·7	·98	37	78	21·3
SR52	50·2	15·1	−2·4	1·01	117	75	20·6
SR52 × 63J 96	42·0	13·6	−3·1	·96	43	77	22·1
SR52 × 63J 347	49·6	13·5	−3·5	·98	48	75	20·4
KCB × IC ..	49·0	12·8	−6·6	1·12	42	78	21·2
UCA × ZCA..	45·7	12·4	−7·3	1·13	84	78	21·6
UCB-W ..	46·4	11·6	−3·5	·87	41	77	21·2
H511	40·8	10·0	−2·5	·72	86	71	17·7
ZCA	37·7	7·0	−4·9	·68	44	77	21·1
ZCA × IC ..	44·2	2·3	−11·1	·77	61	75	19·9
IC	38·4	−3·1	−13·9	·62	77	76	20·0
Mean ..	45·8	17·4	0·0	1·00	63	79	21·8
LSD (·05)	4·4	7·6	8·3	·23	—	1	2·6
No. of locations	37	37	37	37	37	25	25

TABLE IV—(*Contd.*)

Variety	Usable ears per 100 plants	Lodging %	Ear ht. cm.	Bare tips %	Blight score (1–6)	Rust score (1–6)
H611 (R) Cl	84	29	196	16	1·3	1·3
KCB × KCE	77	36	192	18	1·8	1·3
H613B	83	42	190	26	1·5	1·2
KCC	75	36	203	20	1·7	1·3
KCB × KCC	76	34	197	22	1·9	1·4
KCE	73	35	203	20	1·6	1·2
KCC × ZCA	76	37	172	22	1·8	1·5
UCA	84	33	179	17	1·7	1·6
H632	88	40	155	16	1·4	1·4
KCB × UCA	82	32	182	22	1·8	1·3
KCB	75	30	178	22	2·0	1·4
KWN A	81	38	161	16	1·8	1·4
UCA × UCB-W	84	40	163	16	1·8	1·6
SR52	86	30	142	15	1·8	2·2
SR52 × 63J 96	80	33	145	21	2·0	2·4
SR52 × 63J 347	82	39	147	16	2·2	2·7
KCB × IC	89	32	170	18	2·2	1·5
UCA × ZCA	75	31	160	21	2·1	1·9
UCB-W	87	43	150	13	1·9	2·3
H511	83	44	134	24	1·8	1·5
ZCA..	73	38	143	17	2·2	2·4
ZCA × IC	83	37	149	13	2·3	2·7
IC	87	38	149	9	2·6	2·5
Mean	81	36	168	18	1·9	1·7
LSD (·05)	5	5	5	4	·4	·5
No. of locations ..	35	35	33	32	14	13

H611(R)Cl, H613B, KCB x KCE, and KCB x KCC hybrids showed very large responses, but IC showed a slight negative response as measured by bA_i from model 1 (Fig. 1). When the environmental index is included (model 2), the b'_{A_i}'s are adjusted for the environmental response and deviate around zero. If all estimates of b'_{I_i} had been 1.0, one would expect that $b_{A_i} = 17.4 + b'_{A_i}$. Although cultural practices, soil fertility, rainfall, and other factors may be involved in the response to altitude, we hypothesize that temperature is one of the major factors. Griffiths [9] reports a linear regression of mean maximum temperature [$T(°C) = 24.4 — 6.92A$] on altitude (A in km.) for Eastern Africa with a small deviation from regression.

The days to tassel also increased with altitude at the average rate of 21.8 days per km. Although the response ranged only from 17.7 to 23.7 days per km. among the 23 varieties, these small differences were statistically significant. At 2.0 km., H611(R)Cl was much later than SR52 and H511, but at sea level the difference was smaller (Fig. 2). Because the variation in day length is small near the equator, temperature probably is the main factor in the altitude response for days to tassel also, and A (linear) removed 80 per cent of the variation among environments.

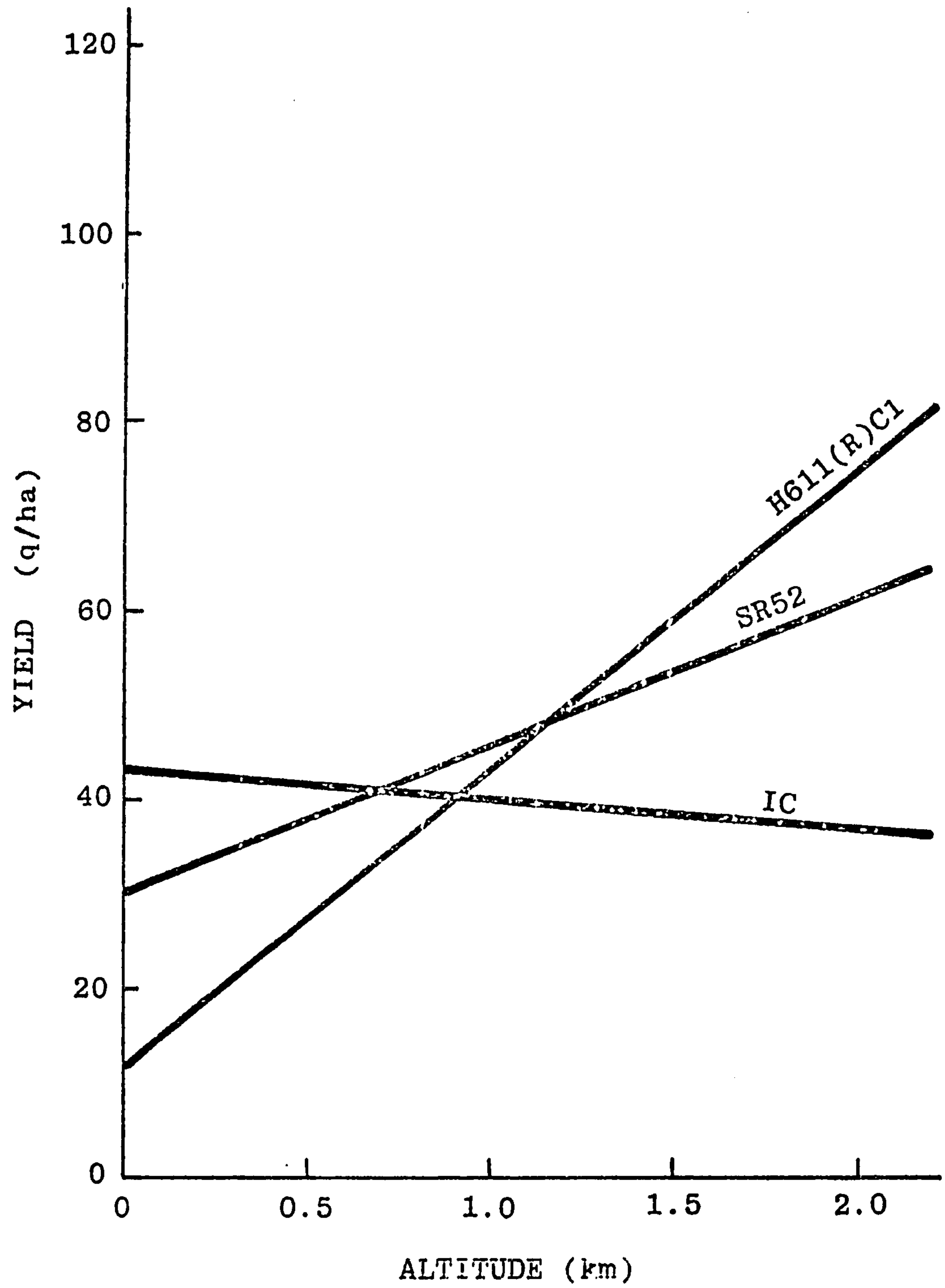

Fig. 1—The yield response to altitude (at an average yield level of 45.8 q/ha) of 3 maize varieties from the 1968-69 Eastern African regional trials grown in 37 environments

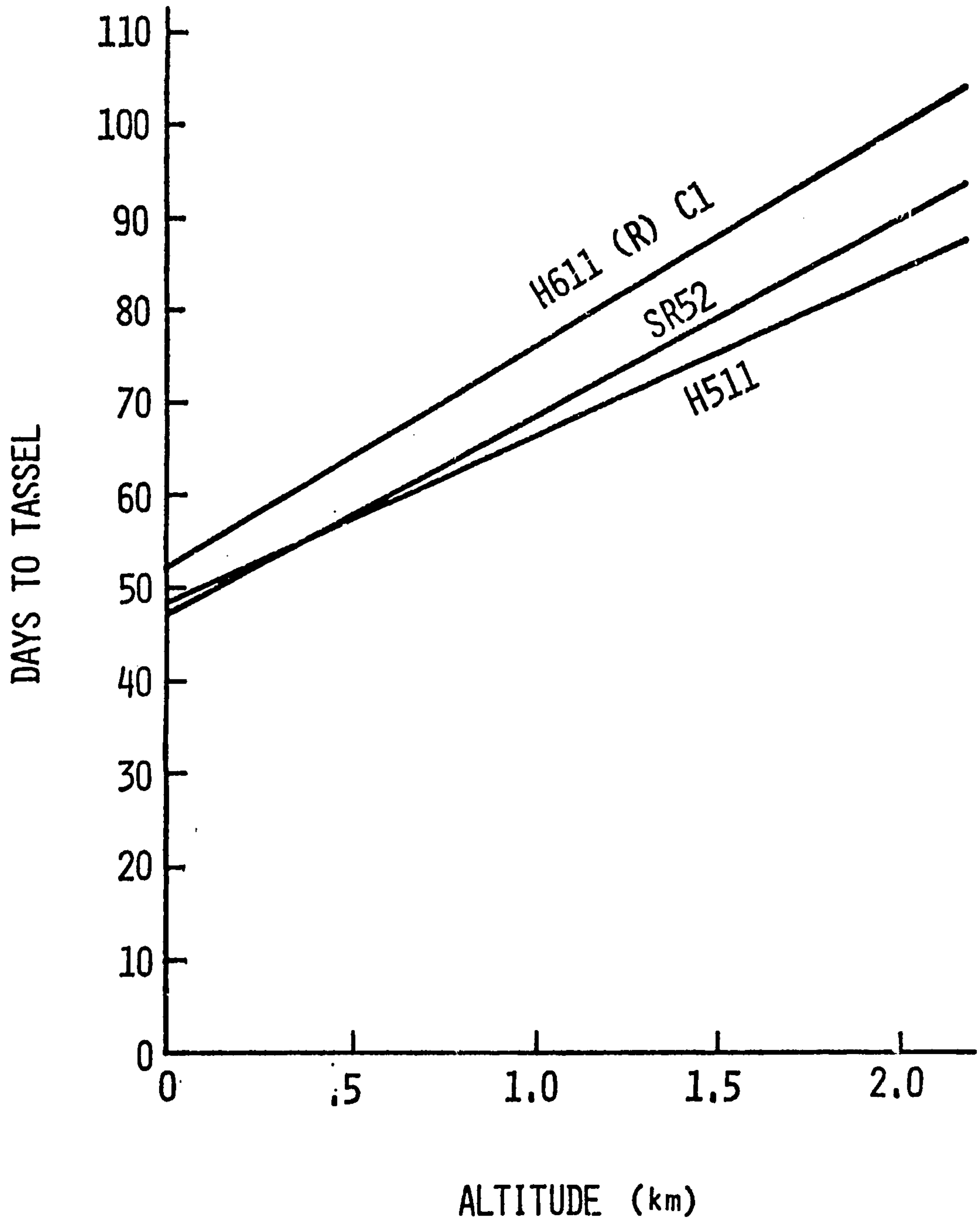

Fig. 2—The days to tassel response to altitude of 3 hybrid varieties from the 1968-69 Eastern African regional trials obtained in 25 environments

The yield response to environments (b'_I) was very different for the varieties in this trial (Table IV). Response of "IC", "ZCA", and H511 was very low, whereas that of H611(R)C1 was very high. The expected yields at 1.35 km. altitude are shown for H611(R)C1, SR52 and IC in Fig. 3. In poor or average environments near sea level IC outyielded SR52 and H611(R)C1, but in favourable environments ZCA and IC were predicted to be the lowest yielding at all altitudes.

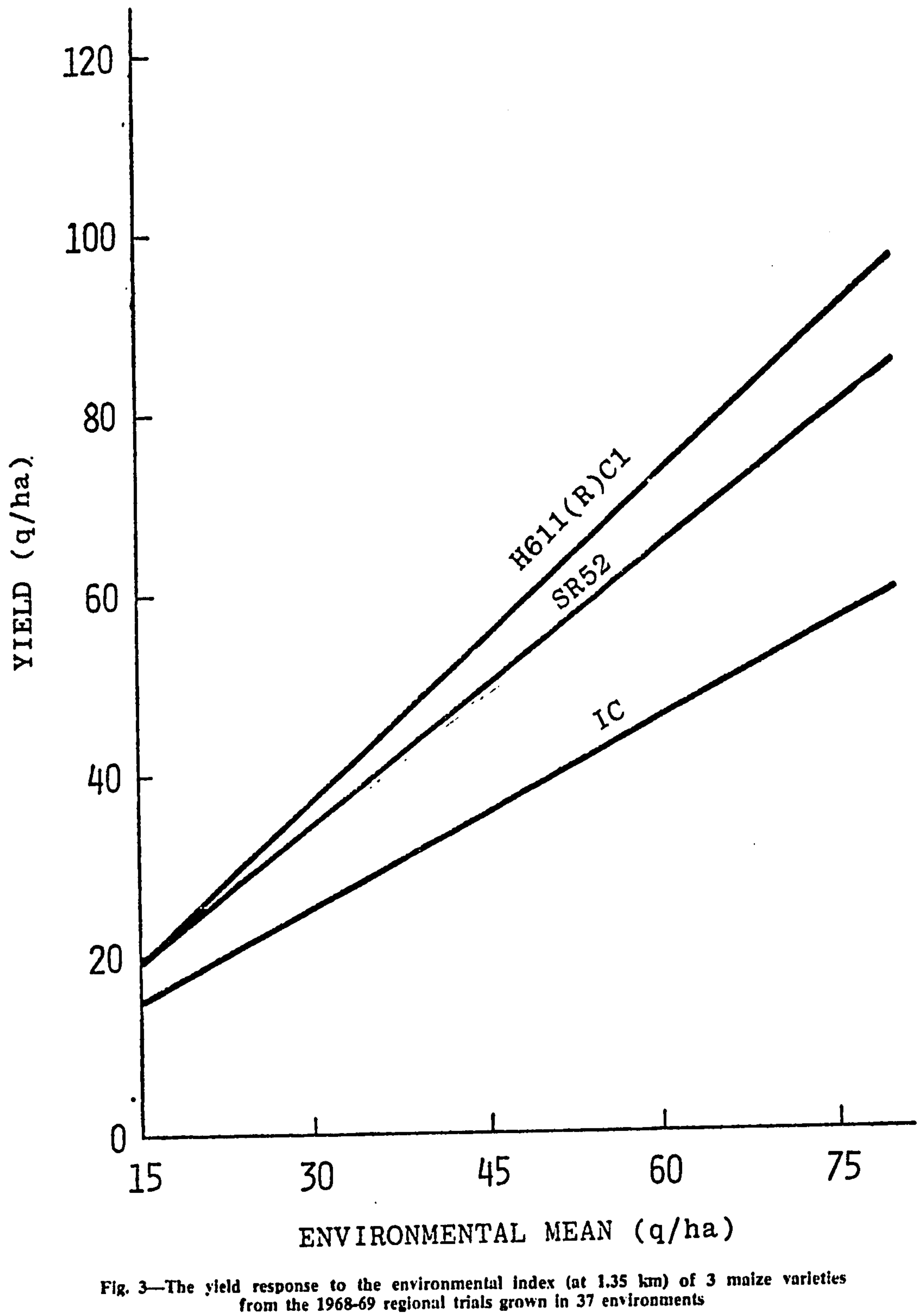

Fig. 3—The yield response to the environmental index (at 1.35 km) of 3 maize varieties from the 1968-69 regional trials grown in 37 environments

Although the altitude coefficient and the environmental index tend to be correlated in the design matrix (because of the increased yield at the higher altitudes) as shown in Table II, the range in yields at a given altitude was great enough in this large trial with 37 environments to reduce this correlation to 0.47. We computed the response to altitude and to the environmental index separately within the 18 medium-altitude environments and the 13 high-altitude environments and obtained very similar coefficients. This similarity of coefficients suggests that the response to altitude has been separated from the response to environments in the estimates of b'_A and b'_I that are presented.

We obtained large estimates of b_A coefficients for the varieties that came from high-altitude germplasm. The Ec 573 collection of the Montana Ecuatoriana race [11], used as the male parent in H611(R)C1 and H613B, was collected at a high altitude in Ecuador. Ec 573 was used also in compositing KCB. KCC, and KCE. The other two sources of germplasm used in KCC, Costa Rica 76 and the Comiteco race bulk [12]. also are from medium to high altitudes. The Kenya Flat White complex used in KCB and as the source of the inbred lines in H632 had been selected for many years at 1.65 to 2.00 km. near Kitale, Kenya [10].

The varieties with a low response to altitude came from low altitude source material. The source material for inbred lines in SR52 and its three-way crosses and in ZCA may be similar to the source of the Kenya Flat White complex [10], but their source material had not been selected at high altitudes. Most sources of IC and UCB-W were from low altitude [1, 2]. UCA was composited from the same sources as KCE but the proportions of Ec 573, Costa Rica 76, and Comiteco were reduced. KCE and UCA included both low- and high-altitude material and their response to altitude was intermediate.

The composites and hybrids involving high-altitude germplasm sources generally had a larger response to environments than did the varieties from low-altitude sources. Maturity may contribute to this differential response because the high altitude source material is later in tasseling. For instance, the medium-maturity hybrid, H511, includes one-half high altitude germplasm, but its estimate of b is very low, and its response to altitude b_A, is below average. All varieties with b'_I coefficients less than 1.0 were below average in days to flower. Bolton [3] reported a much larger response for "H622" than for the earlier varieties "LH7" and "Katumbili".

The deviation mean square was large for H611(R)C1 and H613B because yields were much higher than predicted in high-yielding environments at high altitudes. The observed yield for H611(R)C1 at the Chorlim farm near Kitale, Kenya, was 128.9 q/ha., and yield for H613B was 136.9 q/ha. The deviation mean square for the only single cross in the trial, SR52, was also high, but its susceptibility to blight and rust may have contributed to this lack of stability.

The yield of each variety was predicted with model 2 at the mean yield and mean altitude of the low-, medium- and high-altitude zones and the observed and predicted means are presented in Table V. The agreement of observed and predicted means was extremely good at the medium and high altitudes in Eastern Africa. but the agreement was not as good as the low altitude. In Central Africa (Zambia and Malawi). SR52 yielded more than predicted and H611(R)C1 and IC yielded less than predicted. Yields were predicted for 1.910 km. at a mean yield level of 80 q/ha., and H611(R)C1 was predicted to have an even greater superiority over IC under these conditions.

The estimate of s^2_{ge} from medium-altitude environments within countries were Kenya, 17; Uganda, 19; Tanzania, 20; Zambia, 19; and Malawi, 18. The average was 19. When data from these environments were combined in a single analysis, the estimate of s^2_{ge} was 19 also; and it was 16 when the variation due to V x A and V x I was removed. These results suggest that the genotype by environment interaction is as great for locations within countries as for locations throughout Eastern Africa in the medium-altitude zone. Unless a large number of trials can be grown in a particular location, predicted yields (for the altitude at the expected yield level) with the parameters estimated in extensive regional trials may provide more reliable results than one or two trials grown at that site.

Even though H611(R)C1 and H613B were extremely tall, they were the highest yielding entries at the higher altitudes and lodging was less for H611(R)C1 than for the shorter H632 and no greater than for SR52. At the medium altitudes, yields of SR52 and H632 were as

TABLE V—OBSERVED ($\bar{Y}$) AND PREDICTED ($\hat{Y}$) MEANS OF 23 MAIZE VARIETIES FOR LOW, MEDIUM AND HIGH ALTITUDES IN EASTERN AFRICA, GROWN IN 1968 AND 1969*

Variety	C. and E. Africa Low (·490 km.)		Central Africa Medium (1·215 km.)†		Eastern Africa Medium (1·234 km.)§		Eastern Africa High (1·910 km.)		
	$\bar{Y}$	$\hat{Y}$	$\bar{Y}$	$\hat{Y}$	$\bar{Y}$	$\hat{Y}$	$\bar{Y}$	$\hat{Y}$	$\hat{Y}$‡
H611 (R) C1	32·5	29·2	49·2	56·9	40·6	39·6	77·9	76·8	102·2
KCB × KCE ..	27·2	23·1	49·5	49·0	32·1	33·5	67·1	67·9	90·8
H613B..	28·8	24·8	48·4	50·7	33·0	35·1	70·6	69·4	92·4
KCC	22·6	20·8	40·6	45·3	31·8	31·3	64·2	63·3	84·0
KCB × KCC ..	27·2	23·8	49·0	47·6	30·5	33·2	65·1	64·9	86·1
KCE	25·1	23·3	46·4	44·4	28·4	29·7	58·5	59·0	80·5
KCC × ZCA ..	30·8	30·2	51·9	49·9	32·8	35·3	64·3	63·2	84·4
UCA	32·2	31·5	48·9	51·7	36·4	35·4	64·7	64·7	88·4
H632	35·0	35·5	55·4	55·0	40·8	39·5	67·1	67·8	90·3
KCB × UCA ..	33·1	32·6	53·0	51·8	34·9	36·5	64·9	64·3	86·5
KCB	29·8	29·6	46·8	47·4	31·6	32·7	60·0	58·8	80·1
KWN A	34·4	34·1	50·0	49·7	35·6	36·0	59·6	59·5	79·4
UCA × UCB-W ..	38·7	36·8	50·2	51·7	37·0	38·1	61·6	60·8	80·6
SR52	32·4	39·1	61·6	54·0	41·4	39·9	61·1	62·9	83·3
SR52 × 63J 96 ..	29·5	32·1	46·8	45·8	33·3	32·3	53·6	53·8	73·2
SR52 × 63 J347 ..	36·9	39·9	56·4	53·5	41·1	39·8	60·3	61·4	81·2
KCB × IC	41·8	40·2	51·9	53·8	37·4	38·2	61·9	61·0	83·5
UCA × ZCA ..	30·0	37·2	53·8	50·6	36·9	34·7	56·4	57·5	80·4
UCB-W	36·9	38·2	51·2	50·0	37·7	37·8	56·7	56·6	74·2
H511	32·3	33·6	45·2	43·7	34·2	33·6	48·9	49·5	64·1
ZCA	31·7	33·1	43·2	40·8	31·5	31·2	43·8	44·5	53·4
ZCA × IC	42·5	43·7	47·6	48·4	38·8	37·4	48·2	48·9	64·4
IC	41·2	42·3	36·8	42·5	37·8	33·6	38·6	39·3	51·9
Mean	32·8	32·8	49·3	49·3	35·4	35·4	59·8	60·0	80·2

*Low includes 0 to 0·65 km., medium includes 0·9 to 1·6 km., and high includes 1·65 to 2·3 km.
†Zambia and Malawi trials.
§Kenya, Uganda and Tanzania trials.
‡Predicted yields at the 80 q/ha mean level.

high as those of H611(R)C1, and in Central Africa SR52 was superior to any other entry in that trial. IC was superior to any of the hybrids in low-yielding trials at low altitude where it had been developed.

Although the broad-based Eastern African composites yielded well, heterosis in their variety crosses was small in contrast to the heterosis of H611 [4]. The yields of the open-pollinated composite variety, UCA, compared favourably with those of H632 and SR52 under more favourable environmental conditions at medium altitudes in Eastern Africa.

The large average increase in yield per km. of altitude suggests that environmental conditions may be more favourable for maize at higher altitudes in Eastern Africa. Cultural conditions may still be confounded in the response to altitude in this study, but with the large number of trials and the range of yields within an altitudinal zone, this confounding should be minimized. Further studies are needed on the changes in days from tasseling to black-layer formation [5] with a change in altitude (and mean temperature). Physiological and biochemical studies to determine the differences between varieties adapted to high and low altitudes are needed to identify the cause of the differential responses.

SUMMARY

Eastern African regional maize (*Zea mays* L.) variety trials of 23 varieties were grown in

37 environments in 1968-69. A large proportion of the genotype by environment interactions could be explained by differential responses among varieties to altitude and to environments. Because temperature is highly correlated with altitude in East Africa, the altitude response may be primarily a temperature response.

Days to tassel increased an average of 21.8 days per km. of increased altitude with a range of 17.7 to 23.7 days per km. The average increase in yield was 17 q/ha. per km. with a range of 3.5 to 27.9 q/ha. per km. Varieties that involved high-altitude source material and those that had been selected at high altitudes yielded relatively better at higher altitudes than varieties that involved low-altitude source material and yielded nearly as well as low-altitude varieties at low and medium altitudes.

Predicted yields for an Eastern African location obtained with the parameters mean yield, response to altitude (b_A), and response to the environmental index (b'_I) estimated from extensive regional trials should be more reliable than observed results from a limited number of trials at that location.

The current commercial varieties and recently developed experimental material seem to be adapted throughout Eastern Africa within the appropriate altitudinal zone.

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