Maize landrace accessions of Mexican dent from the Huasteca Region in Hidalgo, San Luis Potosí, and Veracruz

Germoplasma de Maiz Dentado Procedente de la Region de la Huasteca de Hidalgo, San Luis Potosí y Veracruz, Mexico

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Introduction

The Mexican dent races Tuxpeño, Olotillo, Tepecintle, and Celaya (Wellhausen et al. 1952) have been used in tropical and subtropical maize breeding programs worldwide, largely for their productivity, broad adaptation, and combining ability. With support from Mexico's Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), in 2007 CIMMYT collected samples of white, yellow, and blue dent grain landraces in the Huasteca region of the states of Hidalgo, San Luis Potosi, and Veracruz, to fill gap in existing collections and conserve the diversity from the area's non-equatorial, tropical, and subtropical humid (Hartkamp et al. 2000) settings (200-300 masl; 12.5-13.4 hour day-length; 600-2,000 mm annual precipitation). The present study reports on analyses of the samples' phenotypic diversity and efforts to establish a core subset of the materials for breeding and in situ conservation.

Materials and methods

The 292 accessions collected from the Huasteca; reference accessions of races Tuxpeño (8), Olotillo (8), Celaya (3), Tepecintle (5), and Vandeño (3); tropical gene pools (4); single-cross hybrids (2: CML 247 x CML 254, CML 495 x 494); and other populations (5) were grown in a performance evaluation trial at CIMMYT's lowland tropical research station in Mexico (Agua Fría, Puebla; 100 masl, 20:27N/97:38W) during in spring season, AF2008A. The entries were arranged in a 15 x 22 alpha lattice design, replicated twice in two rows of 5 meters per plot. Data taken for multivariate cluster analysis (Ward-MLM; Franco et al. 1998, 2005) of phenotypic diversity were plant height (PH), ear height (EH), days to anthesis (AN), days to silking (SI), stalk lodging (SL), root lodge (RL), ear length (EL), ear width (EW), kernel length (KL), kernel width (KW), kernel row number (KRN), leaf senescence (SE) (days from silking to ear-leaf senescence), grain shelling % (SH), and grain moisture % (MO). The data on ear rot rating (ER), grain yield (YLD), and ear quality rating (EQ) were taken to make a selection index (ESIM; Serón-Rojas et al. 2006). To choose the core subset accessions (11%) with best agronomic performance, the Ward-MLM SAS program (Franco and Crossa 2003) was employed to cluster homogeneous accessions and map phenotypic diversity by canonical analysis. The ESIM was calculated to choose the best 11% of the accessions from each cluster, using the D-method of the sampling strategy (Franco et al. 2005). Race classification was performed according to Wellhausen et al. (1952).

Results and discussion

The cluster analysis of Ward-MLM using the traits mentioned above formed eight distinct clusters. According to agronomic performance based on the selection indexes, cluster 4 was best (Table 1). To form the core subset, 11% of the accessions were chosen according to selection indexes within clusters (Table 2). The core subset included white dent (11), yellow dent (21), and blue colored dent (2) accessions. The core subset is characterized by lateness, tallness, long ears, fewer kernel rows, high root and stalk lodging, as compared with the hybrid checks, which grouped in cluster 8. In the phenotypic diversity of the core subset (Figure 1), Huasteca accessions plot within the range of variation of Tuxpeño, Olotillo, and Tepecintle reference accessions (Vera 39, Chis 440, SNLP 104, Vera 193; Table 2). The hybrids and gene pools are clearly separated from core accessions. Based on our results, the Huastaca maize germplasm is predominantly of races Tuxpeño, Olotillo, and Tepecintle, with possible intervention by other races (Ancho, Tabloncillo, Celaya, or others; Table 2).

The average plant and ear height of the core subset was about 70 cm more than those of single-cross hybrid CML 247 x CML 254. Subset accessions silked about 9-10 days later than the hybrid; ears were long and cylindrical and had fewer kernel rows; ear and plant height ratio (EH/PH) was generally greater (indicating high ear placement on the plant); grain yield for some core accessions was comparable. The subset would require considerable improvement for plant and ear type, for efficient grain production.

Conclusion

The Huasteca late, tropical yellow dents constitute an excellent addition to CIMMYT collections, which had few accessions of this type, and the core subset can be used for participatory breeding—introgressing selected alleles for improved traits as a form of in-situ conservation—and to develop hybrids for tropical and subtropical regions. In addition to the above-mentioned traits, the materials gave deep-flat-wide kernels with medium soft grain texture, when grown at CIMMYT Agua Fría tropical station, and some accessions had deep orange–yellow dent gain type. Given the excellent yield potential of Huastaca maize, more studies would be in order on its relationship with other maize races in the America, as well as its combining ability and nutritional quality.

Table 1. The means of the eight clusters formed by Ward-MLM for agronomic-morphological characters evaluated at AF2008A, Puebla, Mexico.

Cluster	SI (Days)	PH (cm)	EH/PH (Ratio)	SE (Days)	SE/SI (Ratio)	SH (%)	SL (%)	EQ (1-5)	EL (cm)	ED (cm)	KL (cm)	KWD (cm)	KRN (cm)	YLD (ton/ha)	YLD/MO (Ratio)	ESIM
Cluster 1 (8)*	88	266.3	0.70	54	0.61	87.3	6.0	2.4	17.1	4.5	1.3	0.9	11	3787.7	301.34	667.1
Cluster 2 (175)	90	297.6	0.67	53	0.59	86.5	7.0	2.5	15.9	4.7	1.3	1.0	10	3574.1	277.76	662.7
Cluster 3 (43)	81	273.9	0.65	54	0.67	88.3	7.1	2.4	16.0	4.5	1.3	1.0	10	3764.2	295.51	660.0
Cluster 4 (27)	86	289.3	0.68	54	0.63	87.3	6.9	2.4	16.5	4.6	1.3	1.2	9	3865.3	309.18	685.4
Cluster 5 (26)	97	310.6	0.70	54	0.55	85.6	6.0	2.6	16.9	4.5	1.3	1.0	10	3069.2	227.50	627.8
Cluster 6 (13)	86	282.4	0.66	53	0.62	86.0	6.6	2.7	15.9	4.6	1.2	0.9	12	3168.7	247.24	604.4
Cluster 7 (15)	89	297.1	0.67	53	0.59	85.8	7.2	2.5	19.3	4.6	1.3	0.9	12	3501.3	268.77	655.2
Cluster 8 (22)	75	235.1	0.58	51	0.67	86.5	6.3	2.9	14.0	4.6	1.2	0.9	13	2840.3	220.52	523.6
Trail mean	87.38	288.42	0.66	52.93	0.61	86.43	6.81	2.50	16.06	4.62	1.30	1.01	10.66	3.51	272.99	649.63
Standard error	1.55	20.83	0.05	2.42	0.03	1.20	3.07	0.34	1.18	0.22	0.07	0.06	0.72	546.29	52.20	
LSD 0.05	3.04	40.82	0.09	4.74	0.06	2.34	6.02	0.67	2.31	0.43	0.14	0.13	1.40	1070.73	102.32	
CV (%)	1.78	7.22	7.05	4.57	5.28	1.38	45.15	13.66	7.35	4.71	5.37	6.39	6.72	15.57	19.12	

( )* indicates the number of the accessions in the cluster.
SI = Days to silking, PH = Plant height, EH/PH = Ratio of ear height and plant height, SE = Ear Leaf senescence, SE/SI = Ratio of ear leaf senescence and days to silking, SL = Stalk lodging,
EQ= Ear quality (1 = good, 5 = poor), EL = Ear length, ED = Ear diameter, KL= Kernel length, KWD = Kernel width, KRN = Kernel row number
YLD = Grain yield, YLD/MO = Ratio grain yield and gran moisture % at harvest, ESIM = Selection index.

Table 2. The core subset (11%) of the Huasteca maize germplasm and their performance evaluated at AF2008A, Puebla, Mexico.

Accession	SI (Days)	PH (cm)	EH/PH (Ratio)	SE (Days)	SE/SI (Ratio)	SH (%)	SL (%)	EQ (1-5)	EL (cm)	ED (cm)	KL (cm)	KWD (cm)	KRN (cm)	YLD (ton/ha)	YLD/MO (Ratio)	ESIM	Grain Texture	Race Class
White grain type																		
HIDA 260 (4)*	87	285.6	0.71	51	0.59	86.0	7.1	2.2	15.7	4.8	1.4	1.2	9	4.7	0.40	777.0	Dentado	Ancho/Olotillo
HIDA 272 (4)	86	289.9	0.66	52	0.60	87.3	6.4	2.5	18.3	4.9	1.4	1.2	10	4.6	0.36	764.5	Dentado	Tepecintle/Olotillo
HIDA 289 (4)	84	282.7	0.66	54	0.64	88.4	5.6	2.2	16.4	4.6	1.3	1.1	9	4.4	0.35	737.0	Dentado/Cristalino	Olotillo/Ancho
HIDA 293 (4)	87	275.7	0.65	53	0.61	86.0	4.7	2.5	16.7	4.9	1.4	1.2	9	4.6	0.38	754.9	Dentado	Olotillo/Ancho
HIDA 315 (7)	92	311.5	0.70	52	0.57	85.7	6.4	2.1	19.7	4.8	1.3	1.0	12	5.0	0.38	833.7	Dentado	Olotillo/Tuxpeño
SNLP 311 (3)	78	272.3	0.65	56	0.71	89.0	6.5	2.2	16.7	4.4	1.3	1.0	10	4.5	0.35	741.6	Dentado	Olotillo
SNLP 334 (1)	91	272.2	0.65	53	0.58	86.7	7.3	2.5	16.7	4.2	1.3	0.9	12	3.8	0.31	674.7	Dentado	Tuxpeño
SNLP 363 (7)	88	256.1	0.66	54	0.61	86.4	7.6	2.1	22.4	4.6	1.3	0.9	11	4.6	0.36	739.7	Dentado	Tuxpeño/Olotillo
SNLP 372 (6)	85	275.9	0.65	52	0.61	85.5	5.8	2.5	16.2	4.3	1.1	0.9	10	3.8	0.28	665.8	Dentado	Olotillo/Tuxpeño
VERA 745 (6)	89	321.2	0.66	54	0.61	86.0	6.7	2.5	17.0	4.8	1.3	0.9	13	3.7	0.30	688.5	Dentado	Tuxpeño/Olotillo
VERA 760 (2)	88	304.6	0.69	52	0.59	86.7	5.4	2.2	16.3	5.0	1.3	1.0	11	4.6	0.33	776.7	Dentado	Olotillo/Ancho
Mean	86.96	286.15	0.67	52.99	0.61	86.71	6.31	2.32	17.47	4.67	1.32	1.03	10.50	4.39	0.35	741.29		
Yellow grain type																		
HIDA 240 (2)	84	297.0	0.65	50	0.60	87.8	9.6	2.4	16.5	4.7	1.2	1.1	10	4.4	0.36	746.3	Dentado	Olotillo/Tepecintle
HIDA 255 (3)	80	244.9	0.60	56	0.71	87.6	5.5	2.2	15.3	4.6	1.3	1.1	10	4.4	0.36	702.6	Dentado/Cristalino	Olotillo/Tepecintle
HIDA 256 (3)	80	259.3	0.63	54	0.68	89.1	5.4	2.5	15.9	4.7	1.4	1.0	10	4.4	0.36	717.8	Dentado/Cristalino	Olotillo/Tepecintle
HIDA 291 (2)	91	301.6	0.68	53	0.59	87.2	7.5	2.1	16.4	4.7	1.3	1.1	10	4.6	0.37	782.3	Dentado/Cristalino	Olotillo/Tepecintle
HIDA 313 (2)	91	277.9	0.68	55	0.61	86.5	5.0	2.2	15.2	4.8	1.4	1.0	11	4.4	0.33	741.9	Dentado	Olotillo/Tuxpeño
SNLP 299 (1)	84	246.3	0.77	54	0.65	86.8	6.0	2.2	16.2	4.8	1.4	0.9	13	4.5	0.39	732.3	Dentado	Olotillo/Tepecintle
SNLP 300 (6)	84	300.5	0.66	53	0.63	88.1	8.8	2.5	15.5	4.7	1.3	0.9	13	4.0	0.31	703.0	Dentado	Tuxpeño/Olotillo
SNLP 305 (1)	81	215.0	0.80	51	0.63	86.7	6.0	2.2	15.2	4.6	1.3	1.0	11	4.3	0.34	689.3	Dentado	Olotillo/Tepecintle
SNLP 323 (7)	83	308.3	0.66	55	0.66	86.9	9.5	2.5	20.5	4.7	1.3	1.0	11	4.4	0.37	753.7	Dentado	Olotillo/Tuxpeño
SNLP 324 (7)	86	281.8	0.67	50	0.58	88.3	6.8	2.9	18.3	4.5	1.3	1.0	11	4.1	0.31	702.7	Dentado/Cristalino	Olotillo/Tuxpeño
SNLP 328 (2)	91	338.1	0.69	53	0.59	85.6	6.5	2.2	16.7	4.7	1.4	1.0	11	4.6	0.35	803.5	Dentado	Olotillo/Tepecintle
SNLP 339 (3)	84	294.5	0.67	51	0.60	88.8	5.2	2.2	16.6	4.5	1.3	1.0	10	4.6	0.37	764.5	Dentado	Olotillo/Tepecintle
SNLP 340 (3)	80	265.4	0.67	53	0.66	89.9	5.1	2.2	15.5	4.4	1.3	1.0	10	4.7	0.37	758.3	Dentado	Olotillo/Tepecintle
SNLP 348 (5)	97	320.2	0.66	54	0.56	89.1	6.2	2.5	19.7	4.7	1.3	1.0	10	4.4	0.33	771.9	Dentado	Tepecintle/Olotillo
SNLP 351 (5)	97	318.3	0.69	56	0.57	83.8	7.6	2.5	18.8	4.6	1.3	1.0	10	3.8	0.28	709.0	Dentado	Olotillo/Tepecintle
SNLP 353 (5)	97	333.3	0.74	55	0.56	84.9	4.4	2.3	17.1	4.5	1.3	1.0	10	3.7	0.28	720.3	Dentado	Olotillo
VERA 773 (2)	92	320.2	0.63	52	0.56	86.0	8.4	2.2	16.5	4.6	1.3	1.0	12	4.5	0.36	771.7	Dentado	Tepecintle/Olotillo
VERA 788 (4)	84	281.0	0.68	53	0.63	87.5	6.6	2.2	15.7	5.0	1.4	1.2	9	4.9	0.42	783.9	Dentado	Olotillo/Tepecintle
VERA 817 (4)	82	272.8	0.69	55	0.67	85.6	7.2	2.6	18.4	4.8	1.2	1.2	9	4.6	0.37	752.3	Dentado	Olotillo/Ancho
VERA 822 (6)	81	272.6	0.65	56	0.69	87.4	8.3	2.5	14.7	4.7	1.2	0.9	13	3.3	0.25	614.7	Dentado	Olotillo/Tepecintle
Mean	86.41	287.44	0.68	53.42	0.62	87.17	6.78	2.35	16.74	4.66	1.31	1.01	10.76	4.32	0.34	736.10		
Blue Grain Type																		
HIDA 297 (5)	96	315.0	0.64	53	0.55	83.7	7.2	2.3	19.1	4.6	1.1	1.1	10	4.1	0.29	733.9	Harinoso/Dentado	Tepecintle/Olotillo
SNLP 337 (1)	87	287.5	0.68	54	0.62	89.4	5.9	2.3	17.9	4.6	1.4	0.9	11	3.9	0.31	696.0	Harinoso/Dentado	Olotillo/Tepecintle
Mean	91.77	301.21	0.66	53.69	0.59	86.59	6.56	2.27	18.47	4.59	1.26	1.01	10.26	4.04	0.30	714.95		
Reference entries																		
CML 247 x CML 254 (8)	77	211.3	0.60	56	0.73	86.4	5.5	2.2	14.0	4.9	1.4	1.0	13	4.7	0.35	720.4	Dentado/Cemicristalino	Hibrido
CML 495 x CML 494 (8)	76	241.9	0.52	55	0.73	84.6	6.5	2.2	14.9	4.7	1.3	0.9	12	4.7	0.36	729.3	Dentado/Semicristalino	Hibrido
POOL 25 TLYF C32 (8)	76	231.6	0.55	59	0.77	83.5	6.4	2.5	15.1	4.7	1.2	0.9	14	3.6	0.28	600.7	Cristalino	Población
POOL 26 TLYD C32 (8)	75	218.2	0.62	54	0.72	87.7	4.8	2.5	14.9	4.8	1.3	0.9	14	3.9	0.31	628.7	Dentado	Población
CHIS 440 (3)	84	271.0	0.69	55	0.66	86.9	8.3	2.4	16.3	4.3	1.3	1.1	9	3.9	0.31	679.5	Dentado	Olotillo
SNLP 104 (3)	77	248.5	0.64	57	0.74	88.5	5.3	2.9	15.1	4.4	1.3	1.0	10	3.0	0.22	641.5	Dentado	Tuxpeño/Olotillo
VERA 39 (6)	87	291.0	0.66	53	0.61	86.6	9.7	2.7	15.9	4.6	1.3	0.9	12	2.9	0.22	583.3	Dentado	Tuxpeño
VERA 193 (2)	94	276.3	0.67	53	0.57	85.9	4.9	3.1	15.0	4.7	1.3	0.9	13	2.7	0.20	559.4	Dentado/Semicristalino	Tepecintle/Tuxpeño
Mean	80.79	248.73	0.62	55.39	0.69	86.26	6.42	2.57	15.16	4.65	1.28	0.95	12.23	3.69	0.28	642.86		
Trial mean	87.38	288.42	0.66	52.93	0.61	86.43	6.81	2.50	16.06	4.62	1.30	1.01	10.66	3.51	272.99	649.63		
LSD 0.05	3.04	40.82	0.09	4.74	0.06	2.34	6.02	0.67	2.31	0.43	0.14	0.13	1.40	1070.70	102.32			
CV (%)	1.78	7.22	7.05	4.57	5.28	1.38	45.15	13.66	7.35	4.71	5.37	6.39	6.72	15.57	19.12			

( )* indicate the cluster in which it is grouped.
SI = Days to silking, PH = Plant height, EH/PH = Ratio of ear and plant height, SE = Ear leaf senecence, SE/SI = Ratio of senecence and days to silking, SL = Stalk lodging,
EQ= Ear quality (1 = good, 5 = poor), EL = Ear length, ED = Ear Diameter, KL= Grain length, KWD = Kernel width, KRN = Kernel row number,
YLD = Grain yield, YLD/MO = Ratio of grain yield and grain moisture %, ESIM = Selection index, Race class = Observed race(s) at harvest.

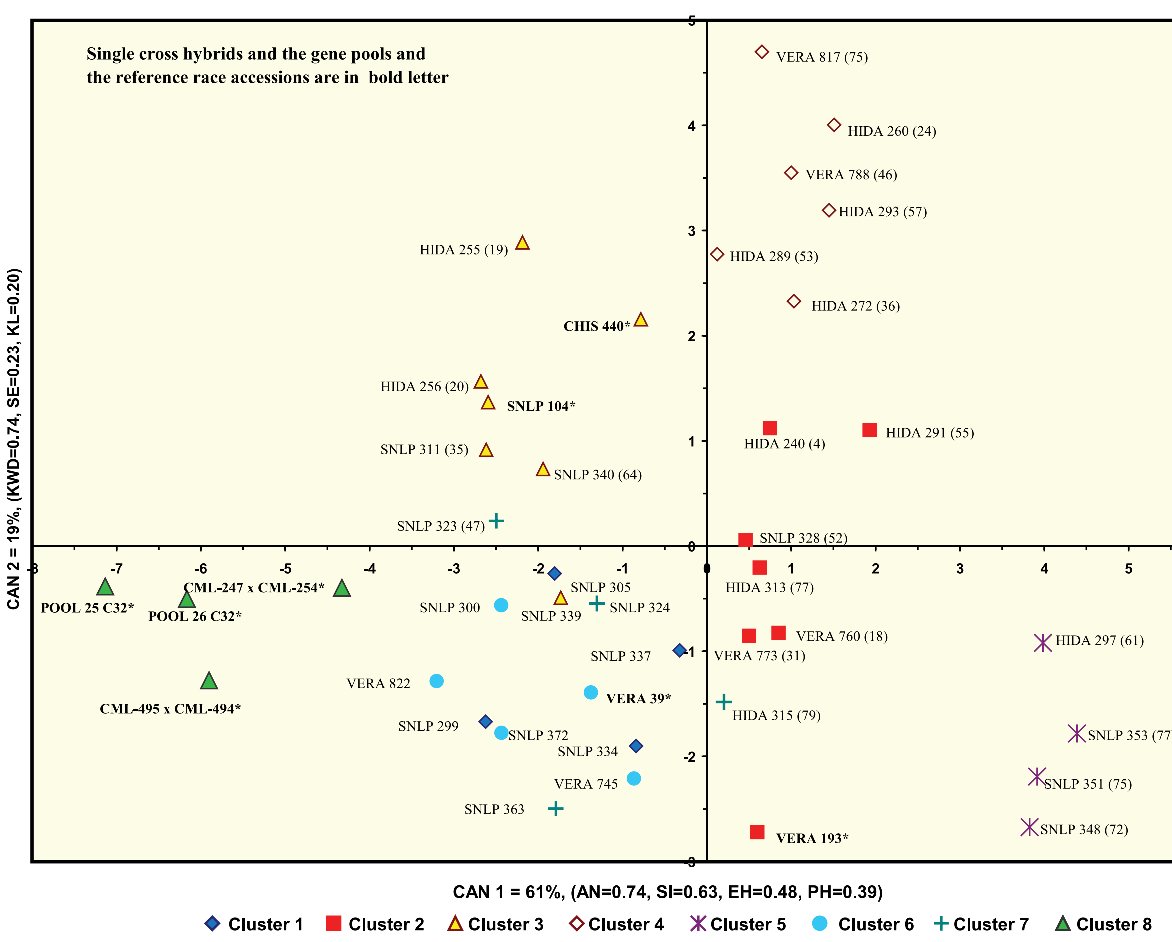

Figure 1. The patterns of the phenotypic diversity of the core subset (11%) and six reference entries (two single cross hybrids and improved gene pools and the reference race accessions) plotted by the canonical variables (Can 1 and Can 2).

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