

**2005 NCR-167 Annual Station Report  
North Dakota State University  
Calendar Year 2004**

**Mission of unit:**

The goal of the corn-breeding program at NDSU is to conduct research in corn breeding for the northern Corn Belt emphasizing germplasm adaptation and improvement, inbred line and population development, and hybrid testing. Specific objectives are:

- 1) Identify elite exotic genetic materials for adaptation
- 2) Maximize genetic improvement of maize germplasm adapted to North Dakota
- 3) Develop improved maize inbred lines and populations for the northern Corn Belt
- 4) Test elite maize population hybrids as low seed cost alternatives
- 5) Coordinate hybrid maize performance testing trials
- 6) Assess the potential for maize diversification
- 7) Educate plant breeders

Our breeding program works towards releasing inbred lines and populations that are competitive in performance, drying costs (maturity), lodging resistance, and quality to those of the industry. Low risk hybrids for North Dakota means early enough hybrids having equal or better potential than late maturing ones. The maize-breeding program at NDSU has distributed diverse early maturing inbred lines to more than 20 companies nationally and internationally in 2004. However, our program continues to devote time and funds for PVP protection of ND newly released inbred lines under the direction of NDSU Research Foundation, owners of the germplasm. Plant Variety Protection certificates for ND291 and ND2000 were submitted. NDSAB(MER-FS)C13 was release for breeding programs developing elite germplasm for short-growing-season areas.

In addition to research and advising, I teach two graduate courses (Crop Breeding Techniques and Quantitative Genetics), serve as editor in *Euphytica*, and serve as chair in the maize registration sub-committee of Crop Science Society of America.

**Major accomplishments:**

Corn planted acreage for North Dakota was once again the highest on record, 1.8 million acres. Rainfall was above average, temperatures were below average, and an early frost happened in August. Planting of research experiments was finished on May 18, 2004 (earliest since 1999) and harvesting was finished on Nov 17, 2004 (latest since 1999). We have used partially balanced designs on most trials and high efficiencies were common. Coefficients of variations were the lowest since 1999. Therefore, very good information was obtained across the state even though the year was challenging for producers.

***Inbred Lines***

Elite inbred lines have been increased, distributed, and crossed to develop recycled ones. We have started the development of inbred lines from exotic maize populations to North

Dakota [NDBSK(M)C2, NDBSK(M)C3, NDBS11(M)C3, NDS1011(M)C4, BS21(R-T)C8, and BS21(R-T)C8]. Emergence and vigor notes on early selections were performed on 13,134 rows in 2004.

Early generation testing complemented with agronomic and disease screening across locations has allowed us to select from thousands of potential lines with higher efficiency. Potential releases representing 23 top experimental lines for two maturity groups were increased and checked for uniformity. In addition, trials of early and late single-cross hybrids including potential releases were conducted across locations in 2004. For this purpose, two hundred crosses (400 rows) were obtained with commercial testers in our 2003 breeding nursery and 50 additional ones (100 rows) were planted in Kauai, HI in 2003-2004. These lines have passed early generation testing with one and two testers across several ND locations. Top lines were planted for testcrossing in Kauai, HI.

Test cross seed of early generation lines with one commercial tester, including selected genotypes from recurrent selection programs, was harvested in Santiago, Chile in 2003-2004. As a result, approximately 500  $S_2$  lines were tested in partially balanced lattice designs across three ND locations. Only 65  $S_3$  lines were selected for testcrossing with two commercial testers. Six hundred and fifteen rows representing  $S_2$  new lines as well as  $S_3$  lines were planted in Santiago, Chile in 2004-2005.

### ***EarlyGEM***

We have defined 'EarlyGEM' as the long-term and continuous effort to incorporate GEM elite germplasm into the northern Corn Belt. The general objective is to determine the suitability of 25% GEM backcross lines for use as grain hybrids in the northern Corn Belt. Parent project, 4296-5050-1510 'EarlyGEM: Incorporating GEM Elite Lines in Early Maize', will determine the usefulness of GEM material in the northern Corn Belt. Late-temperate and tropical derived maize germplasm are already adapted to North Dakota based on the efforts involved in this project. We planted 182 BC1:S0 lines that ranged from 0 to 6 days earlier than the recurrent early maturing parent ND2000. This is the first research devoted to germplasm enhancement with tropical material in the northern Corn Belt.

### ***Maize Population Hybrids***

Our maize population hybrid project was initiated in 1999. This was a consequence of our goal to identify alternative heterotic patterns for the northern Corn Belt. There is increased interest in the commercializing and production of improved open-pollinated corn varieties and their hybrids in certain sectors of U.S. agriculture, especially in the northern Corn Belt. As a consequence of our research program targeted to identify alternative heterotic patterns for the northern Corn Belt we have developed and identified improved maize populations and population hybrids. These can be both, a profitable alternative to commercial  $F_1$  hybrids as well as good elite sources of diverse inbred lines. Maize populations and their crosses (S0 generations) were again evaluated in 2004. Data across environments showed that 20 % of population hybrids evaluated were not different ( $P \leq 0.05$ ) from at least one commercial hybrid for grain yield performance as well as for root lodging and stalk lodging percentages. Breeding efforts toward elite populations and

population hybrids have demonstrated that germplasm improvement is extremely valuable and deserves public funding. These efforts should be addressed to not only develop elite sources of diverse inbred lines but also to develop improved cultivars for specific markets (e.g. organic) and increase producer options. Public maize breeding programs utilizing recurrent selection for germplasm improvement could address the need. These programs, however, should incorporate extensive testing of population hybrids. This initiative has received extensive support since 1999. In theory, crosses between elite inbred lines (tails) should outperform crosses among elite populations (means). The lack of significant differences between single-cross hybrids and elite population hybrids means breeders still need to do a better job identifying elite inbred lines.

### ***Recurrent Selection***

We have identified potential alternative heterotic patterns: BS21(R)C7 x CGSS(S<sub>1</sub>-S<sub>2</sub>)C5; BS21(R)C7 x CGL(S<sub>1</sub>-S<sub>2</sub>)C5; BS21(R)C7 x NDSAB(MER-FS)C13; and BS22(R)C7 x Leaming(S)C4. The average mid-parent heterosis value across population hybrids over 20 environments is 20.4 % (means of the parents equal to 5.0 Mg ha<sup>-1</sup>). However, the average mid-parent heterosis of the population hybrids selected is 46.5 % (means of the parents equal to 5.3 Mg ha<sup>-1</sup>). Reciprocal full-sib families between S<sub>1</sub> selected progenies were produced from BS21(R)C7 and CGSS(S<sub>1</sub>-S<sub>2</sub>)C5. Selections were intermated for NDSAB(MER-FS)C13 Syn1 and NDSAB(MER-FS)C13 Syn2 to form both versions of NDSAB(MER-FS)C14. Selections were also intermated to form BS21(R-T)C8 Syn2 and BS22(R-T)C8 Syn2. Third and fourth cycles of stratified mass selection for adaptation was obtained for NDBS11(M)C3 and NDS1011(M)C4. Full-sib families were evaluated from Leaming(S-FS)C5 and NDCG(FS)C1. Selections will be intermated in 2004-2005 to form Leaming(S-FS)C6 and will be included in early generation testing. Selections were intermated to form NDSF(FS-S)C5, NDSG(M-S)C16, BS5(S)C1, and Leaming(S)C5. Half-sib families from CGL(S-T)C6 were produced.

### ***Biotechnology and SSR Markers***

Our breeding program supports biotechnology research for broadly approved events. The use of conventional and GMO commercial testers within our program has identified public x private elite hybrids for North Dakota. More testing is needed to accurately classify ND inbred lines into heterotic groups. Inconsistency between genotypic and phenotypic data suggested that for our genetic materials extensive testing of phenotypic data should be priority over the use of SSR markers.

We have responded to the request from industry to transform our inbred lines in order to develop stacked hybrids. Therefore, the maize-breeding program at NDSU has decided to incorporate events into specific ND lines. We will reserve the right to decide which lines to transform in order to provide GMO and non-GMO lines.

### **Current personnel:**

M. J. Carena  
Duane Wanner  
Clarissa Barata

Project Leader  
Research Specialist  
Ph.D. Student (SSR Markers/Heterotic Groups)

McDonald Jumbo  
Marcelo Melani  
Juan Osorno  
Bahadir Sezegen

MS Student (Maize Population Hybrids/Mat. Eff.)  
Ph.D. Student (QTLs/Disease Resistance)  
Ph.D. Student (Genetic Diversity/Quality Traits)  
MS Student (Cold Tolerance/S<sub>1</sub> Diverg. Selection)

**Collaborators:**

***State Cooperation***

Dr. D. Hopkins  
Dr. L. Rio  
Dr. C. Bradley  
Dr. W. Wilson  
Dr. T. Wijetunga  
Dr. R. Greenland  
Dr. T. Teigen  
Dr. B. Hanson  
Dr. B. Schatz  
Dr. E. Eriksmoen  
Dr. M. Halvorson  
Dr. N. Riveland  
Mr E. & R. Stover  
Mr. D. Moffatt  
Mr. Wallie Hardie  
Mr. John Bollingberg  
Mr. Paul Langseth  
Ms. Theresa Podoll

Salinity Tolerance  
Disease Screening and Resistance  
  
Market Analyses  
Molecular Analyses  
Irrigated Plots, Oakes location  
Isolations and Disease Nursery, Casselton location  
Cold Tolerance, Langdon location  
Plots, Drought Tolerance, Carrington location  
Hettinger location  
Minot location  
Williston location  
Larimore location  
Barney location  
ND Corn Council Utilization  
ND Corn Growers Association  
Golden Growers Cooperative/Cargill Plant  
Northern Plains Sustainable Agriculture Society

***Major Cooperation off Campus***

Dr. L. Pollak  
Dr. M. Blanco  
Dr. W. Salhuana  
Dr. C. Bauland  
Dr. P. H. Auriel  
Dr. Z. Wicks  
Dr. E. Lee  
Dr. L. Reid

Germplasm Enhancement Maize (GEM) Project  
  
INRA (National Agriculture Research Institute)  
Agri-Obtentions, France  
South Dakota State University  
University of Guelph  
Agriculture and Agri-Food Canada, Ottawa

***Industry cooperation:***

Dr. D. Hoffman  
  
Dr. R. Pinnisch  
Dr. T. Fry  
  
Dr. D. Anderson  
Dr. T. Wofford  
Dr. H. Beeghly  
Dr. R. Nelson

Syngenta, Inc Biotechnology  
Winter Nursery  
Dupont/Pioneer  
Hybrids  
Disease Resistance  
Monsanto/Holdens  
Hybrids  
Inbred/Sister Testers  
Thurston Genetics  
Inbred Line Testers

Dr. Lowell Behrens	SGI Genetics Testers
Dr. Gary Smelser	MBS Genetics, LLC Testers
Dr. Roald Lund Dan Lund Gary Geske	Quality Seed Genetics
Dr. Patrick Gregoire	RAGT Semences, France Hybrids
Dr. Juan Gebauer	Winter Nursery Services, Chile

**Publications, presentations, and manuscripts accepted for publication:**

**Melani, M.D. and M.J. Carena.** Identification of alternative heterotic patterns for the northern Corn Belt. Accepted in Crop Science.

**Carena, M.J.** Maize commercial hybrids compared to improved population hybrids for grain yield and agronomic performance. Accepted in Euphytica.

**Carena, M.J. and P. Glogoza.** Resistance of maize to the corn leaf aphid: A Review. Accepted in Maydica.

**Sezegen, B. and M.J. Carena 2004.** Development of inbred lines with good combining ability across heterotic groups. *In* Agronomy Abstracts [CD-ROM computer file]. ASA, Madison, WI.

**Carena, M.J. 2004.** Should Public Breeders Be Involved with Maize Population Hybrids? *In* Agronomy Abstracts [CD-ROM computer file]. ASA, Madison, WI. (invited presentation).

**Barata, C. and M.J. Carena 2004.** Classification of ND maize inbred lines into heterotic groups. *In* North Central Corn Breeding Research Committee Report. St. Louis, MO.

**Carena, M.J. 2004.** Breeding efforts toward population hybrids. *In* North Central Corn Breeding Research Committee Report. St. Louis, MO.

**Carena, M.J. and J. Ransom, 2004.** North Dakota hybrid corn performance testing 2003. Circular A-793 (Revised). North Dakota Agric. Exp. Station and Ext. Service.

**Jumbo, M. and M.J. Carena 2004.** Evaluation of maize populations and single-cross hybrids across eastern North Dakota environments. North Dakota Academy of Sciences. Fargo, ND.

**Theses:**

**Melani, M.D.** Identification of alternative maize heterotic patterns for the northern Corn Belt. MS thesis defended in April 2004.

**Barata, C.** Simple sequence repeat polymorphisms and heterotic relationships among early maize inbred lines. MS thesis defended in December 2004.

**Field days:**

**Carena, M.J. 2004.** 4<sup>th</sup> Northern Corn Breeding Research Day. Fargo, ND, 7 September, 2004. Fourth nursery tour given to industry corn breeders.

**Carena, M.J. 2004.** 4<sup>th</sup> Corn Breeding Nursery Tour. Fargo, ND, 30 August 2004. Fourth nursery tour given to North Dakota State University Extension Service, North Dakota Corn Council Utilization, North Dakota Corn Growers Association.

**Carena, M.J. 2004.** Casselton, ND, 12 July 2004.

**Carena, M.J. 2004.** Minot, ND, 14 July 2004. .

**Carena, M.J. 2004.** Oakes, ND, 17 August 2004.

**Carena, M.J. 2004.** Carrington, ND, 9 September 2004. EarlyGEM Program Addressed.