A Case of Maize Landrace Authentication Process in Mexico

Plant Authentication workshop

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Maize: Origin, Domestication, and Use

- **Origin**: A single domestication from Balsas teosinte (Zea mays ssp.parviglumis) (Matsuoka, Y. et al. PNAS 2002 99:6080-6084)
- **Domestication**: Central Balsa region, Southwestern Mexico. 8700 B.P. (Piperno, D.R. et al. PNAS 2009 106:5019-5024)
- **Cultivation**: Oaxacan highland: Guila Naquitz Cave: 6200 B.P. (Piperno D.R.and Flannery K.V. PNAS 2001 98:2101-2103).
- **Use**: feed, food, green vegetable, fuel, other industrial products

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Maize: Germplasm at CIMMYT

- The genebank collection: landrace accessions (**24,000 acc. at maize genebank from Latin America**)
- Inbred: homozygous lines of a heterotic pattern: A or B or C, etc. (**530 lines from Breeding Program**)
- Improved population: synthetic, breeding crosses, advanced generations of a hybrid, and heterotic gene pools (**Breeding Program and maize genebank)**
- Hybrid: single cross, three way cross, double cross **(Breeding Program)**
- Wild relatives: teosinte and tripsacum (**each more than 100 acc. maize genebank)**

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CIMMYT Active Genebank

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Maize: Mating system

- Pollination: allogamous and autogamous
- Male: tassel
- Female: ear
- Inbreeding: selfing, full-sib,
- Open pollination: half sib
- Breeding cross: full sib, half sib
- Hybrid and test/top cross: full sib, half sib

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Maize Breeding Methods

- Mass selection: purification, maintenance
- Inbreeding: line development
- Recurrent/reciprocal recurrent selection: population improvement
- Testcross/topcross: line evaluation
- Breeding cross: gene introgression or integration
- Backcross: gene integration

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Breeding plot and hybrids

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Pollination, Harvesting, Storage

- Pollination: pollen tector bags and glassine
- Silking and tasseleing: synchrony
- Time of pollination: a full pollen shed
- Harvest: black layer at 30-35% H2O
- Shelling: seed dried to 12-14% H2O
- The genebank storage: 6-8% H2O

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General Plant and Ear Traits for Authentication

- **Vegetative**: plant height, ear height, tassel size and shape, leaf size/shape/number, plant color (green, purple, red), etc.
- **Reproductive**: ear length/diameter, kernel length/diameter/thickness, kernel types (dent, flint, floury, sugary, morocho, pop), Kernel colors (white, yellow, orange, purple, red), etc.

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Flowering and Tassel type

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Tillers

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Pubescence and plant color

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Colored maize ear

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About Maize Landrace

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General Characteristics

- Specific adaptation: high G x E
- Metapopluation structure of a race: similar plant and ear types but a large phenotype variation within it.
- Good culinary quality: preferred grain texture and color:
- Grown in rain fed and slope land conditions
- Improved by mass selection

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General Characteristics

- On farm conservation in generation to generation: 30-60 years in some cases.
- Multiple use of plant parts: grain, stalk, leaf, husk, cob, tassel
- Marketing opportunity: pozole, tamale, pop corn, sweet maize, and elote.
- Cropping system: single or multiple with squash, beans
- Farmers: food security on farm

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General Characteristics

- Good husk cover for earworm and weevil resistance:
- Poor standability: tall plant, week root, and tillering: (not suited for mechanization)
- Race specific plant and ear traits: kernel size, row number, ear length, kernel texture and color, and plant architecture
- Genetic diversity for nutritional quality and adaptation.

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Tortilla making from race Bolita

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Landrace collection from Papaloapan, Oax. Mx. 2009

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Typical tropical maize landrace in Oaxaca, Mx. and regeneration of an accession at CIMMYT station 2009

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A Case Study:

- Collection, Evaluation, and Enhancement of the race Bolita in Central Valley of Oaxaca, Mexico in 1997-2000

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A Study on Race Bolita

- **Site:** Central Valley of Oaxca, Mexico
- **Landrace collected**: 170 accessions from 15 villages (1997)
- **Evaluation on farm**: first: in 15 villages in the Central Valley of Oaxca, second: in 5 villages, third: in 2 villages.
- **Traits evaluated**: days to silk(SI), days to anthesis (AN), plant height (PH), ear height (EH), grain moisture% (MO), ear length (EL), ear diameter (ED), kernel row number (KRN), kernel length (KL), kernel width (KW), and shelling%(SH).

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A Study on Race Bolita

- **Result 1**: a subset of 38 (22%) accessions from 5 clusters.
- **Result 2:** a subset of 16 (9.4 %) accessions from 5 clusters.
- **Result 3**: a subset of elite accessions VC 40, 42, 118, 39, 145, and 153 to represent diversity of the metapopulations of the race.
- **Result 4**: Seed increase, demonstration, and seed distribution to the farmers.

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Metapopulations of a race Bolita

Table 7.

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CL5	Entry	IdNum	Collection		GE	PP	AN	SI	PH	EH	YLD	ERT	EL	ED	KRN	MO	SH	KL	KW	AGS	EQ	SEL	$D^2(H_j)$	CAN1	CAN2	CAN3
					%				cm	cm	kg/ha	%	cm	cm		%	%	cm	cm	1_5	1_5	%				
a	23	20186	OAXACA	23	70	40	71	75	220	119	4303	20	15	5.0	12	24	79	1.2	1.0	2.7	2.8	95		2.43	-1.41	1.81
a	145	20308	OAXACA	145	67	38	72	75	221	114	4908	27	16	5.1	12	26	82	1.3	1.0	2.5	3.0	89		4.43	-3.26	2.97
a	170	21200	V-233		72	41	69	72	203	107	4522	24	16	5.1	12	25	79	1.2	1.0	2.8	3.0	90		3.44	-2.32	2.29
n=3					70	40	70	74	215	113	4578	24	15	5.1	12	25	80	1.2	1.0	2.7	2.9		77.5			
b	30	20193	OAXACA	30	66	38	69	72	207	109	4300	18	15	4.9	11	23	78	1.2	1.1	2.6	2.6	100		-0.25	-0.94	-0.72
b	43	20206	OAXACA	43	68	39	69	73	212	109	4175	18	14	5.1	11	23	79	1.2	1.1	2.9	2.6	98		-3.00	-0.42	-0.32
b	118	20281	OAXACA	118	69	40	68	71	213	106	4057	21	15	4.9	10	24	78	1.2	1.1	2.4	2.6	89		-1.69	0.38	-0.34
b	128	20291	OAXACA	128	69	40	64	68	200	97	3499	25	15	4.8	9	21	80	1.2	1.2	2.6	2.8	86		-3.41	-0.32	-0.77
b	129	20292	OAXACA	129	68	39	66	70	216	104	3874	26	15	4.8	9	22	79	1.2	1.2	2.9	3.0	87		-2.38	-1.25	-2.28
n=5					68	39	67	71	210	105	3981	22	15	4.9	10	23	79	1.2	1.1	2.7	2.7		85.7			
c	39	20202	OAXACA	39	68	40	68	71	206	102	4540	29	16	5.3	10	23	74	1.2	1.2	2.6	2.7	94		-0.59	5.72	0.50
c	121	20284	OAXACA	121	69	39	69	73	222	112	4211	29	16	5.3	10	22	71	1.1	1.3	3.2	3.2	91		1.46	7.24	-0.99
c	123	20286	OAXACA	123	65	38	70	73	212	105	4473	26	16	5.3	10	25	72	1.2	1.3	2.7	2.9	86		1.19	8.45	1.33
n=3					68	39	69	72	213	106	4408	28	16	5.3	10	23	72	1.2	1.2	2.8	2.9		128.8			
d	40	20203	OAXACA	40	69	38	65	68	202	96	3875	22	14	5.0	10	22	81	1.1	1.1	2.3	2.7	92		-3.89	-1.32	0.69
d	42	20205	OAXACA	42	69	39	65	68	204	101	4079	28	14	5.0	11	21	81	1.2	1.1	2.6	3.0	94		-3.17	-2.52	0.40
d	49	20212	OAXACA	49	67	40	68	71	200	100	4287	21	15	4.8	10	23	79	1.1	1.1	2.7	2.8	98		-3.25	-1.71	-2.05
d	166	20018	OAXACA	435	65	37	65	69	203	104	3277	22	14	4.6	10	21	82	1.1	1.0	2.7	3.1	82		-3.60	-3.93	0.45
n=4					68	39	66	69	202	100	3879	23	14	4.9	10	22	81	1.1	1.1	2.6	2.9		107.7			
e	152	20315	OAXACA	152	64	35	82	85	237	133	4703	20	18	5.0	13	33	74	1.2	0.9	2.9	2.8	70	204.2	12.28	-2.38	-2.94
n=1																										

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Plot of the first three canonical variables for 16 collections representing phenotypic diversity of the race Bolita in the Central Valley of Oaxaca, 1997-1998

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A Study on Race Bolita

- **Result 5:** Variety registration of VC 152 C8 under SNICS by INIFAP as forage, green ear, and grain maize in 2008.
- **VC 152 C8**:
  - 1) Forage yield of 40 tons/ha, long ear (18-22cm), grain yields(3.5 t/ha rain fed, 6.5 t/ha irrigated).
  - 2) 5 tons of the declared (labeled) seed have been distributed since 2000, informally.
  - 3) In 2010, a plan of 20 tons of seed increase for distribution in Central Valley of Oaxaca, Mexico.
  - 4)No study on actual production area has been made.

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VC 152 Registration at SNICS#

- Servicio Nacional de Inspección y Certificación de Semillas
- Catálogo Nacional de Variedades Vegetales
- Núm. Registro Provisional Núm. Registro Definitivo

- **721 VC-152 2034 - MAZ - 1016 - 310108/C INIFAP**

- 722 VENADO MAZ - 558 - 251104 MONSANTO
- #: http://www.sagarpa.gob.mx/snics/default.htm

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VC 152 C8

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Seed law in Mexico and Seed Inspection and Certification

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Numbers of Certified Seeds (source: Taller SNICS, 2007)

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The trend of certified seed production and seed production need for all crops in Mexico (Source: a Taller SNICS 2007)

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Estimated seed requirement for maize in Mexico

- Estimated 3,000,000 ha are planted by certified seeds (statistics of SNICS) in 2007

- If maize is planted in 8 million hectors in Mexico, the certified seeds would cover 37% of maize production acreage, and the rest (63%) would be planted with on-farm seed.

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Sistema Nacional de Semillas (National Seed System)

- SAGARPA (Ministry of Agriculture)
- SNICS (National seed inspection/certification service)
- INIFAP (National Institute of Agriculture and Forestry)
- Productores y comercializadores de semillas: Seed producers and marketing persons
- Obtentores: PVP rights holders
- Fitomejoradores: Breeders
- Mantenedores de semillas: Seed savers
- Comités Consultivos Regionales y Estatales: Regional and State Committees for consultation
- Asociaciones de agricultores: Farmer associations
- Instituciones de enseñanza, investigación y extensión: Institutions

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New Seed Law of 2007

- **LEY FEDERAL DE PRODUCCIÓN, CERTIFICACIÓN Y COMERCIO DE SEMILLAS**
- **Nueva Ley publicada en el Diario Oficial de la Federación el 15 de junio de 2007**
- **Nota:** Esta Ley entrará en vigor el 14 de agosto de 2007.
- Al margen un sello con el Escudo Nacional, que dice: Estados Unidos Mexicanos.- Presidencia de la República.
- **FELIPE DE JESÚS CALDERÓN HINOJOSA**, Presidente de los Estados Unidos Mexicanos, a sus habitantes sabed:
- Que el Honorable Congreso de la Unión, se ha servido dirigirme el siguiente
- **DECRETO**
- "EL CONGRESO GENERAL DE LOS ESTADOS UNIDOS MEXICANOS, DECRETA:
- **SE EXPIDE LA LEY FEDERAL DE PRODUCCIÓN, CERTIFICACIÓN Y COMERCIO DE SEMILLAS.**
- **ARTÍCULO ÚNICO.-** Se expide la Ley Federal de Producción, Certificación y Comercio de Semillas.
- **LEY FEDERAL DE PRODUCCIÓN, CERTIFICACIÓN Y COMERCIO DE SEMILLAS.**
- **CAPÍTULO I**
- **DISPOSICIONES GENERALES**

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Article 33 of Seed Law for Commercilization

- **CAPÍTULO VII**
- **DEL COMERCIO DE SEMILLAS**
- **Artículo 33.-** Para que **cualquier semilla de origen nacional o extranjero**, pueda ser comercializada o puesta en circulación, deberá llevar en el envase **una etiqueta a la vista que incluya los siguientes datos informativos:**
- **I.** El nombre del cultivo;
- **II.** Género y especie vegetal;
- **III.** Denominación de la variedad vegetal;
- **IV.** Identificación de la categoría de semilla, de conformidad con lo dispuesto en esta Ley;
- **V.** Cuando aplique, el porcentaje de germinación y en su caso, el contenido de semillas de otras variedades y especies así como el de impurezas o materia inerte;
- **VI.** En su caso, la mención y descripción del tratamiento químico que se le haya aplicado a la semilla, debiendo en este supuesto, estar teñida para advertir sobre su improcedencia para efectos de alimentación humana y animal;
- **VII.** Nombre o razón social del productor o responsable de la semilla y su domicilio;
- **VIII.** Número de lote que permita dar seguimiento o rastreo al origen y calidad de la misma; y
- **IX.** Los demás datos que en su caso establezcan **las Normas Oficiales Mexicanas** que deriven de esta Ley.
- Tratándose de la comercialización o puesta en circulación de **semillas de organismos genéticamente modificados**, se deberán acatar las disposiciones de esta Ley que les sean aplicables, además de cumplir con lo que dispone la Ley en la materia.
- La Secretaría podrá restringir la circulación o comercialización de semillas o de producto para consumo que pueda ser utilizado como material de propagación, cuando medie una declaratoria de cuarentena debidamente fundada en consideraciones científicas y de acuerdo con **la Ley Federal de Sanidad Vegetal** y demás disposiciones que de ella deriven.

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Classification of Commercial Seeds

- Certified seed by SNICS, SAGARPA
  - Basic
  - Registered
  - Certified
- Qualified seed by SNICS, SAGARPA
  - Suitable seed for Sowing
- Declared Seed by farmers, breeders, farmers associations, university, etc)
  - Experimental, producción,
  - Seed providers and users are responsible.

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Certified Seed Classes in Mexico (source Taller SNICS, 2007)

- Basic seed
- Registered seed
- Certified seed

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Qualified Seed (sources Taller SNICS 2007)

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Declared seeds

- Article 33 of seed law of 2007 requires seed bags labeled on the followings:.
  - Seed treatment
  - Germination and purity
  - Seed treatment for planting only with color coated.
  - Agronomic information
  - Institutions that produced and processed the seeds
  - Traceability

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Declared seed (source: a Taller SNICS 2007)

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Technical Guide for Maize Varietal Certification

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Maize Varieties for Certification

- Line,
- single cross, three way cross, double cross,
- intervarietal cross,
- open pollinated varieties,
- synthetic variety, multiline variety,
- topcross,
- clone,
- others (to show).

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Varietal Descriptors (63) for Certification: (source: technical guide by SNICS)

- **First leaf**: color, length, width, length/width ratio, leaf tip form,
- **Leaf**: angle and form of the leaf above ear, leaf angle and form above and below the ear, leaf margin undulated, wrinkle of ear leaf, ear leaf color, ear leaf sheath color, first three leaf sheath color, ear leaf auricle color, ear leaf sheath pubescence
- **Stalk**: degree of formation of zig-zag, tiller number, node color, adventitious root color, average node length above the ear leaf to the flag leaf, average node length below ear leaf to the leaf above ground, stalk diameter at ear node,
- **Tassel**: degree of tassel emergence from flag leaf at 50% male flowering, days to 50% flowering (flowering in the mid third of a central tassel), glumes base color, glumes color,

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Varietal Descriptors (63) for Certification: (source: technical guide by SNICS)

- **Tassel continued**: Anther color, spikelet density of the principal tassel branch, tassel form, lateral tassel form, number of primary lateral tassel branches, number of secondary lateral tassel branches,
- **Principal ear**: number of days to 50% silking (1 cm of silks emerged in 50% of the plants), silk color, color of the base of stigma, presence of phylloid,
- **Leaf continued**: leaf sheath color in the mid of plant,
- **Tassel continued**: tassel length above flag leaf, principal tassel branch length from the lateral branch peduncle length of the tassel between flag leaf and lateral branch, length of secondary branches,

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Varietal Descriptors (63) for Certification: (source: technical guide by SNICS)

- **Plant:** plant height (including tassel), ear height/plant height ratio, ear height, leaf width of ear leaf, number of ears per plant,
- **Ear continued**: peduncle length, ear length, ear diameter, ear form, kernel row number, number of kernels per row, kernel row arrangement, grain type, ear grain color, dorsal grain color, endosperm color, form of base of the ear, glumes color, intensity of glumes color, cytoplasmic male sterility type (T,C,S. other), braquitic character.

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Complementary Information for Certification

- **Adaptation**: primary and secondary climatic regions, planting season, irrigation requirements,
- **Differential vegetative traits as compared with a control**: Days to silk, ear leaf width, ear length, etc.,
- **Stress resistance**: drought, temperature, acid soil, alkaline soil, winds, other,
- **Diseases and insects**: rating on specific diseases of leaf, ear, kernel, and stalk: *Diploidia maydis*, *Helminthospolium maydis*, Aspergillus sp., *Ustilago maydis*, etc.)

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Summary: Seed Authentication

- Open System after plant quarantine regulation
- Rely on National Seed System
- Use technical guide for seed certification by SNICS
- Incorporate official seed registration: UPOV 1994 guideline for maize excluding supplemental biochemical traits.
- Incorporate trust in seed labels for experimentation and commercialization.
- Facilitate on-farm experiments and seed use of landrace for food security.
- Enhanced elite landrace afterwards can be registered in official seed certification.

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Partipatory Plant Breeding for landrace farmers in Mexico and Latin America

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Pros and Cons for Maize Landrace

- Has a trust of the farmers to some extent
- Slow improvement with introgression and selection
- Bound to compete with hybrids.
- Not good for mechanization
- Good in the slopes, poor soils and in rain-fed conditions

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Needs of farmers in PPB*

1. To experiment with **improved germplasm (declared seeds/certified seeds)**
2. To practice good **selection** on farm
3. To cross between heterotic populations for high yields

* Participatory Plant Breeding

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Needs of Public Breeders in PPB

1. To understand **the diversity of landraces**
2. To improve useful traits of landrace through **germplasm introgression (Breeding cross, Backcross, Testcross, Molecular breeding)**
3. Involve **the farmers** in variety selection (PPB)
4. Expand seed production of **declared seed and certified seed** (PPB)

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- **Expanded Oaxaca Project: 2009-2010**

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Oaxaca Project 2009

- **PPB:**
  - In tropical and highland regions of Oaxaca
- **Demonstration:**
  - CIMMYT gene pools
- **Evaluation:**
  - CIMMYT gene pools and landrace collections

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Collecting a landrace in Chiltepec, Oax. Mx. 2009

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Community meeting on the field day, Chiltepec, Oax. Mx, May 2009

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Demonstration at harvest, Papaloapan, Oax. Mx. May, 2009

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Preparation for a field day, Papaloapan, Oax, Mx

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Field day in Papaloapan, May, 2009

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Inspecting demonstration, Papaloapan, Mx. 2009

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Harvesting for seeds, Papaloapan, Mx. 2009

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Shelling ears, Papaloapan, Oax. Mx. 2009

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Clipper unit for seed processing, treatment, and packaging

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Demonstration on benefiting seeds, Oax. Mx.

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Distribution of Seed packages of INIFAP 233, Bolita mejorada, Oax. Mx.

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Seed Logo of Expanded Oaxaca Project (source Chaping University, Oax. 2009)

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Certified seed of INFAP 233, Oax. Mex. (Bolita Mejorada)

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Planting evaluation trial in Papaloapan, Oax. 2009

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Highland gene pool 11 and 12 at Nochiztlan, Oax. 2009

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Conclusions:

- Maize Landraces for Authentication

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Conclusions on Maize Landraces for Authentication

- Maize landraces are **a major part of seed sources** in Mexico
- Landraces are **open pollinated varieties**
- Landraces have **unique traits for food**
- Landraces can be **improved with introgressions** of useful traits (good root and stalk, shorter plant and ear height, diseases and insect resistance).

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Conclusions on maize landraces for Authentication

- Maize evolution and conservation can be benefitted from **authentication process of the farmers' landraces.**
- **Scientific expertise** of not only **conventional** breeding but also **molecular** breeding for germplasm characterization and selection is needed in future PPB.
- **Declared seed (labeled seed)** of the enhanced germplasm or varieties or hybrids can be effectively used for evaluation and adoption by the famers.
- Variety authentication makes use of **a process of PPB** for useful germplasm registration in national germplasm system.

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Thank you

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