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EVALUATION OF CARIBBEAN MAIZE ACCESSIONS IN PUERTO RICO

L.M. Pollak

Cereal and Soybean Improvement Research Unit
USDA-Agricultural Research Service, Department of Agronomy
Iowa State University, Ames, Iowa, 50011

ABSTRACT

The maize germplasm collection of Caribbean origin from the CIMMYT (Mexico) germplasm bank was evaluated in two stages for yield and agronomic traits in Puerto Rico. This evaluation was part of the Latin American Maize Project (LAMP), a five-stage collaboration of 12 countries in the Western Hemisphere to evaluate their native maize germplasm. The 562 accessions included in the first stage represented seven races and mixtures of these races commonly found in the Caribbean. The top 20% based on yield were re-evaluated in two locations in Puerto Rico. Yields of the top 20% ranged from 3937 to 7773 kg/ha, and 18 accessions had yield exceeding the check, a local improved variety. Accessions with good ear quality and yield were identified for use in tropical breeding programs.

INTRODUCTION

Maize from the West Indies has long been recognized as important breeding material for the lowland tropics, as well as a valuable germplasm source for the improvement and diversification of temperate maize-breeding populations (Brown, 1953b; Brown, 1960; Wellhausen, 1965; Goodman and Brown, 1988). At the time of European contact, maize was well distributed throughout the islands of the West Indies by the Arawak and Carib peoples, who brought their varieties with them when they migrated from South America (Brown, 1953a; 1960). The importance of West Indian maize is shown by the wide distribution it has attained throughout the world. West Indian maize reached Europe by the end of Christopher Columbus's second voyage, where it spread quickly. Varieties from the Caribbean were also a portion of the maize germplasm Magellan's voyage introduced to the East Indies and the Philippines, after which they spread to mainland Asia (Weatherwax, 1954).

The amount of variability among West Indian maize races has been reported by Brown (1960) to be small compared to the variability among races from some other areas, such as Mexico. Maize from the West Indies, however, has been reported to have many desirable and useful traits and properties. Wellhausen (1956) found that a collection and a composite of collections from Antigua combined well with Tuxpeno and the Corn Belt Dents. He also reported Cuban Flints to combine well with Tuxpeno, and they have been widely used in maize breeding programs in Colombia (Timothy, 1963). The races Coastal Tropical Flint, Chandelle, and Haitian Yellow have proven to be sources of good traits, including grain quality, good husk cover, stalk quality, root strength, and Helminthosporium resistance (Goodman and Brown, 1988).

The objectives of the present study were to screen the Caribbean maize collections of the International Maize and Wheat Improvement Center (CIMMYT) for traits of agronomic importance, determine which of the collections would be useful for Caribbean maize breeding programs, and compare the agronomic traits of maize collected from the various islands/countries of the Caribbean. This study represents part of the USA contribution to the first two stages of a five-stage international collaboration of 12 countries of the Western Hemisphere to evaluate their native maize germplasm, The Latin American Maize Project (Anonymous, 1987).

MATERIALS AND METHODS

The CIMMYT maize germplasm bank collection of Caribbean accessions (562 total) were planted in January, 1987, Isabela, Puerto Rico. The objective of the first stage of evaluation was to select the best 20% of accessions, which would undergo more extensive evaluation. For the initial evaluation, it would have been desirable to plant those accessions similar in plant height and date of flowering together in a block, yet since data on these traits was unavailable at time of planting, accessions were blocked together by island or country. Two replications were grown using single-row 6 m long plots. The experiment was hand planted and harvested.

The traits measured were as follows: days to mid-tassel and silk, plant and ear heights (cm), stalk and root lodging (%), amount of tillering (1=none, 9=many), ear number per plant, ear quality (1=very poor, 9=excellent based on uniformity, ear molds, appearance), yield adjusted for stand and moisture (kg/ha), kernel type and color, and predominate racial classification (Brown, 1960). The Puerto Rican variety, Diente de Caballo, was included as a check.

The top 20% Caribbean accessions were planted in January, 1988, in two locations in Puerto Rico (Isabela and Lajas). Additional data was collected in Costa Rica, Mexico, and disease and insect evaluations were undertaken in Puerto Rico. The top 20% were chosen primarily on the basis of yield, but attempting to select accessions within each island/country group and racial classification. A randomized complete block experimental design was used with two replications. Other cultural practices were similar to Stage 1. Traits measured were as described above except that yield was adjusted for shelling percentage as well as stand and moisture. Diente de Caballo was again included as a check.

Means for the measured traits were calculated and compared among island/country and racial classifications for 1987 and 1988, respectively. Data from Mexico and disease and insect evaluations are not reported in this paper.

RESULTS AND DISCUSSION

Stage 1

In Table 1 the means and standard deviations for ten traits of accessions grouped by island or country are presented. The numbers of accessions from each area that were available from CIMMYT'S germplasm bank and thus tested in this experiment ranged from seven from St. Lucia to 165 from Cuba. Although one accession from Barbados and two from Martinique were evaluated, they were not included in this analysis due to the small sample size. The one accession from Barbados was late maturing, and those from Martinique were very early. Six Caribbean composites or populations from CIMMYT (Cupurico, Sanvibag, Cuba Antibarsan, Cuban Dent, Compuesto Caribeño Precos, and Compuesto Caribeño MC2) were also included and are listed under the Composites category in Table 1. The check Diente de Caballo, was included 25 times in each replication.

Classifying these accessions into islands or countries and comparing them can only indicate the general behavior of the germplasm from these places. Germplasm from countries with large numbers of accessions like Cuba and Dominican Republic is quite variable and includes more than one race and most logical at the initial stage of the evaluation, since racial classification was not very precise.

The Puerto Rican check was the earliest in flowering, while the accessions from Grenada, Haiti, St. Lucia, Tobago and Trinidad had mean days to tassel and silk over 80. The accessions from Antigua had the lowest plant and ear heights, while those from Haiti and Tobago were the tallest with large ear heights. The accessions had mean stalk lodging no higher than 25%, and stalk lodging was generally not much of a problem. On the other hand, the lowest mean root lodging percentage was for the accessions from Guadeloupe, and that value was 81%. Mean root lodging for accessions from Tobago was 100%. These results show that root strength is a major problem with Caribbean accessions and must be improved before the germplasm can be commercially successful. A major windstorm occurred just as the experiment began to flower which caused the severe root lodging problem, but most hybrid plots used as filler in the experiment still remianed standing after the storm. The low tilleringm codes and ear number per plant means indicate that these Caribbean accession have few tillers and are not usually prolific. Ear quality means ranged from 3.1 for accession from St. Lucia to 5.8 for the check variety. The accessions from

St. Lucia had the lowest mean yields, while those from Jamaica had the highest, even exceeding mean yields of the check variety.

Table 2 presents the data for days to tassel, plant height and yield in a format that allows the desirable types of accessions to be easily selected. The range of each trait was divided into three equal groups, with means of accessions from an area falling into group 1 for the smallest values, and group 3 for the largest. The total gives a code for the traits. For example, accessions from Antigua have a code of 113, which means that they tend to be early, short, with high yield. Accessions from Grenada, Tobago and Trinidad tend to be late, tall, and low yielding, at least in this particular environment, since they may be somewhat unadapted in Puerto Rico.

Stage 2

In Table 3, data for the top 20% accessions where accessions were divided into predominate racial classifications is given. Most Caribbean accessions show racial mixing, but usually the primary and secondary race can be determined. Where there was so much mixing that no primary race could be determined, the accession was given the classification "Mixed". Most accessions (38) fell into this classification. Twenty-one accessions were classified as predominately Coastal Tropical Flint, while nineteen were classified as Chandelle. The Coastal Tropical Flint accessions came from many islands/countries, while all Chandelle accessions but three originated in the Dominican Republic.

The accessions classified as Haitian Yellow/White and Tuson were the latest-flowering. Early Caribbean, Chandelle and St. Croix were generally the earliest. Haitian Yellow/White and Tuson accessions were over 3 m tall, while ear heights were approximately 2 m. Both stalk and root lodging were less of a problem than in 1987, although the incidence of root lodging was much higher than stalk lodging. Again this indicates that accessions will have to be improved for root lodging before considered very useful. Ear quality was good, with racial means ranging from 5.8 to 6.9. Yield was highest for the three accessions classified as St. Croix. Yields were also good for accessions classified as Coastal Tropical Flint, Mixed and Tuson.

Agronomic traits for the twenty highest-yielding accessions are shown in Table 4. Yields for these accessions ranged from 6387 to 7773 kg/ha, while grain quality ratings ranged from 6 to 8. Eighteen germplasm bank accessions outyielded the check variety. All accessions had predominately yellow grain except for Cuba 164 which had mainly orange grain. Kernel types were mostly semi-flints and semi-dents. The highest-yielding accessions were classified into the following races: nine Mixed,

Table 1. Means and standard deviations of agronomic traits of sets of accessions based on island/country of origin evaluated in Isabela, Puerto Rico, in 1987.

Island/Country	N		Days to Tassel	Days to Silk	Height Plant	Height Ear	Lodged Stalk	Lodged Root	Tillering code	Ear Number	Ear Quality	Yield
					----cm----		-----%-----		1-9		1-9	kg/ha
Antigua	10	Mean	70	70	217	129	16	95	1.8	1.0	4.9	4051
		Std. dev.	1.3	1.5	12.0	8.0	9.4	6.2	0.9	0.1	1.6	958
Barbados	13.	Mean	71	72	235	145	12	91	1.7	0.9	4.2	3356
		Std. dev.	3.7	3.5	32.7	21.9	7.8	12.4	0.6	0.1	1.2	1501
British Virgin Islands	52	Mean	77	77	283	174	13	82	1.9	1.0	4.3	3899
		Std. dev.	7.3	7.4	35.1	32.4	13.4	19.7	0.7	0.2	1.3	1147
Check (Diente de Caballo)	25	Mean	69	69	253	147	6	83	1.3	1.0	5.8	4651
		Std. dev.	1.9	2.1	20.9	12.7	6.2	17.5	0.5	0.2	1.3	952
Composites	6	Mean	71	72	255	146	8	92	1.6	1.0	5.0	3603
		Std. dev.	4.2	4.1	37.4	27.9	10.1	12.2	0.8	0.3	1.7	1407
Cuba	165	Mean	76	76	276	161	7	91	1.6	0.9	4.6	3480
		Std. dev.	3.2	3.1	19.6	15.9	9.5	13.9	0.8	0.2	1.3	1074
Dominican Republic	98	Mean	72	72	281	163	7	94	1.7	1.1	5.1	4219
		Std. dev.	3.2	3.3	21.8	17.1	5.8	10.1	0.8	0.2	1.5	1131
Grenada	21	Mean	81	82	289	184	10	94	1.8	0.9	4.1	3111
		Std. dev.	2.9	3.1	20.7	18.0	7.5	9.8	0.8	0.2	1.6	1147
Guadeloupe	21	Mean	71	71	253	140	9	81	1.6	1.0	4.3	3352
		Std. dev.	4.5	4.2	31.1	27.0	10.4	26.2	0.6	0.3	1.9	1336
Haiti	38	Mean	82	86	307	192	6	87	1.8	1.0	4.5	3635
		Std. dev.	4.2	4.5	20.2	18.3	7.3	17.3	0.9	0.2	1.2	867
Jamica	8	Mean	78	79	277	171	6	98	1.9	0.9	5.6	4758
		Std. dev.	2.9	2.7	18.5	17.8	5.9	6.8	0.9	0.1	1.6	1289

Table 1. (continued)

Island/Country	N		Days to Tassel	Days to Silk	Height Plant	Height Ear	Lodged Stalk	Lodged Root	Tiller-ing code	Ear Number	Ear Quality	Yield
					----cm----		-----%-----		1-9		1-9	kg/ha
Puerto Rico	32	Mean	73	73	271	157	9	95	1.9	0.9	4.2	4000
		Std. dev.	3.2	3.6	19.1	13.4	8.2	8.1	0.8	0.2	1.4	1026
St. Croix	13	Mean	72	72	263	153	10	88	1.5	0.9	5.0	4174
		Std. dev.	3.0	3.2	15.4	12.1	9	18.0	0.6	0.2	1.4	1059
St. Lucia	7	Mean	84	86	271	168	18	97	1.6	0.7	3.1	2298
		Std. dev.	2.1	2.5	19.4	11.8	8.4	3.9	0.7	0.3	1.4	1168
St. Vincent	16	Mean	79	79	229	137	25	90	1.7	1.0	3.5	3859
		Std. dev.	2.7	3.2	27.7	20.0	16.9	10.3	0.8	0.2	1.2	1087
Tobago	19	Mean	85	86	303	198	7	100	2.1	0.8	3.2	3054
		Std. dev.	1.6	1.8	17.6	17.0	8.2	13.8	0.7	0.2	0.9	1035
Trinidad	40	Mean	82	82	292	192	11	96	1.8	0.8	3.4	3271
		Std. dev.	2.8	2.8	17.3	14.5	9.1	7.2	0.8	0.2	1.1	1002

Table 2. Results of classification of sets of accessions based on island/country (where 1 falls into first 1/3, 2 into second, 3 into third equal set of values) for three agronomic traits, evaluated in Isabela, Puerto Rico, in 1987.

	Days to tassel	Plant height	Yield
Antigua	1	1	3
Barbados	1	1	1
BVl	2	3	2
Check	1	2	3
Composites	1	2	2
Cuba	2	2	2
Dominican Republic	1	3	3
Grenada	3	3	1
Guadeloupe	1	2	1
Haiti	3	3	2
Jamaica	2	2	3
Puerto Rico	1	2	3
St. Croix	1	2	3
St. Lucia	3	2	1
St. Vincent	2	1	2
Tobago	3	3	1
Trinidad	3	3	1

Table 3. Means and standard deviations of agronomic traits of sets of accessions based on predominate racial classification evaluated in Isabela, Puerto Rico, in 1988.

Predominate race	N		Days to		Height		Lodged		Tillering	Ear		
			Tassel	Silk	Plant	Ear	Stalk	Root	code	Number	Quality	Yield
					----cm----		-----%-----		1-9		1-9	kg/ha
Cuban Flint	4	Mean	67	69	292	171	0.9	7.7	2.7	1.1	6.7	5101
		SD	2.2	1.7	8.0	14.3	1.3	3.4	0.8	0.1	0.8	606
Chandelle	19	Mean	65	65	287	160	1.6	12.7	2.1	1.2	6.2	5327
		SD	1.9	2.4	11.2	11.9	1.1	9.2	0.4	0.1	0.5	608
Coastal Tropical	21	Mean	67	68	288	172	1.3	10.5	2.3	1.1	6.2	5745
Flint		SD	3.2	3.6	26.0	24.5	1.9	6.4	0.6	0.1	0.6	635
Early Caribbean	11	Mean	64	65	260	143	1.5	12.8	2.3	1.2	6.3	5413
		SD	2.4	2.7	21.8	18.9	2.1	7.1	0.5	0.1	0.4	880
Haitian Yellow/White	8	Mean	75	76	318	203	0.6	8.5	2.5	1.2	5.8	5046
		SD	4.1	4.0	17.0	14.8	0.5	4.6	0.7	0.1	1.0	899
Mixed†	38	Mean	66	67	289	166	1.1	12.7	2.3	1.2	6.2	5719
		SD	3.3	3.6	17.5	17.1	1.3	8.5	0.6	0.1	0.6	709
St. Croix	3	Mean	65	66	261	147	0.8	11.7	2.2	1.1	6.9	6024
		SD	1.0	1.8	5.3	6.2	0.8	10.0	0.8	0.1	0.1	768
Tusón	9	Mean	72	73	310	195	2.0	13.7	2.3	1.1	5.9	5770
		SD	4.0	4.0	15.4	19.9	2.0	8.8	0.3	0.1	1.1	1034

†Accessions where a predominate race could not be determined due to racial mixing.

Table 4. Agronomic traits of the 20 highest-yielding accessions evaluated at Isabela and Lajas, Puerto Rico, in 1988.

Accession	Days to tassel	Height		Lodging		Ear quality	yield	Predominate race	Predom. kernel type
		Plant	Ear	Stalk	Root				
		----cm----		-----%-----		1-9†	kg/ha		
Barbados Groupo 2	69	306	201	1	12	8	7773	Tusón	Semi-dent
Cuba 106	66	278	167	0	9	6	7262	Mixed	Semi-flint
Dominican Republic 150	67	284	178	0	9	6	7029	Mixed	Semi-flint
St. Croix 1	65	284	169	8	20	7	6999	Early Caribbean	Semi-dent
St. Croix Groupo 3	65	260	154	1	24	7	6910	St. Croix	Semi-dent
Cuba 164	64	293	174	1	2	7	6812	Coastal Tropical Flint	Semi-flint
Dominican Republic Groupo 14	65	301	167	3	11	7	6801	Chandelle	Semi-dent
Trinidad 19	70	311	197	2	9	6	6778	Coastal Tropical Flint	Semi-dent
Cuba 96	66	306	181	1	3	6	6702	Mixed	Semi-dent
Dominican Republic 270	66	295	168	1	16	6	6699	Early Caribbean	Semi-dent
Dominican Republic 290	66	300	175	3	13	7	6660	Mixed	Semi-dent
Dominican Republic Groupo 5	64	284	152	4	12	7	6631	Mixed	Semi-dent
Puerto Rico Groupo 5A	66	277	141	0	10	7	6598	Mixed	Dent
Jamaica 7	71	312	195	0	5	6	6569	Mixed	Semi-dent
Cuba 173	66	308	186	4	13	7	6540	Mixed	Semi-dent
Puerto Rico Groupo 3	66	283	168	3	10	6	6512	Mixed	Dent
Barbados 9	69	307	195	2	10	7	6502	Tusón	Semi-flint
Jamaica Groupo 1	70	313	193	1	16	7	6438	Coastal Tropical Flint	Semi-flint
Tester-Diente de Caballo	62	265	143	1	5	7	6427	Coastal Tropical Flint	Semi-flint
Grenada Groupo 5	71	303	196	1	7	7	6387	Haitian Yellow	Semi-flint

†9 = best quality, 1 = poorest.

four Coastal Tropical Flint, two each Tuson and Early Caribbean, and one each St. Croix, Chandelle, and Haitian Yellow. Eight of these accessions were composites of accessions. These results indicate that within the Caribbean germplasm, there is heterosis resulting from the mixing of races.

Many good accessions have been identified from the initial 562 evaluated. These accessions will have value in breeding programs for improvement of yield and grain quality, although root quality will have to be improved.

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