



Germplasm Enhancement of Maize (GEM) Project

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GEM Project History:

The Germplasm Enhancement of Maize Project (GEM) is a collaborative research effort of the USDA-ARS, land grant universities, private industry, and international and non-governmental (NGO) organizations to broaden the germplasm base of maize. The project is administered through the USDA-ARS Plant Introduction Research Unit in Ames, IA, and the Plant Science Research Unit in Raleigh, NC. The Latin American Maize Project (LAMP) preceded the GEM Project and provided the primary source material of exotic germplasm used by GEM. LAMP was a 5 year (1987-1992) combined effort of 12 countries (including the US) to evaluate over 12,000 accessions comprising 74% of the known races of maize.

Fig. 1: Plot harvest with twin plot TR-88 combine



Impacts & uses of GEM germplasm:

Providing useful genetic diversity can reduce risks associated with genetic uniformity and therefore contributes to food security for the consumer. In addition to reducing genetic vulnerability, genetic diversity provides unique alleles for traits that are of economic and scientific interest to our stakeholders, and ultimately will benefit the consumer. The utilization of GEM germplasm in plant breeding programs will ultimately contribute to the development of new commercial products. Our stakeholders will benefit by having new research information shared with the maize community. Field Days are an important means of technology transfer and are held annually in Ames, IA and other GEM sites (Figs. 2, 3 and 4.)



Fig. 2: USDA-ARS GEM Field Day

Table 1: GEM Germplasm Releases

Year Planted	# Lines Released	Institution	Germplasm Attributes
2001	1	USDA-ARS Ames	GEM 001 is 25% exotic with resistance to 1st brood ECB
2002	2*	Univ. of Delaware	50% exotic; yield, agronomics, resistance to anthracnose and GLS
2002	30**	NC State Univ.	50% exotics; yield, agronomics, earlier flowering
2002	1	Ohio State Univ.	GEMS-0002 is 50% exotic; yield, good grain quality
2003	28	USDA-ARS Ames	25% and 50% exotics; temperate adaptation
2003	9	NC State Univ.	50% exotics; yield, agronomics, earlier flowering
2004	16	USDA-ARS Ames	25% and 50% exotic; temperate adaptation, yield, agronomics, VAT
2004	2	Texas A&M	25% exotic; stress tolerance, good general combining ability
2004	1	Univ. of Wisconsin	25% exotic; hi yielding silage with superior nutritional quality
2004	19	NC State Univ.	50% exotics; yield, agronomics, earlier flowering
2005	9	USDA-ARS Ames	25% exotic; temperate adaptation, yield, agronomics, VAT
2005	1	Univ. of Delaware	VAT; high protein
2006	13	USDA-ARS Ames	25% exotics; temperate and tropical, yield, agronomics, VAT
2006	3	NC State Univ.	50% exotics; yield, agronomics, earlier flowering
Total	135		

*Two lines (DE3 & DE4) are Crop Science registered.

**Twenty of these 30 lines are Crop Science registered.

Germplasm description, development, and research:

The 12 LAMP members provided unique exotic germplasm derived from 8 tropical countries (Bolivia, Brazil, Columbia, Guatemala, Mexico, Paraguay, Peru, and Venezuela), and four temperate countries (Argentina, Chile, the United States, and Uruguay). GEM also expanded its germplasm base to include accessions from other maize races from Dr. Major Goodman at NC State, the National Plant Germplasm System maize collection, donated commercial hybrids, and public CIMMYT and University lines.

GEM research in Ames, IA, is focused on 25% tropically derived germplasm, and 25% and 50% temperate derived germplasm. The Raleigh, NC GEM research is focused on 50% tropical germplasm. Ames and Raleigh conduct their own breeding and testing programs (Fig 1). Private companies provide elite proprietary germplasm by crossing their inbreds to GEM accessions, with additional in kind support nurseries, and yield testing. It is estimated that the proprietary germplasm contribution to GEM is in excess of \$3 billion, and other field support approximately \$500,000.

Public cooperators provide new knowledge on the characterization, breeding, and evaluation of exotic germplasm. In the past 5 years, GEM released 135 inbred lines (S3 to S5 generation) based on 2 year's of trial data. Important attributes include resistance to European Corn Borer (ECB), gray leafspot (GLS), southern rust, anthracnose, quality silage, protein, amino acids, oil, and other Value Added Traits (VAT'S). The released lines comprise a broad base of 20 races, or "sources" of germplasm, representing accessions from 9 tropical, and 4 temperate countries (1, 2, 3), and (Table 1 and 2).



Fig. 6: F1 Highland tropical x corn belt line requires a ladder to pollinate



Fig. 3: USDA-ARS GEM Field Day Ames, IA



Fig. 4: GEM inbred AR16026:S17-10-1-b is publicly available as "GEMS-0061" from NCRPIS

Objectives and Challenges:

Exotic germplasm provides unique alleles not found in Corn Belt germplasm. Most of these alleles will not be recovered without successful introgression into adapted germplasm. Exotic germplasm is unadapted and continues to be a challenge due to photoperiod and herbicide sensitivity, late maturity, lack of flowering synchrony, tall, and difficult to work. Pollination of exotics often requires using a ladder and winter nursery sites where photoperiod sensitivity is less of a problem (Fig 5 and 6). Research continues at NCRPIS on methods to introgress exotic germplasm with adapted material.



Fig. 5: Tropical germplasm is often sensitive to herbicides and "buggy-whips"

Table 2. GEM Releases by Race and Country

Country	Race	Location Developed			Total
		IA	NC	Other*	
Argentina	Cristalino Colorado	4		1	5
Argentina	Dentado Blanco	4			4
Argentina	Dent. Blanco Rugoso			2	2
Barbados	Tusón	1			1
Brazil	Hybrid-tropical	4	18		22
Brazil	Cateto		9		9
Brazil	Dente Amarelo	4	1		5
Chile	Camelia	4			4
Cuba	Criollo (mixed)	5			5
Cuba	Argentino	1			1
Dom. Rep.	mixed	1			1
Guatemala	Tusón	1			1
Mexico	Hybrid-tropical	4	1	3	8
Mexico	Tuxpeño	2	6		8
Mexico	Tuxpeño/Olotillo	1			1
Peru	Alazan	1			1
Peru	Cuban yellow	3			3
St. Croix	Tusón		1		1
Thailand	Hybrid-tropical	1	33		34
Thailand	inbred-tropical	3			3
Uruguay	Cateto Sulino	2			2
Uruguay	Dente Branco	3			3
Uruguay	Semidentado Riograndense	2			2
USA	"F58 group"	8		1	9
Totals		59	69	7	135

* Other = DE, OH, TX, and WI

GEM Website:

<http://www.public.iastate.edu/~usda-gem/>

Reference citations:

[1] Balint-Kurti, P., M. Blanco, M. Millard, S. Duvick, J. Holland, M. Clements, R. Holley, M.L. Carson, M. Goodman. 2006. Registration of 20 GEM maize breeding germplasm lines adapted to the southern USA. *Crop Science* 46:996-998.

[2] Hawk, J.A., and T. Weldekidan. 2005. Registration of DE3, DE4, and DE5 parental inbred lines of maize. *Crop Science* 45:2669-2670.

[3] Pratt, R.C., L. M. Pollak, and K. T. Montgomery. 2005. Registration of Maize Germplasm Line GEMS-0002. *Crop Science* 45:2130-2131.