Accepted for publication 12 October 2010. Published 3 December 2010.

Earlier-Maturing Hybrids Improve Corn Grain Profitability in the Northern Corn Belt

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Hao, X., Thelen, K., and Gao, J. 2010. Earlier-maturing hybrids improve corn grain profitability in the northern Corn Belt. Online. Crop Management doi:10.1094/CM-2010-1203-01-RS.

Abstract

With continuous genetic improvement of corn (*Zea mays* L.) hybrids and increasing volatility in energy cost, selecting hybrids with appropriate relative maturity (RM) ratings has significant impacts on profitability for growers. Annual grain yield and moisture at harvest of corn hybrids from 2000-2009 were obtained in three zones across Michigan. Hybrids were classified into either early- or late-maturing groups based on their RM ratings, and the top 5 yielding hybrids of the two groups for each year in each zone were included in the analysis. The relative economic returns of the early- and late-maturing hybrids were evaluated using scenarios of various corn grain price and drying cost combinations. Overall, the late-maturing hybrids had higher grain yield than the early hybrids in the three zones, but only in two of the ten years was the yield difference statistically significant. Meanwhile, grain moisture was consistently and significantly higher for the late hybrids across the region. Consequently, the late hybrids had significantly larger net returns only when they had a large yield advantage combined with a corn grain price higher than \$3.5/bu and drying cost less than \$0.05/bu/point. For most of price and cost scenarios studied, the early-maturing hybrids had greater net returns than the late-maturing hybrids.

Introduction

With the recent increase in energy costs, selecting corn (*Zea mays* L.) hybrids with appropriate relative maturity (RM) ratings is one of the most important management decisions producers in the Northern Corn Belt have to make. Traditionally, relative maturity rating of a hybrid is decided by comparing grain moisture content near the time of "harvest maturity" of a new hybrid with a standard hybrid. These comparisons are made with the assumption that grain moisture loss in the field is about 0.5 percent per day. For example, if the RM rating of the standard hybrid is 100 and grain moisture of a new hybrid is 2 points wetter than that of the standard hybrid at harvest, the new hybrid is assigned with a RM rating of 104.

In the Northern Corn Belt, late-maturing hybrids generally have greater grain yield potential than earlier-maturing hybrids. However, late hybrids often have higher kernel moisture at harvest, especially in a cool and/or wet growing season (10). Higher grain moisture causes harvest delays and higher drying cost, which could offset economic gains from the higher yield of late-maturing hybrids. Therefore, higher yield from late hybrids may not guarantee a higher economic return.

Regarding the potential effects of hybrids with different RM ratings on grain yield, previous studies have focused on the interactions of maturity rating with planting date, row width, and plant population (1,2,5,7,8,10). In those studies, the number of hybrids studied was often relatively small and the study period was relatively short. Few studies investigated the effects of corn hybrids using a large number of corn hybrids and for a long period of time. Harpstead and

Dysinger (3) studied the relative economic return of early and late-maturing hybrids using grain yield and moisture data of corn hybrid trials across Michigan from 1990 to 1998. They concluded that late-maturing hybrids did not result in higher income except in the most favorable corn production zone of Michigan where late-maturing hybrids had substantial higher grain yield. With the adoption of newly developed corn hybrids, changing climatic conditions, and a significant shift in corn grain price and drying cost, there is a need to re-evaluate the effect of hybrid RM ratings on the profitability of corn hybrids using recent data generated from modern hybrids available in the Northern Corn Belt. The objective of this study was to evaluate the profitability of the Northern Corn Belt commercial corn hybrids with different RM ratings based on their grain yield and moisture content at harvest.

Evaluating Profitability of Corn Grain Hybrids

Experimental design and data collection. The performance of commercial corn hybrids was evaluated annually in three zones from south to north across Michigan (Fig. 1). Climatic conditions within each zone are similar and each zone consists of three trial locations (counties) annually. Zone 1 lies across the southeast and southwest corners of the state, and trial sites were located in Branch, Cass, and Lenawee counties. Zone 2 lies in the south-central portion of the Lower Peninsula and the three trial sites were located in Ingham, Kent, and Saginaw counties. Zone 3 lies to the north of Zone 2 and trial sites were located in the counties of Huron, Mason, and Montcalm. These zones were designated on the basis of available growing degree days (GDD) established from long-term weather records. The 30-year (1971 to 2000) normal accumulated GDD units from May 1 to October 31 were about 2629, 2518, and 2304 for Zone 1, 2, and 3, respectively.

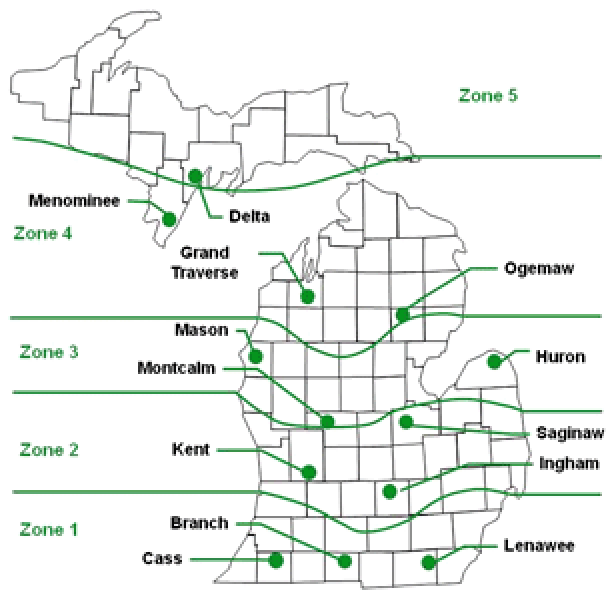

Fig. 1. Trial locations within different zones across Michigan. Lines indicate contour lines of cumulative Growing Degree Days [taken from (6)].

Hybrids entered in a zone were tested in each of the three locations located within the zone. At each location, the field layout was a lattice design with four replicated plots for each hybrid and hybrids were randomly assigned to the plots. There were four rows with 30-inch row spacing in each plot at all locations, and each plot was 22 ft long. The two center rows in each plot were harvested. Trials were conducted on farmers' fields using local management practices, and all hybrids in a location were managed the same with the same fertilization, population, dates of planting and harvesting, and other management practices. Moisture content and field weight were measured by a

Graingage, HarvestMaster system (Juniper Systems, Logan, UT) mounted on the combine. Hybrids were divided into two maturity groups of early or late based on their RM ratings provided by the seed companies. Details about experimental design, field management practices, and other related information of corn performance trials in Michigan could be found in (6). For Zone 1, hybrids with RM ratings < 107 days were classified into the early-maturing group and those with RM ratings ≥ 107 days were classified into the late-maturing group. Similarly, the cutoff number was 102 and 97 days for Zone 2 and 3, respectively. The cutoff numbers were roughly determined by comparisons of accumulative GDD in the three zones with approximate GDD required by a hybrid to reach maturity. For example, a hybrid with a RM rating of 100, which requires approximately 2450 GDD to reach maturity, was classified into the early-maturing group in Zone 1 and 2, but into the late maturity group in Zone 3 given that the accumulative GDD were about 2600, 2500, and 2300 for Zone 1, 2, and 3, respectively (3). These cutoffs were adopted traditionally by the Michigan corn performance trials.

Data analysis. Average corn grain yield and harvest moisture from the four replicated plots of each location were obtained for each hybrid from 2000 to 2009. The grain yield was adjusted to 15.5% moisture. Number of hybrids included in the trial varied from year to year and from zone to zone, ranging from 42 to 80 hybrids. Five top-yielding hybrids of the two groups in each zone and year combination were selected for analysis. Table 1 shows the average RM ratings and standard deviations for each zone during 2000 to 2009. Relative economic returns were evaluated based on combinations of corn price at $2.50, $3.50, and $4.50/bu, which is roughly the range of corn price occurring during 2000 to 2009 study period, and drying cost at $0.03, $0.04, $0.05, and $0.06/bu/point. The drying cost range was roughly the range found in previous reports. The drying cost was set at $0.025/bu point above 15.5% moisture in the research by Harpstead and Dysinger (3), and drying cost was estimated at $0.05/bu/point in 2009 in the Northern Corn Belt (4). Harvesting cost was set as $0.17/bu, which included handling ($0.02/bu), hauling ($0.04/bu), and transportation ($0.11/bu). The net return was represented simply by the difference of gross return (corn price × yield) and total drying and harvesting costs (drying cost × moisture above 15.5% × yield + harvesting cost × yield). No other costs besides drying and harvesting costs were included in the analysis.

Comparisons of the net returns were conducted using a linear mixed model with maturity group, zone, year, and interactions among them as fixed factors while location, interaction of location with year, interaction of location with maturity group, and hybrid were considered as random factors. Year as an effect in a statistical model could be treated as either random or fixed, depending on the specific context at hand (9). In this study, years studied were not randomly chosen, and the effects of an individual year on corn grain yield and moisture were assumed deterministic. At the same time, our objective was to evaluate the performance of the two maturity groups in these individual years, and our conclusions were drawn only to these respective years, not to population of years as a whole. Therefore, year and its interactions with other fixed factors were set as fixed in the model. On the other hand, location and hybrid were set as random because there were many choices of experimental sites and hybrids used in the trials and we made inferences regarding the two factors to all applicable locations and hybrids. The analysis was carried out using PROC MIXED in SAS 9.1.3 (SAS Institute Inc., Cary, NC). The same statistical model was used for grain yield, moisture, and net return.

Generally, late-maturing hybrids have to yield more in order to gain economic advantage over the early maturity hybrids given that the late maturity hybrids often have higher moisture content and subsequently require higher drying cost. The minimum yield difference the late hybrids have to have in order to achieve economic benefit over the early hybrids is closely related to the grain moisture difference at harvest between the two groups, as well as drying cost and grain price. To explore the minimum yield difference under different conditions, multiple test runs using the model described earlier were conducted with yield of the late hybrids artificially increased or decreased by increments of

0.5 bu/ha each time until the late hybrids reached a level of significantly higher net returns than the early group. Data from three of the ten-year study period (2005, 2006, and 2009) were used considering that the average grain moisture differences at harvest in the three years were 2.0, 2.8, and 3.6%, respectively, which covered the range of moisture difference during the ten-year period.

Economic Returns from Earlier-Maturing Hybrids

During the studied ten-year period, the late-maturing hybrids had significantly higher grain yield than the early-maturing hybrids in the three zones, producing on average 3, 6, and 3 bu/acre more for zone 1, 2, and 3, respectively (Fig. 2). The differences seem to be less pronounced than those from a similar study conducted for the 1990 to 1998 growing seasons (4). In their report, the difference was greater than 10 bu/acre in Zone 1 and 2. All hybrids entered into the trials were included in their analysis, and the range of RM ratings between early and late hybrids seemed to be somewhat smaller than that used in this study. We found that the late hybrids had a higher overall grain yield in eight of the ten years studied, with the exception of 2004 and 2009, when the early hybrids had slightly higher grain yield (Fig. 3). Abnormally cool temperatures during the 2009 growing season across the Northern Corn Belt and subsequently substantially lower GDD accumulations had a greater negative impact on late hybrids, contributing to the similar grain production of the early and late maturity groups in the three zones. However, only in the years of 2002 and 2006 was the yield difference statistically significant at the 0.05 level. The late hybrids produced 10.2 and 12.0 bu/acre more corn grain than the early hybrids in 2002 and 2006, respectively, while for the other eight years the grain yield difference between the two maturity groups was smaller than 6.4 bu/acre.

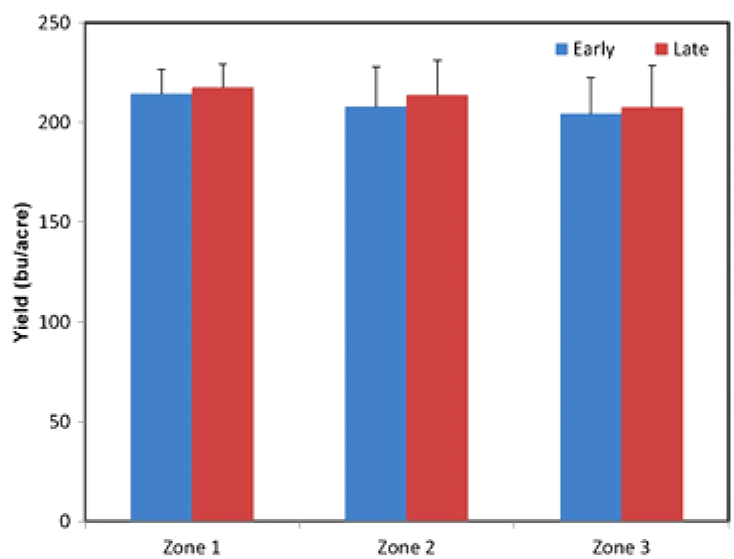

Fig. 2. Average grain yield of the early and late maturity groups in Zone 1, 2, and 3 from 2000 to 2009. The error bars indicate the standard deviations of the average yield over 2001 to 2009 period.

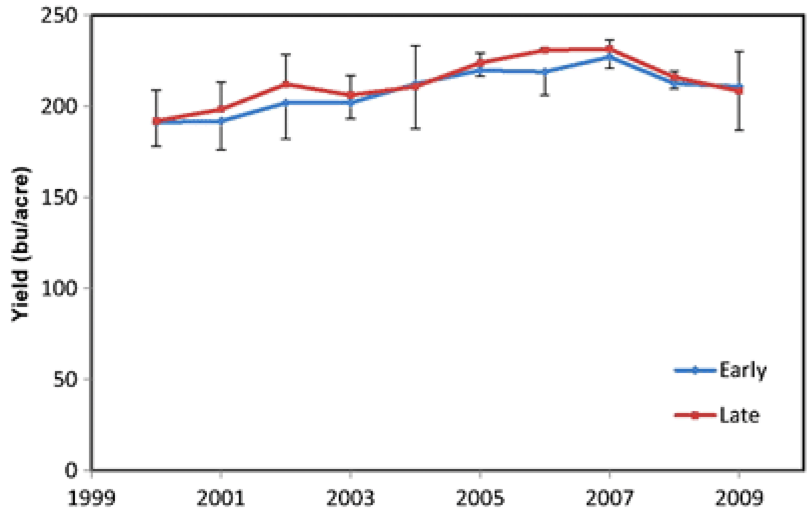

Fig. 3. Average grain yield across the three zones in individual years from 2000 to 2009 for the early and late maturity groups. The error bars indicate the standard deviations of the average yield across the three zones.

As expected, grain moisture at harvest was consistently and significantly higher for the late hybrids over the ten-year span (Fig. 4). Also average grain moisture differences between the two maturity groups were greater in Zone 2 and 3 than in Zone 1. The overall difference in grain moisture between the early and late hybrids was about 1.4% in Zone 1, compared to 3.0% in Zone 2 and 3. This was due to the more northern latitude of Zones 2 and 3 and the resulting shorter growing season relative to Zone 1. The biggest difference was about 6%, taking place in Zone 3 of 2009. In 2009, harvesting could not be completed until late November in Zone 3 due to a very wet October with a well above normal precipitation level.

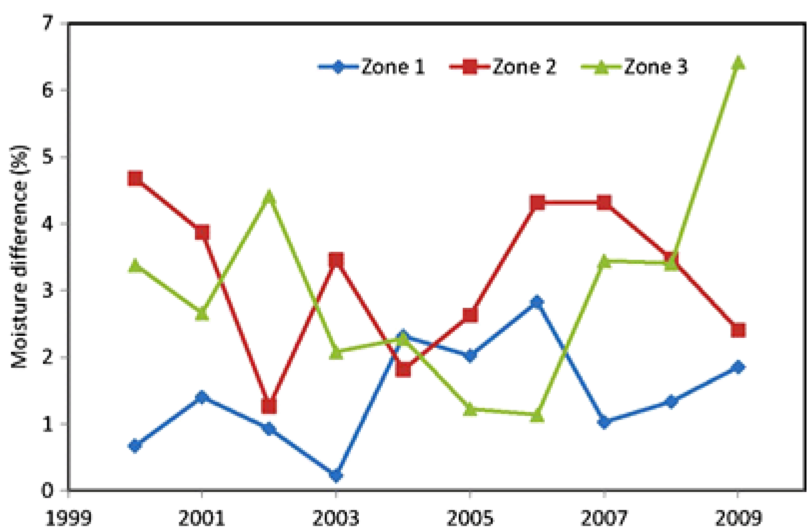

Fig. 4. The estimated moisture differences between the late and early maturity groups (Late-Early) from the mixed model for Zone 1, 2, and 3 over 2000 to 2009.

Since late hybrids in general had higher grain yield and moisture levels, high corn grain price and low grain drying cost scenarios should favor late hybrids in terms of economic returns. Table 2 shows comparisons of net returns between the early and late groups from 2000 to 2009 over the three zones. The late hybrids had significantly larger returns relative to the early hybrids when the corn grain price was $4.5/bu and drying cost was lower than $0.05/bu/point during the favorable growing seasons of 2002 and 2006. In 2006, trials were planted earlier and accumulative GDD units were sufficient to fully mature and field dry even for the latest hybrids, which contributed to the significantly higher grain yield from the late hybrids. When drying cost reached $0.05/bu/point or higher, the late hybrids had no significant benefit in any of the ten growing seasons from 2000 to 2009, even with corn grain was priced as high as $4.5/bu. The early hybrids had substantially higher net returns when weather conditions are cool and drying cost is high, as happened in 2009. The advantage to the early hybrids in the 2009 growing season was from $25 to $50/acre depending on corn grain price and drying cost.

Comparisons were also made between the early and late hybrids for Zone 1, 2, and 3, respectively, with the ten-year data as a whole (Table 3). There was no significant three-way interaction among year, zone, and maturity group for the net returns. The advantage of the early hybrids over the late hybrids increased from Zone 1 to Zone 3 with the same corn grain price and drying cost. For example, the early-maturing hybrids had $1.90, $8.80, and $15.40/acre higher average returns from 2000 to 2009 than the late-maturing hybrids for Zone 1, 2, and 3, respectively, when corn price was $3.5/bu and drying cost was $0.04/bu/point. In Zone 3, the early hybrids had a greater return with each combination of corn grain price and drying cost studied, and the difference was statistically significant when corn price was at $2.5 or $3.5/bu or drying cost was relatively higher at $0.05 or $ 0.06/bu/point. The late-maturing hybrids showed some advantage only in three of 12 scenarios in Zone 1 and one of 12 scenarios in Zone 2. However, none of the differences was statistically significant.

For the net returns, the estimated variances of the random factor of location × year interaction were the largest among all the random factors specified in the model, which were about 7 times large as the estimated variances of residual errors, and accounted for more than 70% of the total variances of all random factors combined. The estimated variances of the location factor were about the same size as those of residuals while estimated variances for the hybrid factor were negligible. Similar results were found for both corn grain yield and moisture. Apparently seasonal difference is a dominant factor contributing to variations in yield, moisture, and economic returns after fixed effects of year, zone and maturity group and interactions among them were taken into account. This result underscores the significance that temporally variable weather conditions have on grain yield, moisture, and ultimately profitability of corn hybrids during a given growing season. Furthermore, the results indicated that the variation among different hybrids was minor relative to the variations among locations in the same year and among different years at the same location, and contributed much less to the variations of yield and the economic return in the Northern Corn Belt.

Table 4 shows the estimated minimum yield advantage the late hybrids required in order to have significantly greater net returns over the early hybrids under various levels of grain moisture difference at harvest between the groups, grain price and drying cost. There was substantial variation in the minimum yield differences among studied scenarios, and understandably the late hybrids required greater yield advantage at higher drying cost, lower corn grain price and wetter grain moisture relative to the early hybrids. To have significantly higher net returns, the late hybrids needed to yield at least 9 to 20 bu/acre more for different grain price and drying cost combinations when grain moisture difference at harvest between the two groups was 2.0%, while the range became 10.5 to 28.0 bu/acre at grain moisture difference of 2.8%, and 11.5 to 36.0 bu/acre at moisture difference of 3.6%. With various levels drying cost and grain moisture difference at harvest, the minimum yield difference ranged from 9.0 to 19.0 bu/acre, 10.0 to 24.5 bu/acre, and 12.0 to 36.0 bu/acre at corn grain prices of $4.50, $3.50, and $2.50/bu, respectively. With the same grain price and grain moisture difference at harvest, the late hybrids need yield about 2.5 bu/acre more with drying cost increased by $0.01/bu/point.

Conclusions

The late-maturing hybrids produced significantly higher grain yield than the early-maturing hybrids in only two of ten years studied (2000 to 2009), while grain moisture at harvest was consistently higher for the late hybrids. As a result, the early hybrids had greater net returns in most scenarios evaluated while the late hybrids had significant economic advantage only with relatively higher corn price (> $3.5/bu), lower drying cost (< $0.05/bu/point) and favorable growing seasonal conditions (such as 2002 and 2006 when the late hybrids yielded at least 10 bu/acre more than the early hybrids). With increasing grain drying cost in recent years, selecting early hybrids will likely give greater average economic returns over time.

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