Research article

Seed quality of high protein corn lines in low input and conventional farming systems

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Abstract — Seed quality is a major issue for crop establishment especially in low input farming systems, where varieties often grow under more stressful conditions than in conventional farming systems. Corn (Zea mays L.) seed for organic (low input) production will eventually need to be grown organically, thus research is needed to ensure excellent seed quality in organic corn seed production. The objective of this study was to compare seed quality and composition differences between a group of high protein corn genotypes grown under low input and conventional farming systems, and to compare the relative seed quality of these genotypes to two well known inbreds, B73 or Mo17. Twenty high protein breeding genotypes were planted during two growing seasons in conventional and organic nurseries near Ames, Iowa, to produce seeds for laboratory tests. The germination, saturated cold, accelerated aging, and soak test percentages of seeds produced organically were 5 to 11% lower than for seeds produced conventionally. Protein, measured by near-infrared reflectance, was unaffected by the production location, but the oil content of seeds produced organically was significantly higher (between 0.2 and 0.3% higher) than in the conventional system. Location by genotype interactions for most tests were non significant both years, indicating that genotypes selected for high seed quality in a conventional system will also have high seed quality when grown in a low input, organic system.

1. INTRODUCTION

Modern agriculture uses high levels of chemical inputs; however, alternative cropping systems such as organic and low-input agriculture are gaining importance as alternatives for mid- and small-size family farms. The premium prices currently paid in the market for organically produced commodities offer small-size farmers new opportunities for generating profit, achieving sustainability in production and minimizing impacts on the environment. In past years organic seeds were in short supply and varieties produced organically did not have seed quality comparable to farmers’ preferred varieties. Thus, organic producers were allowed to plant seeds grown under conventional systems. However, changes in organic farming regulations of the USDA National Organic Program (NOP) will mandate organic farmers to plant seeds produced under organic conditions. Organic producers, small seed companies and universities are concentrating their efforts on developing varieties that meet the new organic crop production regulations (Adam, 2005).

Seed production in organic conditions is increasing because of these changing rules for organic production and also because it offers organic farmers the possibility of producing and keeping their own seed for the following crop by using open-pollinated varieties. Open-pollinated varieties are more vigorous and can represent an alternative to hybrids derived from inbreds (Goldstein, 2001). Inbred lines are difficult to produce in organic conditions because of the lack of vigor throughout their development, leading to increased weed pressure.

In any cropping system, seed germination and vigor are the most important attributes of seed quality to assure uniform emergence and satisfactory stand establishment. Many factors can affect germination and seed vigor. McDonald (1998) attributed physiological seed quality losses to environmental stress and premature or late harvest. Grain composition also affects seed quality. Previous studies determined that there is a significant interaction between the environment where seeds are grown and genotype in maize lines with different grain composition. Inbreds with lower seed protein content had poorer seed quality than higher protein lines. Higher protein lines showed better seed quality independently of the...
percentage of oil content in the seed (Munamava et al., 2002). This study points to the importance of genotypic adaptation to environment. To develop varieties with high seed quality, breeding programs must test their materials in multiple environments.

Most chemical fungicides and insecticides are restricted in organic corn production. This restriction forces farmers to manage crops and use cultural practices to reduce the impact of diseases, insects and weed pressure. Planting time is usually delayed to avoid the wet and cold soils of early spring, which can expose seeds to soil pathogens for a long period of time before emergence, and to reduce contamination by genetically modified pollen from conventional farmers. Higher soil temperatures allow faster seedling emergence and growth, lowering the risk of stand problems. But late planting can have additional adverse consequences, such as unexpected additional delays in planting associated with abundant spring rainfall, yield reductions, or the occurrence of an early fall frost when seeds are still immature on the plant. These problems associated with late planting are usually avoided in a conventional cropping system by planting early and using chemical seed treatments that protect the seed during emergence and plant establishment.

Several seed quality tests are used to assess the germination and vigor of a seed lot. The standard germination test is the official test used for labeling seeds for sale. However, the standard germination test results are poor predictors of field emergence because the tests are conducted under favorable conditions for seed germination and growth (Shah et al., 2002). In contrast, seed vigor tests are conducted under stressful growing conditions, such as cold and wet planting conditions, or hot and humid seed aging conditions. Testing seeds under these stressful conditions is very important to determine the ability of the seed lots to have good performance and uniform emergence in the field. High vigor seeds are particularly important in the organic farming systems, where seeds are planted without seed treatment. Untreated seeds must have rapid seedling emergence in the field to avoid the detrimental effect of soilborne pathogens.

Organic crop practices are different than in conventional systems, and they can affect seed quality. To our knowledge, the impact of the cultural practices used in organic farming on seed quality has not been assessed. The objective of this study was to compare seed quality and composition differences between a group of high protein corn genotypes grown under organic (low input) and conventional farming systems, and to compare the relative seed quality of these genotypes to two well known inbreds, B73 or Mo17.

2. MATERIALS AND METHODS

2.1. Origin of maize genotypes

The germplasm included in this project were 20 high protein narrow-base synthetic genotypes and two public inbred checks, Mo17 and B73. The narrow-base synthetic genotypes were selected from a wide-based synthetic composed of high yielding lines that also had higher protein content. This wide-based synthetic was developed from breeding crosses of a Chilean population (CHZM 05015, PI 467165) crossed with non-Stiff Stalk Corn Belt lines. The breeding cross and high yielding lines developed from it were from the U.S. Germplasm Enhancement of Maize project (GEM; Pollak, 2003). Synthetics are cross-pollinated varieties that present good combining ability when open pollinated (Lammerts van Bueren et al., 1998).

In the Ames IA nursery in 2001, the wide-based synthetic was composed by crossing selected GEM lines in paired rows and harvesting as single ears. Protein content of the ears was analyzed by Near Infrared Reflectance (NIR) to select the materials for the next growing season. The selection was based on a minimum of 12.5 g kg\(^{-1}\) protein content. The top 10 ears with the highest protein content, ranging from 12.52 g kg\(^{-1}\) to 13.51 g kg\(^{-1}\), were bulked for recombination. In 2002, in a winter nursery near Ponce PR, seed from the bulk was sib mated, harvested as single ears, and 20 ears with adequate seed supply were selected for the experiment. We did not choose the ears with highest protein content because we did not know if an interaction between genotype and environment (temperature versus tropical) existed. In 2003 and 2004 seed from the 20 ears were planted in Ames IA nurseries to obtain seed for the seed quality experiments.

2.2. Field experiments

The twenty genotypes were planted in two locations near Ames during the growing seasons of 2003 and 2004. These locations were selected for their very different farming system. One location was under conventional and the other under certified organic farming systems. This classification was based on the type of fertilizer and methods of weed, disease and insect control used in crop production. While the conventional system made use of high amounts of chemical inputs for production, such as synthetic fertilizers and other chemicals, the organic system did not use any synthetic products (Poudel et al., 2002). These locations were chosen to evaluate the seed germination, vigor, and composition characteristics of the selected genotypes, and to compare their performance to the well established lines B73 and Mo17. The field experimental design was a completely randomized design with two replications.

The conventional experiments were planted on 18 May 2003 and 7 May 2004. The organic experiments were planted on 28 May 2003 and 7 June 2004. Seeds from the conventional farming system were harvested on 19 September 2003 and 24 September 2004; and in both years seeds from the organic farming system were harvested on 30 September. Pollinations were conducted from 28 July to 4 August 2003 and 23 July to 29 July 2004 in the conventional experiments; and from 7 to 14 August 2003 and 14 to 20 August 2004 in the organic experiments.

Weeds were controlled with pre- and post-emergence herbicides in the conventional system. A rotary hoe was used immediately after planting in the organic nursery and cultivation