EC 3058

UNL TAPS
TESTING AG PERFORMANCE SOLUTIONS

2020

Farm Management Competitions Report

USDA
United States Department of Agriculture
Natural Resources Conservation Service

N EXTENSION

UNL TAPS
TESTING AG PERFORMANCE SOLUTIONS

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West Central Research, Extension and Education Center
University of Nebraska–Lincoln
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North Platte, NE 69101

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.

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

To think that this program started a little over four years ago, as a brainstorming session to enhance the Extension experience and form a deeper level of engagement among stakeholders and University, is almost unbelievable. The program continues to grow and prosper in both recognition and size. It has been awarded federal grant funding, regional and national awards for its excellence, and continues to expand beyond the State of Nebraska.

The three contests administered at the West Central Research, Extension, & Education Center (WCREEC) in North Platte, NE were Sprinkler Irrigated Corn, Sprinkler Irrigated Grain Sorghum, and Subsurface Drip Irrigated (SDI) Corn. Nearly 150 participants (Figure 4) competed on the 27 sprinkler irrigated corn teams, 16 SDI corn teams, and 12 sprinkler irrigated sorghum teams. These participants represented three states, and included producers, government agency employees, college students, and both first-time and returning contestants.

The Oklahoma State University (OSU) TAPS program, in its second year, included 13 participants from Oklahoma and Nebraska in its Sprinkler Irrigated Corn competition. OSU also did a small trial contest with cotton, which they hope to expand in the future. The UNL-TAPS program finished the first winter wheat contest in August of 2020 and has started their second competition. The contest is comprised of 20 teams and is managed at the High Plains Ag Lab near Sidney, NE. The reports for these affiliate competitions can be found at www.taps.unl.edu/reports.

This innovative program continues to connect industry knowledge and Extension research to the personal experiences of growers by fostering relationships among all stakeholders in crop production. The TAPS program provides these opportunities through interaction between producers, industry, government, and university personnel, among others.

The TAPS program continues to be a successful model of engagement thanks to the support and participation of many partners, sponsors, and contributors. This year, the TAPS program not only received monetary sponsorship from many local and regional businesses and organizations, including the Nebraska Corn Board, Sorghum Checkoff, and Nebraska Sorghum Board, but also a Conservation Innovation Grant (CIG) through the USDA-NRCS. In addition, TAPS appreciates the multitude of various organizations and entities that have provided resources, technology, technical assistance, and innovative approaches that are made available to the participants and observers of the TAPS program. Gratefully, the program's list of partners, participants, sponsors, supporters, and followers continues to grow. These efforts and collective support are top among the reasons why this program continues to advance and improve at such an accelerated rate.

We are eagerly preparing for the 5th year of TAPS. Our hope is that this year's contests and events will be more educational, more exciting, include more stakeholders, reach more producers, increase innovation, create stronger and lasting bonds, and help move the industry forward into the future.

Sincerely,

TAPS Executive Board

PROGRAM OVERVIEW

The three TAPS competitions facilitated at the WCREEC in North Platte, NE are the focus of this report. The competitions include the 4th annual Sprinkler Irrigated Corn competition, the 3rd annual Sprinkler Irrigated Sorghum competition, and the 2nd annual Subsurface Drip Irrigated (SDI) corn competition. The sprinkler irrigated competitions were facilitated under a Zimmatic by Lindsay, Variable Rate Center Pivot and the SDI competition was held on a field equipped with an Eco-Drip SDI system. The sprinkler irrigated corn competition included 27 teams, the sprinkler irrigated sorghum competition had 12 teams, and the SDI competition had 16 teams. Each farm was randomly assigned a set of three experiment-sized plots within the respective competition areas, totaling less than one-half of an acre per farm. University personnel managed the competition plots under the supervision of the TAPS executive committee. The yields and costs from each "farm" were amplified to represent 3,000 harvested acres for the sprinkler irrigated corn competition and 1,000 harvested acres for both the sprinkler irrigated sorghum and SDI competitions. This magnification provided ample opportunity for competitors to develop strategies to market grain and consider the impact the decisions would have had on a full-scale operation. These farm sizes are consistent with modern-sized farming operations and therefore allow easier recognition of the effects even small decisions have on outcomes and profitability.

In each competition, participants controlled six decision types (Figure 1). These decisions have a direct effect on productivity, efficiency, and profitability.

Hybrid Selection
(decision type #1)
and
Seeding Rate
(decision type #2)

Each team was required to select their own seed hybrid and seeding rate. District Sales Manager/s (DSM/s) of multiple seed companies (Arrow, Big Cob, Channel, Dekalb, DynaGro, Fontanelle, Hoegemeyer, Pioneer, Seitec, and Stine) provided seed and seeding rate recommendations, which included 48 corn and 16 sorghum hybrids. These recommendations were based on location, production history, and characteristics of the field used in the competition. While each team had the option of selecting a

Figure 1. The six management decisions made by TAPS competitors in all three of the 2020 competitions.

DSM recommended hybrid, they were also free to select and use their own seed hybrid. Participants were also asked to specify seeding rate, regardless of the hybrid 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 the hybrids reached a 17% moisture content. This was consistent with the maximum moisture content that elevators allow at time of harvest. The sorghum competition was harvested when the majority of hybrids reached 16% moisture content. All farms 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 ensured that all yields were measured equally for each contestant.

Crop Insurance
(decision type #3)

Participants were required to select a multi-peril crop insurance package from the following three options: Revenue Protection (RP), Revenue Protection with Harvest Price Exclusion (RP-HPE), or Yield Protection (YP), using either Enterprise Units (EU) or Optional Units (OU). The available levels of coverage were 65, 70, 75, 80, or 85%. The premium rates were specifically provided by Farm Credit Services for the competition area in North Platte, NE. Due to the risk involved in borrowing funds to cover operating costs, a minimum level of 65% multi-peril crop insurance was required. This minimum level of crop insurance also allows all participants to market the majority of their production before harvest.

Nitrogen Management
(decision type #4)

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 of 5 gallons/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 operating at a depth of about 1.0-inch and at a distance of 5 inches on both sides of the row. Side-dress N fertilizer was available for contestants in the corn competitions and was applied at the ground surface neighboring each row using 360° Y-DROP (360° Yield Center, Morton, IL). Fertigation was applied through the center pivot using a variable rate injection pump (Agri-Inject, Yuma, CO) that maintained proper N 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 pounds/acre for pre-plant, 180 pounds/acre for side-dress, and 30 pounds/acre for each fertigation event (i.e., total possible fertigation amount was 120 pounds/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 available to the sorghum participants. An application cost of $7.00/acre, which did not include the cost of the fertilizer, was charged for pre-plant and side-dress operations, and $1.00/acre for each fertigation application.

Irrigation Management
(decision type #5)

The pivot irrigation system was operated every Monday and Thursday throughout the growing season. Participants had until 10 AM on the day of irrigation to submit their irrigation decision via their password protected online portal. If participants failed to indicate their intent to irrigate by 10 AM on the day of irrigation, irrigation was not applied. Irrigation depth per application could be as much as 1.0-inch, in intervals of 0.05 inches. The SDI system was operated likewise, every Monday and Thursday throughout the growing season. Participants had until 8 AM on the day of irrigation to submit their irrigation decision via their online portal.

Similarly, if participants failed to indicate intent to irrigate by 8 AM, irrigation was not applied for that event. Irrigation per application was as much as 1.0-inch, again in increments of 0.05 inches. If participants chose over 0.5 inches, then the irrigation event occurred over a 48-hour period, due to the capacity of the irrigation system.

Grain Marketing

(decision type #6)

The option to market grain was available to participants in all competitions from March 1 through November 30. Each team had five different avenues to sell their grain. These five options were 1) spot or cash sales, 2) forward contract, 3) basis contract with delivery at harvest, 4) simple hedge to arrive, and 5) hedging with futures contracts. Since this is a farm management contest, using the market to speculate was not allowed.

Other Management Decisions

All other management decisions, (e.g., pesticide use, tillage practices, residue management, etc.), were predetermined and executed by the TAPS team. Each contest was managed uniformly with scientific precision, as plots were randomized and managed identically within each contest on continuous sites, except for the six decision areas. Each team freely made choices in the six decision areas, as they sought to be the most profitable, efficient, and highest yielding farm. The TAPS team did the physical management of all farms (e.g., operation of machinery, irrigation systems, application of chemicals, and harvesting). Participants, however, were encouraged to actively observe their plots, install additional data collecting technology, and collect any additional data from their plots throughout the growing season, but at their own expense. To keep the contest fair, no other inputs (e.g., fertilizers, additives, amendments, operations, sprays, etc.) were permitted.

TIMELINE

Figure 2. A brief look at the 2020 competition timeline, both on the program level and the participant level. Unfortunately, due to the COVID-19 pandemic the events planned throughout the year were carried out online.

Figure 3. Participants were given the opportunity to use over 15 technology companies' services, as well as provided a plethora of other data and research results.

TECHNOLOGY

One of the primary goals of the TAPS program is to provide contestants an opportunity to use innovative technology and services in a financially risk-free environment (Figure 3). These innovations include equipment, ideas, strategies, new methods, etc. The core concept is for all involved to identify methods, technologies, and/or strategies that might bring financial and/or conservation value to their to their own operation(s) and to others who learn from them. In its 4th year, TAPS had an ever-increasing growth in the number of contestants, supporters, and technology providers (Figure 5). Participants were provided access to a variety of technology, ideas, and methods that are designed to help inform production and marketing decisions. The technology provided included in-field and edge-of-field instrumentation, imagery products, sophisticated crop management models, and more. In addition, contestants had access to several agricultural services and recommendations provided by commercial soil labs (e.g., Ward Laboratories, Inc.), DSMs, and others.

DESCRIPTION OF AWARDS

Each competition had three cash awards, 1) Most Profitable Farm, $2,000, 2) Highest Input Use Efficiency, $1,000, and 3) Greatest Grain Yield, $500, adjusted by profitability score. All awards included a plaque, an oversized keepsake check, and a winner's jacket. Each award is described in detail below:

1. Most Profitable – used the profit equation of total revenue minus total cost equals profit. The average yield from each team's three plots was multiplied by their average market price; any government payments, insurance indemnities, and/or losses were then equated into this value to get total revenue. Costs were based on both fixed costs, as shown in the beginning budget, and variable expenses incurred during the season through the execution of the six decisions, which, when totaled, represented total cost. However, the costs of technology (e.g., sensors, imagery, and data collection) were not included in the profit equation. Since all farms in any one contest had the same number of acres, the farm with the most per acre profit was the most profitable.

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 – average grain yield, adjusted by the winner's percentage of total possible profit. Total possible profit was the range of difference between the most and least profitable farms.

PARTNERS & SPONSORS

Figure 4. The TAPS program has seen continued success due to this group of partners and sponsors. Whether donating technology and time to install equipment, supplying seed, or making monetary donations, every one of these entities is greatly appreciated.

PARTICIPANTS

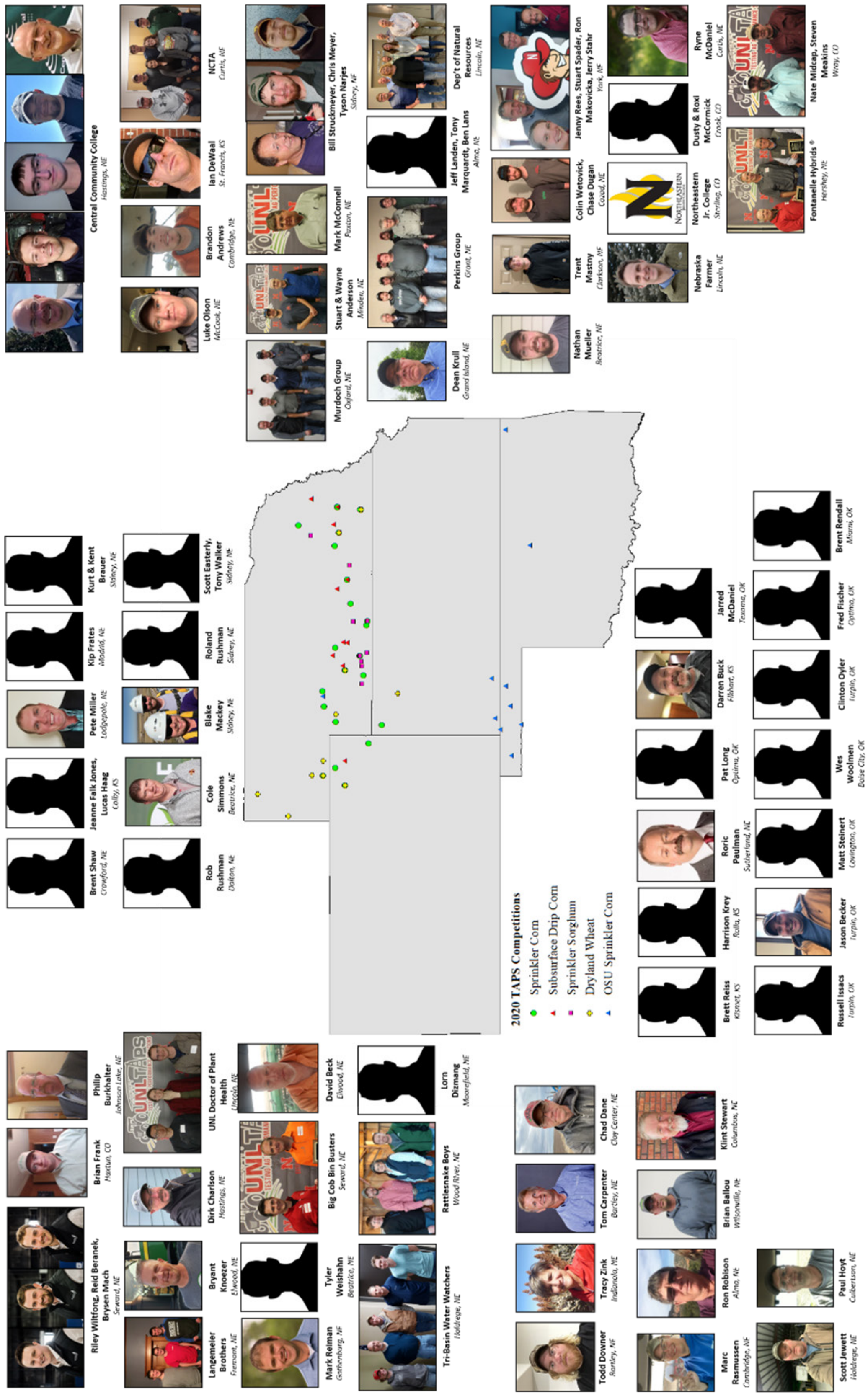

Figure 5. Location of the 2020 TAPS Farm Management Competition participants for all TAPS competitions including the dryland winter wheat competition and the Oklahoma State University's sprinkler corn competition.

SPRINKLER CORN COMPETITION

In the 4th year of the sprinkler corn competition, 27 teams competed, including over 90 participants from throughout the State of Nebraska and some from Colorado and Kansas. In addition to the competitors, there were two noncompetitive entities, the control farm used for determining contestant efficiency, and a UNL Science farm for benchmarking UNL recommendations.

Growing Conditions

As in past years, each team had three randomized plots, (Figure 6), located at the intersection of Highway 83 and State Farm Road in North Platte, NE. North Platte has a semi-arid climate with 80% of annual precipitation occurring between late-April and mid-October (Payero et al., 2009). The predominant soil type at the site is a Cozad silt loam with approximately 1.5 inches/foot of lab-estimated plant available water (i.e., difference between field capacity and permanent wilting point). The 2020 growing season received well-below normal rainfall with 6.3 inches from planting (May 29) to harvest (November 4) of which 85% occurred during the vegetative growth period (i.e., prior to flowering). Furthermore, 2020 experienced warm temperatures with average maximum daily temperatures exceeding 88.8°F for the months of June, July, and August.

Participant Decisions

Participants were responsible for making economic and production management decisions, including insurance coverage, hybrid type, seeding rate, nitrogen and irrigation amount and timing, and marketing, as discussed in more detail above. These decisions were submitted via forms through an online portal that time-stamped all decisions. These decisions are summarized below.

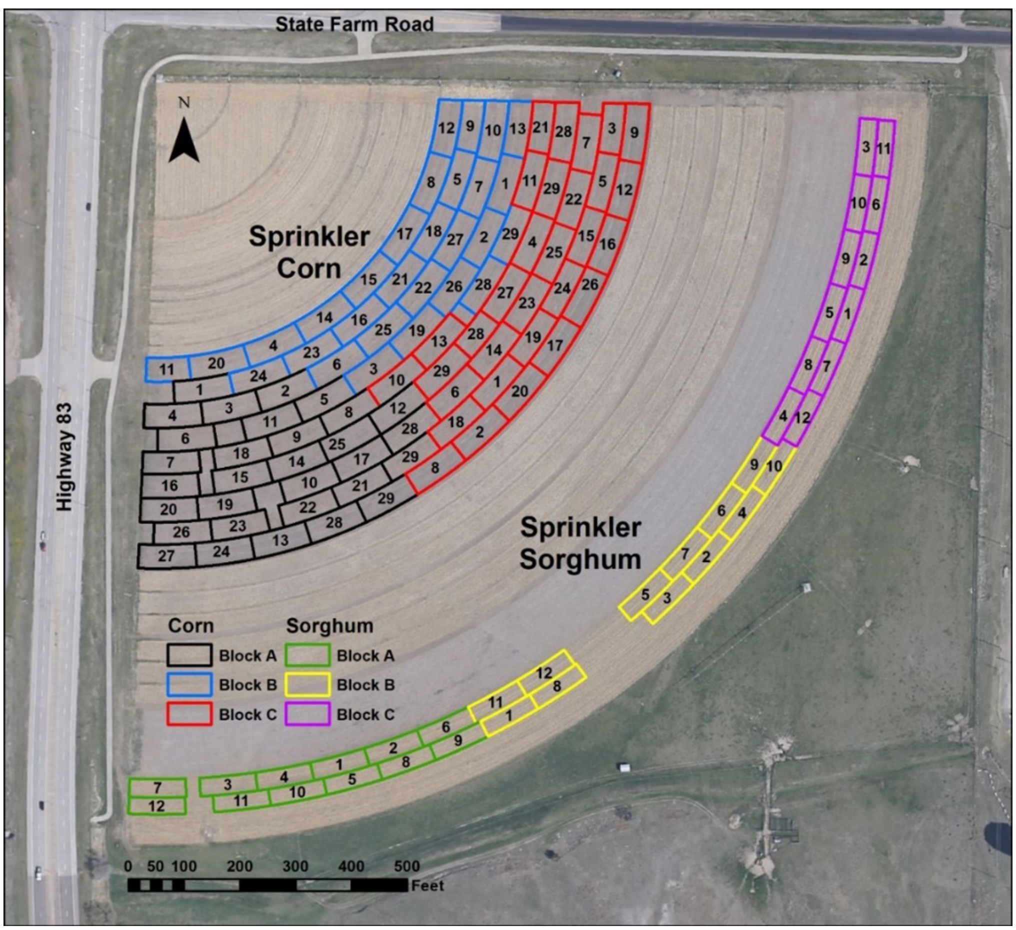

Figure 6. Farm numbers for the 2020 Sprinkler Corn and Sorghum Farm Management Competitions held at the West Central Research, Extension, & Education Center in North Platte, NE. Each team was assigned a randomized plot in blocks A, B, and C.

Agronomic Decisions

Fifteen different corn hybrids were selected from seven seed companies (Table 1, column 2). Three participants selected each of the following hybrids: Channel 213-19 VT2PRIB, Channel 216-36 VT2PRIB, Fontanelle 13G519, while four participants selected Pioneer P1366AML. The Stine 9734-G variety had the lowest cost at $151 per bag while Pioneer 1366Q had the highest cost at $284 per bag. Farm 25 had the lowest seeding rate at 28,500 seeds/acre and planted Channel 216-36 VT2PRIB. The highest seeding rate of 35,000 seeds/acre was planted by Farms 5 and 13 with Channel 213-19 VT2PRIB and Channel 216-36 VT2PRIB, respectively (Table 1, column 3).

The total N fertilizer applied, excluding the control (Farm 6), ranged from 120 to 260 pounds/acre (Table 1, column 10). On average, 29% of N was applied at pre-plant, 27% as a side-dress, and the remaining 45% was applied over the four fertigation events with 12%, 13%, 13%, and 7% applied on July 1, 8, 17, and 30, respectively.

The irrigation season started June 8 and concluded on September 14. Excluding the control (Farm 6), seasonal irrigation ranged from 1.3 (Farm 25) to 16.8 inches (Farm 8), while the average irrigation applied per farm was 7.3 inches, (Table 1, Column 11).

Farm	Hybrid	Seeding Rate	Nitrogen Fertilizer Apr 23	Jun 12	Jul 01	Jul 08	Jul 17	Jul 30	Total	Irrigation	Grain Yield	Profit	WNIPI
#	Name	(1,000/ac)	--------------------------- (lbs/ac)						------------------------	(in)	(bu/ac)	($/ac)	(-)
1	Fontanelle 11D637	32	0	160	0	30	30	0	220	12.5	294.9	437	0.277
2	Pioneer 1082AM	30	50	0	30	30	30	30	170	5.3	185.0	93	0.182
3	Fontanelle 12D558	33.5	60	50	15	30	30	30	215	4.5	178.1	-139	0.146
4	Dekalb 61-41RIB	33	40	75	25	20	20	10	190	5.9	222.2	202	0.241
5	Channel 213-19VT2PRIB	35	30	50	30	30	30	0	170	5.0	186.3	59	0.190
6	Pioneer 1197AMT	34	0	0	0	0	0	0	0	0	107.6	-100	Control
7	Fontanelle 13G519	31	50	50	30	30	30	10	200	4.0	155.0	-247	0.105
8	Pioneer P1082AM	32	30	100	30	30	30	30	250	16.8	286.2	241	0.209
9	Pioneer P1366AML	32	0	96	30	0	30	30	166	10.8	262.5	276	0.273
10	Pioneer 1185AM	32.5	35	75	30	30	30	0	200	9.9	236.9	132	0.223
11	Pioneer 1366AML	34	45	30	0	0	0	0	75	7.8	233.2	154	0.354
12	Pioneer 1366Q	33	90	90	30	20	0	30	260	6.6	232.1	70	0.205
13	Channel 216-36 VT2PRIB	35	50	60	30	30	30	0	200	5.7	181.5	1	0.154
14	Channel 216-36 VT2PRIB	34	50	110	30	30	0	0	220	7.5	223.2	94	0.206
15	Big Cob B13-N22GENVT2P	32	90	0	30	30	30	30	0	6.0	218.3	111	0.245
16	Pioneer P1366AML	32	80	0	30	30	30	10	180	6.6	217.4	96	0.234
17	Golden Harvest G11B63	29	120	0	30	15	15	0	180	9.9	220.0	142	0.210
18	Fontanelle 13G519	32	0	120	30	30	30	30	240	3.3	171.1	-123	0.130
19	Channel 213-19VT2PRIB	34	100	0	30	30	30	30	220	8.0	235.2	129	0.225
20	Fontanelle 11D637	33	30	90	0	0	0	0	120	5.3	203.4	98	0.279
21	Pioneer P1197AM	32	90	0	20	30	30	30	200	1.9	149.6	-94	0.110
22	Pioneer P1366AML	29	180	0	0	30	30	0	240	12.6	276.1	266	0.232
23	Fontanelle 13G519	32	50	75	0	0	30	30	185	5.6	199.5	113	0.203
24	Big Cob B13-N22GENVT2P	33	30	60	30	30	20	0	170	4.9	181.3	-97	0.177
25	Channel 216-36 VT2PRIB	28.5	0	0	30	30	30	30	120	1.3	141.0	-120	0.123
26	Stine 9734-G	34	0	50	30	30	30	0	140	8.2	226.6	178	0.280
27	Channel 213-19VT2PRIB	33	120	0	30	30	30	30	240	13.6	292.8	264	0.247

*Reported as 15.5% grain moisture content. ** Water Nitrogen Intensification Performance Index (WNIPI, Lo et al., 2019)

Table 1: Summary of select inputs, costs, outputs, and profit from the 2020 TAPS sprinkler corn competition.

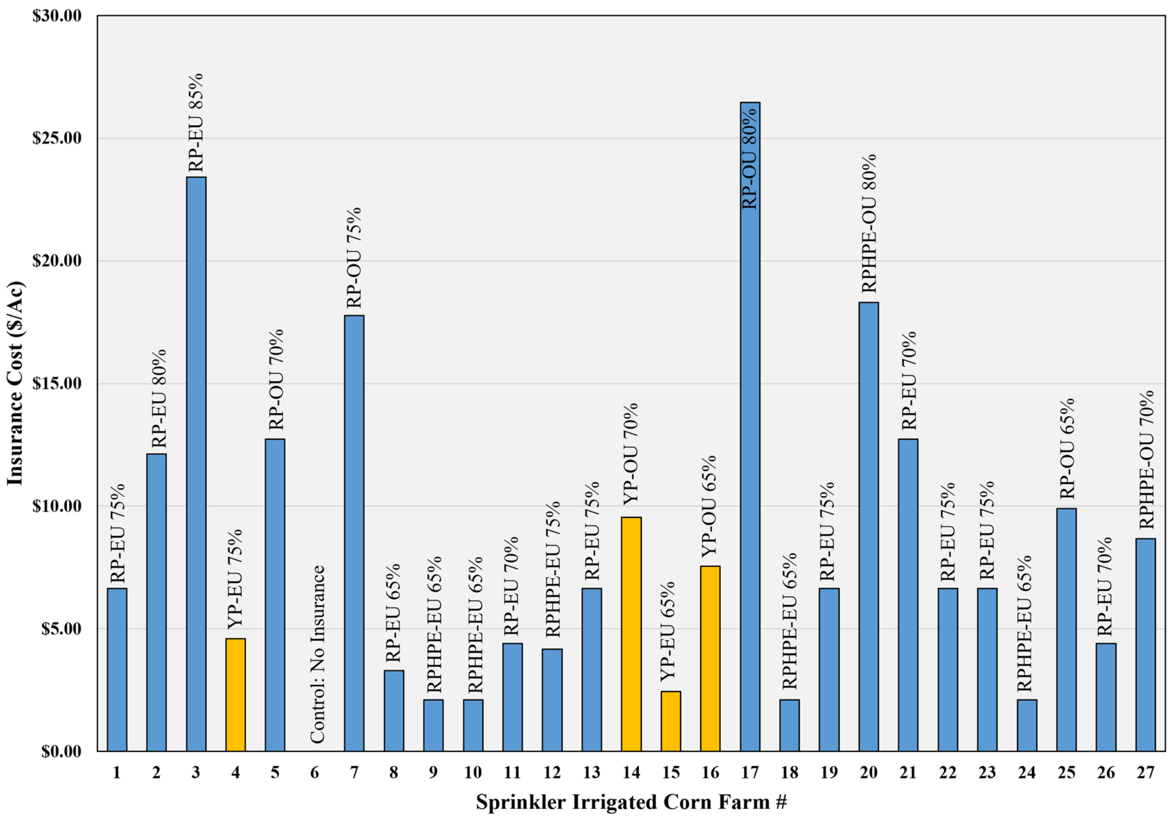

Figure 7. Insurance cost ($/acre) for the individual sprinkler irrigated corn competition teams. Policies offered included Revenue Protection (RP), Revenue Protection with Harvest Price Exclusion (RP-HPE, and Yield Protection (YP) with either Enterprise Units (EU) or Operational Units (OU). The yellow and blue bars represent Yield Protection and Revenue Protection, respectively.

Economic Decisions

Unlike previous TAPS competitions, participants were required to select a multi-peril crop insurance policy with at least 65% coverage. There were no hail or wind insurance options available. Fifteen teams chose to purchase Revenue Protection (RP) policies, seven farms went with Revenue Protection with Harvest Price Exclusion (RP-HPE) and four chose Yield Protection (YP) policies (Figure 7). Of the 26 competitive teams, 18 teams used Enterprise Units (EU). The other eight teams purchased Operational Units (OU). Chosen by five teams, RP-EU at the 75% coverage level was the most common selection. The average cost across all competitors was $8.62/acre. The least expensive policy was RP-HPE-EU at 65% coverage ($2.11/acre), selected by Farms 9, 12, 18, and 24. The most expensive was RP-OU at 80% coverage ($26.46/acre), Farm 17.

Contestants could market expected production, trend adjusted Average Production History (APH), from March 1 through November 30. The high prices were observed at the beginning of the contest in early March and again at the end of the marketing window. This is abnormal, given prices typically peak between March and July, and are lowest during the harvest. Farms 2, 4, 5, 6, 13, 16, and 25 sold all grain as cash sales. Of all transactions, spot sales accounted for about 41%, while the rest was comprised of 38% forward contracts, 12% futures contracts, 7% hedge-to-arrive contracts, and 2% basis contracts. Note that this is only the number of transactions represented as percentage of total transactions and does not account for the size of each transaction. Team 25 sold

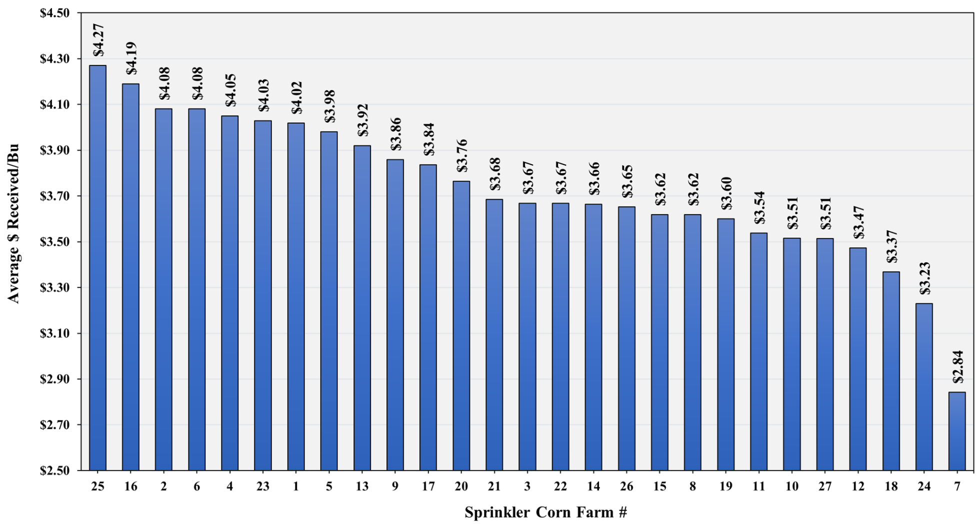

Figure 8. Average market value received ($/bushel) for the individual sprinkler irrigated corn competition teams.

all grain at the end of November and received the highest price of the season at $4.27/bushel (Figure 8). The average price per bushel received among all 27 teams was $3.73.

RESULTS AND RANKINGS

Grain Yield

Although the sprinkler corn grain yields averaged less than the previous year, the greatest grain yield exceeded last year's award winner. The grain yields for the competition averaged 199 bushels/acre, which was below the field's APH of 225 bushels/acre (Table 1, column 12).

Only seven teams had an average yield that exceeded the field's APH, including Farms 1, 8, 9, 10, 11, 12, 19, 22, 26, and 27. Excluding control Farm 6, the farms ranged from 141 bushels/acre (Farm 25) to 295 bushels/acre (Farm 1). There was no observable advantage for any specific hybrid, likely due to the interacting effect of management practices on yield response. Figure 9A shows that for each additional pound of N, about 0.44 bushels were produced, however, this response was weak and highly influenced by the control farm. On the other hand, grain yield had a strong response to irrigation with seasonal irrigation explaining 86% of yield variability, (Figure 9B). Each inch of added irrigation yielded an average of 9.3 bushels/acre of corn.

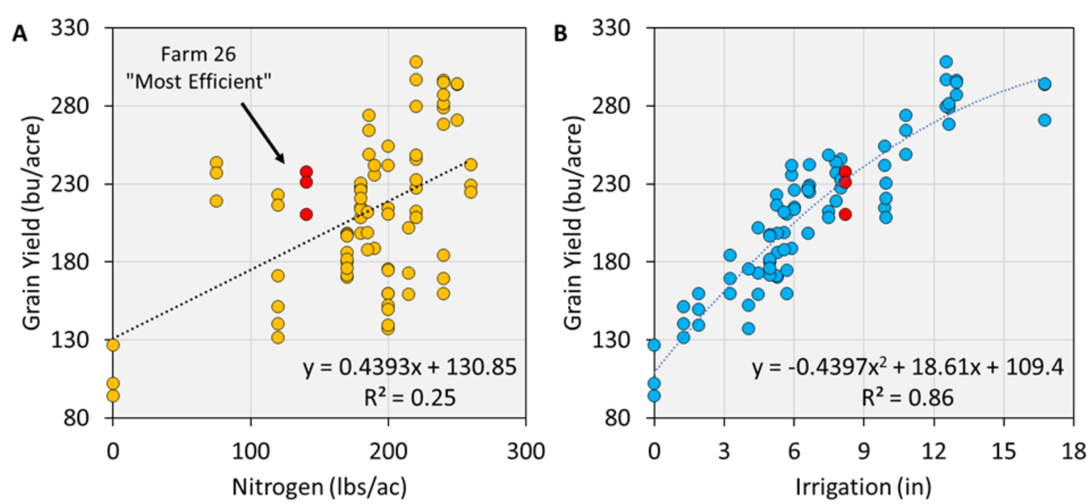

Figure 9. Sprinkler corn grain yield response to seasonal total nitrogen fertilizer (A) and irrigation (B) at the WCREEC in North Platte, NE. The most efficient farm as measured by the Water Nitrogen Intensification Performance Index (WNIPI) is denoted in red.

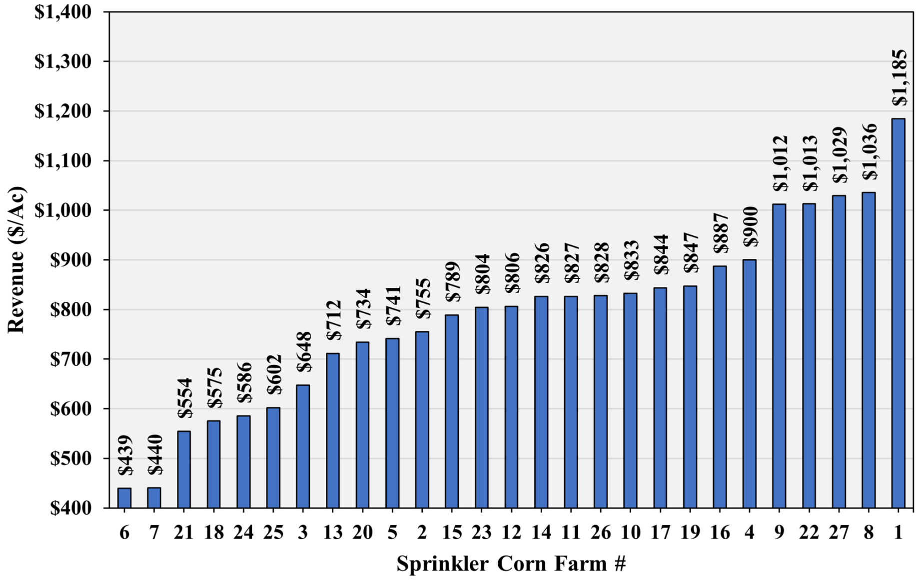

Figure 10. Revenue per acre received for the individual sprinkler irrigated corn competition teams.

Input Use Efficiency

The Water Nitrogen Intensification Performance Index (WNIPI), (Lo et al., 2019), was used to quantify input use efficiency and is reported in the last column of Table 1. It compares the effect of N and irrigation input on grain yield with respect to a control treatment. The control is a baseline and is used to measure the effect of any added water or N fertilizer. The control Farm 6 had no added N or irrigation and yielded 108 bushels/acre. Farm 11, the UNL Science team, had the highest WNIPI score at 0.354 and was therefore the most N and water efficient. Since UNL is not eligible to win awards, the winner of the most efficient award was Farm 26. This farm applied 140 pounds of N/acre and 8.2 inches of irrigation water, resulting in a yield of 227 bushels/acre. Agronomic Efficiency (AE) measures the effect each added pound of N has on yield in terms of bushels. Farm 26 yielded 119 bushels/acre more than the control Farm 6. When the yield difference is divided by the amount of additional applied N fertilizer, 140 pounds/acre, the AE is calculated to be 0.85. This is much higher compared to the average of 0.57 bushels/pound of N of all other farms, except the control farm. On average, Farm 26 produced 0.85 bushels for every pound of N fertilizer applied. Irrigation Water Use Efficiency, (IWUE), is measured in a similar manner, except pounds of N are replaced with acre-inches of applied water. Farm 26's IWUE was calculated to be 14.5 bushels/acre-inch. The overall average was 16.0 bushels/acre-inch. To contrast these results, the least efficient Farm 7 applied 200 pounds of N/acre and about 4.0 inches-acre of irrigation, with a resulting yield of 155 bushels/acre. These levels of application and productivity resulted in a WNIPI of 0.105, AE of 0.24 bushels/pound, and an IWUE of 11.7 bushels/acre-inch. The large difference in performance between the two farms was likely due to the small amount of irrigation used by Farm 7 (4.1 inches/acre), about half that of Farm 26 (8.2 inches/acre), and as illustrated in Figure 9B. It is likely that the lack of water limited the plants' ability to create yield, but also its effectiveness to use the added N. Plainly, efficiency is as much about balance as conservation. Too much of any input is wasteful, but too little can also be costly since it leaves other already applied nutrients unused and potentially lost.

PROFITABILITY

Revenue Per Acre

Revenue per acre is the product of grain price per bushel times bushels per acre sold. Quantity and value of bushels are essential in increasing total revenue.

Revenue ranged from a low of $439.19/acre, Farm 7, to a high of $1,184.84/acre, Farm 25 (Figure 10). More than 53% of the farms had

Revenue/Acre			Revenue/Bushel			Yield/Acre		
Farm #	Rank	$/Acre	**Farm #**	Rank	$/Bu	**Farm #**	Rank	Bushels/Acre
1	1st	$1,184.84	**25**	1st	$4.27	**1**	1st	295
8	2nd	$1,035.59	**16**	2nd	$4.19	**27**	2nd	293
27	3rd	$1,028.55	**2**	3rd	$4.08	**8**	3rd	286
9	4th	$1,012.70	**6**	4th	$4.08	**22**	4th	276
22	5th	$1,012.61	**4**	5th	$4.05	**9**	5th	262

Table 2. Revenue comparisons based on per acre and per bushel calculations, as well as yield for the sprinkler irrigated corn competition.

revenue between $659.19/acre and $859.19/acre. The top five farms had revenue in excess of $1,000/acre. More than 61% of farms received less than $3.85/bushel. Farms with revenue less than $1,000/acre sold on average just under 200 bushels/acre at an average value of $3.71/bushel.

Farm revenue per acre is ranked in descending order and listed in Table 2. Top five includes Farms 1, 8, 27, 9, and 22. None of the top five revenue per acre farms had the highest per bushel value, as shown in the center section of Table 2. For this year's contest, the quantity difference outperformed sales price difference among the leading farms.

Cost Per Acre

Like revenue, cost has a relationship with yield. Mathematically, cost per bushel is derived by dividing acre cost by acre yield. Naturally, there is an expected relationship between cost and productivity. Productivity is dependent on physical conditions, which can be augmented or changed by the addition or use of varying practices, inputs, or resources, such as fertilizer, water, herbicides, etc. The addition of inputs and resources is expected to increase productivity; if not, then cost would increase without any change in productivity, and this is one of the reasons why farms have varying costs. It should be remembered that not all resources are equal in their ability to increase productivity and that usefulness of most inputs has a limit of practicality and will diminish in potency if over-used.

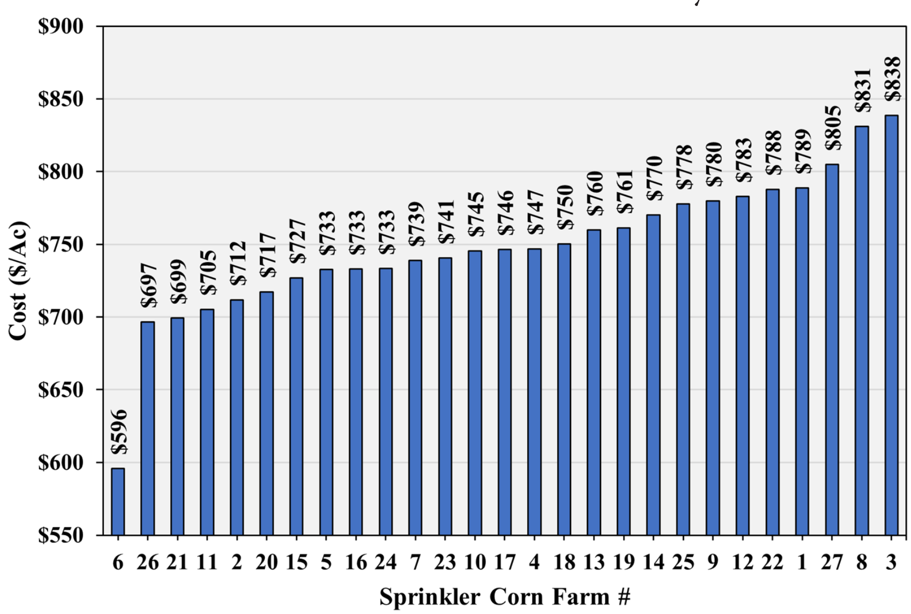

Figure 11. Cost Per Acre

The farm with the lowest cost per acre, Farm 6, was used by the TAPS executive team as a control farm, received no added water or N fertilizer, and was not considered a competing entity. Of the competing farms, there was about a $160/acre cost difference between lowest and highest cost operations, while the average cost was $712.33/acre (Figure 11). Over 57% of the farms had cost

Costs/Acre			Costs/Bushel			Yield/Acre		
Farm #	**Rank**	**$/Acre**	**Farm #**	**Rank**	**$/Bu**	**Farm #**	**Rank**	**Bushel/Acre**
6	1st	$538.93	**1**	1st	$2.53	**1**	1st	295
21	2nd	$645.21	**27**	2nd	$2.61	**27**	2nd	293
26	3rd	$649.87	**22**	3rd	$2.70	**8**	3rd	286
2	4th	$661.57	**8**	4th	$2.78	**22**	4th	276
20	5th	$667.07	**9**	5th	$2.81	**9**	5th	262
			6	26th	$5.01	**6**	27th	108

Table 3. The top five listing of costs per acre, per bushel and yield per acre for the sprinkler irrigated corn competition.

between $666.93/acre and $730.93/acre. Farm 1, with the 23rd most costly per acre production and best overall yield, ended up as the least costly per bushel at $2.53/bushel (Table 3).

Farm 1 was the best-balanced operation, due to lowest cost per bushel and highest yield. In the opposite way, Farm 6 had best cost per acre of all 27 farms but earned 26th place in cost per bushel, which is 2nd worst. This is caused by the lowest yield, as well as cost and productivity levels that were not well-balanced, and is a classic case of savings decisions that are ultimately costly. Farm 21 had a similar outcome as Farm 6, again, due to low yields.

If two farms have the same cost per acre, then the farm with the higher yield will have the lower cost per bushel. Higher yields also increase revenue, as long as the market value of the production remains unchanged. The cost per bushel is derived from cost per acre divided by bushels produced by acre. Per acre revenue is derived from per bushel price times per acre production. If cost per acre is constant, any increase in yield also increases profit, and it is therefore important to have a clear understanding of how cost affects yield and how market price drives input affordability. The conclusion of these inter-relationships indicates that, while increasing productivity is highly desirable, it is important to use inputs wisely, controlling costs and maximizing profit.

Profit Per Acre

The top ranked Farm 1 was $161.15/acre more profitable than the 2nd ranked Farm 9

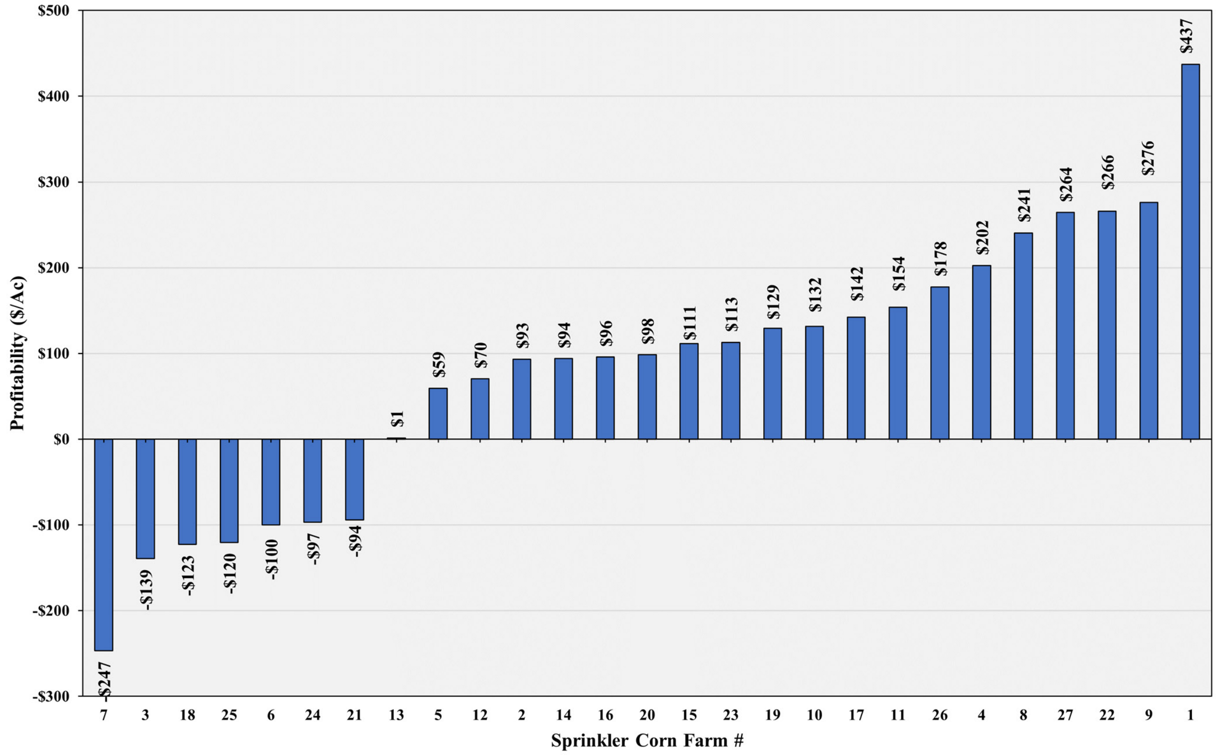

Figure 12. Profit Per Acre

(Figure 12). The difference was created by lower cost of $0.27/bushel, higher average price received per bushel sold at $0.16/bushel more, and greater productivity of 32.4 bushels/acre. After Farm 1, the next four farms had less than a $40/acre difference in profit.

The top five profit per acre farms ranked in descending order were Farms 1, 9, 22, 27, and 8 (Table 4). These farms, excluding Farm 1, had a different cost per bushel ranking order, but are each ranked among the five farms with the lowest cost (Table 3). Not surprisingly, the same five farms also ranked among the top five revenue per acre farms (Table 2). Market prices ranged from $2.84/bushel for Farm 7 to $4.27/bushel for Farm 25. Farm 1 had highest sale value among the top five highest yield per acre farms and was ranked 1st place in profit. Farm 9 ranked 2nd in profit and had the 2nd highest sales price among the five leaders. Farm 22 had the 3rd highest per bushel value and ranked 3rd in profit. Farm 23 was dominated by other farms with higher per bushel prices, while Farm 8 was dominated by those with higher yields.

Profit/Acre			Profit/Bushel			Yield/Acre		
Farm #	Rank	$/Acre	**Farm #**	Rank	$/Bu	**Farm #**	Rank	Bu/Acre
1	1st	$437.35	**1**	1st	$1.48	**1**	1st	295
9	2nd	$276.20	**9**	2nd	$1.05	**27**	2nd	293
22	3rd	$265.95	**22**	3rd	$0.96	**8**	3rd	286
27	4th	$264.36	**4**	4th	$0.91	**22**	4th	276
8	5th	$240.64	**27**	5th	$0.90	**9**	5th	262

Table 4. The top five listing of profit per acre, per bushel and yield per acre for the sprinkler irrigated corn competition.

AWARD RECIPIENTS

Photo 1. ***The Most Profitable and Greatest Grain Yield*** awards were both claimed by Farm 1 with a yield of 294.9 bushels/acre and was managed by Mark McConnell of Paxton, NE. McConnell planted Fontanelle 11D637 at a population of 32,000 seeds/acre, used 12.5 inches of irrigation, and 220 pounds/acre of N fertilizer. McConnell marketed his crop for the value of $4.02/bushel, which earned him $437/acre profit. This farm cleared $161 more than the 2nd place team.

Photo 2. ***The Highest Input Use Efficiency*** award was presented to the M&M's team from York, NE. Team members were Jerry Stahr, Ron Makovicka, Stuart Spader, and Jenny Rees. The group planted Stine 9734-G at a rate of 34,000 seeds/acre, applied 140 pounds/acre of N and 8.2 inches/acre of irrigation water.

Figure 13. Plot layout for the 2020 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.

SDI CORN COMPETITION

In the 2nd year of the Subsurface Drip Irrigated (SDI) corn competition 16 teams competed. There were 41 people who participated from across Nebraska and Colorado.

Growing Conditions

As in the past, each team had three randomized plots, (Figure 6), located southwest of the intersection of Highway 83 and State Farm Road in North Platte, NE. North Platte has a semi-arid climate with 80% of annual precipitation occurring between late-April and mid-October (Payero et al., 2009). The predominant soil type at the site is a Cozad silt loam with approximately 1.5 inches/foot of lab-estimated plant available water (i.e., difference between field capacity and permanent wilting point). The 2020 growing season received well below normal rainfall with 6.3 inches from planting (May 29) to harvest (November 4) of which 85% occurred during the vegetative growth period (i.e., prior to flowering). Furthermore, 2020 experienced warm temperatures with average maximum daily temperatures exceeding 88.8°F for the months of June, July, and August.

Participant Decisions

Participants were responsible for making economic and production management decisions, including insurance coverage, hybrid type, seeding rate, nitrogen and irrigation amounts and timing, and marketing, as discussed in more detail above. These decisions were submitted via a form through an online password protected portal that time-stamped all decisions. These decisions are summarized below.

Agronomic Decisions

Thirteen different corn hybrids were selected from seven seed companies (Table 5, Column 2). Two participants selected each of the following hybrids: Pioneer 1197AMT, Pioneer P1082AM and Pioneer P1366AML. Other hybrids were selected by only one team. Seitec 6377 G2PRO and Seitec 6111 G2PRO had the lowest cost at $217 per bag and Hoegemeyer 8268Q had the highest cost at $300 per bag. For seeding rate, Farms 1 and 3 had the lowest rate at 32,000 seeds/acre and planted Pioneer P1366AML and Seitec 6377 G2PRO, respectively (Table 5, column 3). The highest seeding rate was 35,000 planted by Farms 2 and 14 with Pioneer P0622AML and Channel 213-19VT2PRIB, respectively.

The total N fertilizer applied, not including the control (Farm 11), ranged from 75 to 280 pounds/acre (Table 5, column 10). On average, 35% of N was applied at pre-plant, 28% side-dress, and the remaining 37% was applied over the four fertigation events with 8%, 11%, 12%, and 6% applied on July 1, 8, 17, and 30, respectively.

The teams were given the option to irrigate starting June 8 with irrigation concluding September 14, although the last irrigation decision was submitted on September 10 by Farm 1. Excluding the control (Farm 11), seasonal irrigation ranged from 3.0 inches (Farm 12) to 14.8 inches (Farm 16), with an average of 7.5 inches (Table 5, Column 11). The average depth of irrigation per event, excluding fertigation, was 0.64 inches.

Farm	Hybrid	Seeding Rate	Nitrogen Fertilizer: Apr 23	Jun 11	Jun 25	Jul 08	Jul 16	Jul 30	Total	Irrigation	Grain Yield*	Profit	WNIPI**
#	Name	(1,000/ac)	(lbs/ac)	(lbs/ac)	(lbs/ac)	(lbs/ac)	(lbs/ac)	(lbs/ac)	(lbs/ac)	(in)	(bu/ac)	($/ac)	(-)
1	Pioneer P1366AML	32	50	50	0	0	25	25	150	8.2	238.0	$179	0.195
2	Pioneer P0622AML	35	0	99	30	30	30	0	189	8.6	244.4	-$4	0.179
3	Seitec 6377 G2PRO	32	60	0	25	30	25	0	140	9.4	250.7	$55	0.220
4	Pioneer P1082AM	33	0	75	30	30	30	30	195	8.1	265.7	$465	0.216
5	Big Cob B13-N22 GENVT2PRIB	34	140	80	0	10	0	0	230	3.7	159.9	-$192	0.031
6	Pioneer P1366AML	33.5	0	75	20	20	15	15	145	11.8	247.9	$6	0.193
7	Dekalb DKC70-27	34	0	100	0	30	0	30	160	9.5	273.8	$44	0.246
8	Fontanelle 13G519	33.5	100	0	30	30	30	0	190	3.6	206.5	$41	0.136
9	Big Cob 15-H64	33	100	0	30	30	30	0	190	7.8	260.4	$82	0.213
10	Hoegemeyer 8268Q	33	90	0	30	30	30	0	180	7.0	267.3	$81	0.239
11	Pioneer 1197AMT	34	0	0	0	0	0	0	0	0.0	144.0	-$61	-
12	Seitec 6111 G2Pro	32	80	20	20	20	20	0	160	3.0	194.2	-$65	0.126
13	Pioneer 1197AMT	34	45	30	0	0	0	0	75	7.8	242.0	-$184	0.289
14	Channel 213-19VT2PRIB	35	60	0	0	0	30	30	120	5.9	225.2	$119	0.208
15	Pioneer P1197AM	34	125	140	0	0	20	25	310	3.2	178.6	-$103	0.028
16	Pioneer P1082AM	32	100	90	10	30	30	20	280	14.8	285.3	$138	0.156

*Reported as 15.5% grain moisture content. ** Water Nitrogen Intensification Performance Index (WNIPI, Lo et al., 2019)

Table 5. Summary of select inputs, costs, outputs, and profit from the 2020 TAPS subsurface drip irrigated corn competition.

Economic Decisions

Unlike previous TAPS competitions, participants were required to select a multi-peril crop insurance policy with at least 65% coverage. There were no hail or wind insurance options available. Only two of the teams, Farms 4 and 9, selected Yield Protection (YP) coverage (Figure 14). The other teams chose some variant of Revenue Protection (RP) coverage. All SDI teams chose Enterprise Units (EU), which includes all fields of the same crop for that enterprise. The most common option selected was a RP-EU policy at 75% coverage ($6.64/acre). The average cost across all teams was $5.98/acre. The least expensive policy was YP-EU at 65% coverage ($2.44/acre), Farm 9, and the most expensive was RP-EU at 80% coverage ($12.12/acre), Farm 15.

Contestants could market expected production, trend adjusted Average Production History (APH), from March 1 through November 30. Each contestant was able to use up to five methods of selling grain, including forward and basis contracts, hedge-to-arrive contracts, hedging using futures contracts, and cash sales. The high prices were observed at the beginning of the contest in early March and again at the end of the TAPS marketing window. This is abnormal, given prices typically peak between March and July, and are the lowest during harvest. Seven teams used all cash contracts, and all but one remaining team used a combination of two methods, while the remaining team tried three different methods of marketing. Of all SDI corn production, 63% was sold using cash contracts, 20% using forward contracts, 13% via basis contracts, and the remaining 4% through hedge to

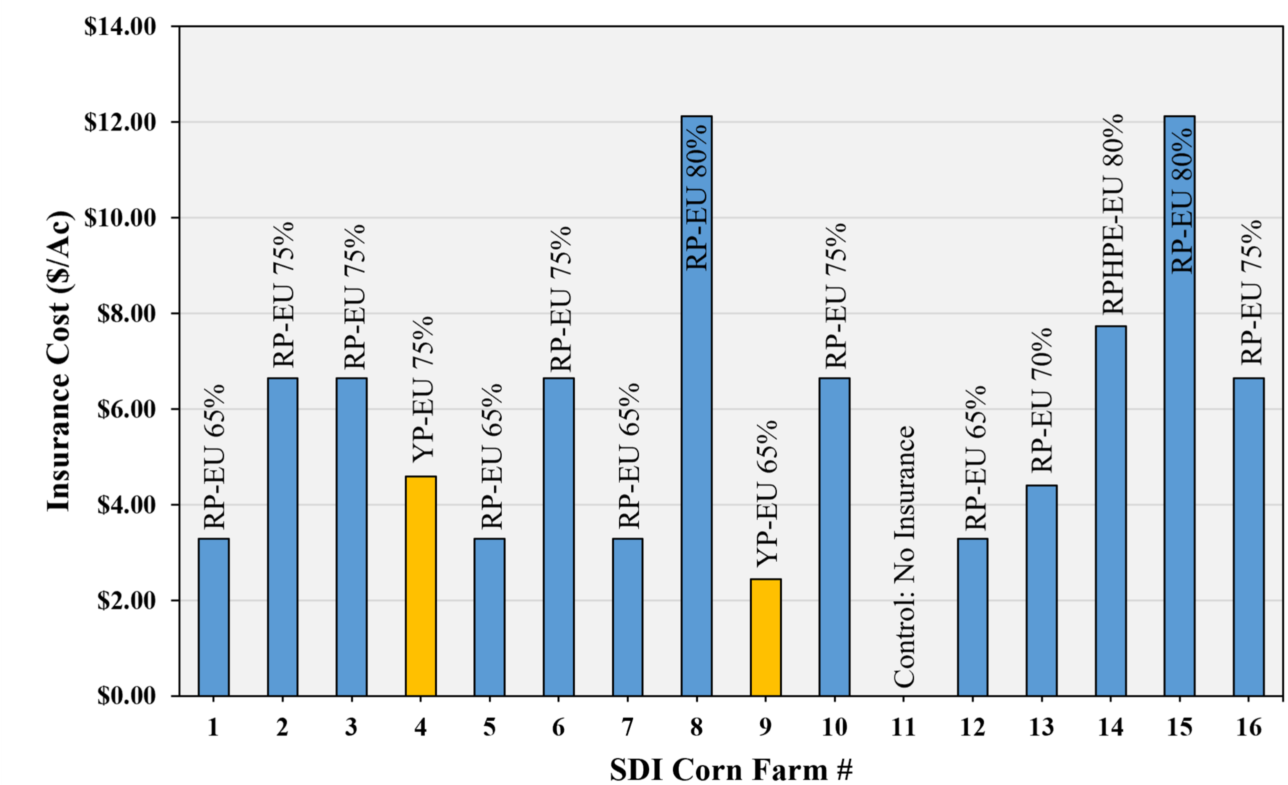

Figure 14. Insurance cost ($/acre) for the individual subsurface drip irrigated corn competition teams. Policies offered included Revenue Protection (RP), Revenue Protection with Harvest Price Exclusion (RP-HPE, and Yield Protection (YP) with either Enterprise Units (EU) or Operational Units (OU). The yellow and blue bars represent Yield Protection and Revenue Protection, respectively.

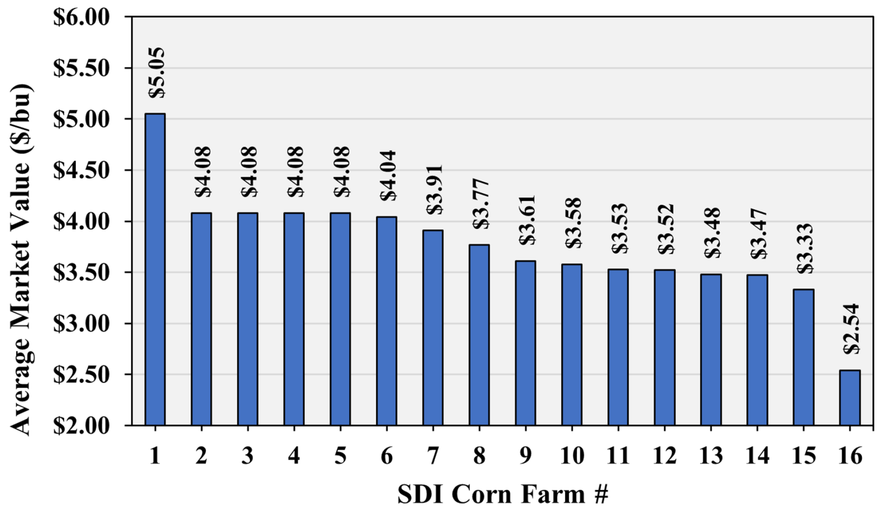

Figure 15. Average market value received ($/bushel) for the individual subsurface drip irrigated corn competition teams.

arrive contracts. These marketing decisions led to average prices received from $2.54 to $5.05/bushel (Figure 15). Farm 4, who used hedge to arrive contracts and then sold all their grain with basis contracts, received the highest price of the season at $5.05/bushel. The average price received per bushel among all 12 teams was $3.76.

RESULTS AND RANKINGS

Grain Yield

Although the SDI corn farm grain yields averaged less than the previous year, the greatest grain yield exceeded last year's award winner. The grain yields for the SDI competition this year averaged 236 bushels/acre (Table 5, column 12), which exceeded the field's APH of 225 bushels/acre. Five of the teams fell short of meeting the field's APH (Farms 5, 8, 11, 12, and 15). With the exception of the control Farm 11, the farms ranged from 160 bushels/acre (Farm 5) to 285 bushels/acre (Farm 16). There was no observable advantage for any specific hybrid, likely due to the interacting effect of management practices on yield response. Figure 16A shows a slight response of grain yield to N application but was not significant. On the other hand, grain yield had a strong response to irrigation with seasonal irrigation explaining 79% of yield variability (Figure 16B). Using the equation below, the estimated optimal use of water was 14.7 inches. Each inch of added irrigation yielded an average of 9.6 bushels/acre of corn.

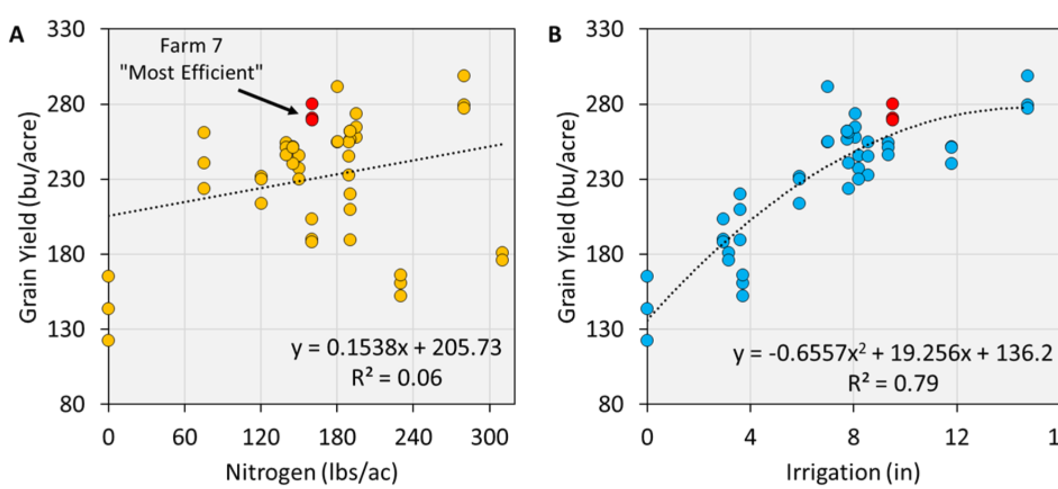

Figure 16. SDI corn grain yield response to seasonal total nitrogen fertilizer (A) and irrigation (B) at the WCREEC in North Platte, NE. The most efficient farm as measured by the Water Nitrogen Intensification Performance Index (WNIPI) is denoted in red.

Input Use Efficiency

The Water Nitrogen Intensification Performance Index (WNIPI), (Lo et al., 2019), was used to quantify input use efficiency and is reported in the last column in Table 5. It compares the effect of N and irrigation input on grain yield with respect to a control treatment. The control is a baseline and is used to measure the effect of any added water or N fertilizer. The contest control was Farm 11, which had no added N or irrigation and produced 137 bushels/acre. The farm with the highest efficiency for this year with a WNIPI of 0.289 was the UNL Science Team. Since UNL is not eligible to win awards, the winner of the most efficient award was Farm 7. This farm applied 160 pounds of N/acre and 9.5 inches of irrigation water resulting in a yield of 273.8 bushels/acre. Agronomic Efficiency (AE) measures the effect each added pound of N has on yield in terms of bushels. Farm 7 yielded 129.8 bushels/acre more than the control Farm 11. When the yield difference is divided by the amount of additional applied N fertilizer, 160 pounds/acre, the AE is calculated to be 0.81. This is much higher compared to the average of 0.57 bushels/pound of N of all other farms, except the control farm. On average, Farm 7 produced 0.81 bushels for every pound of N fertilizer applied. Irrigation Water Use Efficiency, (IWUE), is measured in a similar manner, except pounds of N are replaced with acre-inches of applied water. Farm 7's IWUE was calculated to be 13.7 bushels/acre-inch. The overall average was 12.3 bushels/acre-inch. To contrast these results, the least efficient Farm 15 applied 310 pounds of N/acre and about 3.2 inches-acre of irrigation, with a resulting yield of 178.6 bushels/acre. These levels of application and productivity resulted in a WNIPI of 0.028, AE of 0.11 bushels/pound, and an IWUE of 10.81 bushels/acre-inch. The large difference in performance between the two farms was likely due to the small amount of irrigation used for Farm 15 (3.2 inches/acre) as compared to Farm 7 (9.5 inches/acre), and as illustrated in Figure 9B. It is likely that the water limited the plants' ability to create yield, but also its effectiveness to use the added N. Plainly, efficiency is as much about balance as conservation. Too much of any input is wasteful, while too little can also be costly since it leaves other already applied nutrients unused and potentially lost.

PROFITABILITY

Revenue Per Acre

Revenue per acre is the product of grain price per bushel times bushels per acre sold. Quantity and value of bushels are essential in increasing total revenue.

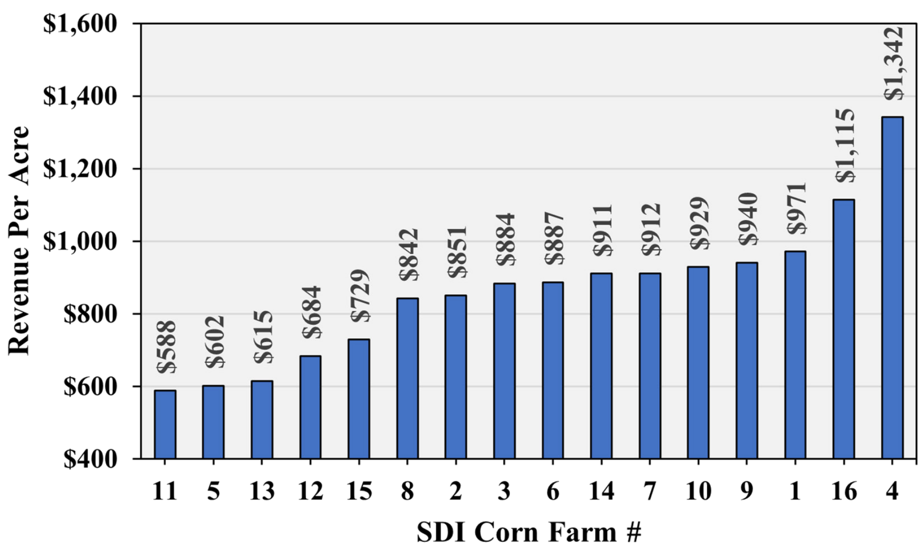

Figure 17. Revenue per acre received for the individual subsurface drip irrigated corn competition teams.

Revenue ranged from a low of $588/acre, Farm 11, to a high of $1,342/acre, Farm 4 (Figure 17). The top two farms had revenue in excess of $1,000/acre. Unlike many of the TAPS outcomes, where the winner usually has a moderately high yield, this contest had a winner with a less than average yield. This was

	Revenue/Acre			Revenue/ Bushel			Yield/Acre	
Farm #	Rank	$/Acre	**Farm #**	Rank	Cost/Bu	**Farm #**	Rank	Bushels/Acre
4	1st	$1,341.76	**4**	1st	$5.05	**16**	1st	285.3
16	2nd	$1,115.08	**15**	2nd	$4.08	**7**	2nd	273.8
1	3rd	$971.08	**8**	3rd	$4.08	**10**	3rd	267.3

Table 6. Revenue comparisons based on per acre and per bushel calculations, as well as yield for the subsurface drip irrigated corn competition.

primarily due to a successful marketing strategy and capturing an average price of $5.05/bushel, almost a dollar higher than the next best price of $4.08/bushel.

Per acre farm revenues were ranked in descending order, including top three Farms 4, 16, and 1, all listed in Table 6. The top three revenue per acre farms, except Farm 4, did not have the highest per bushel value, as can be seen in the center section of Table 6. Farm 16 ranked 7th and Farm 1 ranked 5th in revenue per bushel. In comparison to other farms, it is the combination of yield and per bushel value that helped achieve the top tier of revenue per acre. Farm 16 was the only one to rank in the top three yielding and top three in revenue per acre. It was Farm 4, however, where the value per bushel brought the revenue per acre to the top-most level, despite ranking 4th in yield. These farms produced larger quantities per acre in comparison to others. The farms with the highest sales price or revenue per bushel were not those with the most revenue per acre.

Cost Per Acre

Like revenue, cost has a relationship with yield. Mathematically, cost per bushel is derived by dividing acre cost by acre yield. Naturally, there is an expected relationship between cost and productivity. Productivity is dependent on physical conditions, which can be augmented or changed by the addition or use of varying practices, inputs, or resources, such as fertilizer, water, herbicides, etc. The addition of inputs and resources is expected to increase productivity; if not, then cost would increase without any change in productivity, and this is one of the reasons why farms have varying costs. It should be remembered that not all resources are equal in their ability to increase productivity and that usefulness of most inputs has a limit of practicality and will diminish in potency if over-used.

The lowest cost per acre was achieved by Farm 11 at $649/acre (Figure 18). The highest

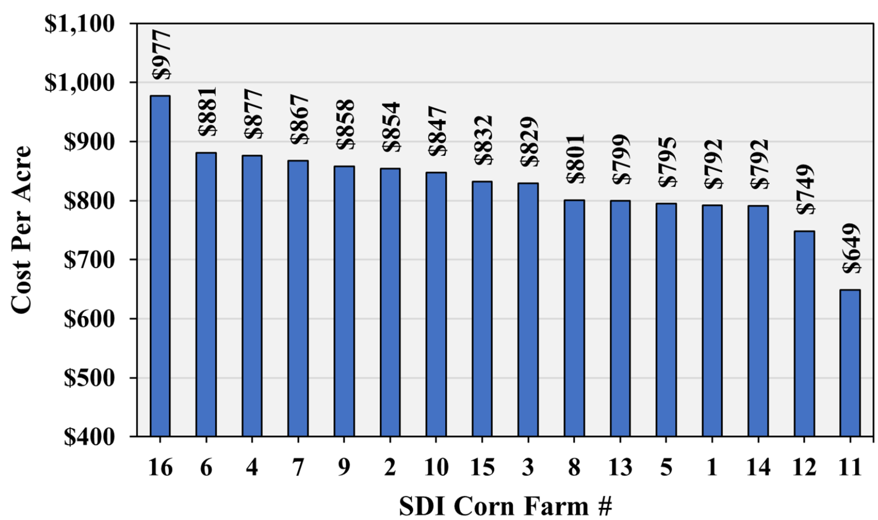

Figure 18. Cost per acre received for the individual subsurface drip irrigated corn competition teams.

Farm #	Costs/Acre Rank	$/Acre	Farm #	Costs/Bushel Rank	Cost/Bu	Farm #	Yield Rank	Bu/Acre
11	1st	$648.90	**7**	1st	$3.17	**16**	1st	285.3
12	2nd	$748.62	**10**	2nd	$3.17	**7**	2nd	273.8
14	3rd	$791.53	**9**	3rd	$3.30	**10**	3rd	267.3
			11	14th	$4.50	**11**	16th	144.0

Table 7. The top three listing of costs per acre, per bushel and yield per acre calculations, as well as yield for the subsurface drip irrigated corn competition.

cost per acre was Farm 16 at $977/acre. The average cost of producing an additional bushel per acre on all farms was $2.32/bushel, meaning a single dollar per acre of added cost would produce an additional 0.43 bushels/acre.

The lowest per acre cost farms were Farms 11, 12, and 14 (Table 7). For Farm 11 to achieve lowest cost per bushel at $3.17/bushel, their operation would have needed to either 1) Yield nearly 61 bushels more or 2) Reduce cost by $192.63/acre. Control Farm 11 received no added N fertilizer or irrigation water during the TAPS growing season, resulting in low overall costs, as well as lowest productivity. Consequently, very high per unit cost occurred at $4.50/bushel on control Farm 11, as seen in the middle section of Table 2, which is $1.34/bushel more than Farm 7.

Profit Per Acre

The top ranked Farm 4 profited $465/acre, $286/bushel more than the 2nd ranked team (Figure 19). The per bushel cost for the winning farm was $0.32/bushel higher than 2nd place. The average price received per bushel sold was about $0.97/bushel more, thus having a huge impact on profit. The winning farm had an average yield that exceeded the 2nd farm by 27.73 bushels/acre.

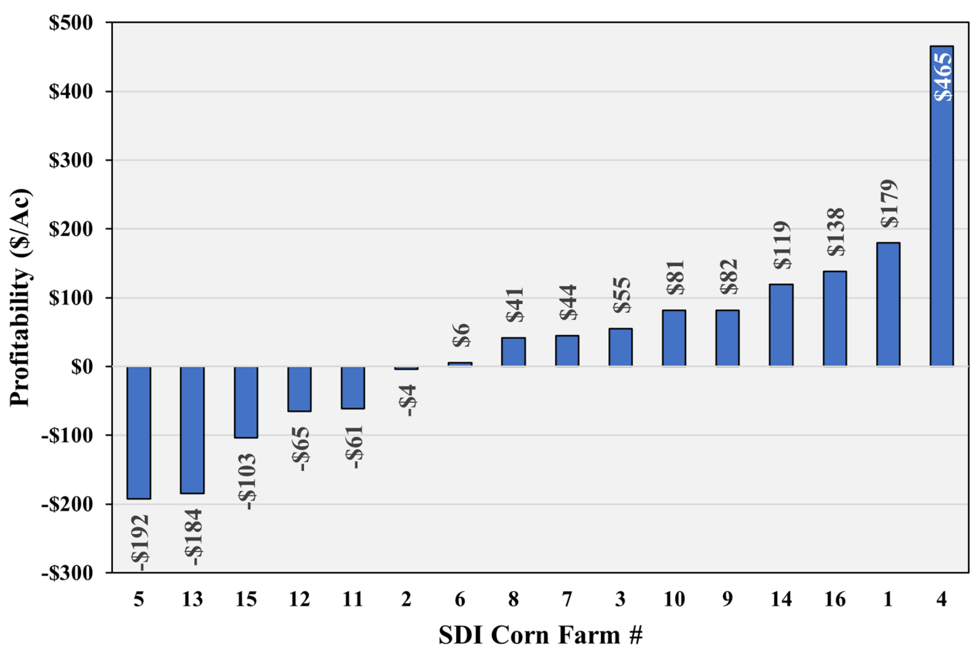

Figure 19. Profit per acre received for the individual subsurface drip irrigated corn competition teams.

Profit/Acre			Profit/Bushel			Yield/Acre		
Farm #	Rank	$/Acre	**Farm #**	Rank	Profit/Bu	**Farm #**	Rank	Bu/Acre
4	1st	$465.23	**4**	1st	$1.75	**16**	1st	285.3
1	2nd	$179.40	**1**	2nd	$0.75	**7**	2nd	273.8
16	3rd	$137.99	**14**	3rd	$0.53	**10**	3rd	267.3

Table 8. The top three listing of profit per acre, per bushel and yield per acre for the subsurface drip irrigated corn competition.

The top three profit per acre farms ranked in ascending order are Farms 4, 1, and 16 (Table 8). These three farms, while having different ranking order, are also within the top three of revenue per acre, found in the far-left section of Table 6. The most profitable farms had market prices that ranged from a low of about $3.91/bushel to a high of nearly $5.05/bushel. The 16 farms' lowest price was near $2.54/bushel and ranged to a high of $5.05/bushel. The top ranked profit winner, Farm 4, won largely due to the extraordinarily high price received through their use of the futures market. Farm 1 was successful in competing, due to their combination of above average yield in an additional 8.0 bushels/acre, above average marketing at $4.08/bushel, and below average cost by about $0.34/bushel. In 3rd place, Farm 16 did well, due to having best yield, a market price nearly $0.15/bushel higher than average, and cost incurred at about $0.25/bushel less than average.

The most profitable Farm 4 had an average yield of 265.7 bushels/acre and an average grain price of $5.04/bushel, which led to the highest per acre revenue of $1,341.76/acre. This farm had $876.53/acre cost, making cost $3.30/bushel. The difference between revenue and cost amounted to $465.23/acre, more than double that of the next most profitable farm. Much of the profit was due to using futures contracts and by going short and long numerous times during the season, selling high and buying low. Other competitors who used futures contracts only did so once and resulted in loss. There was enough variability in the market that the ups and downs provided room to create a positive profit. This is risky, however, if the market is in a completely downward trend. In summary, this team focused on efficiency, not productivity, as their cost per bushel was the 3rd lowest and yield was 4th highest, but the team was outstanding in their marketing strategy.

Photo 3. The Greatest Grain Yield Award of 285.3 bushels/acre was grown by Lorn Dizmang of Dizmang Ag of Moorefield, NE. He chose to plant Pioneer P1082AM at a population of 32,000 seeds/acre.

Photo 4. The Highest Input Use Efficiency Award was presented to the Tri-Basin Water Watchers from Holdrege, NE. Team members included Pat Nott, Chris Ecklun, Reed Philips, Rick Reinsch, & Curtis Scheele. The group planted Dekalb DKC70-27 at a seeding rate of 34,000 seeds/acre and applied 160 pounds/acre of N and 9.5 inches/acre of irrigation water.

Photo 5. The Rattlesnake Boys from Wood River, Nebraska, won the Most Profitable Award. The team included Kevin and Amy Harsch, Jay Johnson, and Jeremy Gewecke. The group planted Pioneer P1082AM at 33,000 seeds/acre. They applied 120 pounds of N and 8.05 inches of irrigation water, which led to a yield of 265.7 bushels/acre. The group's average revenue of $5.05/bushel was the driving factor in winning the top award in the 2020 SDI Corn competition.

SPRINKLER SORGHUM COMPETITION

The 2020 sprinkler sorghum competition, in its 3rd year, had 12 teams, including 10 farmers from throughout the state of Nebraska, as well as a team of UNL Educators, and the control farm.

Growing Conditions

As in past years, each team had three randomized plots, (Figure 6), located at the intersection of Highway 83 and State Farm Road in North Platte, NE. North Platte has a semi-arid climate with 80% of annual precipitation occurring between late-April and mid-October (Payero et al., 2009). The predominant soil type at the site is a Cozad silt loam with approximately 1.5 inches/foot of lab-estimated plant available water (i.e., difference between field capacity and permanent wilting point). The 2020 growing season received well-below normal rainfall with 6.3 inches from planting (May 29) to harvest (November 4) of which 85% occurred during the vegetative growth period (i.e., prior to flowering). Furthermore, 2020 experienced warm temperatures with average maximum daily temperatures exceeding 88.8°F for the months of June, July, and August.

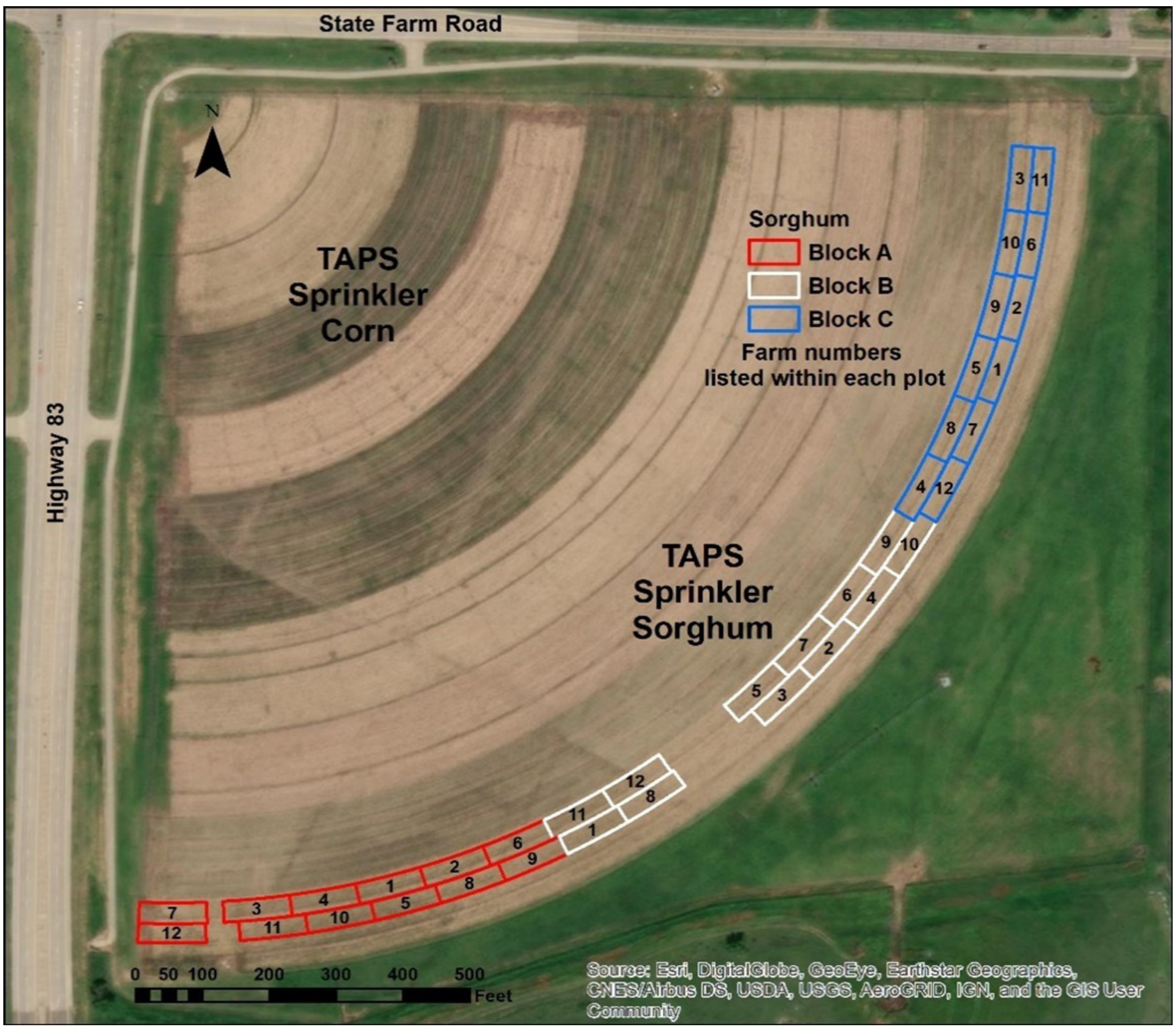

Figure 20. Farm numbers for the 2020 Sorghum Farm Management Competition held at the West Central Research, Extension, and Education Center in North Platte, NE. Each team was assigned a randomized plot in blocks A, B, and C.

			Nitrogen Fertilizer									
Farm	Hybrid	Seeding Rate	Apr 27	Jul 01	Jul 08	Jul 17	Jul 30	Total	Irrigation	Grain Yield*	Profit	WNIPI**
#	Name	(1,000/ac)	------------------------ (lbs/ac) ------------------------						(in)	(bu/ac)	($/ac)	(-)
1	Channel 6B55	92	40	30	30	30	30	160	9.7	167.7	105.85	0.144
2	Arrow 292	95	100	30	30	30	30	220	2.6	126.1	138.01	0.059
3	Channel 6B55	85	0	0	0	0	0	0	0.0	102.4	139.02	-
4	Dekalb DKS37-07	85	90	30	0	25	25	170	3.6	156.7	126.44	0.152
5	Pioneer 86P33	110	75	30	10	30	0	145	5.7	156.0	53.33	0.150
6	Dekalb DKS37-07	80	125	25	20	0	10	180	6.5	148.7	127.84	0.109
7	Channel 6B60	85	50	30	30	30	20	160	7.2	150.3	2.96	0.118
8	Channel 6B55	90	75	0	0	30	30	135	7.4	170.6	161.69	0.184
9	Pioneer 84P72	85	120	30	0	25	25	200	7.4	168.7	113.75	0.139
10	Dekalb DK45-23	90	140	0	30	0	30	200	8.6	159.4	278.39	0.114
11	Channel 6B55	90	60	20	20	30	30	160	8.5	160.8	130.80	0.136
12	Channel 6B55	110	110	0	0	30	30	170	9.6	176.5	84.57	0.158

*Reported as 14% grain moisture content. ** Water Nitrogen Intensification Performance Index (WNIPI, Lo et al., 2019)

Table 9. Summary of select inputs, costs, outputs, and profit from the 2020 TAPS sprinkler sorghum competition.

Participant Decisions

Participants were responsible for making economic and production management decisions, including insurance coverage, hybrid type, seeding rate, nitrogen and irrigation amount and timing, and marketing, as discussed in more detail above. These decisions were submitted via a form through an online portal that time-stamped all decisions. These decisions are summarized below.

Agronomic Decisions

Seven sorghum hybrids were selected from four seed companies (Table 9, column 2). Channel 6B55 was the participant favorite, planted by five of the 12 farms. Channel 6B60 had the lowest cost per bag at $104 and Arrow 292 had the highest cost per bag at $162. The lowest seeding rate, 80,000 seeds/acre, was planted by Farm 6 with the Dekalb DKS37-07 hybrid. The highest seeding rate, 110,000 seeds/acre, was planted by Farms 5 and 12 with Pioneer 86P33 and Channel 6B55, respectively (Table 8, column 3). Farms 8 and 11 planted Channel 6B55 at 90,000 seeds/acre and had the lowest cost/acre at $15.84.

The total N fertilizer applied, not including the control (Farm 3), ranged from 135 to 220 pounds/acre (Table 9, column 9). On average, 51% of N was applied at pre-plant with the remaining 49% applied over the four fertigation events with 12%, 9%, 14%, and 14% applied on July 1, 8, 17, and 30, respectively.

Farm 1 started irrigating at the 3-leaf growth stage on June 8 with 0.5 inches applied. The majority of teams, however, waited an additional 21 days or more and initiated irrigation on June 29 or July 1 (first fertigation option). Excluding the control (Farm 3), seasonal irrigation ranged from 2.6 (Farm 2) to 9.7 inches (Farm 1), (Table 9, column 10). The average seasonal irrigation was 7.4 inches, while the median was 7.0 inches. The average depth of irrigation per event, excluding fertigation, was 0.77 inches/acre.

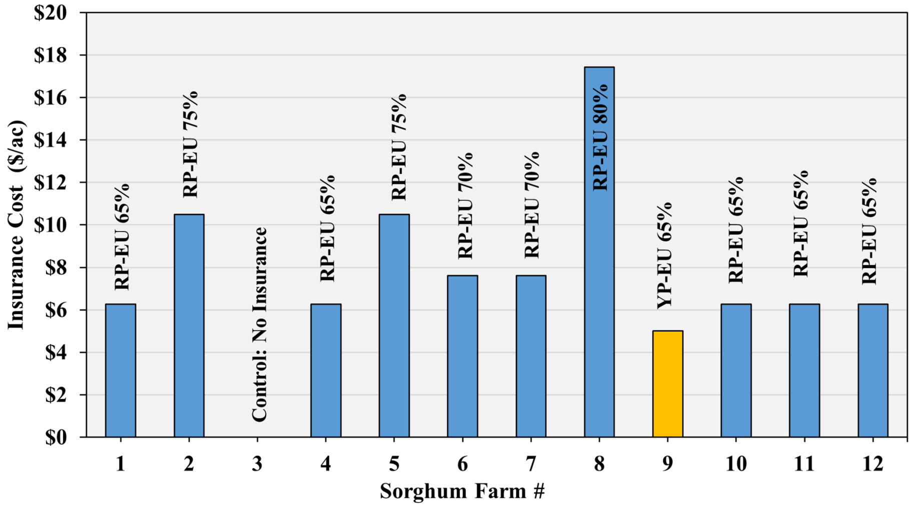

Figure 21. Insurance cost ($/acre) for the individual sprinkler irrigated sorghum competition teams. Policies offered included Revenue Protection (RP), Revenue Protection with Harvest Price Exclusion (RP-HPE, and Yield Protection (YP) with either Enterprise Units (EU) or Operational Units (OU). The yellow and blue bars represent Yield Protection and Revenue Protection, respectively.

Economic Decisions

Unlike previous TAPS competitions, participants were required to select a multi-peril crop insurance policy with at least 65% coverage. There were no hail or wind insurance options available. Most competitors chose Revenue Protection (RP) policies except for Farm 9, which selected a Yield Protection (YP) policy (Figure 21). All farms applied Enterprise Units (EU) to their policies, which includes all fields of the same crop for that enterprise. The most common policy, selected by five participants, was RP-EU at 65% coverage ($6.27/acre). The average cost across all competitors was $8.18/acre. The least expensive policy was YP-EU at 65% coverage ($5.01/acre), Farm 9, and the most expensive was RP-EU at 80% coverage ($17.44/acre), Farm 8.

Contestants could market expected production, trend adjusted Average Production History (APH), from March 1 through November 30. The high prices were observed at the beginning of the contest in early March and again at the end of the marketing window. This is abnormal, given prices typically peak between March and July, and are lowest during harvest. Farms 2, 3, and 10 sold all grain as cash sales on November 30. Farm 11 used all basis contracts, and the remaining teams used a combination of two methods. Of all sorghum production, 42% was sold via cash contracts, followed closely by 39% basis contracts, and 20% forward contracts. These marketing decisions led to average prices received from $3.75 to $5.50/bushel (Figure 22).

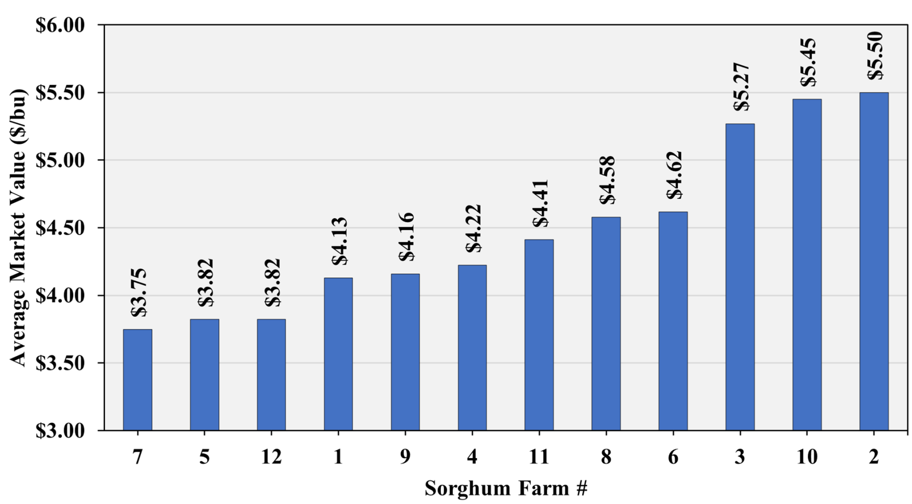

Figure 22. Average market value received ($/bushel) for the individual sorghum competition teams.

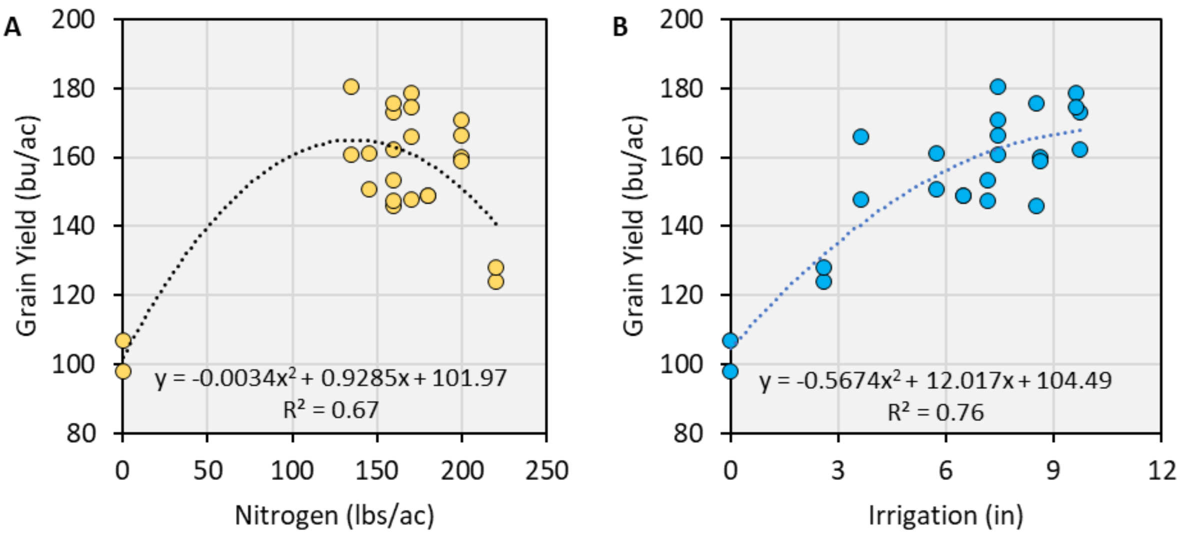

Figure 23. Sorghum grain yield response to seasonal total nitrogen fertilizer (A) and irrigation (B) at the WCREEC in North Platte, NE. The most efficient farm as measured by the Water Nitrogen Intensification Performance Index (WNIPI) is denoted in red.

Team 2 sold all grain at the end of November and received the highest price of the season at $5.50/bushel. The average price/bushel received among all 12 teams was $4.48.

RESULTS AND RANKINGS

Grain Yield

Sorghum grain yields ranged from a low of 102.4 bushels/acre to a high of 176.5 bushels/acre (Table 9, column 11). Excluding the control, the average yield was 158 bushels/acre, which was nearly identical to the 2019 average. Eight of the 12 farms exceeded the field's APH of 155 bushels/acre. There was no observable advantage for any specific hybrid. Figure 23A shows the response of grain yield to N application. Including the control (0 pounds of N/acre), a diminishing effect of N after the addition of 136.5 pounds of N/acre was observed. On the other hand, grain yield had a strong response to irrigation with seasonal irrigation explaining 76% of yield variability (Figure 23B). The equation below suggests that the estimated optimal use of water was nearly 10.6 inches/acre. Each inch of added irrigation yielded an average of 8.0 bushels/acre of grain sorghum.

Input Use Efficiency

The Water Nitrogen Intensification Performance Index (WNIPI), (Lo et al., 2019), was used to quantify input use efficiency and is reported in the last column in Table 9. It compares the effect of N and irrigation input on grain yield with respect to a control treatment. The control is a baseline and is used to measure the effect of any added water or N fertilizer. The control Farm 3 had no added N or irrigation and produced 102.4 bushels/acre of sorghum. Farm 8 had the highest efficiency this year with a WNIPI of 0.184 and earned the most efficient award. This farm applied 135 pounds of N/acre and 7.4 inches of irrigation water, resulting in a yield of 170.6 bushels/acre. Agronomic Efficiency (AE) measures the effect each added pound of N has on yield in terms of bushels. Farm 8 yielded 68.2 bushels/acre more than the control Farm 3. When the yield difference is divided by the amount of additional applied N fertilizer, 135 pounds/acre, the AE is calculated to be 0.50. This is much higher compared to the average of 0.33 bushels/pound of N of all other farms except the control farm. On aver-

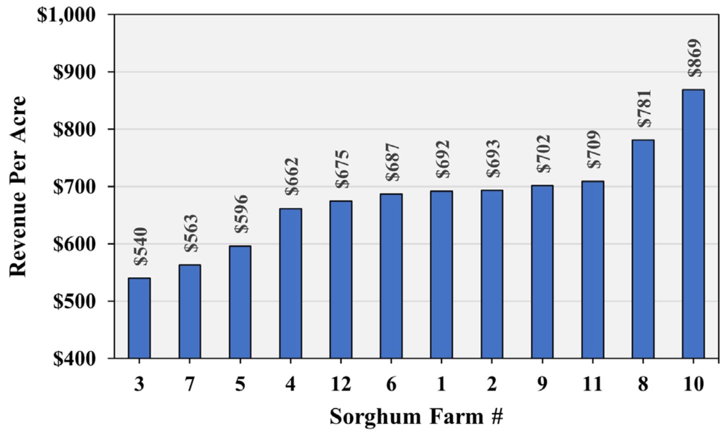

Figure 24. Revenue per acre received for the individual sprinkler irrigated sorghum competition teams.

age, Farm 8 produced 0.50 bushels for every pound of N fertilizer applied. Irrigation Water Use Efficiency, (IWUE), is measured in a similar manner, except pounds of N are replaced with acre-inches of applied water. Farm 8's IWUE was calculated to be 9.2 bushels/acre-inch. The overall average was 8.35 bushels/acre-inch. To contrast these results, the least efficient Farm 2 applied 220 pounds of N/acre and about 2.6 inches-acre of irrigation, with a resulting yield of 126.1 bushels/acre. These levels of application and productivity resulted in a WNIPI of 0.059, AE of 0.11 bushels/pound, and an IWUE of 9.0 bushels/acre-inch. The large difference in performance between the two farms was likely due to the small amount of irrigation used for Farm 2 (2.6 inches/acre), as compared to Farm 8 (7.6 inches/acre), and as illustrated in Figure 23B. It is likely that the water limited the plants' ability to create yield, but also its effectiveness to use the added N. Plainly, efficiency is as much about balance as conservation. Too much of any input is wasteful, but too little can also be costly since it leaves other already applied nutrients unused and potentially lost.

PROFITABILITY

Revenue Per Acre

Revenue per acre is the product of grain price per bushel times bushels per acre sold. Quantity and value of bushels are essential in increasing total revenue.

Revenue ranged from a low of $539.91/acre, Farm 3, to a high of $868.69/acre, Farm 10 (Figure 24). Unlike many of the TAPS outcomes, where the top three had moderately high yields, this contest had a participant with the lowest yield, Farm 3, ranked 3rd most profitable. This was due to also having the lowest input cost per acre, about $400/acre, and a high market value of $5.27/bushel, the 3rd highest price.

Only one of the top three yielding farms, Farm 8, was in the top revenue per acre category, and none of the top three revenue per bushel farms were ranked in the top three per acre revenue category (Table 10). The other two top farms, Farms 10 and 11, were ranked 5th and

Revenue/Acre			Revenue/Bushel			Yield/Acre		
Farm #	Rank	$/Acre	**Farm #**	Rank	$/Bushel	**Farm #**	Rank	Bu/Ac
10	1st	$868.69	**2**	1st	$5.50	**12**	1st	176.5
8	2nd	$781.08	**10**	2nd	$5.45	**8**	2nd	170.6
11	3rd	$709.08	**3**	3rd	$5.27	**9**	3rd	168.7

Table 10. Revenue comparisons based on per acre and per bushel calculations, as well as yield for the sprinkler irrigated sorghum competition.

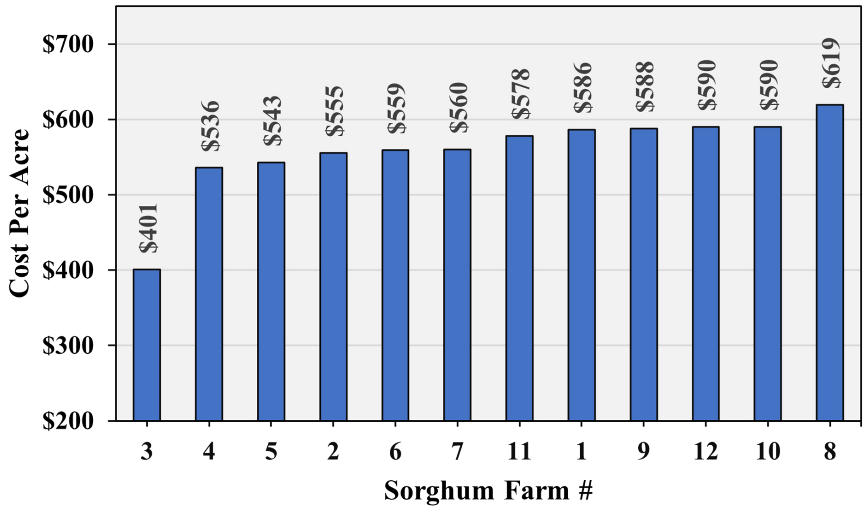

Figure 25. Cost per acre received for the individual sprinkler irrigated sorghum competition teams.

6th in yield. Farms 2 and 3, which received two of the top three grain prices in the competition, had the two lowest yields. Low yields kept these two farms from being in the top three revenue per acre farms. Farm 2 was ranked 5th and Farm 3 was ranked 12th in revenue per acre. If Farm 2 had produced approximately 32 bushels/acre more, about 19 bushels/acre less than the top producing farm, this farm would have earned the leading revenue per acre title. This clearly illustrates the key role both price and productivity play in the generation of revenue.

Cost Per Acre

Like revenue, cost has a relationship with yield. Mathematically, cost per bushel is derived by dividing acre cost by acre yield. Naturally, there is an expected relationship between cost and productivity. Productivity is dependent on physical conditions, which can be augmented or changed by the addition or use of varying practices, inputs, or resources, such as fertilizer, water, herbicides, etc. The addition of inputs and resources is expected to increase productivity; if not, then cost would increase without any change in productivity, and this is one of the reasons why farms have varying costs. It should be remembered that not all resources are equal in their ability to increase productivity and that usefulness of most inputs has a limit of practicality and will diminish in potency if over-used.

The lowest cost was achieved by Farm 3 at $400.89/acre (Figure 25). The highest cost was Farm 8 at $619.39/acre. The average cost of producing an additional bushel per acre on all farms was $2.95/bushel, meaning a single dollar per acre of added cost would produce an additional 0.34 bushels/acre.

The lowest per acre cost farms were Farms 3, 4, and 5 (Table 11). Farms 4 and 5 also ranked among the three lowest cost per bushel farms.

Costs/Acre			Costs/Bushel			Yield/Acre		
Farm #	Rank	$/Acre	**Farm #**	Rank	Cost/Bu	**Farm #**	Yield Rank	Bu/Ac
3	1st	$400.89	**12**	1st	$3.34	**12**	1st	176.5
4	2nd	$535.56	**4**	2nd	$3.42	**8**	2nd	170.6
5	3rd	$542.99	**5**	3rd	$3.48	**9**	3rd	168.7

Table 11. The top three listing of costs per acre, per bushel and yield per acre. The top three listing of costs per acre, per bushel and yield per acre calculations, as well as yield for the sprinkler irrigated sorghum competition.

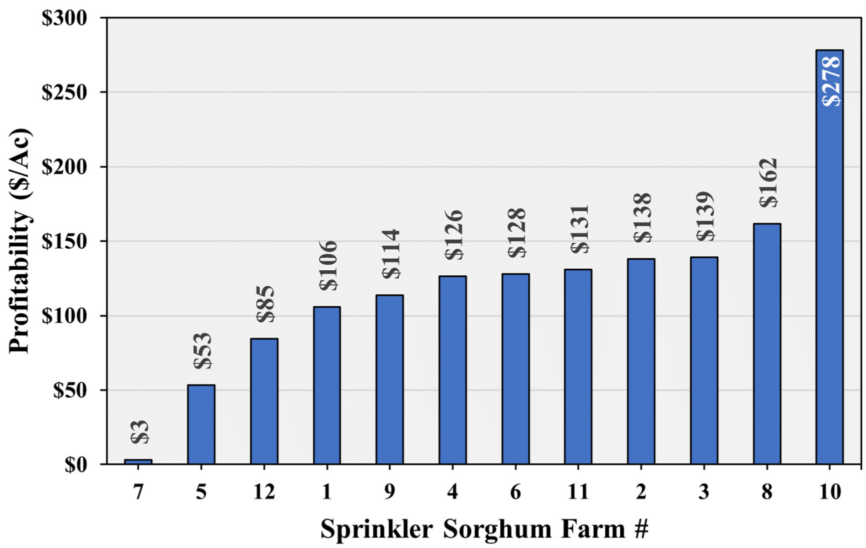

Figure 26. Profit per acre received for the individual sprinkler irrigated sorghum competition teams.

This indicates that their yields, compared to other farms, were sufficient to maintain their ranking between per acre and per bushel costs.

Profit Per Acre

The top ranked Farm 10 profited $278.39/acre, $116.70/bushel more than the 2nd ranked team (Figure 26). Factors that determine profitability established that high revenue, due to above average yield and the 2nd highest price received at $5.45/bushel, led to this achievement. The per bushel cost for Farm 10 was $0.07/bushel higher than 2nd place Farm 8. The average price received per bushel sold was about $0.83/bushel more, the difference having a positive impact on profit. The winning farm had an average yield of 11.2 bushels/acre less than 2nd place Farm 8.

The top three profit per acre farms ranked in descending order were Farms 10, 8, and 3 (Table 12). Farms 8 and 10 ranked the same as they did in revenue per acre. Market prices ranged from $3.75/bushel for Farm 7 to $5.50/bushel for Farm 2. Farm 2 had the highest price per bushel but dropped to 5th place in revenue per acre, due to low yield, emphasizing the importance of productivity. Table 9 provides a visual representation of the per acre factors for all teams, including cost, revenue, and profit.

The most profitable Farm 10 had an average yield of 159.4 bushels/acre and an average grain price of $5.45/bushel, which led to the highest per acre revenue of $868.69/acre. This farm had $590.08/acre cost, making cost $3.70/bushel. The difference between revenue and cost amounted to $287.39/acre, over $116/acre more than the next most profitable farm. This farm had higher input levels than others, but lower production than the 2nd ranked farm. A strategic point of view alludes that they intended to have a higher level of production. It was the marketing, however, that made the difference in comparison to the 2nd place Farm 8 since their grain was sold for a much higher value.

Profit/Acre			Profit/Bushel			Yield/Acre		
Farm #	Rank	$/Acre	**Farm #**	Rank	Profit/Bu	**Farm #**	Rank	Bu/Ac
10	1st	$278.39	**10**	1st	$1.75	**12**	1st	176.5
8	2nd	$161.69	**3**	2nd	$1.36	**8**	2nd	170.6
3	3rd	$139.02	**2**	3rd	$1.09	**9**	3rd	168.7

Table 12. The top three listing of profit per acre, per bushel and yield per acre for the sprinkler irrigated sorghum competition.

AWARD RECIPIENTS

Photo 6. The Greatest Grain Yield Award of 176.5 bushels/acre was grown by Marc Rasmussen of Cambridge, NE. He chose to plant Channel 6B55 at a population of 110,000 seeds/acre.

Photo 7. The Highest Input Use Efficiency Award was presented to Scott Jewett from Holdrege, NE. Scott planted Channel 6B55 at 90,000 seeds/acre and applied 135 pounds/acre of N and 7.43 inches/acre of irrigation water.

Photo 8. Paul Hoyt from Culbertson, Nebraska, won the Most Profitable Award. Paul planted Dekalb DK45-23 at 90,000 seeds/acre. He applied 200 pounds of N and 8.63 inches of irrigation water, which led to a yield of 159.4 bushels/acre. Paul's average revenue of $5.45/bushel was the driving factor in winning the top award in the 2020 sorghum competition.

CONCLUSION

In this year of unusual challenges, the TAPS team is greatly appreciative to have hosted these competitions. Although unable to have many of the in-person events, we appreciate the many partners and sponsors, who continued their substantial and needed support of the program, as well as the many participants, who have been great sports and maintained an active and positive part in the contest. We recognize the enduring spirit of community during a time of so much adversity and continue to be grateful for everyone's understanding and patience, as impromptu changes and modifications were made to the program and schedule. The 2020 competitions provided another year of valuable data in a year that was drastically different than normal. The circumstances offered participants an unusual opportunity to benchmark and reflect on their use of available information, effectiveness and performance of technologies, management practices, and strategies under stressful conditions. We extend our congratulations to everyone involved in this year's success and applaud the 2020 winners.

At the closing of this contest year, we acknowledge the Nebraska Farmer and Tyler Harris, who were selected to receive the "Outstanding TAPS Advocate Award." This award honors a person, group, or business, who advocated for the TAPS program, either behind the scenes or publicly. We are grateful for Tyler's years of featuring the TAPS program in the Nebraska Farmer publication and consequential impact.

ACKNOWLEDGEMENTS

The TAPS program continues to be successful due to the commitment and support provided by our participants, partners, and sponsors (Figures 1 and 2). The 2020 competitions were supported through the following grants: USDA-NRCS Conservation Innovation Grant under award number NR203A750013G011, Nebraska Corn Board under award number 88-R-1819-10, National Sorghum Checkoff under award number CI001-20, and the Nebraska Sorghum Board.

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