UNL TAPS

TESTING AG PERFORMANCE SOLUTIONS








N EXTENSION

2019

Farm Management Competitions Report

TABLE OF CONTENTS

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Mission Statement

To fully engage agriculturalists, scientists, educators, students, and industry in an innovative endeavor, to TAP into the University of Nebraska's potential to facilitate and create an environment for all stakeholders to work together in finding solutions through innovation, entrepreneurialism, technological adoption, new managerial applications, improved techniques and cutting edge methodologies for farms, farm businesses, and farm families to maintain profitability, sustainability, and productivity.

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EXECUTIVE SUMMARY

As we conclude the third year of the Testing Ag Performance Solutions (TAPS) Farm Management Competitions, we would like to look back at the past year. The TAPS concept was created to keep pace with ever-increasing innovation and increasing need for technical capacity development among producers. This program represents an evolution of the University's research and extension efforts, to better meet these needs. With the many challenges related to and faced by agricultural production, there is a need for a deeper level of engagement among all its stakeholders.

This third year of the TAPS program has been one of expansion with the addition of a subsurface irrigated corn contest in North Platte, Nebraska and the debut of a sprinkler irrigated corn contest in Guymon, Oklahoma in partnership with Oklahoma State University. The three contests administered at the West Central Research, Extension, & Education Center (WCREEC) in North Platte, Nebraska, were sprinkler irrigated corn, sprinkler sorghum, and subsurface drip irrigated (SDI) corn. There were nearly 150 participants across the 24 sprinkler corn teams, 16 SDI corn teams, and 10 sprinkler sorghum teams. These participants represented five states, and included producers, government agency employees, college students, and both first-time contestants as well as returning ones. The OSU competition in its inaugural year included 9 participants from Oklahoma and Nebraska. While not summarized in this report, the TAPS program is debuting a winter wheat contest that began in August of 2019 and will conclude in August of 2020 after harvest. The contest has 20 teams and is managed at the High Plains Ag Lab near Sidney, NE.

One of the continued key benefits of the TAPS program is that it fosters peer-to-peer exchange of ideas and innovation. Some of these exchanges have become mentoring relationships, business relationships or friendly interactions among participants, including contestants, sponsors, researchers and extension personnel. For example, winners from previous years have collaborated with other participants to implement some of the management skills on their own operations along with technology sponsors that have made time to visit participants' operations and discuss the use of their product.

The TAPS program is successful thanks to the help from the many partners and sponsors that contribute in so many different ways. We recognize the Nebraska Corn Board, Nebraska Sorghum Board, and the National Sorghum Checkoff for their financial and moral support of the TAPS program. In addition, we are very appreciative of the many different organizations and entities that have provided resources, technology, technical assistance, and innovative approaches that are available to the participants and observers of the TAPS program.

We look forward to 2020 with excitement and anticipation to facilitate another year of sharing knowledge, implementing the latest in technologies, and offering a risk-free environment for testing contestants' farming techniques and ideas.

Sincerely,

TAPS Executive Board

PROGRAM OVERVIEW

The 3rd Annual Sprinkler Irrigated Corn Farm Management Competition and the 2nd Annual Sprinkler Irrigated Sorghum Farm Management Competition were facilitated under a Zimmatic by Lindsay Variable Rate Center Pivot at the West Central Research, Extension, & Education Center (WCREEC) in North Platte, Nebraska. Also held at the WCREEC this year was the 1st Annual Subsurface Drip Irrigated (SDI) Corn Farm Management Competition. This was made possible by the donation and installation of a SDI system by Eco-Drip Irrigation Solutions Inc. (Hastings, NE). Lastly, in Guymon, Oklahoma, the 1st Annual Oklahoma State University Sprinkler Irrigated Corn Farm Management Competition was held under a center pivot equipped with a Zimmatic by Lindsay Variable Rate Irrigation system. This report focuses on the competitions held at WCREEC. The UNL sprinkler corn competition included 24 farms (i.e., teams), the sorghum competition had 10 farms, and the SDI competition had 16 farms. Each team was randomly assigned a set of three experiment-sized plots, within their respective competition area, totaling less than one-half of an acre per team (Figures 3 and 4). University personnel managed the competition plots. The yields and costs from each "farm" were amplified to represent 3,000 harvested acres for the sprinkler corn competitions and 1,000 harvested acres for the sorghum and SDI corn competitions. This amplification provided the opportunity to market grain in quantities consistent with modern-sized farming operations and to make it easier to recognize the effect of smaller decisions related to costs.

Participants had control over six decisions in each competition that are known to affect production, efficiency, and profitability:

Irrigation Management – The TAPS pivot irrigation system was operated every Monday and Thursday throughout the growing season. Participants had until 10 AM to submit their irrigation decision via their password protected online portal. If participants failed to indicate their intent to irrigate by 10 AM, no irrigation was applied. Irrigation depth per application could be between 0 and 1.0 inch, in intervals of 0.05 inches. The variable cost to pump an acre-inch of water was $7.80/inch. Whereas, the SDI system was operated every Monday, Tuesday, Thursday and Friday throughout the growing season. Participants had until 8 AM to submit their irrigation decision via their password protected online portal. Similarly, if participants failed to indicate their intent to irrigate by 8 AM, no irrigation was applied for that irrigation event. Irrigation per application could range from 0 to 0.5 of an inch in increments of 0.05 of an inch.

Nitrogen Management – Participants were able to select the amount of pre-plant and/or in-season (via side-dress and/or fertigation) nitrogen (N) fertilizer in the form of UAN 32%. All plots and competitions received a baseline 5 gallons per acre of starter fertilizer (10-34-0) at time of planting. Pre-plant N was available in all competitions and was applied using a double-coulter liquid applicator at about 1 inch in depth and a distance of 5 inches on both sides of the planted row. Side-dress N fertilizer was available for contestants in the corn competitions and was applied at the ground surface neighboring each crop row using 360^0 Y-DROP (360^0 Yield Center, Morton, IL). Fertigation was applied through the center pivot using a variable rate injection pump (Agri-Inject, Yuma, CO) that maintained proper concentrations as the irrigation system flow rate changed. In-season N was also available to the SDI plots using a constant rate injection pump. Maximum application of N was limited to a total of 180 lbs/acre for pre-plant, 180 lbs/acre for side-dress, and 30 lbs/acre for each fertigation event (i.e., total possible fertigation amount was 120 lbs/acre). Pre-plant, side-dress (V4-V6), and four fertigation events (V9, V12, VT/R1, and R2) were available to the corn participants; whereas, pre-plant and four fertigation events (Stages 2, 3, 4, and 5) were made available to the sorghum participants. An application cost, not including the value of the fertilizer, of $7.00 per acre was charged for the pre-plant and side-dress operations and $1.00 per acre for each fertigation application.

Hybrid Selection and Seeding Rate – Each team was required to select their own seed variety and seeding rate. District sales managers (DSMs) of multiple seed companies (Arrow, Big Cob, Channel, Dekalb, Dyna-Gro, Fontanelle, Hoegemeyer, Pioneer, Seitec, Stine) provided a recommended list which included 43 corn and 14 sorghum varieties, with accompanying seeding rates. These recommendations were based on the location, production history and characteristics of the field used in the competition. While each team had the option of selecting a DSM recommended hybrid, they were also free to select and use their own seed variety. Participants were also free to specify seeding rate regardless of the variety chosen. If participants selected a recommended hybrid, the seed was provided by the respective DSM otherwise they had to provide it. The sprinkler and SDI corn competitions were harvested when the majority of hybrids reached 17% moisture content. This was consistent with the maximum moisture content elevators allowed at time of harvest. The sorghum competition was harvested when the majority of hybrids reached 16% moisture content. All hybrids were charged a drying fee of $0.04 per point per bushel above 15.5% moisture content for corn and 14% for sorghum at time of harvest. This ensures that all yields are measured equally for each contestant.

Grain Marketing – Crop marketing was an ongoing option for the length of the competitions. Each team had five different avenues to sell their grain. These five options were 1) spot (cash) sales, 2) forward contract, 3) basis contract with delivery at harvest, 4) simple hedge to arrive, and 5) hedging with futures contract. Marketing was allowed between March 20th and November 15th for sorghum and November 22nd for corn contests. Since this was a farm management contest using the market to speculate was not acceptable.

Crop Insurance – Participants were asked to select a coverage package from the following options: Revenue Protection (either enterprise or optional units), Revenue Protection with Harvest Price Exclusion (either enterprise or optional units), and Yield Protection (either enterprise or optional units) at the levels of 65, 70, 75, 80, or 85%. The rates were provided by Farm Credit Services and were for the competition area in North Platte, NE. Hail and wind coverage options were also available. Hail yield loss and indemnity payments were calculated based on measured field loss on five preselected fields located in Lincoln County, NE, for corn and Red Willow County, NE, for sorghum contests.

Other Management Decisions – All other management decisions, such as pesticide use, tillage, residue management, etc., were predetermined and executed by the TAPS Team. Each contest was managed uniformly for that contest with all plots being randomized and managed identically except for those decisions made by the assigned teams. This means that the actual physical management (i.e., operation of machinery, irrigation systems, application of chemicals, and harvesting were done by the TAPS Team or designated staff). Participants were encouraged to observe, install their own data collecting technology, and/or collect additional data from their plots throughout the growing season at their own expense. However, no additional inputs (i.e., fertilizers, additives, amendments, operations, sprays, etc.) were allowed.

TIMELINE

The 2019 competitions started with a kick-off meeting on March 19, 2019, at the Bayer Crop Science (Monsanto) Water Utilization Learning Center in Gothenburg, NE, where the rules and regulations of the three Nebraska competitions were discussed with competitors. Teams were required to make their insurance selection within 10 days of the kick-off, March 29. By April 10, each team had to indicate their pre-plant N amount, select their hybrid and specify their seeding rate. Planting occurred on May 13 and June 3 for corn and sorghum, respectively. Irrigation was available starting June 17 and ended on September 27. Fertigation applications were scheduled based on growth stages throughout the season as indicated in the Nitrogen Management section. There was a formal field tour and barbeque on June 27 where participants were able to visit the field and observe differences among plots. Contestants were also encouraged to visit their plots anytime throughout the contest. The primary in-season TAPS event was held in conjunction with the West Central Water and Crops Field Day on August 22. The field day spotlighted the TAPS program including a program overview and a grower discussion panel with TAPS participants. The field events provided opportunities for contestants to interact with each other as well as the facilitators, industry, and observers. Corn and sorghum reached physiological maturity on October 10 following a hard freeze. Harvest was completed on October 24 for sorghum and November 6th for both corn competitions. The competition officially ended for sorghum competitors on November 15 and November 22 for both corn competitions at which time any unsold grain was priced on the local spot cash price for all teams.

TECHNOLOGY

One of the primary goals of the TAPS program is to provide participants an opportunity to use innovative technology and services in a risk-free environment as well as to try, test, and develop unique strategies to become more successful at farming. This program helps to identify which method, technology and/or strategy might bring value to their operation. In its third year, TAPS has had an ever-increasing growth in the number of contests, contestants, supporters, and technology providers. Participants have enjoyed access to a variety of technology, ideas, and methods that are designed to help inform their production and marketing decisions. The technology provided to the contestants ranged from in-field and edge-of-field instrumentation, to imagery products, to sophisticated crop management models, and more. In addition, contestants had access to a number of agricultural services and recommendations provided by commercial soil labs (e.g., Ward Laboratories, Inc.), district seed sales managers, among others.

DESCRIPTION OF AWARDS

Each competition had three awards, 1) Most Profitable Farm, 2) Highest Input Use Efficiency, and 3) Greatest Grain Yield. Cash awards of $2,000, $1,000, and $500 (minus penalty) were granted for each competition winner. All awards were accompanied with an honorary plaque. Description of each award is presented below.

1. Most Profitable – included average yield from each teams three plots minus any hail damage accessed and amplified to 3000 or 1000 acres, marketing decisions, and costs of production (variable and fixed) based on the UNL budget costs and the teams prescribed management choices.

2. Highest Input Use Efficiency: Water-Nitrogen Intensification Performance Index (WNIPI, Lo et al., 2019)

$$WNIPI = \frac{\left(\frac{Y_{Farm} - Y_{Control}}{Y_{Control}}\right)}{\left(\frac{ET_{Control} + I_{Farm}}{ET_{Control}}\right) \times \left(\frac{ANU_{Control} + N_{Farm}}{ANU_{Control}}\right)}$$

   where, “control” is a farm managed by UNL that receives no irrigation or N fertilizer (except for 10-34-0 at planting), “ET” is seasonal evapotranspiration, “I” is seasonal irrigation, “N” is total seasonal applied nitrogen, and “ANU” is aboveground nitrogen uptake. The farm with the highest value was determined the winner.

3. Greatest Grain Yield Award – adjusted by the winner’s percent of total possible profit. Total possible profit was the range of difference between the most and least profitable farms.

PARTICIPANTS

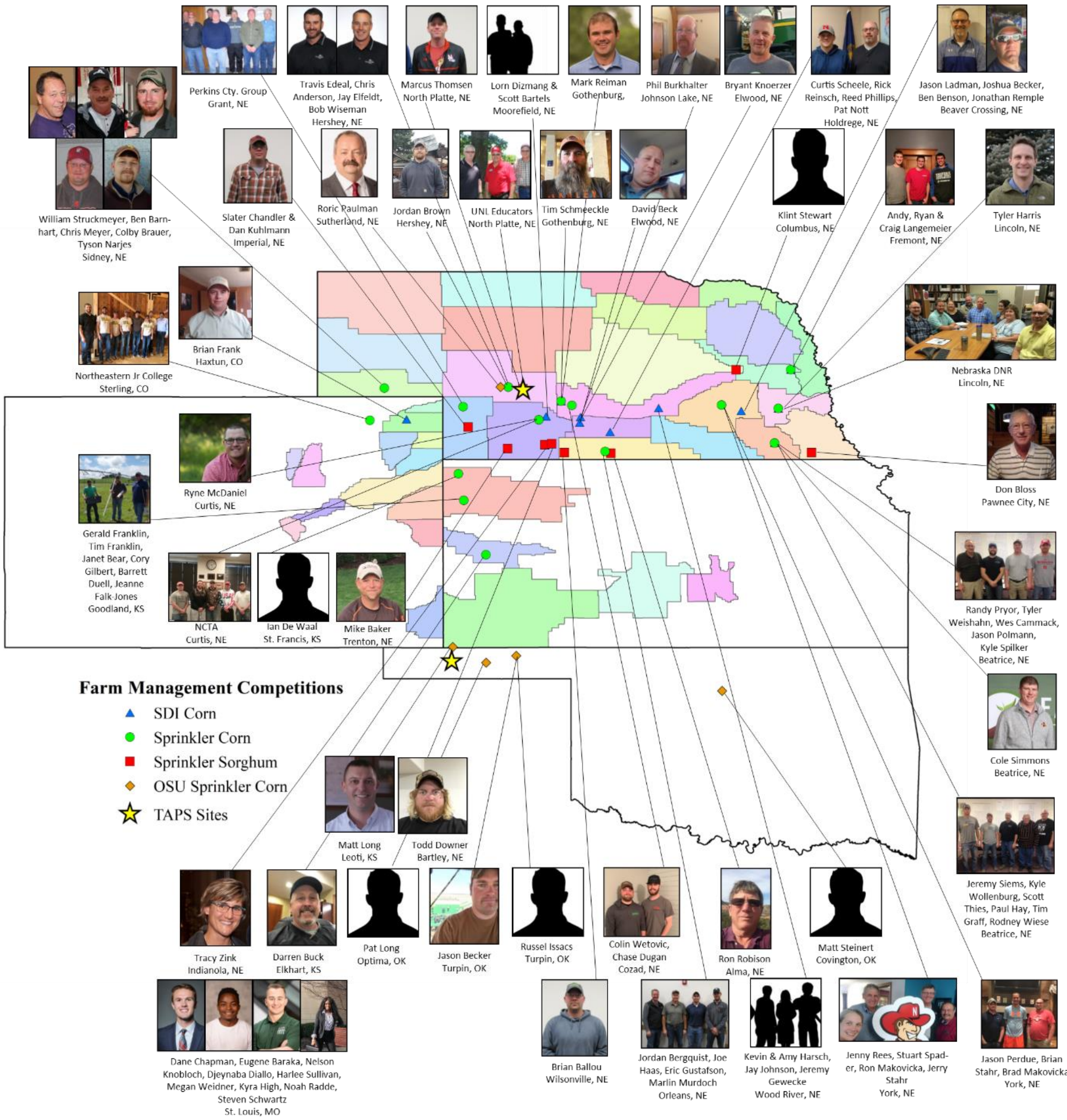

Figure 1. Location of the 2019 TAPS Farm Management Competition sites, participants, and boundaries of the Nebraska Natural Resource Districts, Colorado Groundwater Management Districts, and Kansas Groundwater Management Districts.

PARTNERS & SPONSORS

Figure 2. The TAPS program has seen continued success due to this group of partners and sponsors. From donating technology and time to install equipment, to supplying seed, to making monetary donations, every one of these entities is appreciated.

TAPS in North Platte, NE

Synopsis of Competitions

The sprinkler irrigated corn, sprinkler irrigated sorghum, and SDI corn competitions had 24, 10, and 16 teams, respectively. The University of Nebraska-Lincoln West Central Research, Extension, & Education Center (WCREEC) in North Platte, NE, hosted the competitions. Each team within a competition had three randomized plots (Figures 3 and 4). The sprinkler-irrigated competitions were irrigated using a Zimmatic variable rate irrigation pivot (Lindsay Corporation, Omaha, NE) located at the intersection of Hwy 83 and State Farm Road. The SDI competition was located approximately 275 yards west of the pivot and was donated and installed by Eco-Drip Irrigation Solutions out of Hastings, Nebraska. The pivot was operated on Mondays and Thursdays and the SDI system on Mondays, Tuesdays, Thursdays, and Fridays throughout the irrigation season.

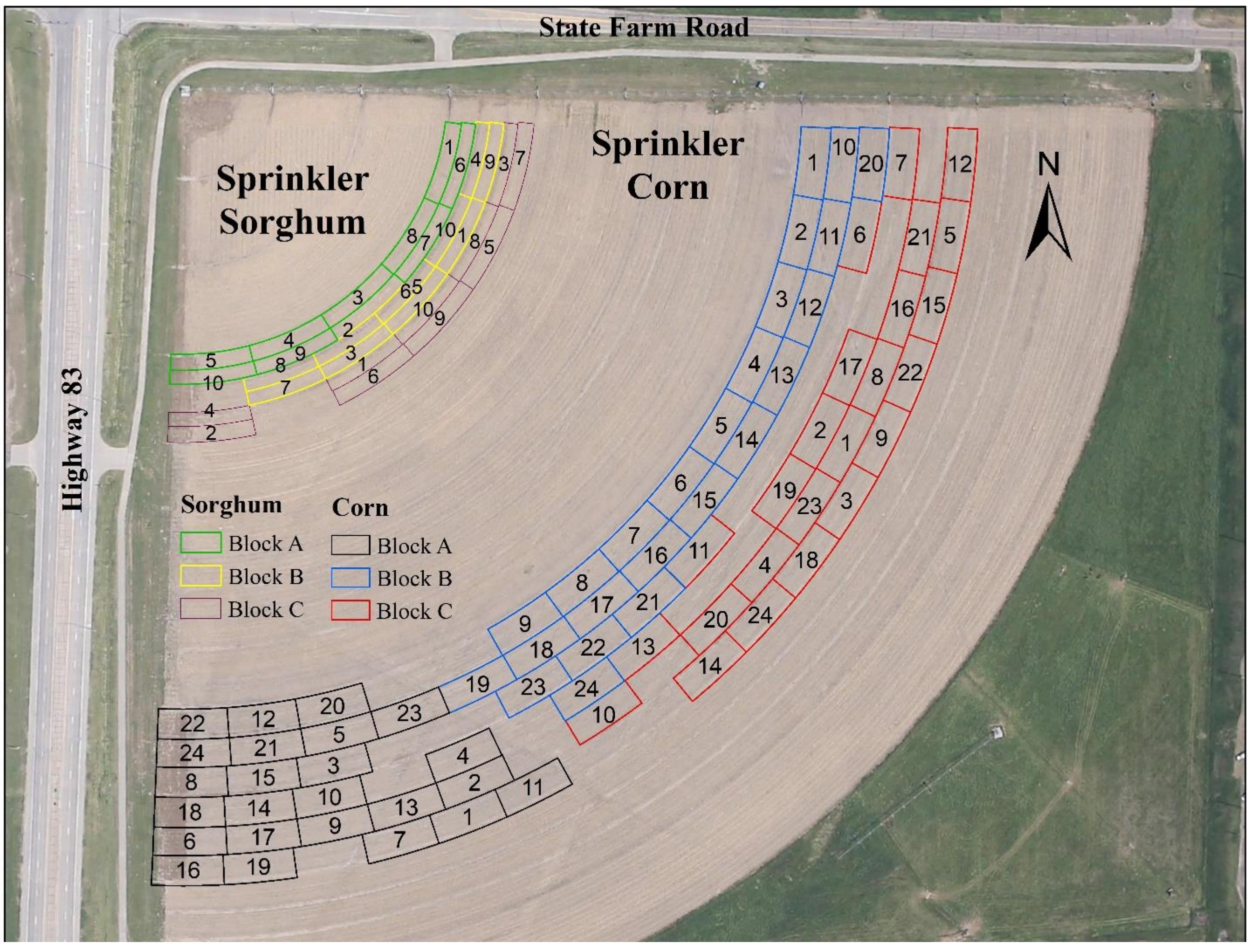

Figure 3. Plot layout for the 2019 Corn and Sorghum Farm Management Competitions held at the West Central Research, Extension, & Education Center in North Platte, NE. Each team within each competition had a randomized plot located in blocks A, B, and C. Flying M Aviation collected the background Airscout imagery on June 13, 2019.

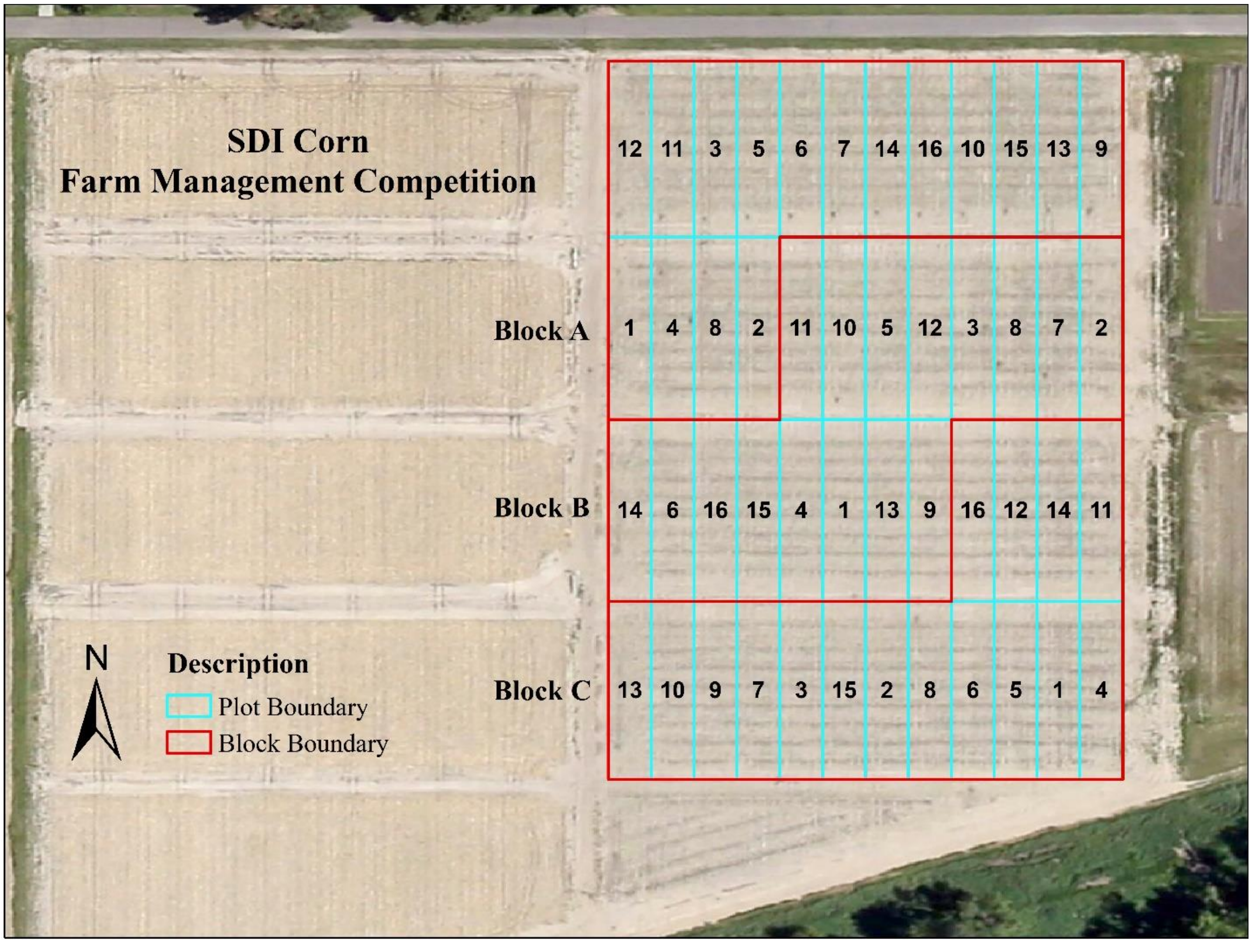

Figure 4. Plot layout for the 2019 Subsurface Drip Irrigated (SDI) Corn Farm Management Competition held at the West Central Research, Extension, & Education Center in North Platte, NE. Each team had a randomized plot located in blocks A, B, and C. Flying M Aviation collected the background Airscout imagery on June 13, 2019.

Weather Conditions

The TAPS sites in North Platte, NE, received above normal rainfall in 2019 (Figure 5). In fact, the seasonal rainfall from May 1 to September 30 for the past three years (2017, 2018, and 2019) of 18.2, 14.9, and 21.2 inches (Nebraska State Climate Office (https://nsco.unl.edu/)) has exceeded the long-term (1986-2015) average rainfall of 12.5 inches (High Plains Regional Climate Center's Automated Weather Data Network (HPRCC-AWDN; www.hprcc.unl.edu/awdn). There were 64 rainfall events from emergence to crop maturity. These numerous events lowered the average seasonal incoming solar radiation to 227 W/m^2. In addition, early season wet conditions, low air temperatures, and cool soil conditions delayed planting. The average maximum daily air temperature during the growing season was 77.2°F, which was slightly lower than the average daily maximum air temperature of 81.4°F observed for the 2018 growing season.

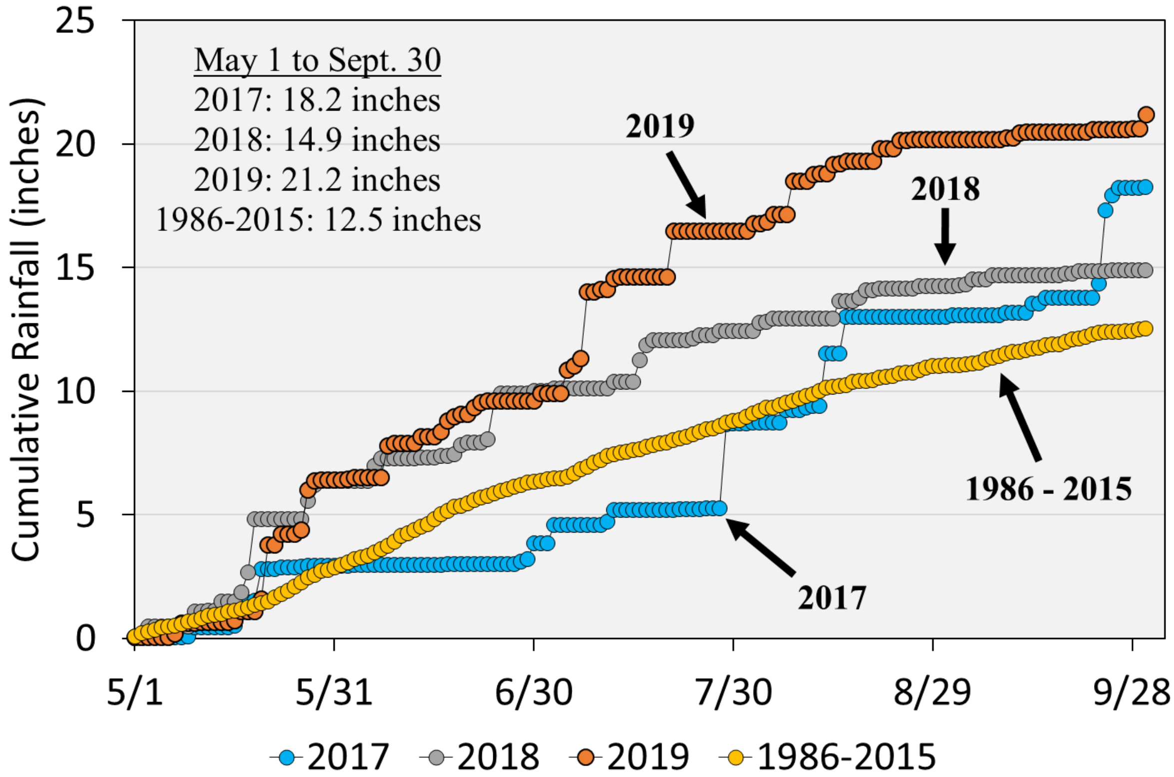

Figure 5. Cumulative rainfall (inches) from May 1 to Sept. 30 for 2017, 2018, 2019, and long-term (1986-2015) at WCREEC in North Platte, NE.

Market Conditions

For the past several seasons, corn prices during the late spring to early summer have spiked higher than during later parts of the year (Figure 6). The 2019 season was no different. During the early part of the year (January, February, and March) corn prices traded with no real upward or downward trends in price, just some minor variations. This sideways movement was due to the stable fundamentals in the markets. Fundamental factors are those that affect supplies and the demand for the commodity. These factors could include weather, changes in technology, economic downturns, animal disease outbreaks, etc. The big news for this early period was in February when USDA released the 2018 estimate of corn grain production, which was 14.4 billion bushels, 1% less than the 2017 season. This led to a projected carryout, or carry over (physically remaining corn left for the following year) of 11.7% but did not move prices higher. The previous World Agricultural Supply Demand Estimate (WASDE) report estimated 1.85 billion bushels of corn carryout, a stocks-to-use ratio of 10.9%. The next big news of the year was in late March when USDA's Prospective Planting Intentions report was released. This report estimated 3.66 million acres more would be planted than were planted in 2018. This news pushed corn prices lower until mid-May. At that point, the market began to recognize the serious planting challenges corn farmers were facing in 2019. Wet weather, flooding, and saturated soils caused some farmers to take prevented planting payments on millions of acres of soybeans. These acres were then late-planted often to corn or other crops. The USDA June WASDE report set the stage for the year's high corn price, which occurred on June 17. On June 28, USDA - National Ag Statistics Services (NASS) estimated 83.6 million acres of corn would be harvested for 2019, 6.2 million less than March estimates. This number was later revised on August 12 when projected harvested acres was lowered by an additional 1.6 million acres to 82 million acres. Higher corn prices lasted until about mid

July then declined until September 9 and then trended slightly upward until the beginning of October. The December 2019 corn contracts topped at $4.73 per bushel on June 17, while the low was $3.52 per bushel on September 9.

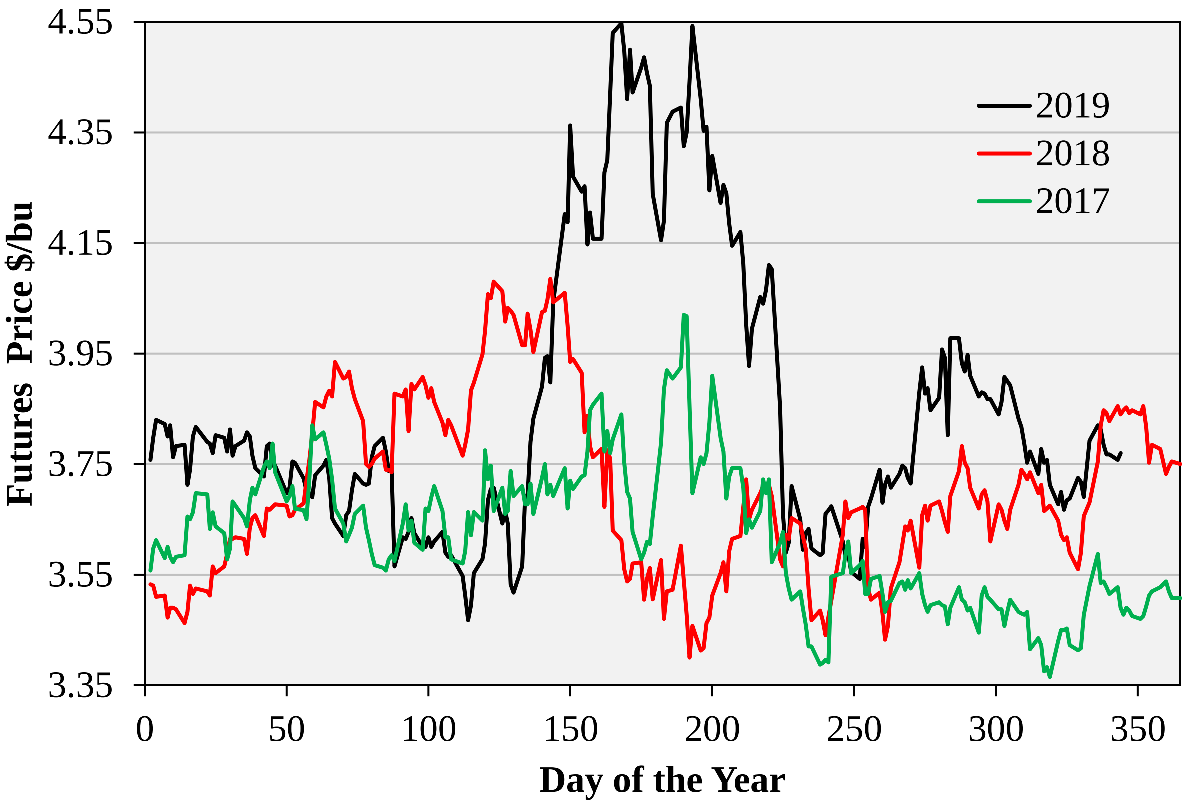

Figure 6. Daily average historical corn futures prices for 2017, 2018, and 2019. For reference, day 1 is January 1, day 150 is May 30, day 200 is July 19, and day 250 is September 7.

Sprinkler Corn Competition

Crop Insurance

All but two corn competitors (Farm 7 and 17) purchased crop insurance of some type (Figure 7). Seventeen of the twenty-one teams that purchased insurance selected revenue protection (RP) with an average coverage of 73%. Nine of the seventeen teams that bought RP, bought enterprise unit (EU) with an average of almost 72% coverage and cost of $6.98/acre. An enterprise unit includes all fields of the same crop for that enterprise. The other eight teams purchased operational units (OU) with an average coverage of 75% and cost of $22.47/acre. An operational unit is defined here as an individual field. The remaining four farms bought yield protection (YP) insurance, all with EU coverage with an average coverage of 70% and cost of $4.17/acre. In addition to RP and YP insurance, eleven farms bought hail coverage with costs varying from $8.85 to $46.76/acre. No team purchased wind insurance. The highest total cost for insurance was $66.99/acre, which included RP-OU-75% and hail coverage. The least costly coverage was a simple YP-EU-65% for $2.86/acre.

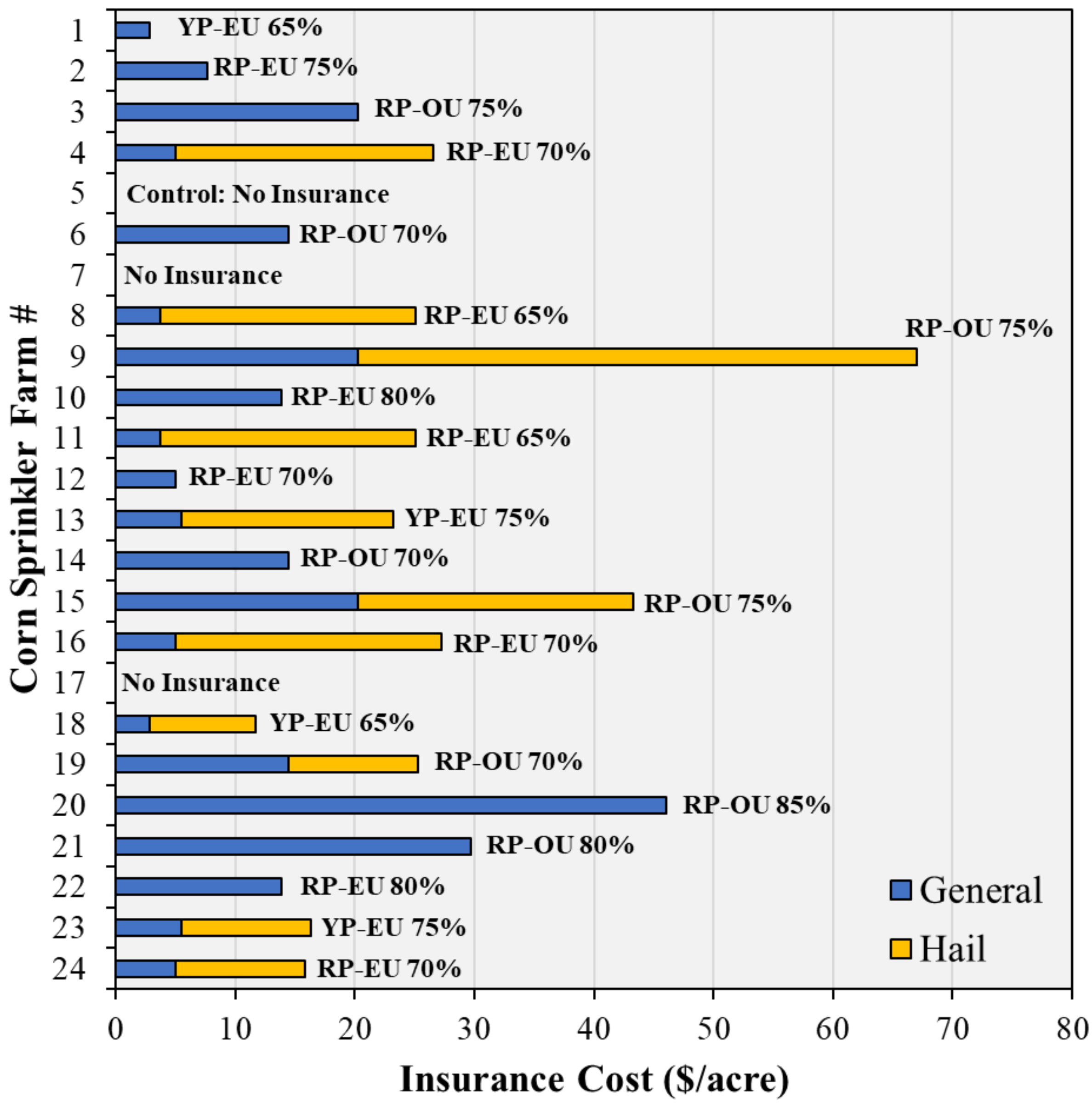

Figure 7. Cost for insurance as well as hail and wind coverage ($ per acre) for the 24 teams competing in the sprinkler irrigated corn competition. The insurance package and coverage rate is noted next to each team. RP stands for revenue protection, YP for yield protection, EU for enterprise units, and OU for operational units.

Hybrid Selection and Seeding Rate

Nineteen of the twenty-four farms selected a seed from the recommended hybrid list provided by various district sale managers (DSMs). Fifteen different hybrids were selected across the teams (Figure 8). The most common hybrid (Farms 6, 7, 14, and 16) was Pioneer 1197AM which has a 111 day comparative relative maturity with an associated cost of $235 per bag. The range in seed cost per bag varied from $182 (Stine 9734-G) to $270 (Dyna-Gro 50VC30 and Channel 213-19 VT2) with an average cost of $238 among the 15 selected hybrids. The seeding rate per acre selected by the teams (excluding Farm 5 - control farm) ranged from 29,000 (Farm 20) to 35,000 (Farms 10 and 17) with a median of 33,000 and average of 32,717. Considering seed cost and seeding rate the total seed cost per acre ranged from $77 (Stine 9734-G at 34,000 seeds per acre) to $118 (Channel 213-19 VT2 at 35,000 seeds per acre) with an average of $98.85.

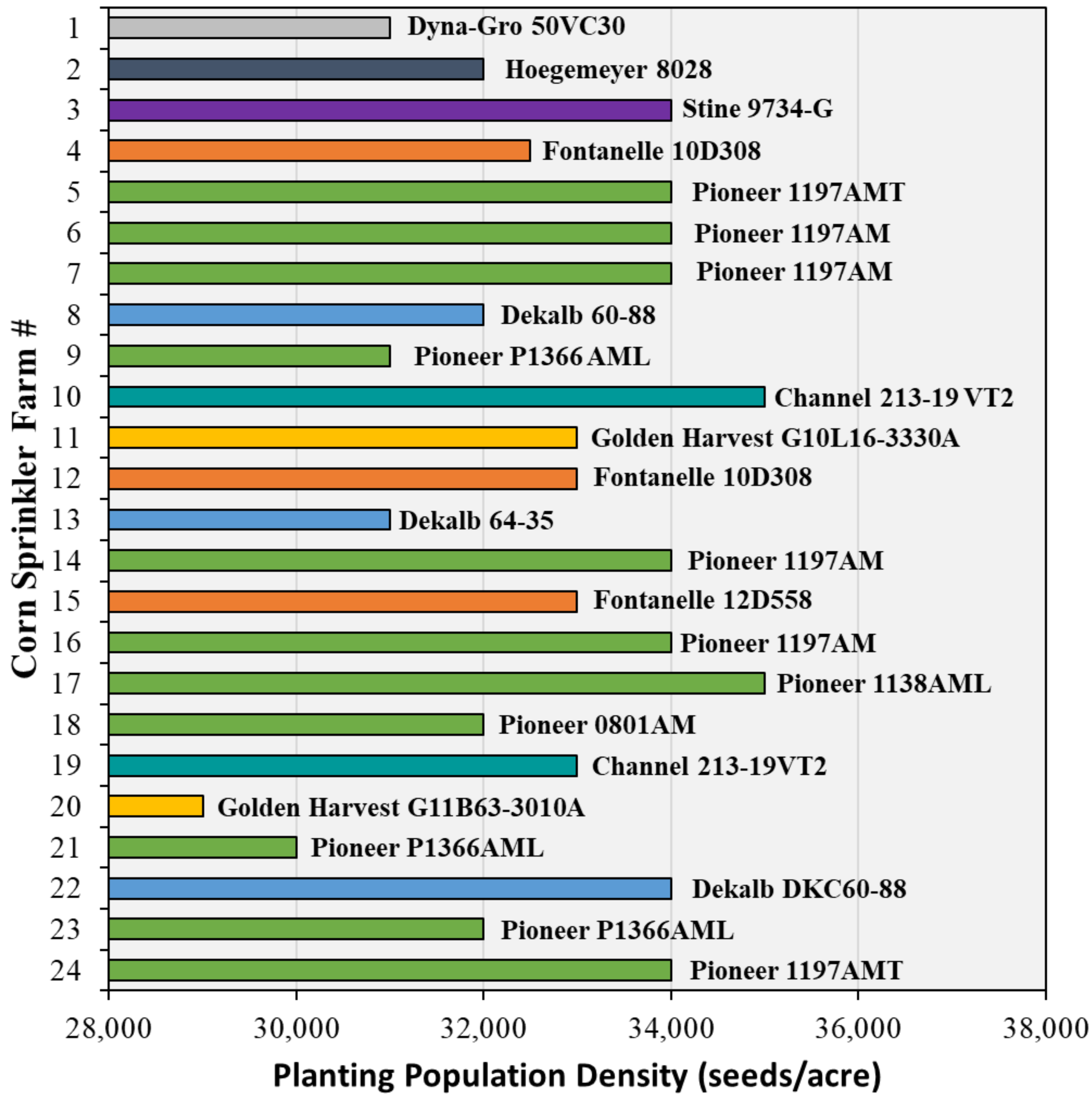

Figure 8. Hybrid selection and seeding rate for the sprinkler irrigated corn competition in North Platte, NE.

Figure 9 below shows each farm with three horizontal bars, red, yellow, and green. These bars indicate one of three benchmarked levels of costs or production for each team. The red bars indicate percent seed costs per acre, the yellow bars are percent seed costs per bushel, and the green bars measure relative yields in percent. All bars are in percent of their respective averages. For instance, Farm 1 had a percent seed cost per acre of 105% (red bar), meaning its seed cost was 5% higher than the average. This same farm had a percent per bushel seed cost of 107% (yellow bar) of average and had a yield that was 88% of the contest's average yield (green bar). As expected yields over 100% lower the per bushel seed cost percent relative to per acre seed cost and vice-versa.

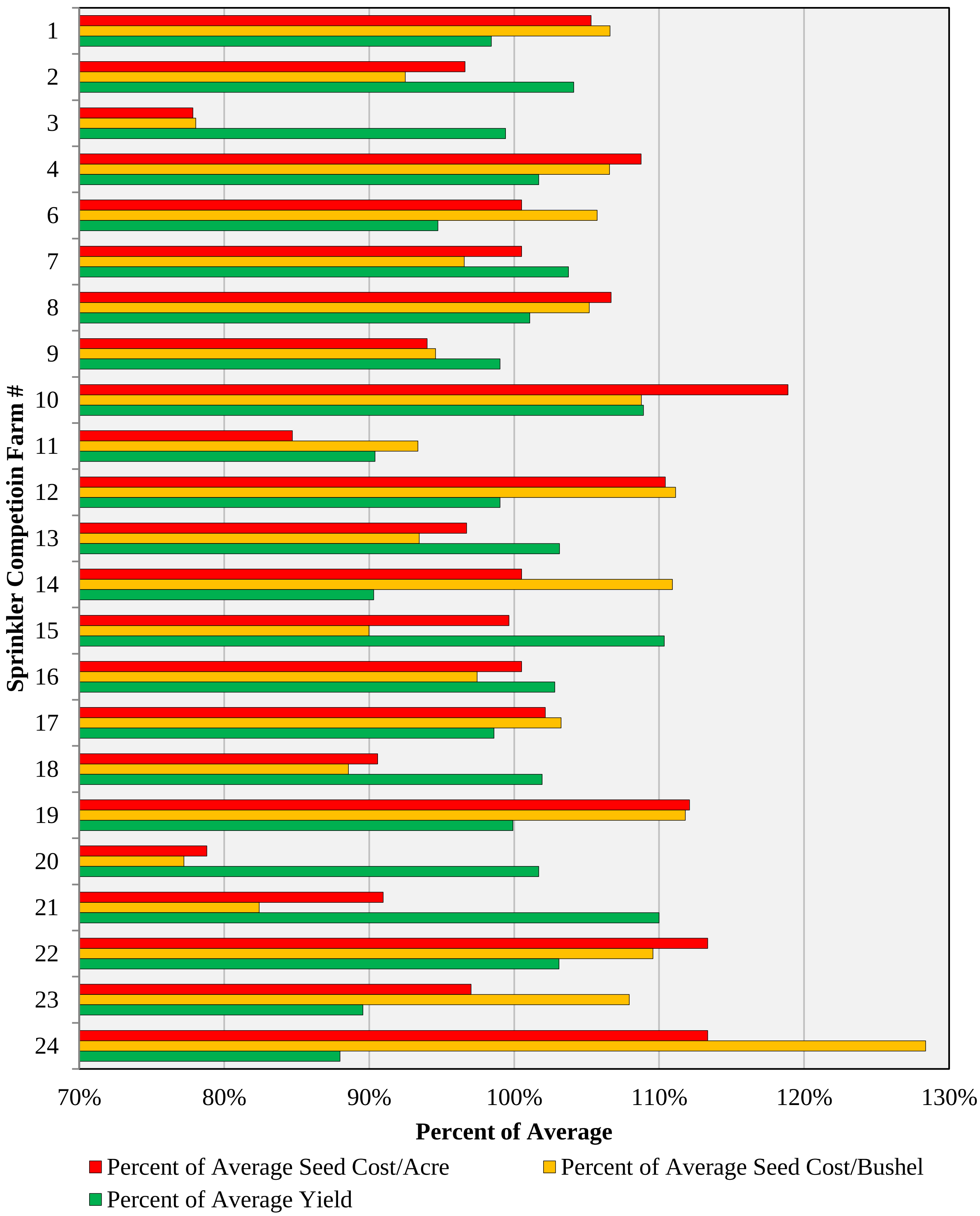

Figure 9. Benchmarked seed costs per acre, per bushel and yields as a percent of the overall average.

Thirteen of the twenty-three competing teams (i.e., excluding Farm 5 – Control) incurred above average per acre seed costs (Farms 1, 4, 6, 7, 8, 10, 12, 14, 16, 17, 19, 22, and 24). However, only three (Farms 7, 10, and 16) of these thirteen teams had yield performance high enough to justify the added costs. For the remaining ten farms with per acre seed cost below 100%, six teams (Farms 2, 13, 15, 18, 20, and 21) had above average yields of 104%, 103%, 110%, 102%, 102% and 110%, respectively. Interestingly, on average, the below average valued seed outperformed the above average valued seed. However, environmental and management practices can influence hybrid selection, thus these outcomes can vary by year, region, and producer management style.

Irrigation Scheduling

The irrigation system was first initiated to apply N fertilizer (i.e., fertigation) on July 3 and concluded on September 26 (Figure 10). With the exception of the control (Farm 5), the total irrigation applied among the corn teams ranged from 0.30 (Farm 23) to 9.90 inches (Farm 21) with an average and median of 3.68 and 3.30 inches, respectively. Approximately 50% of each farm's total irrigation was applied between July 18 and August 15, which coincides with peak ET demand and the application of N fertilizer via fertigation. The irrigation water used for fertigation was proportional to the amount of N fertilizer requested, thus irrigation depth associated with a fertigation event ranged from 0.05 to 0.30 inches. Whereas, the depth of irrigation per event ranged from 0.25 to 1.00 inch with an average of 0.76.

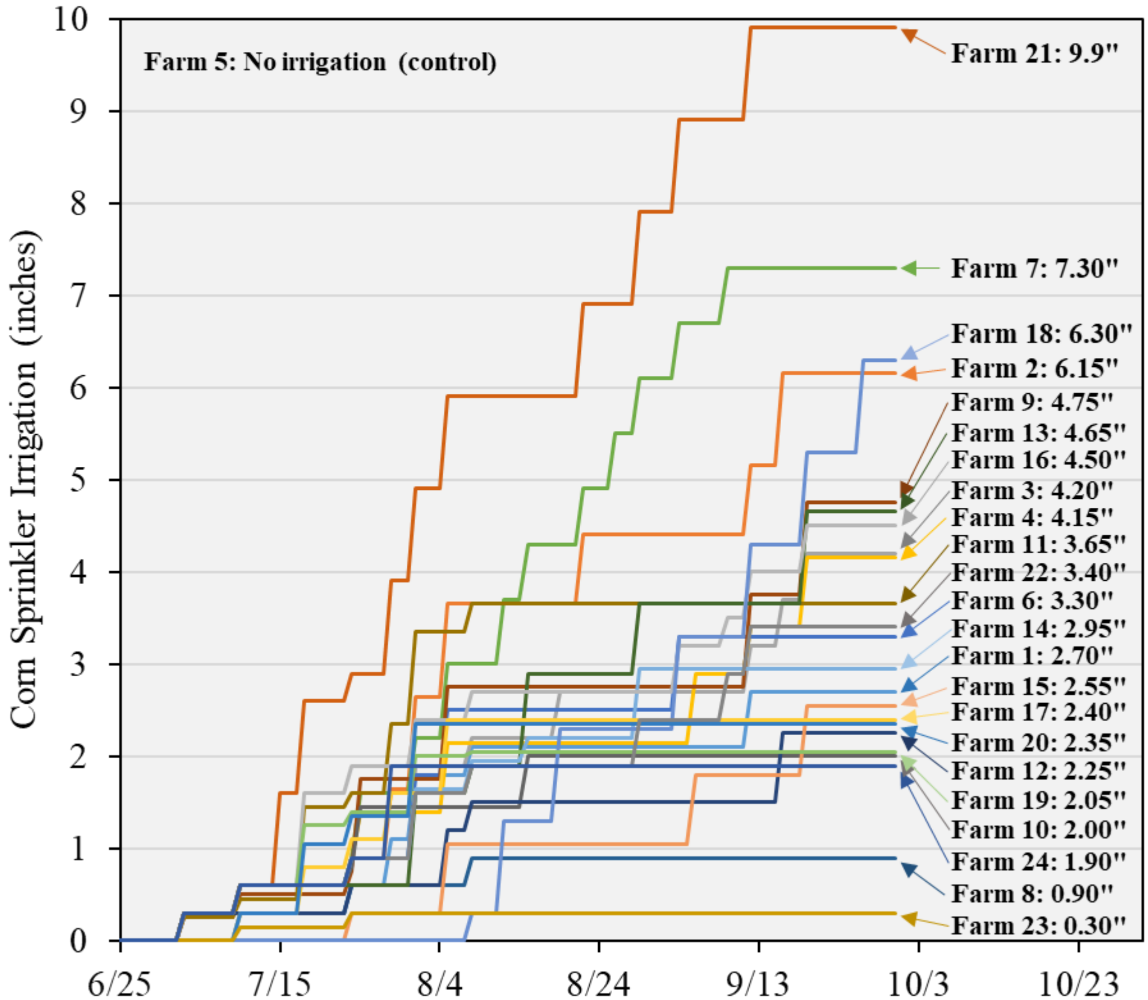

Figure 10. Cumulative irrigation (inches) for the individual sprinkler corn farms in North Platte, NE.

The estimated range of seasonal irrigation requirement to prevent yield loss was between 3 and 4 inches. The upper range was estimated using a model that was calibrated from the 2017 TAPS evapotranspiration (ET) data generated from a LI-COR eddy covariance station (Lo et al., 2019); whereas the lower range was taken as 75% of the upper estimate. A review of deficit irrigation practices across the High Plains Region by Rudnick et al. (2019) found that 75 to 80% of full irrigation requirement had minimal impact on corn grain yield and crop water use efficiency. Nine teams (Farms 2, 3, 4, 7, 9, 13, 16, 18, and 21) exceeded, three teams fell within (Farms 6, 11, and 22), and eleven teams (Farms 1, 8, 10, 12, 14, 15, 17, 19, 20, 23, and 24) were below the estimated irrigation range. As noted above, environmental conditions and management practices can influence hybrid performance. Thus, different hybrids can have different responses to irrigation, which can make it difficult to evaluate the production and economic outcomes, especially when irrigation is applied below the lower range (Rudnick et al., 2019). For example, the team with maximum yield of 241.3 bu/acre only applied 2.55 inches, which was below the estimated optimum range. Nevertheless, the estimated range can serve as a general guide to avoid potential over-or-under irrigation.

Nitrogen Application

The amount and distribution of nitrogen (N) fertilizer prescribed by the sprinkler irrigated corn teams are shown in Figure 11. The total seasonal N fertilizer, not including the control (Farm 5), ranged from 140 (Farm 12) to 270 lbs/acre (Farm 21) with an average and median of 187 and 180 lbs/acre, respectively. Similar to 2017 and 2018, all teams opted to split apply their N fertilizer with all teams fertigating at least once in addition to their pre-plant and/or side-dress application (Figure 11). Total fertigation accounted for 17% (Farm 18) to 69% (Farm 14) of the total N applied. Four fertigation options were made available to the participants, of which six teams opted to fertigate each time, twelve teams fertigated three times, three teams fertigated twice, and two teams fertigated once. The most commonly fertigated growth stage was VT/R1, where all teams fertigated except for Farms 13 and 18. The least commonly fertigated growth stage was at blister (R2), which is consistent with the management practices of the 2017 and 2018 TAPS competitions.

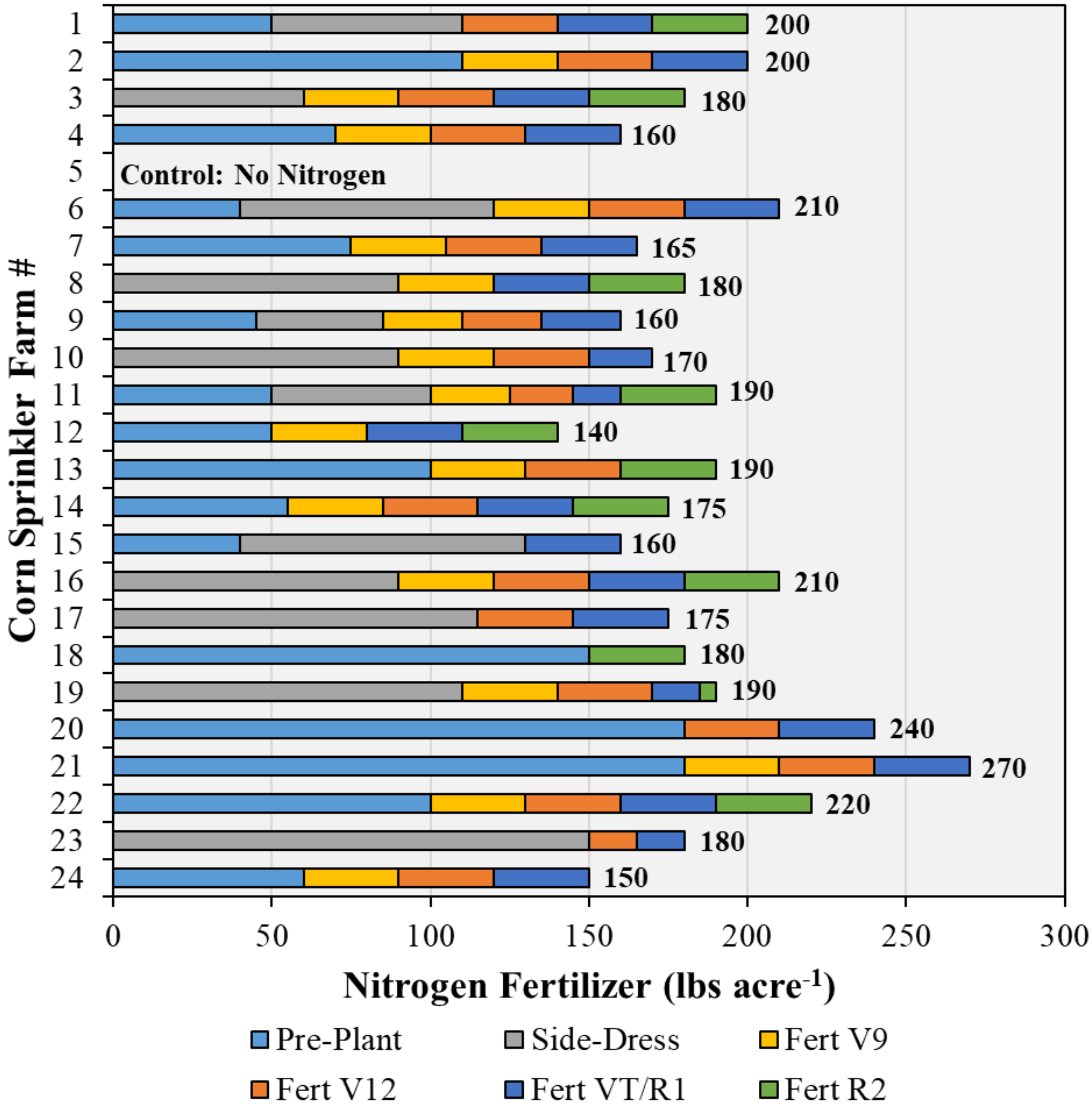

Figure 11. Nitrogen application method and amount (lbs/acre) for the individual corn farms. Pre-plant was applied on 4/19/19, side-dress on 6/20/19, and fertigations on 7/3/19, 7/10/19, 7/24/19, and 8/8/19.

The majority of teams applied less N fertilizer than the 205 to 210 lbs/acre recommendation by Ward Laboratories, Inc., using a preseason soil test and yield goal of 280 bushels/acre. The yield goal was reflective of the upper range of observed yields from the 2018 TAPS sprinkler corn competition (Rudnick et al., 2019). Prior to tasseling on July 18, leaf tissue samples were collected for percent N and normalized difference red edge (NDRE) was calculated using canopy reflectance measured from four crop circles (Holland Scientific Inc., Lincoln, NE, USA) (Figure 12). At time of leaf tissue sampling, sufficiency for N is considered when leaf N% is between 3 and 4% (Bryson et al., 2014). With the exception of the control, each farm's average leaf N% ranged from 3.12% (Farm 9) to 3.58% (Farm 8) and only two farms had one of their plots below 3% (Farm 8: 2.98% and Farm 9: 2.97%). At time of sampling, the corresponding NDRE values ranged from 0.485 (Farm 7) to 0.519 (Farm 23) and the range of applied N fertilizer was from 80

(Farm 12) to 240 lbs/acre (Farm 21). A non-linear relationship existed between applied N fertilizer and Leaf N% as well as NDRE (Figure 13A) and a linear relationship existed between NDRE and leaf N% (Figure 13B).

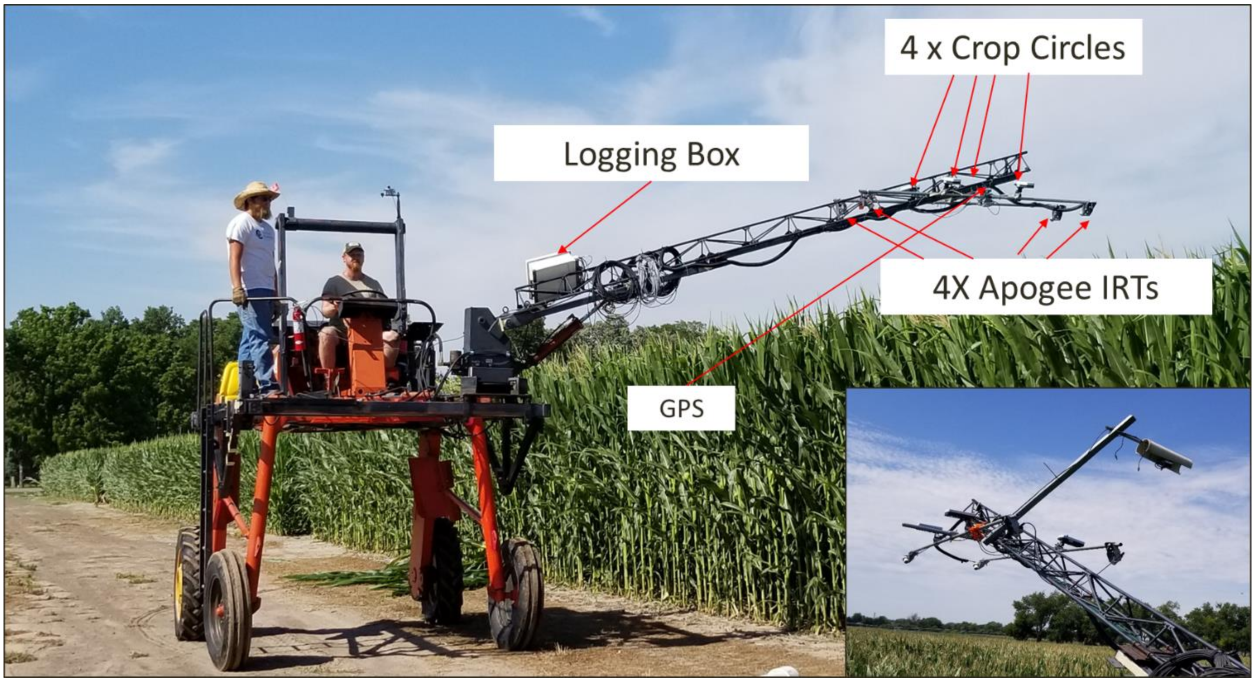

Figure 12. Crop sensing high clearance platform equipped with four crop circle sensors (Holland Scientific Inc., Lincoln, NE, USA), four Apogee SI-1H1 infrared thermometers (Apogee Instruments Inc., Logan, UT, USA), and an external differential GPS (DGPS) receiver (Holland Scientific Inc., Lincoln, NE, USA). This research is in collaboration with Kendall DeJonge from USDA-ARS in Fort Collins, CO.

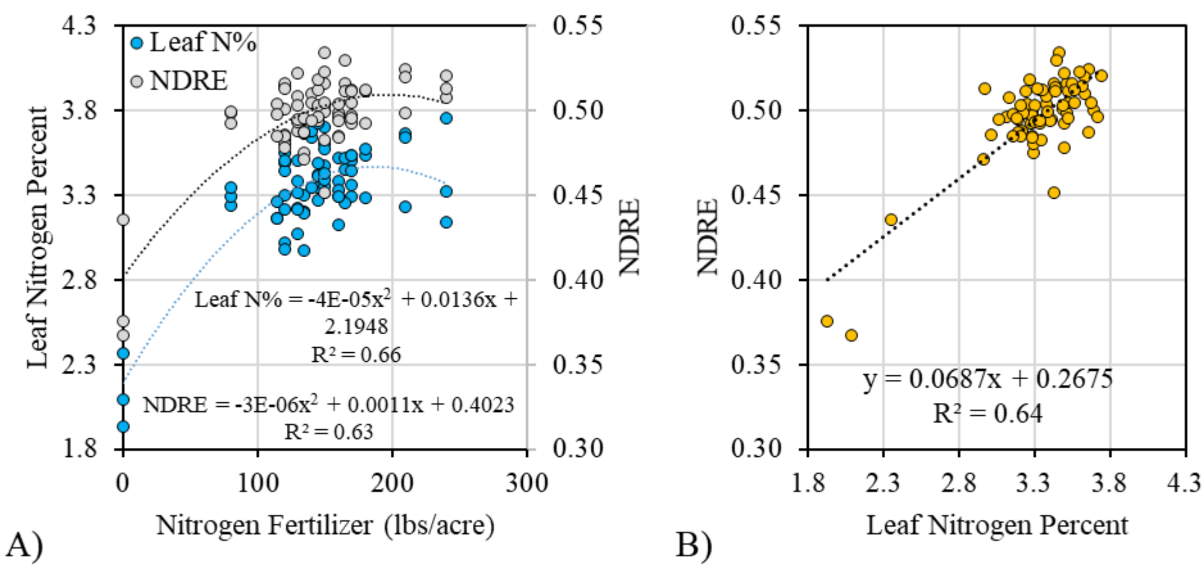

Figure 13. On July 18, leaf tissue samples were collected for percent nitrogen (N) and normalized difference red edge (NDRE) was calculated using canopy reflectance measured from four crop circles (Holland Scientific Inc., Lincoln, NE, USA). Leaf N percent and NDRE as compared with applied N fertilizer (A) and NDRE as compared with leaf N percent (B).

Crop circle sensors provide two main vegetation indices; NDRE and Normalized Difference Vegetation Index (NDVI) derived from canopy reflectance wavelength bands to monitor leaf's chlorophyll content levels. To avoid non-linearity or saturation between a vegetation index and leaf N status, narrow band indices such as NDRE are often preferred to NDVI (Lu et al., 2017). It is then from the indices that a N Sufficiency Index (SI, eqn. 2) can be calculated using a reference plot with maximum desired N rate compared with other areas in the field.

$$SI = \frac{NDRE_{Area\ of\ interest}}{NDRE_{High\ Ref.}} \tag{2}$$

It is preferred to calculate SI using the same hybrid as it is possible to receive different NDRE responses across hybrids. If we assume the hybrid impact on NDRE was minor and that Farm 21 (240 lbs /acre) was non-N limiting at time of sampling, we can calculate each farm's SI using the crop circles' NDRE values. Among the competitive teams, only Farm's 7 and 9 were at or below a SI value of 0.95, which is the recommended threshold to trigger additional N fertilizer (Lu et al., 2017). However, all but Farms 13 and 18 fertigated the following opportunity on July 24 (i.e., six days later). The additional application of N for some of these farms may have been warranted given the crop was actively taking up N fertilizer as it approached the reproductive period (i.e., silking); whereas, other farms may have had little to gain from the additional N.

Marketing

One of the exciting things about TAPS is watching the outcome develop as the contest year moves forward. Grain pricing is one of the key factors needed in both the contest and in real life to excel in the area of profitability. Since TAPS began in 2017, early season marketing has played a huge role in affecting per bushel value. Figure 14 provides insight into the sprinkler corn competitors' market decisions through time. From Figure 14, the vertical blue bars show average prices received by those who priced grain by date. These bars are identified in sequential order with the price being indicated by their height relative to the values on the left axis. The combined weighted average price received by all pre-harvest priced grain was $3.82/bu. This is a $0.44/bu premium compared to the $3.38/bu harvest price on November 22. The black line shows the percent of pre-harvest grain priced on a particular date. About 45% of all grain produced was priced on or prior to November 22 or 6,727,800 bushels. Total bushels sold in the contest was 15,062,700. The most pre-harvest sales occurred in May, which accounted for about 45% of all pre-harvest sales. Approximately 71% of the pre-harvest sales had an average price below $4.00/bu with the remaining 29% priced above that mark. About 17% of pre-harvest pricing occurred between June 3 and July 11, where prices received were the highest and had a weighted averaged near $4.15/bu. If Farms 10, 11, and 21 with no pre-harvest pricing had sold 60% of their production at the $4.15/bu price they would have increased profitability by about $108, $90, and $109/acre, respectively.

Net income increased on average by $0.76/acre for every 1% increase in pre-harvest sales (Figure 15). However, this relationship was weak and is specific to this contest and season. The key take home here is that during this past season producers had many opportunities to price their crop at a higher value than if they had sold at harvest. In this case, those who were proactive in pre-pricing were among those that made more profit. In terms of risk, however, those that market more grain than they insure are adding an increased burden of risk to an already volatile business and should be cautious when doing so.

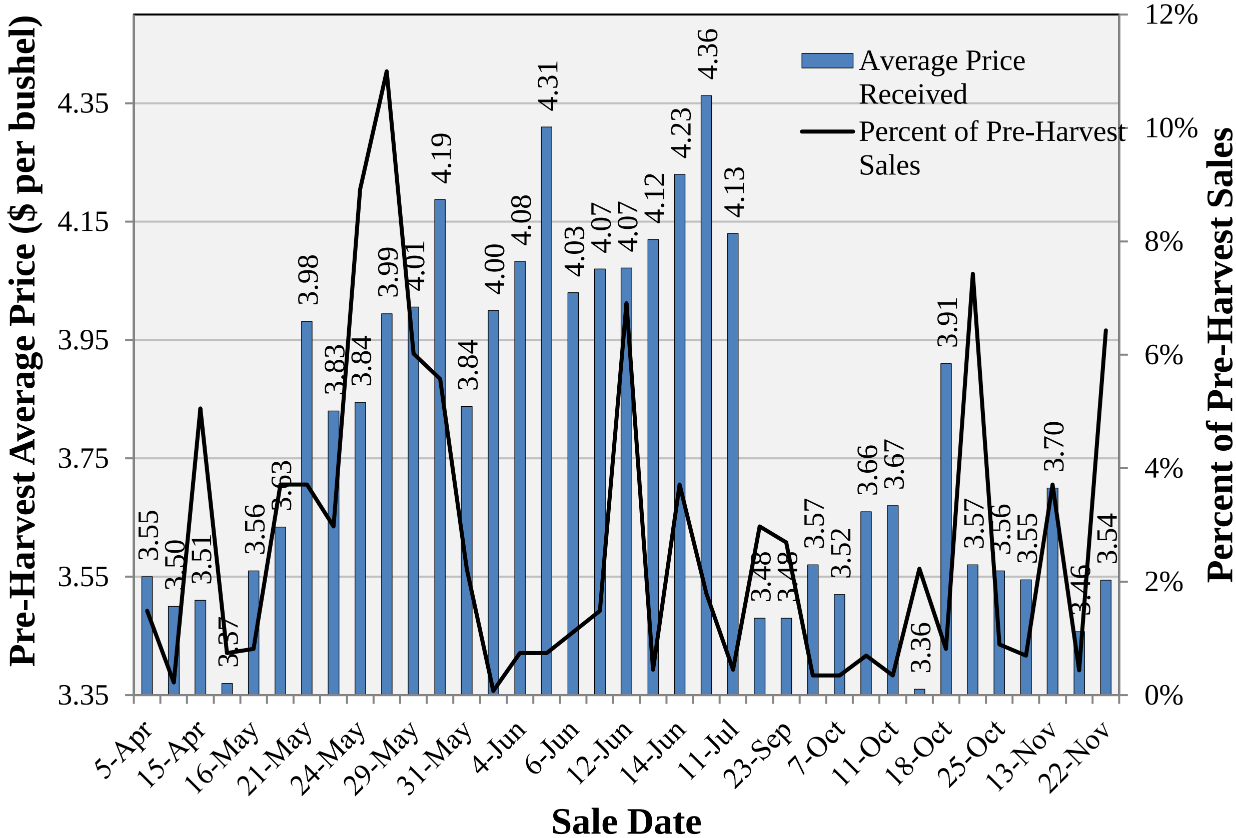

Figure 14. Average price received per date (columns) and percent of pre-harvest sales (black line) for the sprinkler irrigated corn competition.

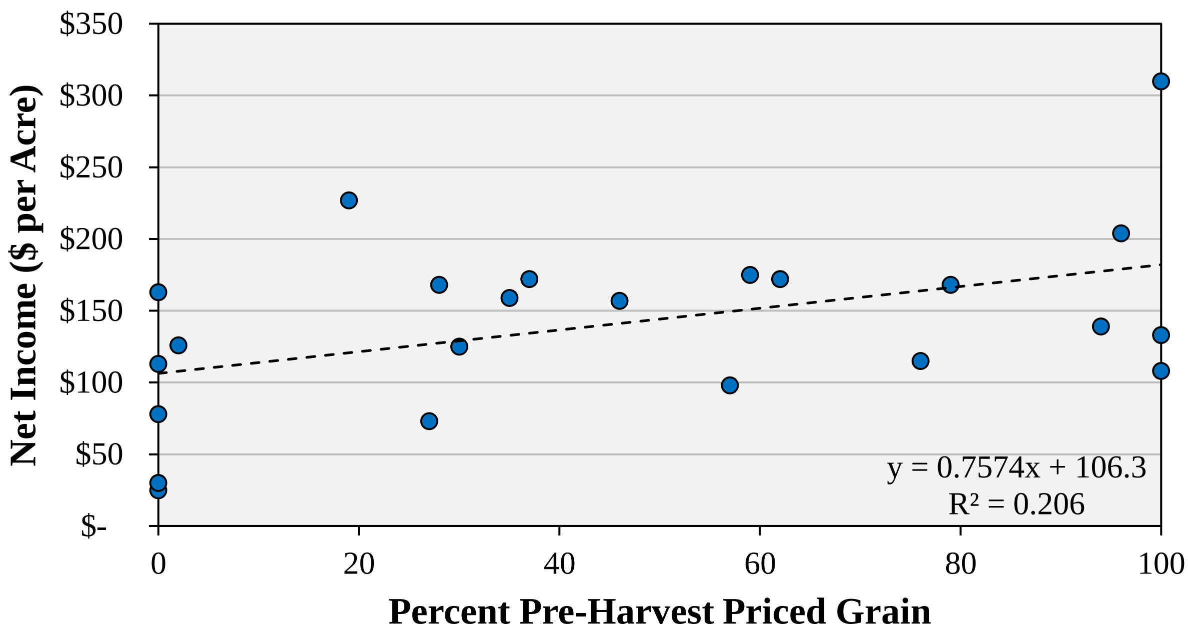

Figure 15. The imposed trend line shows that there was a tendency for profit to increase with the level of pre-harvest sales. However, what is not shown is the risk associated with marketing uninsured production.

RESULTS AND AWARD WINNERS

Greatest Grain Yield

Individual corn farm grain yields ranged from 90.2 (Farm 5 - Control) to 241.3 bu/acre (Farm 15) with an average of 219.0 bu/acre, excluding the control farm. Only eight farms met or exceeded the field's APH of 225 bu/acre (Figure 16). The competitors' grain yields appeared, for the most part, to fall within three groups: low (190 to 200 bu/acre), middle (215 to 230 bu/acre), and high (> 238 bu/acre). Scrutinizing the above groups suggests irrigation and N fertilizer amount and timing as well as hybrid selection jointly affected yields. For example, Farms 6, 7, 14, and 16 all planted Pioneer 1197AM and it was evident irrigation management was the primary contributor to differences in yield and that N management had minor to no influence. Whereas, the high grain yields of Farms 10 and 15 appeared to be heavily influenced by hybrid selection as their yields relative to irrigation and N fertilizer were greater than the general response functions. Nevertheless, the timing of irrigation is an important consideration as poor timing of water can mitigate yield potential for any hybrid.

Winner of the Greatest Grain Yield award with a yield of 241.3 bu/acre was Farm 15, Fontanelle Hybrids® Team, which includes Chris Anderson, Bob Wiseman, Jay Elfeldt, and Travis Edeal. Farm 15 planted hybrid Fontanelle 12D558 at a population of 33,000 seeds/acre. Congratulations Farm 15 (See Figure 37 on Page 42)!

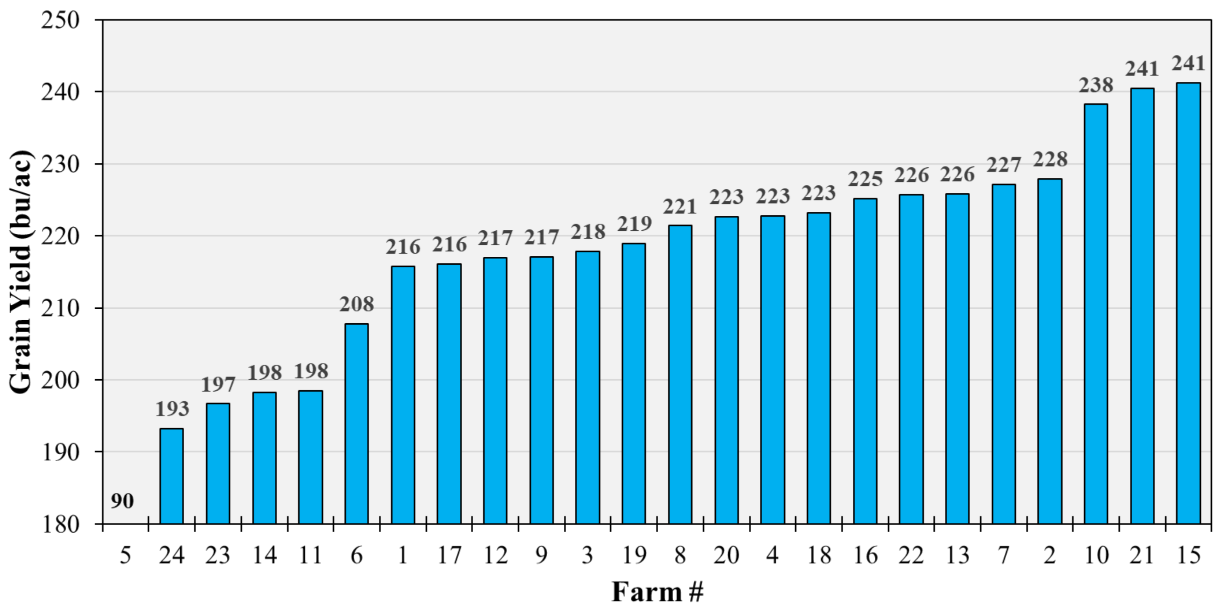

Figure 16. Grain yield (bu/acre) adjusted to 15.5% moisture content for the individual corn farms.

Highest Input Use Efficiency

Input use efficiency was quantified using the Water × Nitrogen Intensification Performance Index (WNIPI, Lo et al., 2019), which evaluates each farm relative to the control (Farm 5) that received no irrigation or N fertilizer. The WNIPI promotes effective irrigation and N management without sacrificing production and profitability (Rudnick et al., 2019) The WNIPI essentially evaluates the increase in yield above the control relative to the increase in inputs above the control's water use (evapotranspiration, ET) and aboveground N uptake. A higher WNIPI value indicates higher efficiency and a lower value indicates lower efficiency. Since the WNIPI accounts for both irrigation and N fertilizer, both inputs have to be managed well to receive a high value.

The WNIPI values ranged from 0.19 (Farm 21) to 0.39 (Farm 15) with an average of 0.28 (Figure 17). Nitrogen fertilizer management due to a low aboveground N uptake of 57 lbs/acre for the control farm heavily influenced the WNIPI values for the sprinkler corn competition. This is illustrated with a decreasing trend in applied N fertilizer relative to WNIPI in Figure 17. Whereas, the irrigation term tended to have less of an impact due to the wet conditions that resulted in the control farm's ET of 18.4 inches.

The winner of the Input Use Efficiency award with the highest WNIPI value was Fontanelle Hybrids ® Team, Farm 15. The team planted Fontanelle 12D558 at a seeding rate of 33,000/acre. The team did have the highest yield with 241.3 bushels/acre. With the exception of fertigation, the team did not initiate irrigation until August 5 and then followed with two irrigations during grain fill in September. Their N management consisted of applying a base rate of 40 lbs/acre as pre-plant, sidedressing 90 lbs/acre at V6, and then fertigating just once at VT/R1 with 30 lbs/acre. Congratulations to the Fontanelle Hybrids ® Team, which included Bob Wiseman, Travis Edeal, Chris Anderson and Jay Elfeldt (See Figure 37 on Page 42)

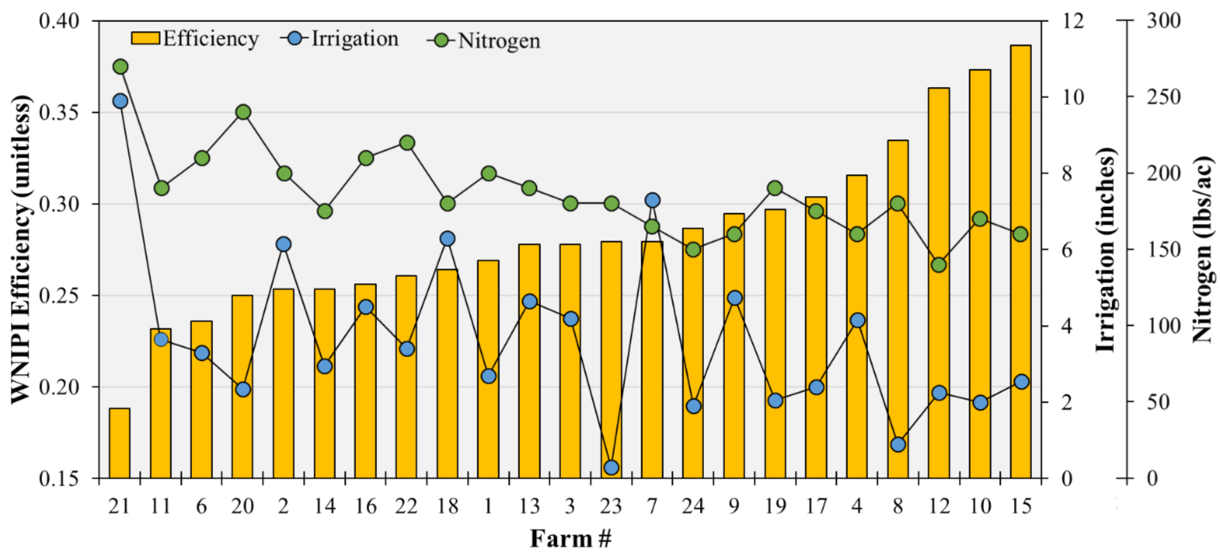

Figure 17. Input use efficiency (Water × Nitrogen Intensification Performance Index, WNIPI) of the sprinkler irrigated corn farms, along with irrigation (inches) and nitrogen fertilizer (lbs/acre).

Most Profitable Farm

Being most profitable requires a balanced management approach. Figure 18 ranks profit from left to right starting with the least profitable and moving towards the most profitable. Profit is the result of three primary factors: 1) controlling costs, 2) adequate productivity, and 3) obtaining a good price. Farm 7 was $83/acre more profitable than the next competing farm. Farm 7 had the fifth highest yield of 227 bu/acre, third lowest per bushel cost at $2.92/bu, and second highest price per bushel of $4.18/bu.

To illustrate why balance is important, let us look at what it would have taken for the 2nd ranked team, Farm 17, to match Farm 7 for profitability. Farm 17 had about $83/acre less profit than Farm 7. If this team had increased yields by 21.35 bu/acre, or increased average market value to $4.28/bu or lowered cost to $2.57/bu they would have tied for first place. The foregoing changes in price, costs and yields were assumed to happen in isolation. That is a reduction in per bushel costs was not accompanied by a change yield, and an increase in yield was not accompanied by a change in costs per bushel. The farm's yield was 211.2 sellable bu/acre, so increasing to 232.9 bu/acre might have been feasible given three other farms produced more than this. However, it would have been difficult to win, but not impossible, by increasing average price received since the highest single recorded price received during the season was $4.36/bu. Lowering cost would also have been difficult, if not impossible, since it would have required a $0.25/bu reduction which is less than the lowest observed costs of $2.81 (Farm 10).

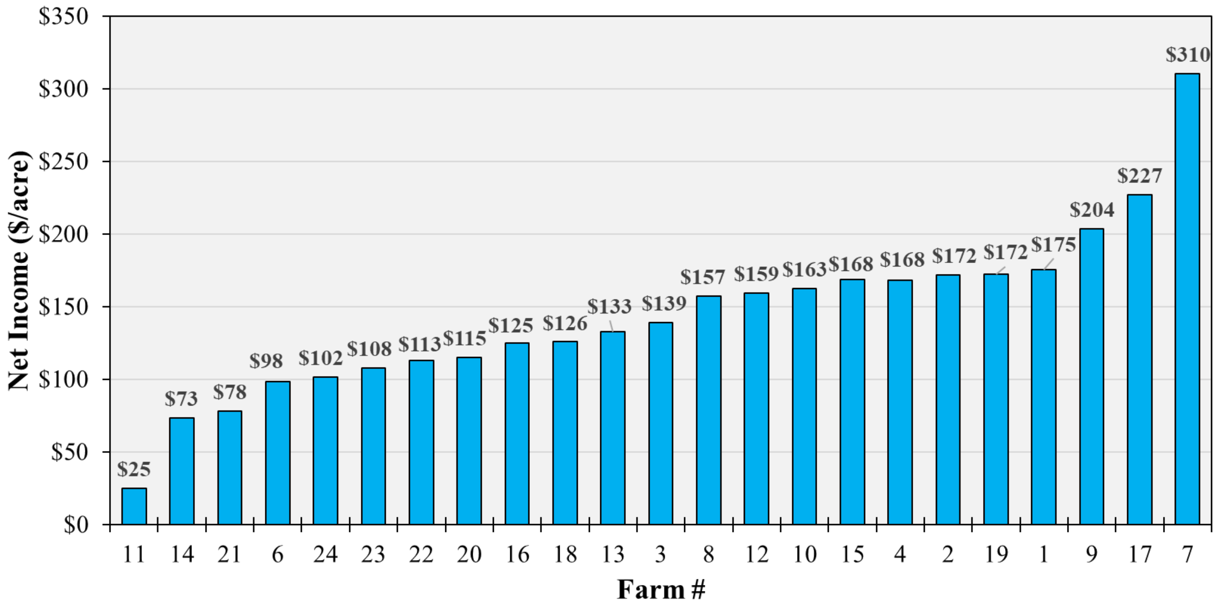

Figure 18. Profitability ($/acre) for individual corn farms ranked from lowest to highest.

The Most Profitable award goes to Farm 7, The Perkins Group, with team members Bruce Young, Ted Tietjen, Jim Kemling, Ron Hagan, Shawn Turner, Troy Kemling, Rick Salsman, Curt Richmond, Bill Richmond, and Brent Gloy. Farm 7 planted hybrid Pioneer 1197 at a seeding rate of 34,000/acre and applied 7.3 inches of irrigation and 165 lbs/acre of N fertilizer throughout the growing season. Farm 7 marketed 600,000 bushels by forward contract and futures contracts the last 10 days of May as the Decembers Futures market was increasing. Congratulations to Farm 7 (See Figure 38 on Page 42)!

SDI Corn Competition

Crop Insurance

All SDI corn competitors with the exception of one team (Farm 15) purchased crop insurance of some type (Figure 19). Farm 15 did not purchase any insurance coverage. Thirteen of the fourteen teams that purchased insurance selected revenue protection (RP) policies, which averaged close to a 75% coverage. Ten of those that bought RP bought enterprise unit (EU) with an average of 75% coverage at a cost of $9.77/acre. One farm bought RP with a harvest price exclusion (RPHPE) with EU with 80% coverage at a cost of $9.21/acre. The other four teams purchased operational units (OU) with an average cost of $14.98/acre and 72.5% coverage. One farm bought RPHPE with OU at 75% coverage at a cost of $14.28/acre. Only one farm bought yield protection (YP) insurance with OU coverage at the 70% level and a cost of $11.00/acre.

In addition to RP and YP insurance, eight of the farms bought hail coverage at varying rates, with two of the eight also purchasing wind insurance. The highest cost for insurance was $55.64/acre, which included RP-EU at 85%, as well as hail and wind. The least costly coverage, other than the team that took out no insurance, was a simple RP-EU at 70% for $4.99/acre.

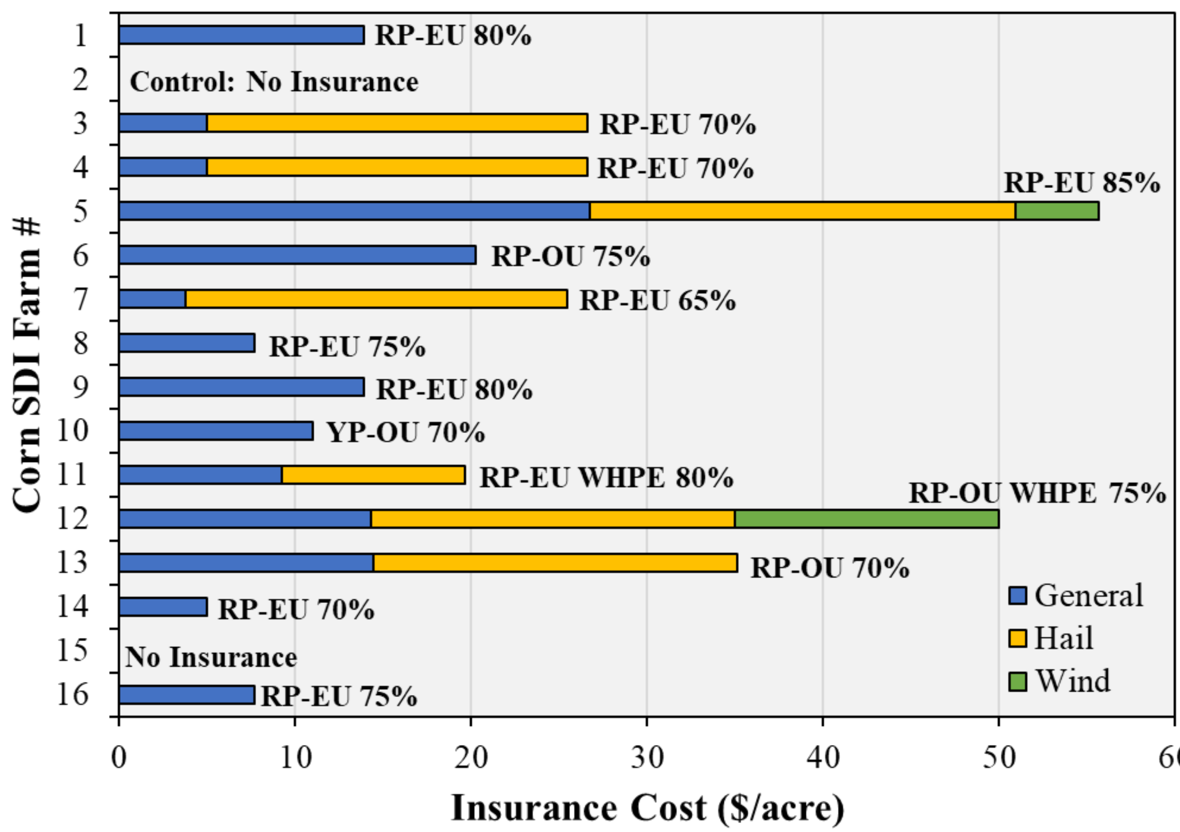

Figure 19. Cost for insurance as well as hail and wind coverage ($/acre) for the 16 teams competing in the SDI corn farm management competition. The insurance package and coverage rate is noted next to each team. RP stands for revenue protection, YP for yield protection, EU for enterprise units, OU for operational units, and HPE for harvest price exclusion.

Hybrid Selection and Seeding Rate

All SDI corn participants selected hybrids from the DSM recommended list with eleven different varieties being chosen for the competitions (Figure 20). The most common hybrid was Pioneer 1366AML, (Farms 1, 5, 6, and 16), which has a 113 day comparative relative maturity (CRM) and a cost of $241 per bag. The range in seed cost varied from $182 (Stine 9734-G) to $277 (Pioneer P0950AM) per bag with an average cost of $229/bag. The seeding rate per acre ranged from 28,000 (Farm 9) to 34,000 seeds/acre (Farms 1, 2, 4, 7, 12, and 13) with a median of 33,000 seeds/acre and average of 32,625 seeds/acre. All teams with the exception of Farm 9 planted above 30,000 seeds/acre. Considering seed cost and seeding rate, the total cost per acre ranged from $77 (Farm 7) to $118/acre (Farm 12) with an average of $94/acre.

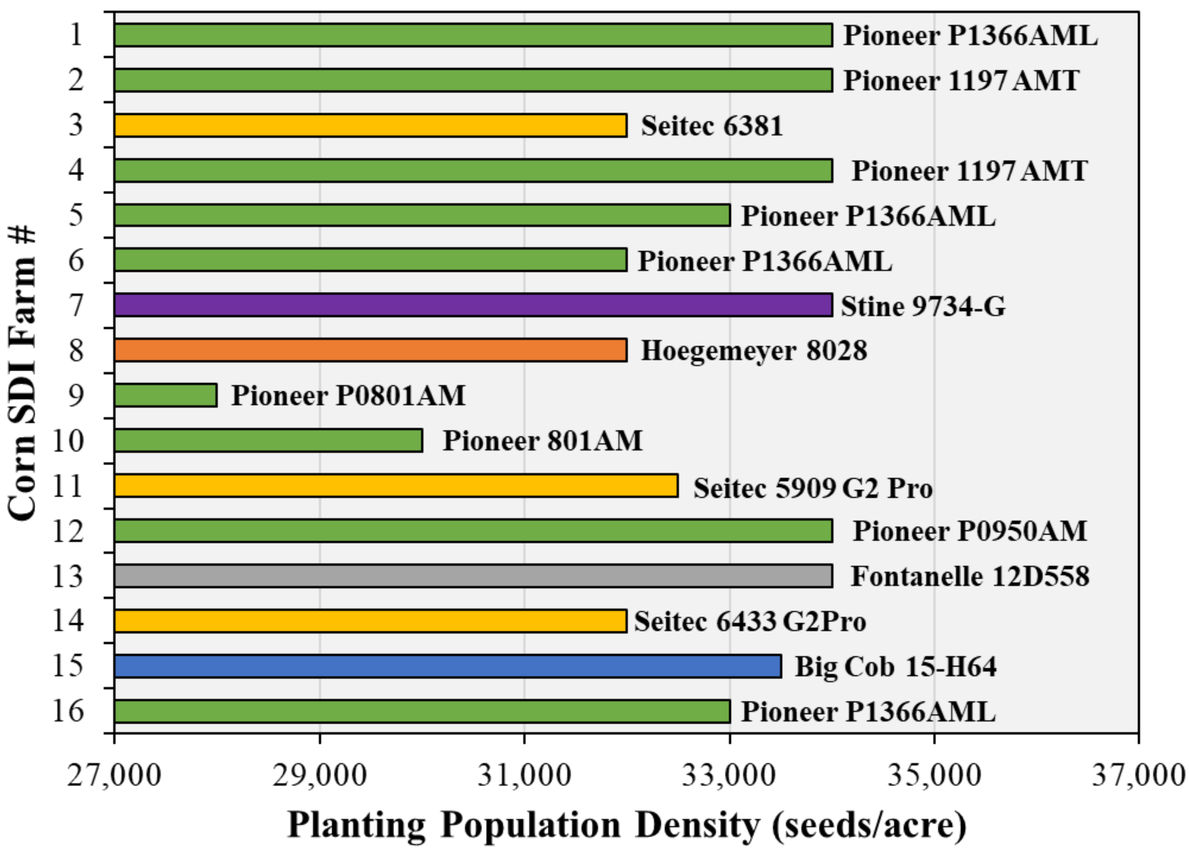

Figure 20. Hybrid selection, cost, and seeding rate for the SDI corn competition.

Seed costs per acre, per bushel, and grain yields as a percentage of the overall average for the SDI competition are presented in Figure 21. Ten of the sixteen teams (Farms 1, 2, 4, 5, 6, 8, 12, 13, 15, and 16) had above average per acre seed costs, with the highest being Farm 12 with 124%. Five of the ten above average per acre cost farms had less than 100% yield (Farms 1, 2, 4, 12, and 13). The farm with the highest per bushel seed cost at 132% of the average was Farm 2, as it had the lowest yield at 89% of average and had the second highest per acre cost at 118% of average. Four of the top seven producing teams (Farms 15, 8, 5, and 6) had above average per acre costs. The second ranked yield percent was Farm 14 with the second lowest per bushel cost at 80% of average.

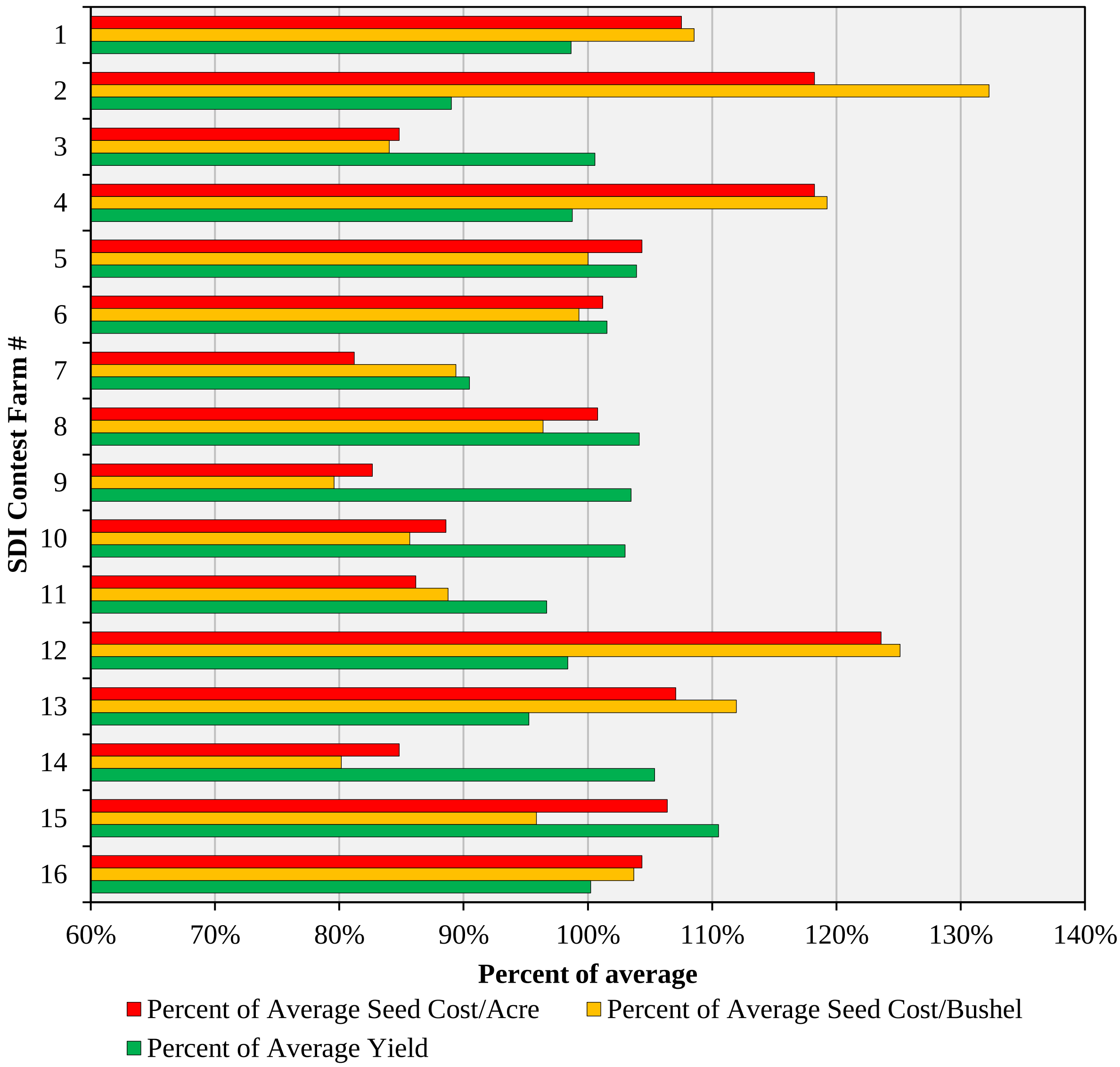

Figure 21. Benchmarked seed costs per acre, per bushel, and yields as a percent of the overall average for the SDI corn competition.

Irrigation Scheduling

The SDI irrigation system was first initiated by Farm 9 on July 15 and concluded on September 27 by Farm 5. With the exception of the control (Farm 2), the total irrigation applied among the SDI corn teams ranged from 0.60 (Farms 1 and 12) to 4.80 inches (Farm 9) with an average and median of 2.44 and 2.55 inches, respectively (Figure 22). Twelve of the sixteen teams chose to apply irrigation at some point through the irrigation season. If we assume the modelled irrigation range of 3 to 4 inches, as described earlier in this report, is applicable for the SDI field (same planting date and soil type), nine teams (Farms 1, 4, 5, 6, 7, 12, 13, 14, and 16) applied below, four teams (Farms 3, 10, 11, and 15) applied within, and two teams (Farms 8 and 9) applied above. Of the nine teams that applied below the modelled results, three teams (Farms 1, 12, and 13) only applied irrigation to deliver N fertilizer (i.e., fertigation). On average, the SDI corn competition farms applied 1.24 inches less irrigation than the pivot corn competition. It is hypothesized that the lower irrigation depth on SDI as compared with pivot was, in part, due to management style. In other words, the SDI competitors intentionally opted to minimize irrigation inputs given the higher application efficiency of the system.

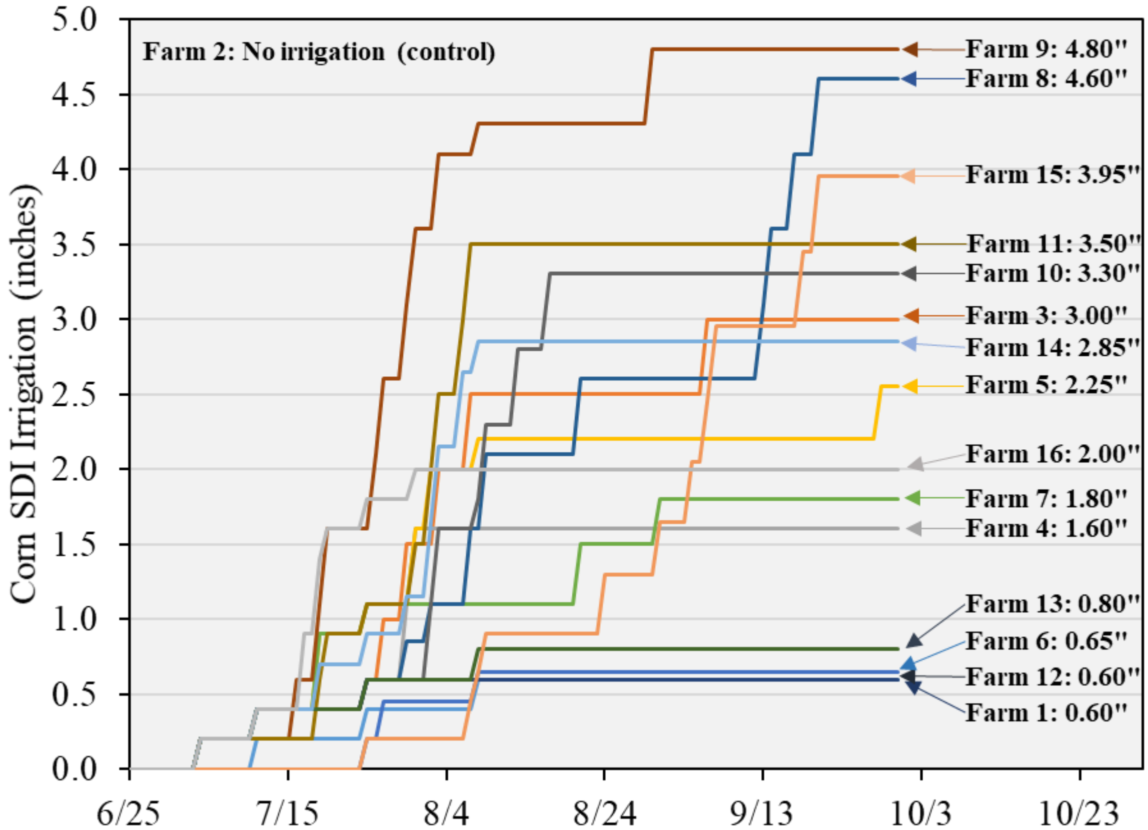

Figure 22. Cumulative irrigation (inches) for the individual Subsurface Drip Irrigated (SDI) corn farms.

Nitrogen Application

The amount and distribution of N fertilizer prescribed by the SDI teams are shown in Figure 23. The total seasonal N fertilizer, not including the control (Farm 2), ranged from 120 (Farm 1 and 13) to 220 lbs/acre (Farm 14). All teams opted to apply a portion of their N fertilizer via fertigation. Four fertigation options were made available to the participants, of which four teams opted to fertigate each time; whereas, seven teams fertigated three times, and four teams fertigated twice. The most commonly fertigated growth stage was VT/R1, where all teams fertigated except for Farm 9. All teams except for Farm 13, applied a portion of their N fertilizer via pre-plant or sidedress. The teams applied on average 45% of their total N as pre-plant and/or sidedress, or in other words, the teams applied on average 55% via fertigation. Interestingly, two teams (Farms 5 and 9) applied N via pre-plant, side-dress, and fertigation, and therefore, incurred the highest application costs. However, these farms had the fourth and fifth highest yields and sixth and third highest profitability, respectively.

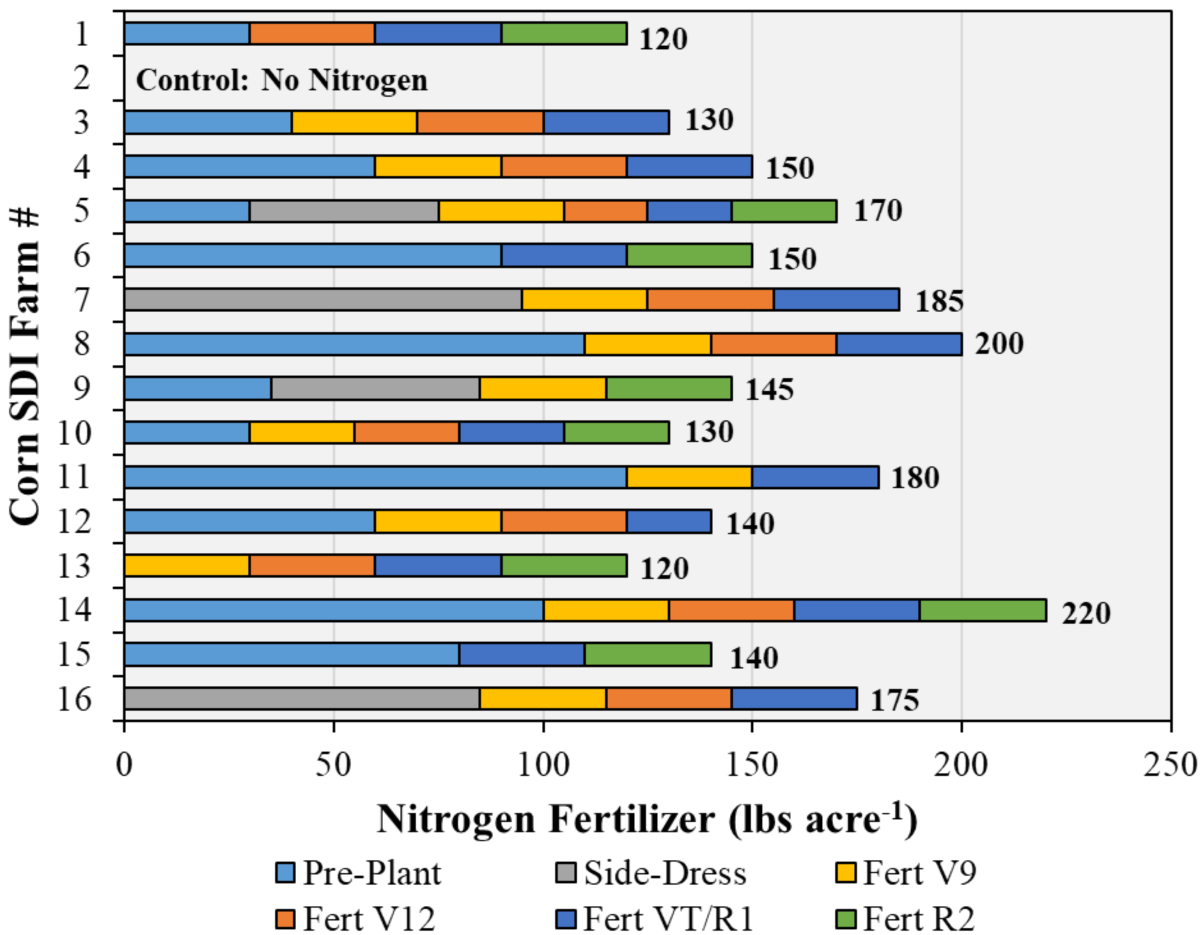

Figure 23. Nitrogen application method and amount (lbs/acre) for the individual SDI corn farms.

Marketing

Figure 24 provides insight into the season's overall market timing. The vertical blue bars show average prices received for grain priced by date. These bars are identified in sequential order with the price being indicated by their height relative to the values on the left axis. The combined weighted average price received by all pre-harvest priced grain was $3.85/bu, three cents more than the contest average. There was a $0.47/bu premium compared to the $3.38/bu harvest price on November 22. On average, if all contestants had been able to price 50% of their production at the $3.85/bu level average revenues would have increased by approximately $50,000 per farm. This is on par with the results of $150,000 per farm since this contest has one-third the number of acres (1,000 acres) to market as compared with the sprinkler corn (3,000 acres). The bold black line in the figure tracks the percent of pre-harvest grain priced on a particular date. About 33% of all grain produced was priced on or prior to November 22 or 1,304,600 bushels. In percentage terms, this is about 12% less than the sprinkler corn competition. Total bushels sold in the contest was 3,952,100. Like the sprinkler corn and sorghum contests, the most pre-harvest sales occurred in the month of May, which accounted for about 44% of all pre-harvest sales. Approximately 64% of the pre-harvest sales had an average price below $4.00/bu with the remaining 36% priced above that mark. About 11% of pre-harvest pricing occurred between June 3 and July 11, where prices received tended to be higher with a weighted averaged near $4.21/bu. If Farms 1, 4, 8, 10, 11, 12, 13 and 14, which had no pre-harvest pricing, had sold

60% of their production at the $4.21/bu price (i.e., weighted average during June-July) they would have increased profitability by about $123/acre on average.

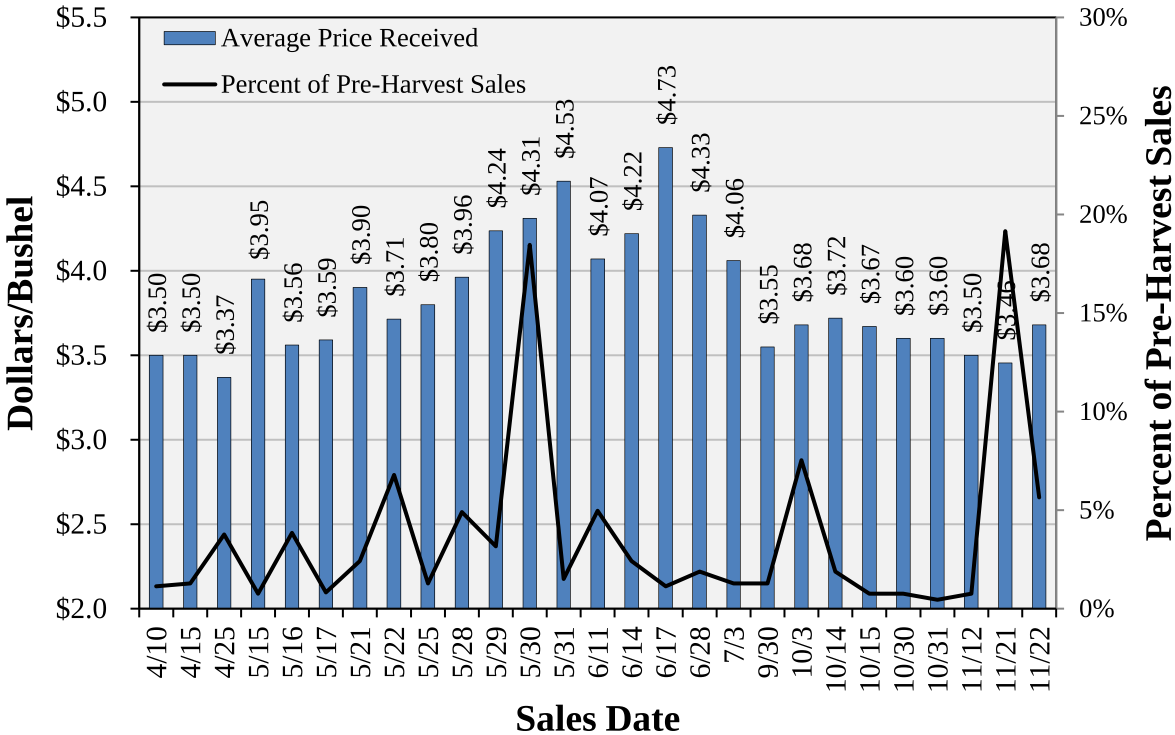

Figure 24. Average price received per date (columns) and percent of pre-harvest sales (black line) for the subsurface drip irrigated (SDI) corn competition.

Similar to the sprinkler corn, on average net income increased by $0.80 for every 1% increase in pre-harvest sales. Please note that marketing is not the only contributor to profit, which also depends on costs and productivity. The key take home here is that for the past few years, early season marketing has offered producers many opportunities to price their crop at a higher level than those found at harvest.

RESULTS AND AWARD WINNERS

Greatest Grain Yield

Individual SDI corn farm grain yields ranged from 224.4 (Farm 2 - Control) to 277.5 bu/acre (Farm 15) with an average of 253.3 bu/acre, not including the control. All competing farms exceeded the field's APH of 225 bu/acre and fell between 240 to 265 bu/acre, except for Farms 7 and 15 (Figure 25). Farm 7 had the lowest yield of 228 bu/acre, only exceeding the control (Farm 2) by 4 bu/acre, while applying 1.8 inches of irrigation and 185 lbs/acre of N fertilizer. Whereas, Farm 15, had the greatest yield of 277.5 bu/acre, exceeding the second highest yield by 13 bu/acre, while applying 3.95 inches of irrigation and 140 lbs/acre of N fertilizer. Grain yield had a positive response to irrigation and these two farms deviated the most from this relationship, which illustrates the impact of hybrid performance along with appropriate management of inputs.

The SDI Greatest Grain Yield award goes to Farm 15, the Big Cob Bin Busters, who is comprised of Josh Becker, Ben Benson, Jonathan Remple, and Jason Ladman. Congratulations to this group (See Figure 39 on Page 42)!

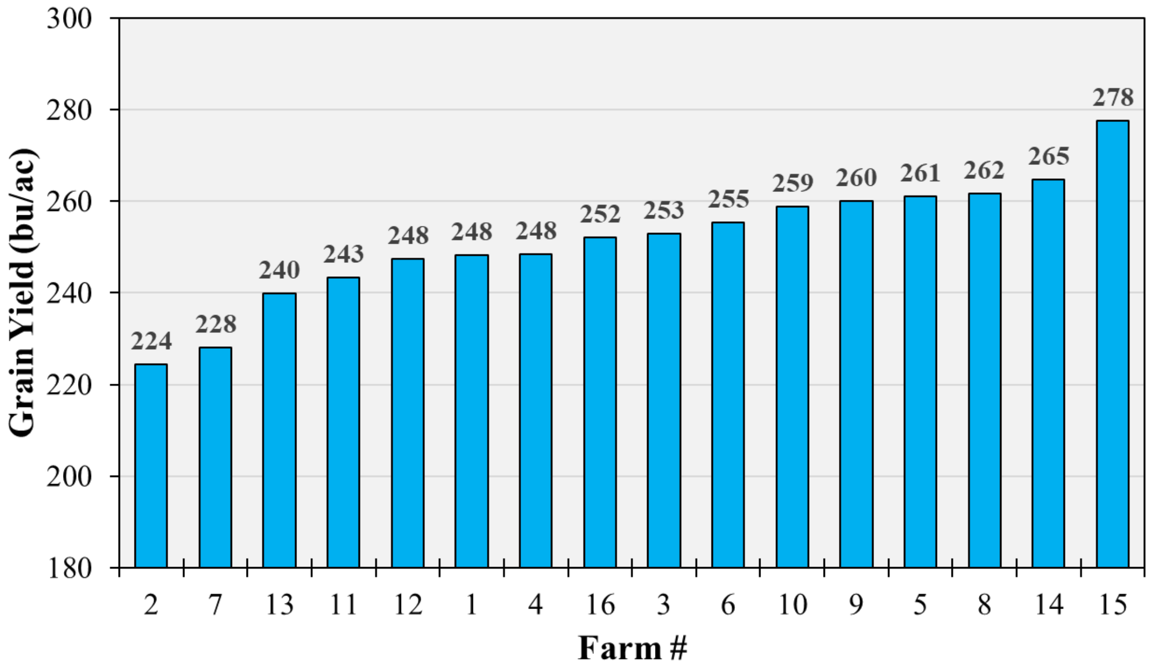

Figure 25. Grain yield (bu/acre) adjusted to 15.5% moisture content for the individual SDI corn farms.

Highest Input Use Efficiency

Input use efficiency measured as WNIPI for the SDI competition is presented in Figure 26. The WNIPI values ranged from 0.01 to 0.13 with an average of 0.07. The WNIPI index is influenced by the performance of a control (Farm 2) that receives no irrigation or N fertilizer. The control farm yielded 224 bu/acre, had a seasonal ET of 21.9 inches, and aboveground N uptake of 167 lbs/acre. Unlike the sprinkler corn competition, N fertilizer was not the primary driver of WNIPI for SDI. Instead, yield performance was the primary driver followed by irrigation management.

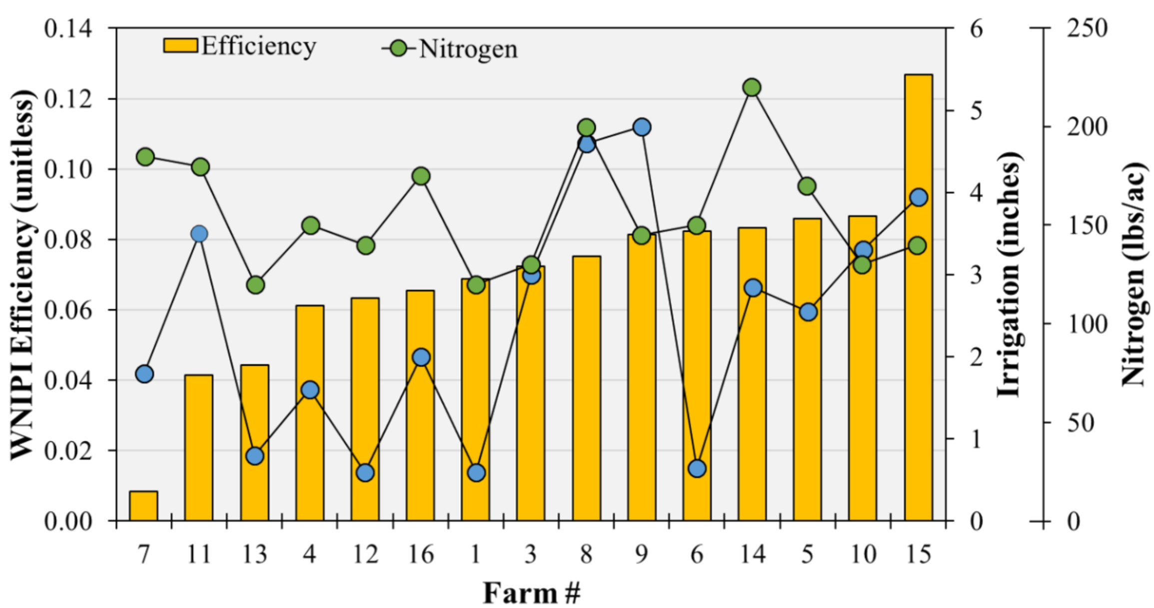

Figure 26. Input use efficiency (Water × Nitrogen Intensification Performance Index) compared against irrigation (inches) and nitrogen fertilizer (lbs/acre) of the SDI corn farms.

The winner of the SDI Input Use Efficiency award was Farm 15, the Big Cob Bin Busters. The group planted Big Cob 15-H64 at a seeding rate of 33,500/acre. With the exception of fertigation, the team did not initiate irrigation until August 6 and concentrated most of the water in August and early to mid-September. The team chose to apply 80 lbs/acre as pre-plant and then waited to fertigate 30 lbs/ac N at VT and R2 growth stages. Congratulations to the Big Cob Bin Busters and team members Josh Becker, Ben Benson, Jonathan Remple, and Jason Ladman (See Figure 39 on Page 42).

Most Profitable Farm

Net income of the SDI competition is ranked from least to most profitable in Figure 27. Farm 15 was about $67/acre more profitable than the next team (Farm 16). Farm 15 had the lowest overall per bushel cost of $2.76 and the highest yield of 277.5 bu/acre; however, the revenue per bushel of $3.85/bu was $0.12/bu lower than Farm 16 and was ranked 6th best. For Farm 16 to have tied Farm 15 they would have had to increase yield by 16.8 bu/acre or increased average market value of grain sold to $4.26/bu or lowered cost to $2.79/bu. This farm's productivity was 247.6 sellable bushels (i.e., yield minus losses), so increasing to 264.4 bu/acre seems feasible. However, it would have been difficult to win by increasing average price received. This farm had the second highest average price received of $3.99/bu. Increasing this by $0.27/bu would have been challenging. This farm would have had to sell a much larger portion of their crop during the June-July period. There were only five recorded price points that received more than the needed $4.26/bu price. Lowering costs by $0.27/bu seems more likely since doing so would put costs at $2.79/bu, which is $0.03 higher than the lowest cost of $2.76/bu, again achieved by Farm 15. The most likely path to being more competitive would be to increase yield and reduce costs.

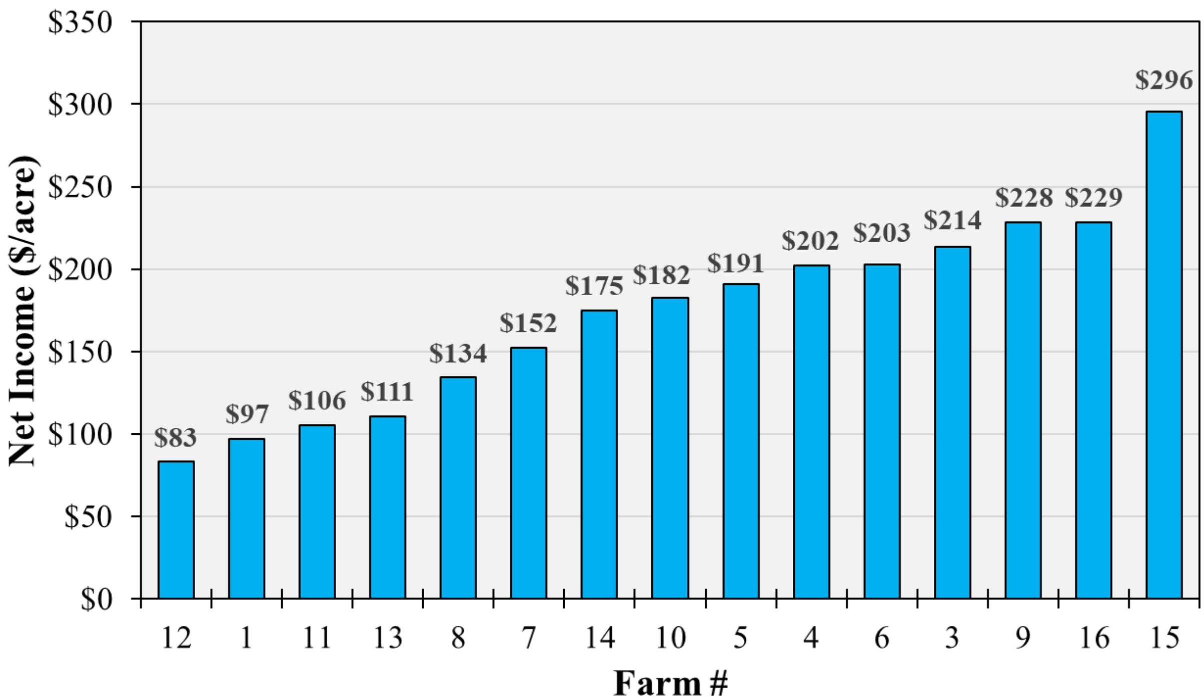

Figure 27. Profitability ($/acre) for individual SDI corn farms ranked from lowest to highest.

Congratulations to the Big Cob Bin Busters and team members Josh Becker, Ben Benson, Jonathan Remple, and Jason Ladman on winning all three awards in the SDI competition (See Figure 39 on Page 42).

Sprinkler Sorghum Competition

Crop Insurance

All sorghum competitors, with the exception of Farm 6, purchased crop insurance of some type (Figure 28). All competitor teams that selected insurance purchased revenue protection (RP) policies with an average of 68% coverage. Seven of the eight teams that bought RP bought enterprise unit (EU) with an average of 69% coverage at an average cost of $9.74/acre. Farm 3 purchased operational units (OU) with 65% coverage at a cost of $19.25/acre. One farm bought RP with a harvest price exclusion or RPHPE for EU with 75% coverage at a cost of $11.91/acre. In addition to RP insurance, two of the farms bought hail coverage at varying rates, but none of the farms purchased wind insurance. The highest total cost for insurance was $27.81/acre, which included RP-EU at 65% and hail. The least costly coverage of those that selected insurance was RP-EU at 65% for $8.21/acre.

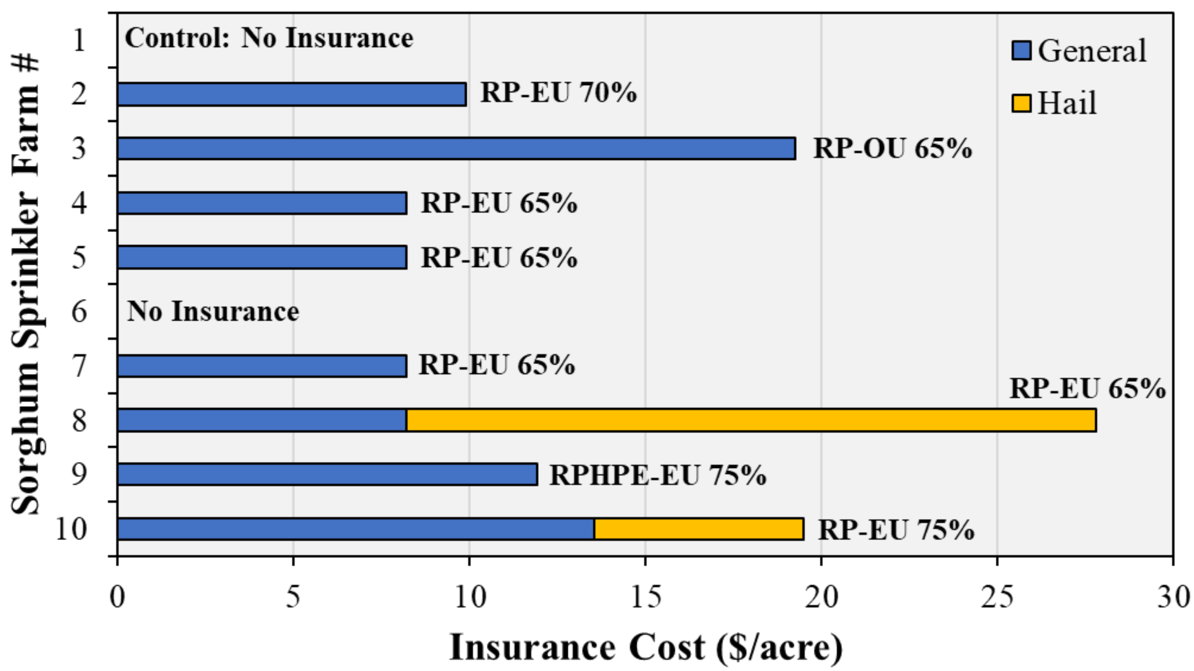

Figure 28. Cost for insurance as well as hail coverage ($/acre) for the 10 teams competing in the sorghum farm management competition. The insurance package and coverage rate are noted next to each team. RP stands for revenue protection, EU for enterprise units, OU for operational units, and RPHPE for revenue protection with harvest price exclusion.

Hybrid Selection and Seeding Rate

Half of the sorghum participants (Farms 1, 2, 3, 5, and 10) selected a seed from the recommended hybrid list provided by various district sale managers (DSMs). A total of 10 different hybrids were selected (Figure 29), which means there were no hybrids used twice in the competition. The range in seed cost varied from $1.42 (Seitec SG7317B) to $2.92 (Dyna-Gro M60GB31) per 10,000 seeds with an average cost being $1.96 per 10,000 seeds. The seeding rate per acre selected by the sorghum teams ranged from 70,000 (Farm 9) to 125,000 (Farm 4) with a median of 92,500 and average of 93,060. Considering seed cost and seeding rate the total seed costs per acre ranged from $13.35 (Farm 2) to $27.74 (Farm 5).

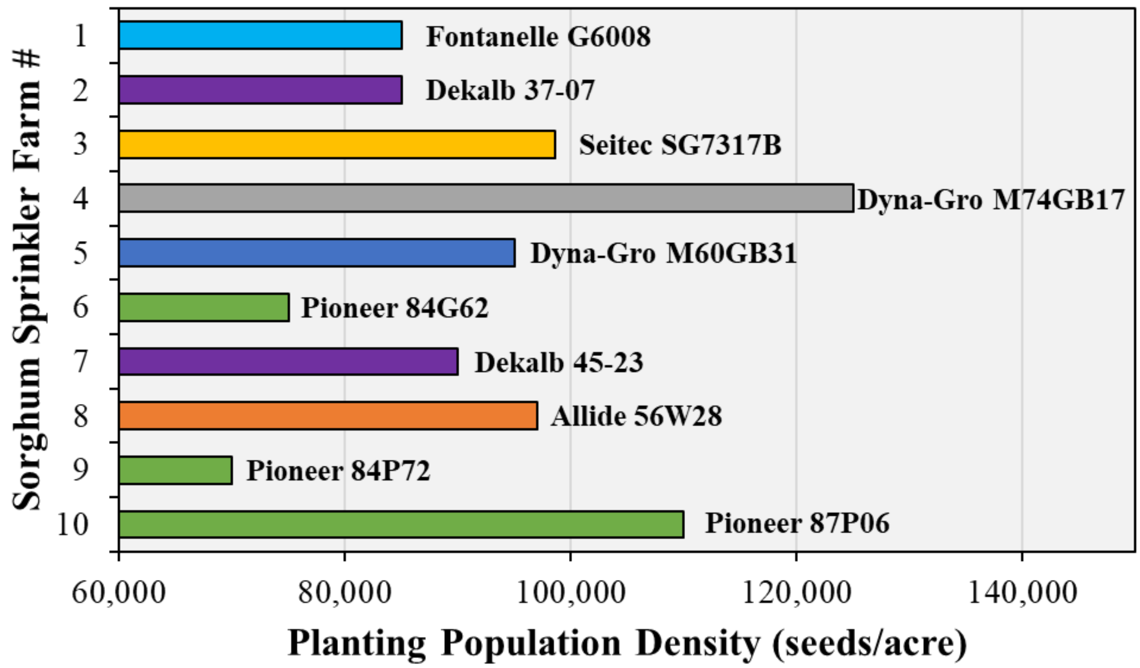

Figure 29 Hybrid selection, cost, and seeding rate for the sorghum competition.

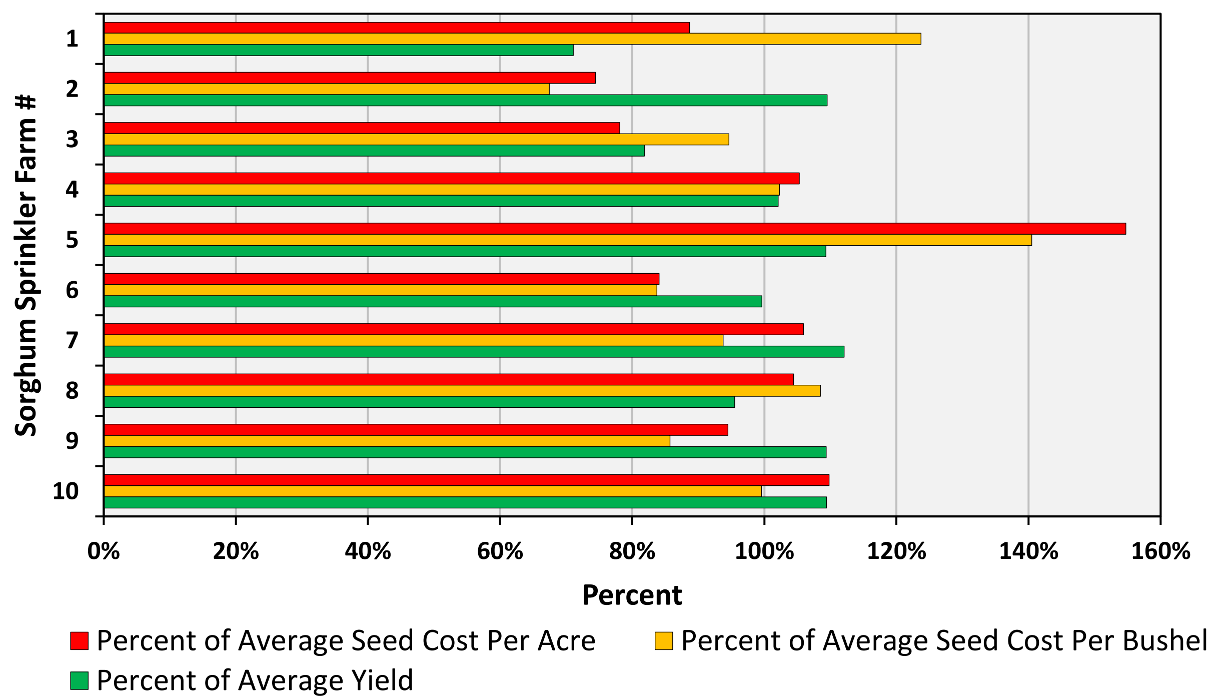

Figure 30. Benchmarked seed costs per acre, per bushel and yields as a percent of the overall average.

Figure 30, shows each farm with three bars, red, yellow and green. These bars indicate one of three benchmarked levels of costs or production for each competing team. The red bars indicate percent seed costs per acre, the yellow bars are percent seed costs per bushel, and the green bars measure relative yields in percent. All bars are in percent of their respective averages. This method of reporting provides a benchmark with respect to each category's average. Five of the ten teams (Farms 4, 5, 6, 7, 8 and 10) had above average per acre costs, with the highest being 155% of average (Farm 5). This farm also had the highest per bushel seed costs of 140%, but was fourth highest percent yield with 109.3% behind Farms 7 (112.1%), 2 (109.5%), and 8 and 9 (both with 109.4%). Without considering other factors such as fertilizer and irrigation costs, Farm 2 appeared to have purchased the best hybrid.

Irrigation Scheduling

The irrigation system was initiated on June 27 by the scheduling of irrigation by Farm 4, and concluded on August 21 when Farms 3, 5, 6, and 8 scheduled fertigation (Figure 31). With the exception of the control farm (Farm 1), the total irrigation applied among the sorghum teams ranged from 0.00 inches (Farm 9) to 2.25 inches (Farm 4). Excluding the control farm, the average and median irrigation water applied was 0.94 and 0.90 inches, respectively, with both values being considerably lower as compared to the 2018 average (3.64 inches) and median (3.50 inches). In fact, Farms 5, 6, 7, 8, 9, and 10 did not irrigate except to deliver N fertilizer (i.e., fertigation).

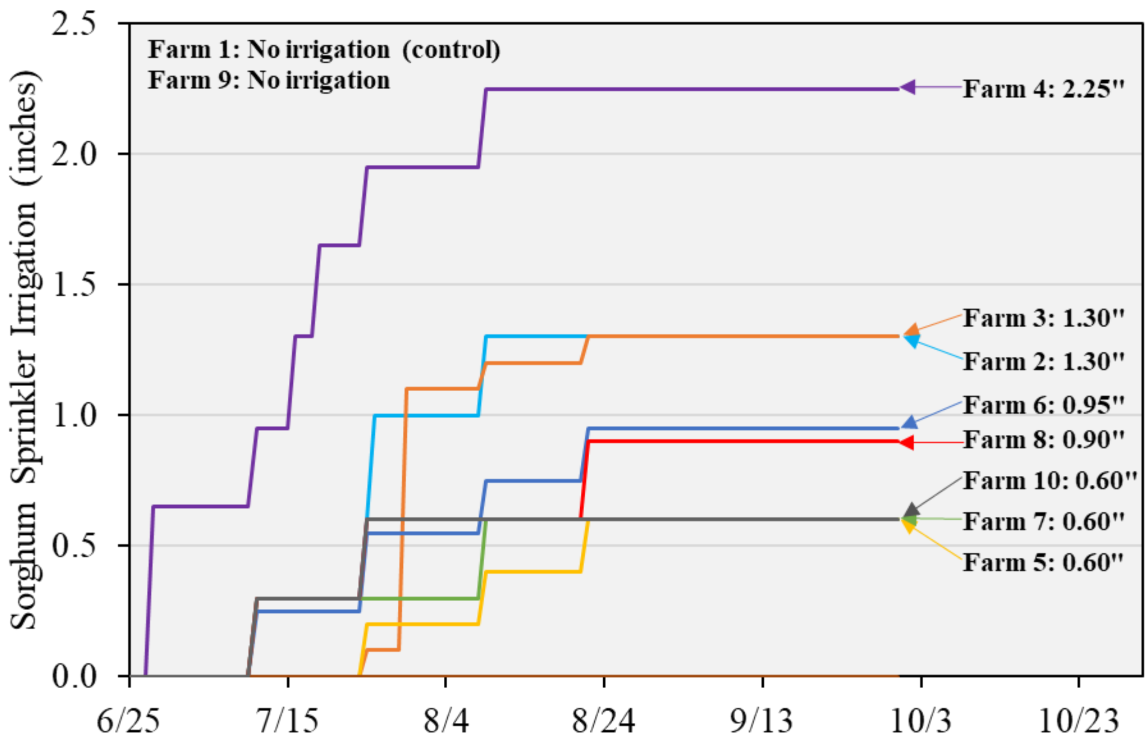

Figure 31. Cumulative irrigation (inches) for the individual sorghum farms.

Nitrogen Application

The amount and distribution of N fertilizer prescribed by the sorghum participant teams are shown in Figure 32. The total seasonal N fertilizer, not including the control farm (Farm 1), ranged from 70 (Farm 3) to 215 lbs/acre (Farm 4). All but two teams (Farms 6 and 9) opted to split apply their N fertilizer. Farm 6 applied their entire N via fertigation and Farm 9 applied only as pre-plant. Four fertigation options were made available to the participants, of which only one team opted to fertigate each time, five teams fertigated three times, and two teams fertigated twice. The fertigation on July 24 at approximately Stage 3 was the most common, where seven teams (Farms 2, 3, 4, 5, 6, 8, and 10) fertigated.

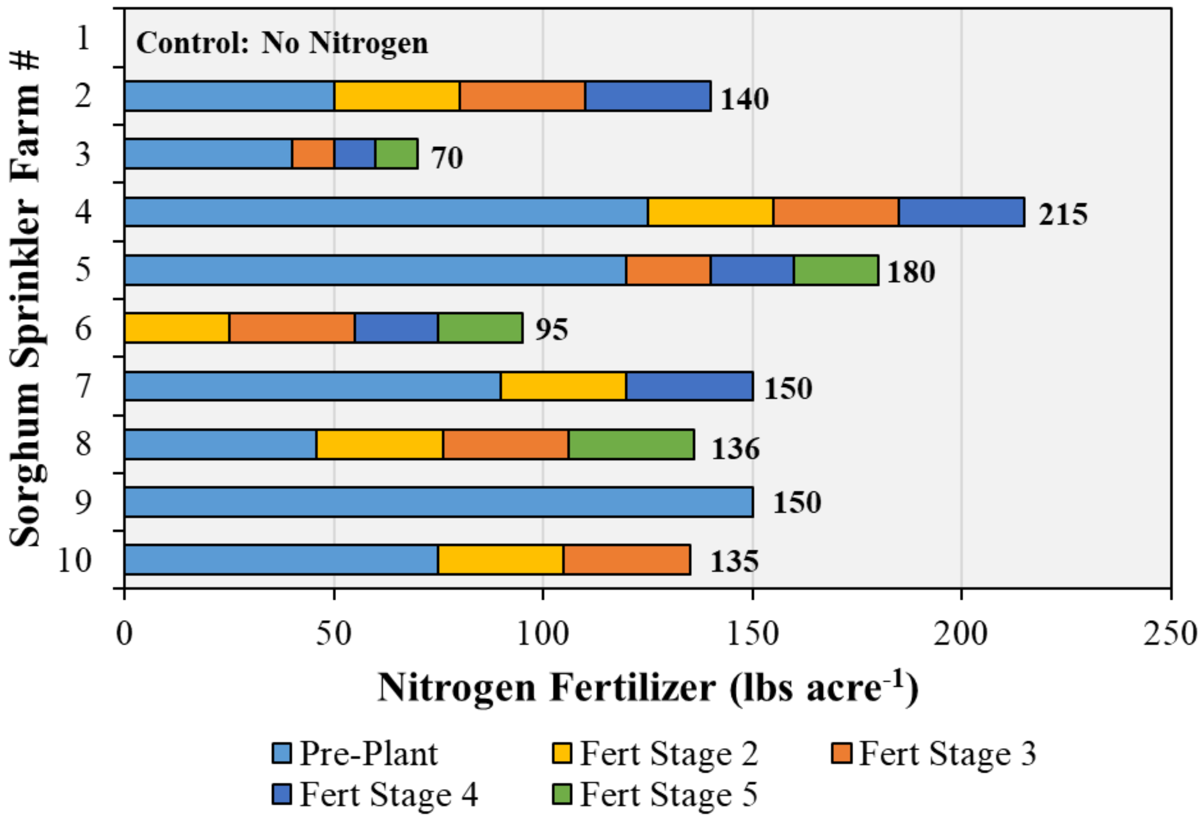

Figure 32. Nitrogen application method and amount (lbs/acre) for the individual sorghum farms.

Crop circle (Holland Scientific Inc., Lincoln, NE, USA) sensors provide two main vegetation indices, Normalized Difference Red Edge (NDRE) and Normalized Difference Vegetation Index (NDVI), derived from canopy reflectance wavelength bands to monitor leaf's chlorophyll content levels and to help guide N fertilizer management. NDRE values collected on August 5 from the sorghum plots are presented in Figure 33. Farm 10 had the highest average NDRE of 0.52 and Farm 1 (control) had the lowest average of 0.39. Not shown, but NDRE was linearly related to the final grain yield, indicating that N fertilizer, in part, contributed to differences in grain yield. A frequent application of the NDRE is to calculate a sufficiency index (SI), which is a targeted area's value divided by the value of a sufficient (non-N limiting) area. However, it is preferred to calculate SI using the same hybrid, as it is possible to receive different NDRE responses across hybrids. If we assume that the hybrid impact is minor and consider Farm 4 (185 lbs N per acre) as a non-N limiting reference, we observe that two farms had considerably lower SI values than the rest. Farm 3 (50 lbs/acre) had an average SI value of 0.91 and Farm 6 (55 lbs/acre) had an average value of 0.92. There corresponding grain yields were 126.2 and 153.6 bu/acre.

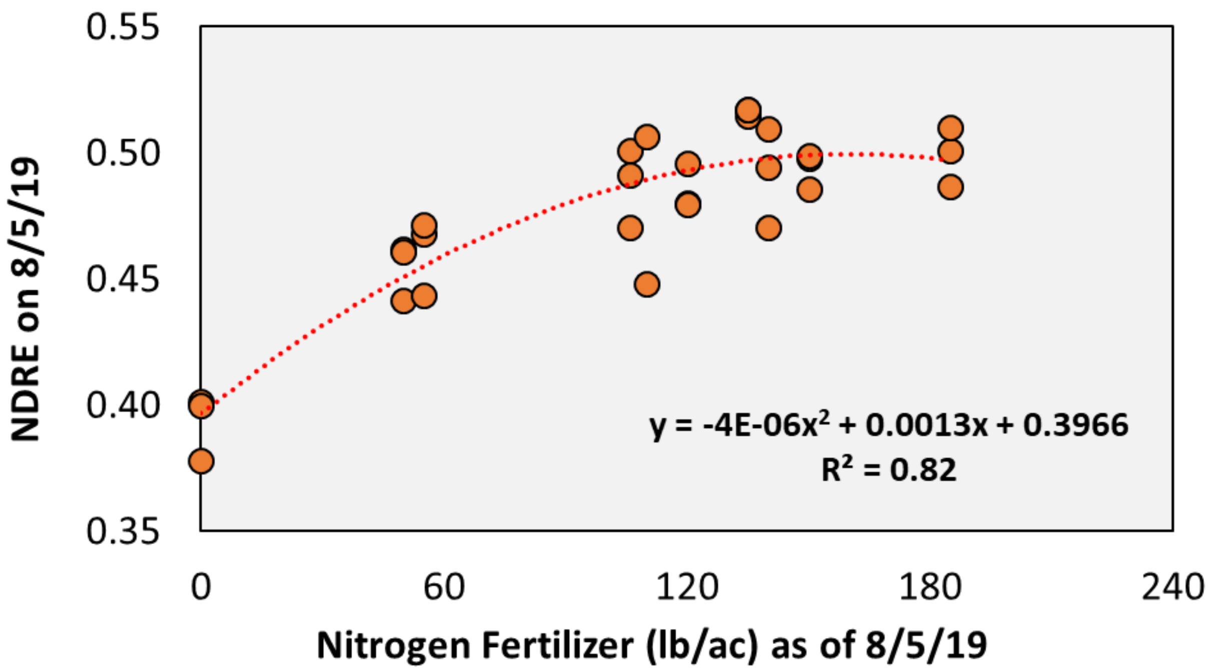

Figure 33. Normalized difference red edge (NDRE) values calculated from Crop Circle (Holland Scientific Inc., Lincoln, NE, USA) sensors on August 5 as compared to applied nitrogen fertilizer (lbs/acre).

Marketing

Grain pricing is a key factor for farm profitability. The combined weighted average price received by all pre-harvest priced grain was $3.60/bu. As expected this is lower than either corn contests, since grain sorghum is generally sold at a discount relative to corn. However, the $3.60 is about $0.60/bu premium compared to the harvest price settled on November 15. This premium averages about $0.15 to $0.18/bu higher than either corn contests. If the contestants that did not pre-market any grain would have sold 50% at $3.60/bu, on average, their net income would have increased by more than $48,000 or $48/acre. About 42% of all grain produced was priced on or prior to November 15. The most pre-harvest sales occurred in May, which accounted for about 43% of all pre-harvest sales. Approximately 94% of the pre-harvest sales had an average price below $4.00/bu with the remaining 6.2% priced above that mark. A very small portion of the pre-harvest sales occurred between May 29 and Oct 6, 1.6%. This is a bit surprising since the sorghum market is usually reflective of the corn market and this was a high price period. The highest observed price was $4.25 on March 26.

Further scrutiny of the sorghum results indicate the same pattern observed in the two other contests. As the level of pre-harvest sales increased, net income on average also increased, in this case to the tune of about $0.50/acre for every 1% increase in pre-harvest pricing. This fact made sorghum pre-pricing about two-thirds as effective as pre-pricing corn. This is not surprising since sorghum volume and price are usually less than corn. This is also evident in that the sorghum had some farms with negative net income, whereas corn did not. Again, this is most likely due to the disparity in yield and price between the two crops. Please remember that these results are specific to this contest and season. The key take home here is that during this year there were many opportunities to price grain sorghum at a value much higher than that available at harvest and to do so would have resulted in higher net returns. In this case, those who were proactive in pre-pricing were among those that made higher levels of profit.

RESULTS AND AWARD WINNERS

Greatest Grain Yield

Individual sorghum farm grain yields ranged from 109.6 (control Farm 1) to 172.8 bu/acre (Farm 7). Excluding Farm 1 (control) the average yield was 159.1 bu/acre. Six of the ten farms exceeded the field's APH of 155 bu/acre (Figure 34). The maximum yield of 172.8 bu/acre was grown with hybrid Dekalb 45-23 planted at a population of 90,000 seeds/acre, and belongs to Farm 7, Mike Baker (See Figure 40 on Page 42). Yields were limited in 2019 due to the wet conditions and lack of solar radiation and heat. In addition, stalk lodging may have contributed to the lower yields. Stalk lodging ranged from 3% (Farm 10) to 77% (Farm 5) with an average of 37% (excluding the control).

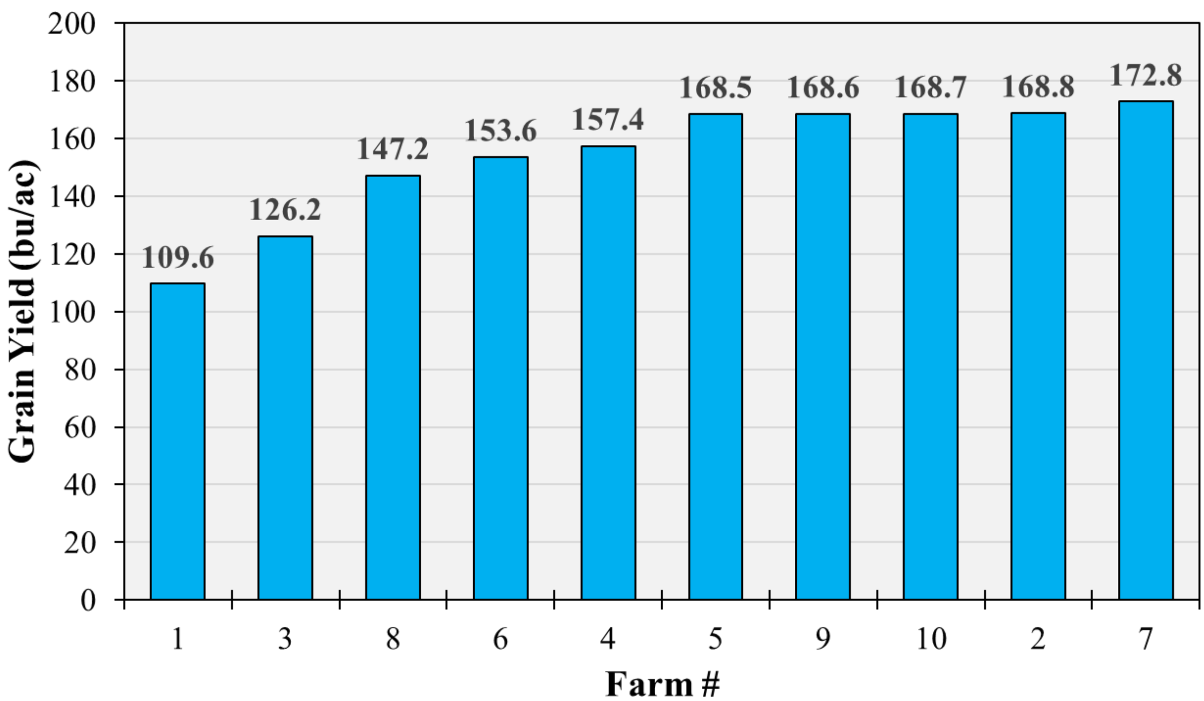

Figure 34. Grain yield (bu/acre) adjusted to 14% moisture content for the individual sorghum farms.

Highest Input Use Efficiency

Two teams, Farms 7 and 10, with very similar decisions for irrigation and N management tied for the highest WNIPI value of 0.22 and winner of the Input Use Efficiency award. Farm 7 planted Dekalb 45-23 at a seeding rate of 90,000/acre, while Farm 10 selected Pioneer 87P06 at a seeding rate of 110,000/acre. Neither of the contestants chose to irrigate their plots, other than during their selected fertigations. Farm 7 applied 150 lbs N per acre, with 90 lbs/ac as pre-plant and then 30 lbs/ac at Stages 2 and 4. Similarly, Farm 10 applied 135 lbs N per acre, with 75 lbs/ac as pre-plant and then 30 lbs/ac at Stages 2 and 3. Figure 35 shows the range in efficiency values among the teams, along with their seasonal applied irrigation and N fertilizer. There were modest differences among Farms 5, 6, 2, 9, 10, and 7, and relatively lower efficiency values for Farms 3, 4, and 8. The lower efficiency values for Farms 3 and 8 were attributed to lower yields.

As described earlier in this report, Farm 3 showed signs of N stress as indicated by the NDRE values collected on August 5. Whereas, Farm 4 had a lower efficiency value due to higher application rates of irrigation and N fertilizer without the accompanying yield increase to maintain a comparable efficiency. Furthermore, Farm 4's higher inputs and middle of the pack yield of 157.4 bu/acre, in part suggests the selected hybrid underperformed compared to the other teams' chosen hybrids. Congratulations to Mike Baker (Farm 7) and Ron Robison (Farm 10) for winning the efficiency award (See Figures 40 and 41 on Page 42 and 43)!

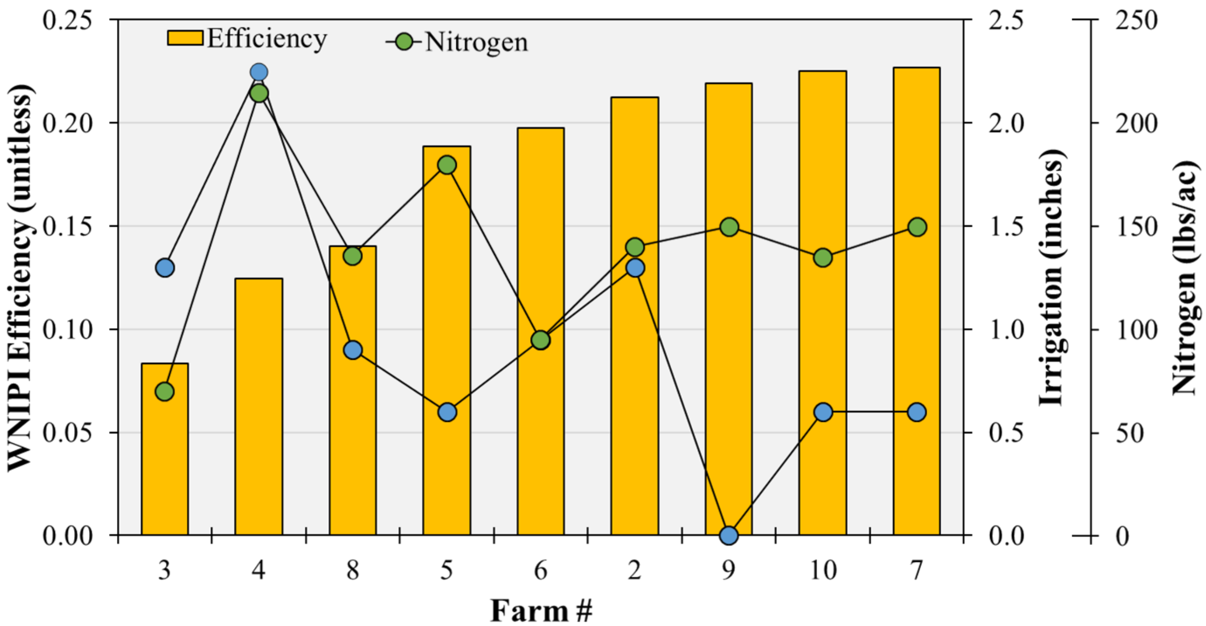

Figure 35. Input use efficiency (Water × Nitrogen Intensification Performance Index) of the sorghum farms and their accompanying irrigation (inches) and nitrogen fertilizer (lbs/acre) rates.

Most Profitable Farm

Being most profitable requires a balanced production and management approach. Figure 36 ranks profit from left to right starting with the least and moving toward the most. Profit is the result of three primary factors: 1) Costs, 2) Productivity, and 3) Market value received. Controlling the right costs is essential since costs may affect productivity. Without having adequate productivity, it is difficult to have the necessary volume to cover all costs and provide an acceptable net return. While the market is not controllable, producers have flexibility in when to sell grain. Obtaining an above average value for production can go a long way in providing increased business stability and continuance. Farm 7 was about $35/acre more profitable than the next competing team (Farm 2). Farm 7 had the lowest overall per bushel cost of $2.90 and the highest yield of 172.8 bu/acre, and an average revenue of $3.31/bu. A job well done by Mike Baker in winning all three awards in the sorghum competition (See Figure 40 on Page 43).

To better understand why balance is important to winning let us consider the three factors of profit and estimate what it would have taken for Farm 2 (2nd place) to be competitively equal in net income to Farm 7. As mentioned earlier, Farm 2 was about $35/acre less profitable than Farm 7. This farm would have had to increase yields by 11.17 bu/acre, or increase average market value of grain sold to $3.36/bu or lower cost to $2.73/bu to tie for first place. This farm's contest productivity was 168.8 bu/acre so increasing to 179.97 may be feasible, but this yield is 7 bu/acre higher than the highest yielding farm with 172.8

bu/acre. Obtaining a high enough price per bushel would have been difficult since that price would have to exceed the best average price received by $0.05/bu. Lowering costs by almost $0.21/bu would also be difficult, if not impossible, since that costs would be $0.17/bu lower than the lowest observed cost. It is apparent that having respectable yields, controlling costs, and securing above average grain prices is important for high profitability. Also true is that the opportunity to obtain a higher price happened in a time when few competitors took advantage of a higher market, the June July period.

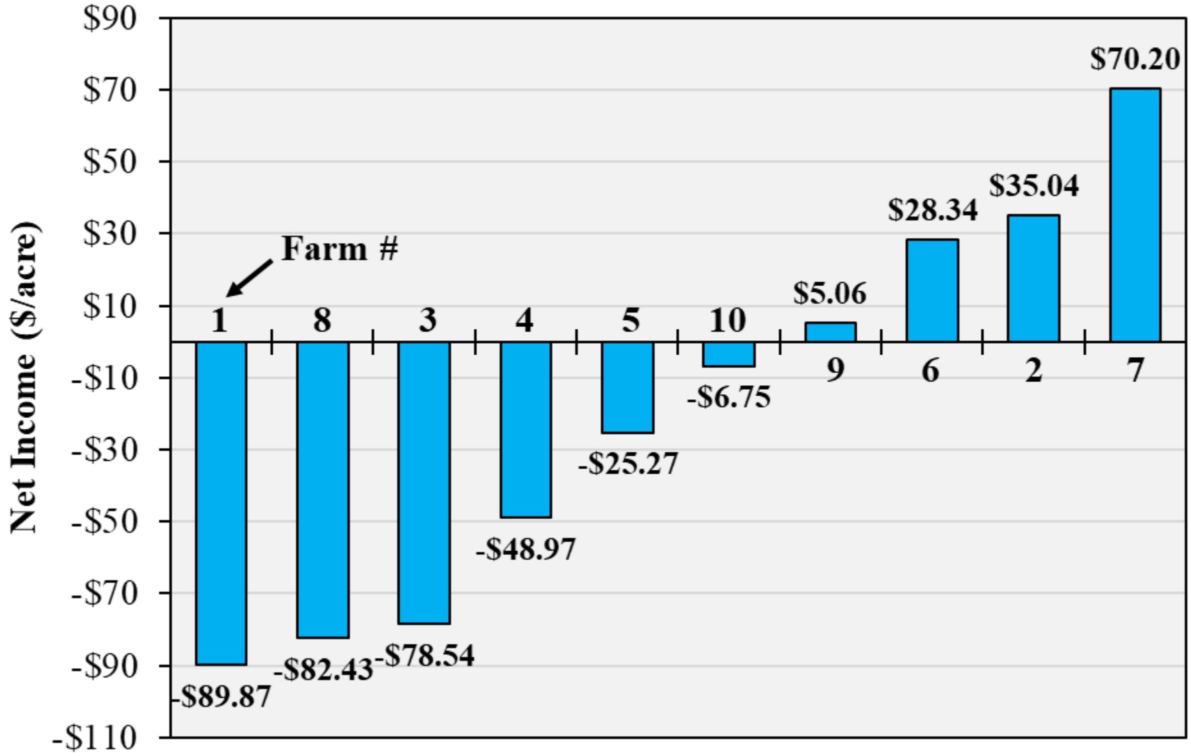

Figure 36. Profitability ($/acre) for individual sorghum farms ranked from lowest (left) to highest (right).

CONCLUSION

The 2019 TAPS competitions provided a wealth of information and interaction among competitors, industry and Ag service providers, researchers, and others. Like any farming operation, the participants were subjected to varying environmental and market conditions that resulted in a range of successes. The outcomes of the competitions allow growers to benchmark and reflect on their use of available information, the effectiveness and performance of new technologies, management practices and strategies used during the season. The data generated will continue to build in the discovery of better practices and the application of new ideas and technologies. This year's competition has added much value to the already significant information of previous years. The TAPS team is excited to see so many supporters, participants and followers and thank each of them for their enthusiasm and help. Congratulations again to the winners of each competition. In addition, we want to thank the Nebraska Water Balance Alliance who we recognized at the annual banquet with the first ever "Outstanding TAPS Advocate Award" (See Figure 42 on Page). This award was created to honor a person or group that has advocated for the TAPS program either behind the scenes or by speaking about it at public events.

ACKNOWLEDGEMENTS

The TAPS program is successful due to the commitment and support provided by our participants, partners, and sponsors (Figures 1 and 2). The 2019 competitions were supported through the following grants: Nebraska Corn Board under award number 88-R-1819-10, National Sorghum Checkoff under award number CI001-19, and the Nebraska Sorghum Board.

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2019 TAPS Award Winners

Figure 37: Fontanelle Hybrids ® Team members Bob Wiseman, Chris Anderson and Jay Elfeldt receive their awards for having the Greatest Grain Yield and Highest Input Use Efficiency in the Sprinkler Corn Competition from Nebraska Corn Board representative Boone McAfee.

Figure 38: Perkins Group team members Jim Kemling, Shawn Turner, Troy Kemling & Ted Tietjen receive their monetary award for being the Most Profitable Sprinkler Corn Competition from Nebraska Corn Board Boone McAfee and UNL Educator Chuck Burr.

Figure 39: Ben Benson and Joshua Becker receive their awards for the subsurface drip irrigation competition from Eco-Drip Representative Taylor Reynolds and UNL Educator Chuck Burr.

Figure 40: Mike Baker (L) of Trenton, Nebraska accepts the monetary award for winning all three divisions of the UNL-TAPS Sorghum contest, from Chuck Burr, UNL Educator.

2019 TAPS Award Winners (Cont.)

Figure 41: Ron Robison (L) of Alma, Nebraska is presented with the award for winning the Highest Input-Use Efficiency Award for the UNL-TAPS Sorghum contest, by Chuck Burr, UNL Educator.

Figure 42: The Outstanding TAPS Advocate Award was presented by Chuck Burr and Daran Rudnick to members of the Nebraska Water Balance Alliance (NEWBA) including Ted Tietjen, Roric Paulman and Mark McConnel.

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