Final Report
Moving Corn Northward: Identification of high quality corn under cold stress
Project 4102-13SP

Project Title
Moving Corn Northward: Identification of high quality corn under cold stress

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Abstract
Northern Minnesota (MN) farmers do not have the same opportunities as southern MN farmers to enhance their quality of life. Millions of dollars are being lost annually to processing low quality grain from cold susceptible hybrids in central and northern MN. Our project objective was to improve the cold tolerance and quality of northern U.S. hybrids in order to increase farmer profitability and sustainable production of corn in northern MN. The NDSU corn breeding program has utilized unique corn products and methods for this purpose. Unique tropical and temperate genetically diverse corn, not available in industry, was adapted to northern MN northern conditions. Over 200,000 new corn lines and hybrids have been screened in marginal regions under severe controlled cold stress short-season winter nursery environments aiming at fast cold tolerance short-season genetic improvement. Cold tolerant lines were evaluated for agronomic and grain quality traits per se and in public x public and public x private hybrid combinations with top commercial products as checks across >50 locations in cooperation with industry. Statistical analyses within and across locations confirmed our hypotheses and achieved objectives successfully. NDSU germplasm has shown uniqueness to break new environmental margins for corn production which has large positive implications to producers and industry in the long run. We have identified and released 22 early maturing high quality corn products tolerant to cold stress. Therefore, incorporating our cold tolerance screening methodology as a routine in the pedigree selection process of inbred line development was successful for the present and future development of the next generation of corn products. The program will add value to U.S. northern farmers and ranchers. NDSU advanced existing knowledge by becoming the leader in the development of the next generation of healthier short-season hybrids for a better livestock and human nutrition. The NDSU EarlyQPM (Early Quality Protein Maize) and NDSU EarlyQPMF (EarlyQPM for Feedstock) programs were created in order to increase the utilization of short-season products, adding value to the crop, and balancing the nutritional needs in the livestock market.
Introduction

Northern MN corn grower members have reported too many production failures. Therefore, even though MN corn acres keep increasing and MN farmers continue to select corn as one of their most profitable choices the risk they face is high. In addition, long-term plans to make corn production sustainable in this vast region are missing (Carena, 2011; Sharma and Carena, 2012). Knowledge gaps have also been present when moving corn north (Carena, 2011).

Industry is currently not offering stable cold tolerant hybrids for central and northern Minnesota (MN). Hybrids are provided by retailer companies licensing products from foundation seed companies located in southern MN. Therefore, still most northern hybrids are not locally bred and northern MN farmers do not have options to select from. Available hybrids are often late maturing products with below average grain quality (Osorno and Carena, 2008; Carena et al., 2009a) and cold tolerance (Sezegen and Carena, 2009). Therefore, hybrids are neither reliable nor stable for northern MN. In addition, hybrids offered by industry carry similar genetics making corn genetically vulnerable (Carena et al., 2009b).

However, industry hybrids still lack cold stress tolerance, are slow driers, and often end up with poor quality. The main reason for this problem is that current commercial hybrids are mostly bred elsewhere (e.g. southern MN) making their adaptation to short-seasons challenging. There is still no breeding program in charge of developing corn cultivars for central and northern MN. Our approach to develop cold tolerant high quality lines for utilization in the northern U.S. Corn Belt is proving to be successful. Continuity for this kind of research is essential in order to have this type of products available annually (Hallauer and Carena, 2009; Hallauer et al., 2010).

Our hypothesis is that early maturing lines with cold tolerance can be obtained in a very efficient way retaining the grain yield and agronomic and quality traits that late maturing hybrids have. Only if there is enough screening and testing (breeding) in the northern U.S. this can be accomplished so that we identify the real strengths and weaknesses of current and future hybrids and thus, farmer’s choice will become profitable. This can only be done with large sample sizes which, thanks to this project, it is becoming a routine in our program.

This project is an opportunity to expand corn north to cooler seasons and increase the profitability of central and northern MN farmers. A long-term solution for improving profitability in this vast region was addressed and cold tolerant high quality products were developed for the sustainable corn production in central and northern MN.

Objectives

The long-term goal of this project is to improve the cold tolerance and quality of early maturing northern U.S. available hybrids.

Specific Objectives:

1) To identify early maturing high quality inbred lines and hybrids tolerant to cold stress
2) To incorporate cold tolerance screening as a routine in the pedigree selection process of inbred line development

Materials and Methods

The NDSU corn breeding program is utilizing unique corn products and methods developed in joint historical successful efforts between ND and MN. Over 200,000 genotypes, including tropical and temperate diverse corn, have been screened in marginal regions under severe controlled cold stress short-season winter nursery environments aiming at fast cold tolerance short-season genetic improvement. The new set of genotypes has been screened under severe cold stress during the 2012-2013 winter growing season and top genotypes were planted in a second 2012-2013 winter nursery (November 2012 in New Zealand) for production of the hybrids that were tested across northern U.S. environments in 2013. Cold tolerant lines were evaluated for agronomic and grain quality traits per se and in hybrid combinations with top commercial products as checks across >50 locations in cooperation with industry. Statistical analyses within and across locations were conducted to test our hypotheses and objectives. Cold tolerance screening was continued during the 2013-2014 season and all 2014 locations were planted even though the planting season was challenging due to early rains. 2014 data collection was initiated including hybrid observation for tillers as they will specifically affect yields contrary to some Extension seasonal reports. The NDSU corn breeding program has selected against tillers for the past 15 years.

Results and Discussion

Hybrid trials including lines selected for cold tolerance have shown higher yield under short-season cold stress when comparing with commercial checks. NDSU was the only genetic provider of <70RM hybrids (Carena and Wanner, 2009) in 2013 as shown in state commercial trials. Successful results were obtained with this project as 94 % of 2013 experiments produced NDSU hybrids beating top commercial industry checks vs. 54 % when controlled winter nurseries were initiated for abiotic stress screening purposes. During this project, 12 new varieties were created and released from recombining top cold tolerant and diverse lines in order to increase the genetic diversity and value-added of northern U.S. hybrids with reduced risk to farmers. Additional 10 unique and outstanding NDSU new cold tolerant corn products were released and sent to NDSU’s exclusive foundation seed company partner during this season. In addition, new knowledge was generated with the creation of the NDSU EarlyQPM and EarlyQPMF programs for grain quality. They provided a new value added alternative to farmers through the availability of new healthier and short-season cold tolerant corn hybrids with QPM characteristics adapted to the northern U.S. for the first time.

Conclusion

This project was of particular benefit to MN corn farmers and industry since it addressed the need of stable cold tolerant hybrids for central and northern MN. Too many production failures have been reported by MN Corn Grower members to us. Most northern hybrids currently available to farmers are not locally bred and northern MN farmers do not have too many options to select from. The NDSU corn breeding program is the first breeding program to breed locally and strategically for this area. In addition, this project represents the first corn quality research
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effort to incorporate exotic QPM germplasm for improved protein quality in the northern U.S. Corn Belt.

Next research steps are to continue breeding for very short-season germplasm with unique and competitive genetic diversity as the future of corn production in this area relies on early maturing corn products carrying diverse genetics.

Education, Outreach, and Publications

Keynote Lectures and Invitations with exposure to this project:

- January: Minnesota Corn Research and Promotion Council, US
- February: North Dakota Corn Utilization Council, US
- March – April: Invitations from National Institutes and Universities in Brazil and Argentina
- August – September 2013: Private and public institutions from Puerto Rico, China, and Germany.

Fargo, ND North Dakota State University Field Days:

- Over 100 people touring winter nurseries for seed production and screening for cold and drought tolerance with thousands of new genetic materials.
- 4 Ph.D. students as major advisor, 17 students as instructor in Quantitative Genetics, 16 students as instructor in Crop Breeding Techniques, where products and procedures were directly exposed.
- >500 national/international nursery visitors, and main consultant to several institutions, toured summer breeding nursery with new line and population releases.

2013-2014 Manuscripts


Laude, T.P., and M.J. Carena. 2014. Diallel Analysis Among 16 Maize Populations Adapted to the U.S. Northern Corn Belt for grain yield and quality traits. Euphytica (May 2014).
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Carena, M.J. 2013. Developing Cold and Drought Tolerant Short-Season Maize Products for Fuel and Feed Utilization. Crop Breed. & Appl. Biotech. 13:1-8. I was invited to give a lecture on this paper at the research institute INTA Pergamino, Argentina.

Carena, M.J. 2013. Developing the Next Generation of Diverse and Healthier Maize Cultivars Tolerant to Climate Changes. Euphytica 190:471-479. I was invited to give a lecture on this paper at University of Rosario, Argentina.


References


