Department of Agriculture, Trade and Consumer Protection
Division of Agricultural Development
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Grant Project Final Report

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Grant Project Title: Improving the Stability of Corn Hybrid Output Characteristics for Expanded Market Development

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What did you want to accomplish with the grant?

Wisconsin agriculture has experienced a rapid expansion of commodity markets which desire specific grain output characteristic (grain composition) for their processing requirements as well a commercial offerings of hybrids/ varieties which claim to have elevated levels of certain grain components to meet those requirements. In the ethanol industry for example, corn grain with higher levels of highly fermentable carbohydrate (HFC) used in the process result in greater ethanol yields and process efficiency than common, commodity grade corn. In response, several companies offer branded hybrids which are reported to have HFC levels which exceed industry averages, and are promoted for the dry-grind ethanol market. Examples of branding include Processor Preferred ™ and Industry Select ™. The ethanol market is rapidly gaining in importance in Wisconsin as four existing plants use 20% of the States corn production and several more plants are proposed. The economic impact on producers is positive even without premiums paid for quality because of improvements in basis and local price, compared to traditional terminal markets. Other output characteristics of interest include protein levels for the feed industry and oil for the processing industry.

Several studies have evaluated hybrid stability across multiple environments, but have focused on grain yield and not output characteristics. This project examined hybrids in multiple cropping systems to determine if stability in output characteristic existed. The converse of this formed the central research question:

Is there a tendency for hybrid output characteristics to change between different cropping systems?

If stability does not exist, it may be possible and practical for producers to modify production practices when targeting a specific market to produce grain whose characteristics match the end-use. If the difference of the output characteristic of interest between commodity corn and the grain produced were great enough, it should be possible if not appropriate for a premium to be paid for that specific grain. This would be particularly important if a yield trade-off occurred with an enhanced grain characteristic. Its doubtful producers would accept a yield penalty without compensation.

Specific objectives of this trial were to evaluate nine corn hybrids, some branded, for grain output characteristics after three previous crops: corn, soybean and winter wheat, and compare their specific component yield to determine likelihood of acceptance by producers. Physical changes to the trail, specifically changing locations necessitated a change in experimental design, which prohibits direct statistical comparison between cropping systems but trends and implications will be discussed.

What steps did you take to reach your goal?

Study Methods

Field studies were conducted on the Rock County Farm (N42^{o} 43.650', W089^{o} 01.291') near Janesville on a Plano silt loam soil (fine-silty, mixed, mesic Typic Argiudoll) in 2003 and 2004. Nine corn hybrids (Table 1) were grown following corn, soybean and wheat in three separate trials. The hybrids selected represent the top performing entries in the University of Wisconsin-Extension hybrid evaluation trials based on yield (Joe Lauer, personal communication) of hybrids adapted to southern Wisconsin. Experimental conditions and field operations can be found in Table 2.

All field activities of the three trials were identical except harvest of the prior crop. Primary tillage consisted of fall chisel plowing followed by field cultivation in spring. Corn was planted at a rate of 33,000 kernels/a in 30-inch rows with a corn planter designed for conservation tillage. Nitrogen was applied broadcast, prior to planting, as a 28% UAN solution at a rate of 160 lb. actual N/a. Weed control consisted of a broadcast application (with the nitrogen solution) of 1.8 pt. Dual II Magnum and 3.0 oz. Hornet per acre. Soil nitrate-N was measured in the top 12" of soil in June of 2004 to insure adequate N remained following a prolonged period of precipitation beginning in mid-May of that year.

Corn was harvested as grain and analyzed for moisture content and test weight. Grain from two rows measuring 17ft 5in was used for yield determination. Grain samples were air-dried using forced ambient air and analyzed for protein, oil, total starch and highly fermentable carbohydrate (HFC) using near infrared (NIR) transmittance. Results of this analysis are reported on a dry matter (DM) basis.

The experimental design is a randomized complete block with 4 replications. Data analysis consisted of analysis of variance procedures using a general linear model (SAS Institute) both by year and combined over years. Means were separated using a least significant difference at the 0.05 % level of probability when significant treatment differences occurred. Individual trials were analyzed separately and no statistical inference is made between them. Branded hybrids were compared against non-branded for appropriate variables using orthogonal contrasts.

Results

<u>Growing Season Conditions</u>

The 2003 and 2004 growing seasons differed and resulted in significant year effects for most trial variables measured. Both were similar in precipitation amounts, both slightly below normal, but had different distributions. Abnormally wet Mays were common to both, with almost 5 inches of rainfall in excess of normal. Distribution was better in 2003, with adequate rain until August, the grain-filling period. Cycles of wet and dry months occurred in 2004. Continued precipitation in June resulted in saturated conditions and periods of standing water were common, while September was extremely dry, stressing plants which were already struggling to reach maturity because of a lack of growing degree day (GDD) accumulation. Temperatures in 2003 were near normal while 2004 was much cooler that normal. Growing degree day accumulation was slow and if not for a much warmer September than normal, some of the

hybrids may not have made it to maturity. Despite these challenges, corn grain yields were exceptional in both years.

Hybrid yield, grain composition and total component yield are reported in Tables 3 through 8. Data are reported by year because significant hybrid by year interactions occurred for most variables reported (Table 9) and results from individual trials are reported side by side for comparison. Also, only one-year analysis is available for protein and HFC.

Hybrid Yield

Over the three trials, significant differences occurred between hybrids on 50% of the time. This result should not be unexpected because 8 of the 9 are top performers in the University of Wisconsin-Extension Hybrid performance evaluation trials. Where significant differences occurred, hybrid clustered into higher and lower yield groups (2003 after corn, 2004 after soybean) or the single non-elite hybrid (Jung 6580) yielded significantly below the others (2004, after corn).

A comparison of trial means for all trials is reported in Table 10. Data are reported this way to allow general comparison, but no direct statistical comparison can be made. It does however allow for trends to be identified and discussed. In general, yields were greater in 2004 than 2003. Trial means were similar in 2003, but had greater range in 2004. Corn following wheat was greatest each year, while the other trials exchanged ranking between years. This is somewhat surprising for 2003 as corn following corn typically yields less than rotated corn, whose reported yield advantage is typically 10% to 15% more (Lauer et al., 1997). This may be explained by variant Western Corn Rootworm (VWCR) damage following soybean, although variant activity in 2002 was not monitored nor suspected in Rock County. Below threshold beetle populations in continuous corn and sub-threshold VWCR in 2003 led to the decision not to treat the trials in either year.

Grain Composition

Trial means for grain composition (Table 10) show a tendency for component differentiation by previous crop in 2003, based on ranking. Unfortunately, that relationship cannot be determined for 2004 because results of protein analysis were inadvertently not recorded at the analysis lab. However, a new component assay for HFC was analyzed, increasing the value of project data as it related to ethanol production using a dry-grind milling process. While between trial differences are small, the potential impact is large when combined with yield differences, resulting in more or less yield of the individual component on a per acre basis, discussed in the next section.

Protein

Significant hybrid response for protein occurred after soybean and wheat in 2003. Following soybean, hybrids tended to segregate into higher and lower groupings with a distinct, statistically significant separation. Following wheat, overall protein levels were greatest, and although hybrids were significantly different, the difference was small and protein level more consistent, regardless of hybrid.

Highly Fermentable Carbohydrate
Significant hybrid responses for HFC occurred following all three crops. As with protein, hybrids tended to segregate into higher and lower concentration groups. The difference between means of the high and low groups is small, 0.7, 0.5 and 0.8 following corn, soybean and wheat respectively, but could be of great economic significance if claims of 3 to 4% increases in ethanol yield from higher HFC hybrids (McMahon, 2003) hold true. Unlike protein, where hybrid rank within trials was highly variable, ranking across trials was remarkably consistent. Table 11 lists the top hybrids (not significantly different from the greatest hybrid for each measured variable) in each trial. Hybrids common to all three trials within each year are listed below and are defined as stable hybrids, hybrids whose top output characteristic held up across all three trials and therefore previous crops. Three hybrids: Pioneer 33V14; Midwest G7101B and Jung 6580 were stable for HFC in 2004.

Branded hybrids, those designated as Processor Preferred ™ and Industry Select ™, were compared as a group against the rest (non-branded) to determine if they as a group had higher levels of HFC. In 2004, there was no significant difference between branded and non-branded hybrids for HFC, and none of these hybrids exhibited stability for this output characteristic. As a group, their HFC concentration was 0.1% below trail mean following corn, 0.1% above trial mean following soybean, and equal to the trial mean following wheat.

Oil
Oil content of the hybrids as a group showed no trends across all three trials. Mean oil levels were greater in 2003 than 2004 and the effect of year was significant. Significant hybrid by year interactions occurred following both soybean and wheat, showing general trait instability. Even with lower mean oil concentration in 2004, the statistically greatest oil concentration hybrids had similar or greater concentration as a group in 2004 compared to 2003 and of these, one was stable across all three trials.

Starch
Growing season had an affect on starch levels. As with oil, mean starch concentrations were greater in 2003 than 2004 and significant hybrid differences existed in all three trials in 2004, as did a significant year by hybrid interaction. Hybrids with the statistically greatest starch concentration in 2004 had concentrations similar to 2003 indicating some degree of stability. Three of these: Pioneer 33A14; Jung 2710 and Novartis N58D1 ranked as stable across trials in 2004. Had significant differences between hybrids occurred in 2003, these three may well have rated stable in both years.

As with HFC, branded hybrids were compared against the others for starch concentration using contrasts. No significant differences existed except following wheat in 2004 where the branded hybrids as a group had a lower starch concentration. While interesting, the relationship between total starch and HFC remains unclear, so this result may have little meaning.

<u>Component Yield</u>
Component yields were calculated to examine the relationship between overall yield and grain composition, resulting in a quantity yield for each component. Across trials, significant component yield differences between hybrids existed in 56% of cases. Where significant

differences occurred, both yield and grain output characteristic were significant in 50% of cases. In the remainder, a significant component difference resulted from hybrid yield 20% of the time and component concentration 30%.

Within individual component yield classes, protein yield as always non-significant (1 year data). Highly fermentable carbohydrate was always significant, with both contributions from hybrid yield and grain concentration accounting for 67% of the cases, and grain HFC accounting for the other 33% (1 year data). Oil yield was more variable, significant in 50% of cases, which were equally divided between contributions of significant yield, concentration or the combination. Starch yield by hybrid was significant 60% of cases, of which half had both significant hybrid yield and starch concentration and the other divided between hybrid yield and concentration.

Where multi-year comparisons were possible (oil and starch yield), oil yield was significant only following corn where all hybrid by year interactions for all variables was not significant. Starch yield was always significant, and in 67% of cases both hybrid yield and starch concentration were significant, while only concentration was significant in the other.

How should the agricultural industry or the State of Wisconsin use the results from your grant project?

The central question to this project is does stability exist for corn hybrid output characteristics across cropping systems (previous crop) or conversely, do they change between them. Results of this study are mixed and limited by the inability to directly compare previous crop, or for some variables, only one year's data. However, it gives indication that differences do exist for some traits and that stability for others exist. As such results have implications for future research as well as immediate market potential.

It appears that previous crop has no consistent impact on mean grain output characteristic. Although they segregated nicely in 2003, results were inconsistent when 2-year data for oil and total starch was examined. When viewed solely for production of a desired grain output characteristic, it appears impractical to select/target a particular previous crop. Hybrid choice is however important, and hybrid performance within different cropping histories variable.

Overall, hybrid had variable performance in output characteristics, as well as grain yield. When variable for output characteristic however, hybrids tended to segregate into higher and lower classes, significantly different from each other, and their concentrations and component yield were similar to their performance (levels) in the non-variable year.

Hybrid stability for a desired trait is important for a targeted end-use, especially in years with variability. Variability was not as issue in 2003, so hybrid choice less important. However, 2004 was highly variable, hybrid choice did matter and stability patters emerged. If differences between hybrids are not significantly different, any hybrid is acceptable. Using data from Table 11, if we interpret a not significant rating as meaning any hybrid is acceptable; a combined list of stable hybrids can be constructed. Hybrids that are stable over years of high and low variability as well as across cropping history are important to end-users because of consistency of grain

composition. Year to year consistency is important for obvious reason, and consistency across multiple previous crops as less grain is coming from corn-soybean rotation, and more where corn follows corn or wheat as producers change rotation in response to recent soybean production problems manifested as stagnant or reduced yield and more income potential with corn. This recent phenomenon may increase as new pests such as soybean rust or the VWCR threaten soybean or the integrity of the corn-soybean rotation.

The combined list of stable hybrids reduces the number of acceptable hybrids and further shows differentiation by desired output characteristics. In other word a hybrid stable for one is in most cases not stable for others. Producers should select hybrids which are stable for the specific end-user desired trait. A number of ethanol plants are conducting hybrid trials to provide this information. Hybrids should be selected based on multi-location and multi-year performance for both yield and the output characteristic of interest.

In corn, the traits of most economic significance are HFC and starch because they are unique to corn and do not compete with oilseeds for either component. Of these economically important traits, 33% of the hybrids evaluated were stable for one or the other trait. Branded hybrids tested did not rank stable, nor rank better than average for these traits.

Price premium is an important issue the market should decide for enhanced traits, and the important question is: would a premium offer incentive for grain with higher concentrations of HFC or starch? This question is important if a negative relationship existed between hybrid yield and the industry desired output characteristic existed. This study found that stable hybrids were positively correlated between yield and HFC and starch concentration which translated into stability rating for component yield. In other works, for the hybrids studied, no economic disincentive exists for producers because the top yielding and most stable hybrids also had the greatest output characteristic concentration, resulting in greatest component yield, when crops were grown following UWEX recommendations. Variation existed within previous crop, and choices become more numerous as wheat is eliminated as a previous crop because fewer hybrids differentiate for HFC and starch following wheat than corn or soybean.

What do you plan to do in the future as a result of this project?

Results of this project will be used in UWEX programming and are the basis of a next generation of research trials.

Trail results and knowledge will be used in local UWEX educational programming and will be provided to Dr. Joe Lauer for use at his discretion. Local programming in Rock County is important because much of the corn production supplies Badger State Ethanol in Monroe and will supply the proposed plant in Milton once its in operation. A fact sheet will be developed and provided to UWEX offices in surrounding counties.

A second generation of research will be initiated in 2005. With improved experimental design which will allow complete statistical comparison, selected stable and nonstable hybrids with similar yield performance will be compared following the same three previous crops. Multiple management factors will be applied to each to determine which may have an impact on output

characteristics, as indicated by improved performance by the non-stable hybrid(s). Should management practices prove to have a significant impact, revised recommendations would be developed to improve grain composition for targeted end use.

References:

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