RESULT DEMONSTRATION/PERFORMANCE REPPORT

PROJECT INFORMATION

Project Title	Evaluating Strawberry Varieties Statewide to increase Producer Competitiveness and Publish Updated Production Guides and Online Training Modules From Current Texas Research			
Recipient Organization Name:	Texas A&M AgriLife Extension			
Period of Performance:	**Start Date:**	10/1/2020	**End Date:**	9/30/2022
Recipient's Project Contact				
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PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Provide enough information for the reader to understand the importance or context of the project. This section may draw from the background and justification contained in the approved project proposal.

Texas A&M AgriLife Extension, Texas Tech University, Prairie View A&M University, the Poteet Strawberry Festival Association, the Poteet Rotary Club, and Texas strawberry growers collaborated on this research project to increase the sustainability and profitability of Texas-grown strawberries. Through this research and subsequent training, we observed an upsurge (estimated about 15%) in grower numbers and acreage in the state. This project evaluated first, improved fertilizer strategies using four grower-selected varieties through soil and yield analyses combined with plant gas exchange measurements (photosynthesis using LiCor 6400 XT Portable Photosynthesis Instruments) to determine water use efficiency under two diverse Texas climates. Second, we reevaluated herbicides/rates to submit potential candidates for 24C Special Local Needs registrations. Third, we evaluated planting dates by variety to evaluate plant growth and determine positive or negative yield effects. Fourth, we evaluated two general strawberry types (June-bearing vs. day-neutral) using low tunnels with shade cloth to determine potential season extension and the effects on plant growth and fruit quality. Fifth, we held annual outreach programs (workshops, on-farm field days, and online training programs) for growers, agents and specialists, and other stakeholders. Sixth, we evaluated four irrigation levels for plant growth and total soil nitrogen in the root zone, and effects on yield. Trials were conducted at the Texas A&M AgriLife (Lubbock), the Prairie View A&M University Research Farm, and on a grower's farm (KH Farm) located in Poteet. Throughout our project we collected berry counts, plant vigor ratings, soil nutrient analyses, and plant carbon assimilation/photosynthesis, transpiration, etc. in response to selected treatments. Our data was analyzed, summarized, and reported through our quarterly reports to TDA, as well as summarized for our producers and collaborators for instruction at workshops, field days, websites, and news releases. Finally, we are currently in the process of writing three peer-review articles.

ACTIVITIES PERFORMED

Address the below sections as they relate to the entire project's period of performance.

OBJECTIVES

Provide the approved project's objectives.

#	Objective	Completed?	
		Yes	No*
1	To improve fertilizer strategies by variety using soil analyses combined with plant gas exchange measurements (carbon assimilation, transpiration, etc.) using LiCor 6400 XT Portable Photosynthesis Instruments to determine strawberry variety water use efficiency, and best management practices in the diverse Texas climates.	Yes	
2	To reevaluate herbicides/rates to potentially submit candidates for 24C Special Local Needs registrations, and train growers on using herbicides.	Yes	
3	To evaluate planting dates by variety for overall growth and yield.	Yes	
4	To evaluate strawberries using low tunnels with shade cloth for extended plant growth and fruit quality.	Yes	
5	To continue with annual outreach and trainings for growers, agents and specialists through workshops, on-farm field days, and online training programs.	Yes	
6	To evaluate irrigation levels for plant growth and total soil nitrogen in the root zone.	Yes	

**If no is selected for any of the listed objectives, you must expand upon this in the challenges and lessons learned sections.*

ACCOMPLISHMENTS

List your accomplishments for the project's period of performance, including the impact they had on the project's beneficiaries, and indicate how these accomplishments assist in the fulfillment of your project's objective(s), outcome(s), and/or indicator(s).

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	For Objective 1, soil fertility trials were conducted and completed both years at two sites including Lubbock and Poteet (grower's field). Plant vigor, total yield and quality data were collected. Analysis indicated that yield performance (weight and quality) by fertilizer rate was dependent on variety. In both years, *Albion* and *Merced* had higher yields at lower nitrogen rates (60 lbs N/A) compared to *Camino Real* and *Fronteras*. *Camino Real* and *Fronteras* required higher nitrogen rates (120 lbs N/A) to achieve higher yields. Overall, our assessment for Texas growers to be aware of variety selection when applying fertilizer. Although we only investigated four varieties, more research into the impact of fertilizers in Texas production is needed. Understanding specific variety responses more or less fertilizer while maintaining optimal yields will save on fertilizer costs and reduce potential nitrogen leaching into Texas soils.	Objective 1 fertilizer trial was relevant to Outcome 5 and Indicators 1, 2, 6 and 8. For Indicator 1, growers were instructed on adapting their soil fertility needs to selected varieties. Most growers indicated that they were not aware of the different varietal responses. In some cases, it was determined that they may be under- or over-fertilizing crops. Indicator 2 (number of innovations adopted is one (adjusting fertilizer rates). Many planned to reevaluate their fertilization program and not plan for a single fertilization program for all their strawberry varieties. For Indicator 3, we believe that growers can increase their yields by as much as 15 – 20% by either decreasing or increasing nitrogen applications. This could account for increased corresponding revenues as well. For Indicator 8, the number of growers trained at our meetings was approximately 250. We also provided over 250 'Nutrient Management Guides for Texas Strawberries' at these meetings.
2	For Objective 2, weed control trials were conducted both years at Lubbock and Poteet, TX to determine whether selected products or tank-mixes support improved weed management in	Objective 2 weed control trial is relevant to Outcome 5, and is relevant to Indicators 1, 2, 3, 6 and 8. While we did not find potential candidates for an additional 24C label, we did demonstrate

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	Texas, including potential 24C labeling. During both years, weed control was influenced by climate. At both locations, dry weather from an extended drought limited visual differences in weed populations and control treatments, thus, we had few weeds to rate. However, at both locations our research data suggests better control with no crop injury when preemergence applications of Prowl H2O (2.0 pints/A) was combined with Spartan 4F (6.0 – 8.0 oz/A). Yield response at Lubbock indicated where this tank-mixture was applied, yields increased an average 15% compared to the weedy check. We also evaluated SelectMax herbicide for postemergence grass control. There was no related crop injury with this treatment. Several growers indicated that SelectMax applications saved their crop from severe grass infestations and saved significantly on handweeding costs. These treatments resulted in a significant impact on many growers who now are starting to include herbicides in their production practices in order to reduce hand-weeding costs. Therefore, our new recommendations in the state for strawberries are (combined with handweeding) an application of Spartan 4F + Prowl H2O preemergence followed by in-season applications of SelectMax for grass control (as needed).	the benefits of current products for growers. For Indicator 1, we believe that significantly more growers are including herbicide technology to improve their overall production and cost efficiency. While handweeding strawberry crops will always be needed, less time spent hand hoeing significantly reduces labor costs. Successful weed control improves grower's product by increasing yield and berry quality, reducing time spent handweeding, and pulling weeds away from berries to be harvested. Adding herbicide technology to grower's field production is one of the four adoptions for Indicator 2. For Indicator 3, it is difficult to collect revenue associated data from growers as they are hesitant to share this with others. However, several growers indicated that handweeding costs were reduced by as much as $1,500 or more per acre. Across 400 acres statewide, this would be a savings of $600,000 in labor costs for handweeding. With less time spent handweeding, growers can accomplish other required farm tasks. Based on discussions with growers, we estimate that herbicide use is up by 30 - 40% in the state. For Indicator 6, we estimate that at least 250 first responders were trained on weed management techniques in strawberries. For Indicator 8, we estimate that all growers (250) gained knowledge about our science-based tools during our programs.
3	For Objective 3, we conducted five planting date trials during the project at three locations including Lubbock (2), Prairie View (2), and one KH Farm in Poteet. At all locations, four varieties (*Albion*, *Camino Real*, *Fronteras*, and *Merced*) were transplanted in the field beginning at the arrival of plants (mid-October) followed by two-week intervals ending in mid-November. At Prairie View, trials were severely damaged both years by the extreme low temperatures (February 2021 polar vortex), and in 2022 by severe high temperatures and drought. As a result, crop yield was extremely low, and we were unable to determine effects on yield. At Poteet, a single rep demonstration trial was planted at KH Farm, but a replicated trial was conducted at Lubbock. At both locations, ratings for early % green canopy cover showed an 18% and 33% decrease in plant growth when the varieties were planted two and four weeks after the first planting, respectively. At Lubbock, our results indicated that except for *Merced*, varieties	Objective 3 is relevant to our Outcome and all Indicators. For Indicator 1, our research demonstrated that the improved model of planting strawberries without delay increases yield and income. Many growers still struggled with being ready for planting when bare roots arrived, however, we demonstrated increased economic losses when fields and labor are not prepared in time and planting is delayed. At Poteet, there was a 100% good to fair increase in understanding the need for earlier planting. Indicator 2 includes innovations adopted. Our grower surveys indicated good acceptance and a high potential adoption (>90%) for this innovation. Based on one-to-one grower discussions, the adoption of this model is of extreme importance. At most meetings, planting date was a significant topic for discussion. For Indicator 3, the number of growers suggesting they would adopt this new model was high, generally over 90% (225), largely due to the fact that we demonstrated significant revenue losses

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	averaged a yield loss of 1.7% – 1.9% per day for every day planting was delayed. This accounted for potential lost revenues of up to $352 for each day planting was delayed. Interestingly, *Merced* had no yield loss regardless of planting date and showed more tolerance. As a result, we instructed growers at all our programs (conferences and field days) to always have beds ready for transplanting strawberries before the bare roots arrive from California. The loss of revenue had a critical impact on growers as determined by our surveys. On average, growers indicated a greater than 90% adoption of earlier planting dates.	(depending on variety of up to $20,000/A) when planting is delayed. An average estimate across the state (400 acres) suggests increased revenues of $4.9 million statewide if all berries (and varieties) were planted within 2 or 3 days following arrival in mid-October and were harvested over a five week period. Overall, planting date was considered a highly achievable model for growers to improve best management practices in Texas strawberries. Finally, for Indicator 8, the number of growers that gained knowledge through our outreach programs was approximately 250.
4	For Objective 4, we evaluated strawberries grown under low tunnel hoops covered with shade cloth. The goal was to determine whether shading will extend the harvest season, increase fruit quality and reduced plant stress. Four replicated trials were conducted at Lubbock (2) and at KH Farms (2) in Poteet. Treatments included three shade levels (full sun, 30% and 50% shade), and timing of shade cloth placement (full season or spring season only), with two types of strawberry varieties, *Camino Real* (June-bearing) and *Albion* (day-neutral). Leaf, soil, and air temperatures were somewhat higher in full sun compared to shade cloth treatments. However, CO_2 gas exchange/photosynthesis was not necessarily affected. We found that fruit size and quality slightly increased (in *Camino Real*, (a June-bearing type) when 30% or 50% shade cloth was used, regardless of timing of placement. However, with *Albion*, a day-neutral variety, there was no benefit of using shade cloth, and yields were slightly lower when used. With *Camino Real*, yields were initially lower under shade cloth but increased to be higher than full sun by final harvest. In general, harvests were extended one and two weeks compared to the full sun treatment. The results suggest that there is a potential benefit of using shade cloth on June-bearing strawberries in Texas, but perhaps not on day-neutral types. Additional varieties need further evaluation. Several growers indicated interest in using shade cloth techniques to reduce the effect of high temperatures, however; the initial high cost of shade cloth is a potential prohibiting factor for adopting this practice.	Objective 4 was relevant to the strawberry project as it suggested that reducing plant stress is important to overall plant health and yield in Texas. Using low tunnels covered with shade cloth assisted our research with this objective. For Indicator 1, our research demonstrated that this model (decreasing plant stress and improving yield) is achievable through shading; however, the majority of growers were concerned with the high cost of this innovation. This research did demonstrate that during periods of high temperature, strawberry plants are more susceptible to flower and yield losses. Corrective actions on a large scale can be difficult to achieve. For Indicator 2, it is unlikely that most growers would adopt this model. The initial cost of shade cloth is too prohibitive. With Indicator 3, it is likely that less than 5% would adopt using low tunnels and shade cloth in their production. The potential increase in revenues is unlikely to be cost efficient in the short term, and possibly the long term as well. For Indicator 8, the number trained was 280 face-to-face contacts.
5	For Objective 5 we held elven face-to-face strawberry programs, including two zoom meetings over the 2-year project. Outreach programs were held at Poteet (4); Denton (2), Taylor (1), Prairie View (zoom), and Lubbock (2) and College Station (zoom). Although growers	Objective 5 included the dissemination of our research in useable and understandable forms for strawberry growers statewide. At all our meetings we covered all research topics from Objectives 1,2,3,4, and 6. This objective is relevant to Indicators 1,2,3,6, and 8. The objective

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	were our main target audience, Texas A&M AgriLife Extension Specialists were taught these models during our annual Hot Topics Meeting in 2021, with approximately 30 faculty attending. Total participation included 280 growers, gardeners, agents, and specialists. County agents played a significant role in organizing and conducting most of our outreach meetings. At our outreach events, our research results were presented including our objectives (1) soil fertility, (2) weed control, (3) planting dates, and (4) plant stress/shade cloth and (6) irrigation trials. During our presentations, growers were given opportunities question and discuss our results. After the meetings, county agents handed out anonymous surveys to assist in defining participant's pre- and post-knowledge of our research. Questions included whether growers increased their overall understanding, and whether they would 'probably or definitely adopt at least one practice'. Overall, our surveys indicated that 100% of growers increased their knowledge, and that over 80% would probably or definitely adopt at least one model introduced. On average, grower percent mean increase in knowledge before to after our trainings was over 50%. Survey information was extremely beneficial in identifying gaps in grower's understanding and their willingness to change. We followed up with growers through various communication means and will continue to do so. Through our meetings, a good percentage of growers indicated they will continue to follow at least one of the new recommendations for future planting seasons. Finally, we delivered over 200 copies (handouts or PDF emails) of selected strawberry guides to growers from results produced during this project.	was accomplished via our multiple face-to-face meetings and field days (11). At most meetings (7), participants were surveyed following our presentations. Since our surveys were anonymous, often the same growers attended our meetings, and they were surveyed multiple times, the actual number of 250 trained growers is likely lower. Regardless, for Indicator 1, there was a general agreement by participants that our models (Objectives 1,2,3,4,6) were significantly important to their production success and they learned techniques to improve their overall production. For Indicator 2, a high number of participants (over 90%), indicated they would adopt at least one or more of our models. This indicates excellent acceptance of our research from our project. For Indicator 3, while difficult to assess, based on our surveys with 90% adoption of at least one model, we can estimate that of the 250 participants, approximately 225 would adopt some of this technology. Whether growers adopt one or more of the models research, revenue increases could be as little as $1,500/A (weed control), but as high as $20,000 per acre (planting time). An example of the benefits is that if all growers adopted Objective 2 (herbicide technology to lower handweeding costs), and Objective 3 (earlier planting dates) to the entire 400 Texas acres, we could estimate revenue increases of $5.5 million statewide. Indicator 6 includes the number of first responders trained to combat pests. In our project, these pests were primarily weeds. First responders (growers and agents, etc.) were trained on Objective 2 (weed control) at all meetings. Through our trainings we estimate that at least 280 first responders (growers, agents, specialists, industry, etc.). For Indicator 8, total number of stakeholders trained through our meetings, and through distribution of strawberry guides is estimated at over 500.
6	For Objective 6, irrigation trials were conducted at Lubbock during both seasons. During the first year, our data showed that when strawberries were irrigated at rates determined to be 100%, 80%, 60%, and 40% by volume, that yields increased with lower irrigation rates. In fact, yields were 31% higher in the 40% and 60% volume rates compared to the 100% volume. Total nitrogen analyzed from soil samples showed 16% more nitrogen in the lower irrigation rates compared to 100% irrigation.	Although Objective 6 was not in the original protocol; it became significant and relevant to our project during Year 1. Our data showed significant improvement (Indicator 1) in irrigation models by demonstrating that strawberry crops can either be over- or under-irrigated which influences soil available nitrogen. All growers present at our meetings gained knowledge and this innovation should be adopted (Indicator 2) by all. Growers were taught that irrigation and fertilization are significantly

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	This indicated that in that year, the 100% and 80% irrigations reduced total soil nitrogen soil through leaching. However; in Year 2, the results were opposite. Data showed that higher yields were found in the 100% and 80% irrigation rates compared to the lower rates, and no differences in total nitrogen. The difference in results between years can attributed to different growing climates. In Year 1, adequate rainfall occurred during the harvest season, while in Year 2, high temperatures and a severe drought occurred with no rain during the entire crop season. Our results suggest that during hotter, dryer seasons, growers must be increasingly cognizant of their irrigation needs and methods and the amount of water needed to maintain optimal yields.	linked to overall plant growth and yield. For Indicator 3, 100% of meeting participants indicated that this is critical to their overall production and their understanding increased by about 90%. We estimate that 100% of growers should adopt some changes in irrigation management to improve water use efficiency and reduce nitrogen leaching. Though this is largely dependent on farm location and soil type. With the increasing cost of fertilizer, this model becomes significantly important. Growers have indicated that the high fertilizer costs are impacting their production costs and revenues. Increased yields through reducing irrigation costs (Year 1) may result in significant revenue increases. The number of growers gaining knowledge through our scientific tools (Indicator 8) was 280.

CHALLENGES AND DEVELOPMENTS

Provide any challenges to the completion of your project or any positive developments outside of the project's original intent that you experienced during this project. Also, provide the corrective actions you took to address these issues. If you did not attain an approved objectives, outcome(s), and/or indicator(s), provide an explanation in the Corrective Actions column.

#	Challenge or Development	Corrective Action or Project Change
1	Weather challenges in both years influenced our results with some of our objectives. In spring 2021, extreme low temperatures throughout Texas killed many crowns and buds, thus reducing leaf area and plant growth resulting in lower yields. The trial in Prairie View was particularly hit hard, and data was essentially useless. In 2022, a drought combined with excessive high temperatures effected flowering in all locations and specifically again at Prairie View. In fact, at Lubbock, yields were lower in 2021 compared to 2022 indicating that severe cold damage to plants may have greater negative impact on yield than high temperatures (at least in the early season). In 2022, early and multiple freezes statewide, followed by drought and high temperatures resulted in the shortest harvest season on record in Texas.	Weather is difficult to control and adjust for optimal strawberry production. In our southern state trials, it may have been beneficial to use low tunnel plastic during the unexpected extreme cold weather, as well as use shade cloth during the drought. However, these techniques are expensive and can be difficult to use. At Lubbock, cold weather is expected during November through April, and the trials are always protected by low tunnel plastic technology. Ultimately, there was not a lot that could be done to reduce weather/climate influences on our strawberry trials in the south. The low tunnels were not as effective at protecting our plants at temperatures below zero in our northern trials (Lubbock).
2	Loss of project graduate student in June 2021, and hiring of new technician in early 2022	As mentioned in our Year 1 report, due to unexpected health concerns, our graduate student withdrew from the program. While this did not affect our data collection, it was cause for some concern due to the need for hand labor. As a result, it took approximately six months to reallocate funds and replace the student with a research technician. Once hired, the new research technician was responsible for all data collection

#	Challenge or Development	Corrective Action or Project Change
		and analysis, similar to what the graduate student was doing. The research technician needed to be trained and did an excellent job in data analysis and is currently in the process of co-writing our publications. As a result of this loss of the student and time to hire a new technician we were unable to use about $15,000 of our funds.

LESSONS LEARNED

Provide recommendations or advice that others may use to improve their performance in implementing similar projects.

Overall, our research trials and the data collected from them were very successful in regard to our objectives and the information gathered. It would benefit future Texas strawberry researchers to increase the number of varieties for evaluating fertilizer rates and other effects from our objectives. In our fertilizer trial, we used only four varieties that were selected by growers. With older varieties going away and newer varieties being released, new varieties should be evaluated for more accurate recommendations to Texas growers. Similarly, the planting dates for more varieties should be evaluated. With our irrigation trial, although we obtained useful data, collaborating with an irrigation specialist would have been better suited, and perhaps more detailed data could be obtained. With water use an increasingly important topic, irrigation needs in strawberry production is at a critical phase. Additional research on the combined effects of irrigation and nitrogen rates with different strawberry varieties in the different Texas soil types will enhance our knowledge. Additional research is needed on strawberry plant stresses including the changing climate (acute low and high temperatures) effects on crown, flower and fruit development is important., Finally, the use of alternative types of shade cloth i.e., different colors, different levels of shade, and varying heights of shade cloth above the plant canopy would be beneficial if shown to benefit grower revenues.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Describe your plans for continuing the project (sustainability; capacity building) and/or disseminating the project results.

We will continue to improve the strawberry guides that we've currently published for Texas growers as we gather additional information. Our new TDA funding (2022 – 2024) will give us resources to continue to teach the data from this grant at local and statewide grower meetings. Dr. Montague and Dr. Wallace will be presenting selected data from this project at an upcoming (March 2023) North American Strawberry Growers Association Meeting in San Luis Obispo, CA. Finally, we have three peer-review publications in preparation including papers on (1) an article on the methodology of our LiCor gas exchange system use on strawberry leaves, (2) an article on irrigation by plant spacing trial; and (3) an article on the effects of planting date on strawberry yield and quality.

BENEFICIARIES

Number of project beneficiaries: 250 meeting participants, 5,000 or more consumers

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

Provide the results of the project outcome(s) and indicator(s) as approved in your application and project proposal. The results of the outcome(s) and indicator(s) will be used to evaluate the performance of the Program on a national level.

OUTCOME MEASURE(S)

Select the Outcome Measure(s) that were approved for your project.

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☐ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access

☐ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources

☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems

☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety

☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources

☐ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

Provide the indicator approved for your project and the related quantifiable result. If you have multiple outcomes and/or indicators, repeat this for each outcome/indicator (add more rows as needed).

#	Outcome and Indicator	Quantifiable Results
1	**Outcome 5: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems.** Indicator 1: Assessing the number of new or improved innovation models (biological, economic, business, management, etc.), technologies, networks, products, processes, etc. developed for specialty crop entities including producers, processors, distributors, etc.	In this project, we assessed five models including: 1) improving strawberry seasonal weed management strategies, 2) improving irrigation methodology to reduce water use and nitrogen losses, 3) selecting the appropriate nitrogen/fertilizer rate depends on variety selection 4) planting time influences crop production, and 5) using shade cloth to extend the season and improve yield and quality in June-bearing varieties. First, we demonstrated that weed control is improved, and labor costs significantly reduced when growers apply Spartan 4F + Prowl H2O preplant followed by handweeding and if needed for grasses, a postemergence application of SelectMax. Second, we found that depending on climate, strawberry irrigation can be reduced while maintaining optimal yields. Over-irrigation of berries results in a loss of total nitrogen in the soil making it less available for plant uptake. Third, we determined that when applying nitrogen, the rate should be consideration depending on variety planted. Reducing nitrogen use in some varieties resulted in higher yields, while increasing rates resulted in excess runner growth. Fourth, we demonstrated that significant yield and revenue losses likely occur when planting strawberries is delayed up to four weeks for most strawberry varieties. Fifth, using shade cloth, may not enhance production in day-neutral types, and may also not justify the initial high costs of purchase.
2	Indicator 2:	We estimated in our initial protocol that four innovations may be adopted by some or all Texas strawberry growers. However, we evaluated five innovations including (1) improved planting, (2) fertilization by selected variety, (3) improved weed control using herbicides, (4) improved

	Number of innovations adopted: 4	irrigation management and plant spacing, and (5) plant stress prevention using shade cloth. These innovations were researched and presented to growers statewide at meetings and conferences. Almost 100% of growers indicated adoption of at least one if not more of these innovations.
3	Indicator 3: Number of specialty crop growers/producers (and other members of the specialty crop supply chain) that have increased revenue expressed in dollars: 35	We estimated that at least 35 growers would adopt one or more of the innovations researched. With the increased interest in berry production statewide, we achieved that goal, and estimate that it may be twice (70) that number for the innovations described in Indicator 2. Although growers are hesitant to share revenues, we do know that if growers adopted just our herbicide technology and planting date innovations on our 400 strawberry acres statewide, there would potentially be increased revenues of $5.5 million. Irrigation costs vary by grower depending on their method used, but significant savings can be achieved through improved and more efficient irrigation management to reduce nitrogen losses while maintaining optimal yield performance. Finally, some benefits of shade cloth on yield were obtained found, but the high costs of shade cloth likely outweigh the benefits.
4	Indicator 6: Number of first responders trained in early detection and rapid response to combat plant pests and diseases: 150	For Indicator 6, we estimated that we would train at least 150 first responders on rapid response to combat plant pests (in our case, weeds). During eleven statewide programs, over the course of this project, we trained approximately 300 growers, agents, specialists, gardeners, and other stakeholders, and produced one 'Weed Control Options in Strawberries' guide that was distributed to all meeting attendees as well as through email upon request (over 200 copies).
5	Indicator 8: Number of growers/producers that gained knowledge about science-based tools through outreach/education programs: 250	Again, we had eleven outreach programs, including conferences, workshops, and field days during this 2-year project. Locations for these outreach programs included Lubbock, Prairie View, Poteet, Denton, and Taylor. We trained at least 250 participants. We also distributed our research/training information through the presentations, and through printed copies of prepared strawberry guides. At the meetings, growers received copies of the presentations and handouts. We also estimate over 250 copies of our guides were distributed at the meetings or through email including 'Strawberry Weed Control Options', 'Nutrient Management for Strawberries in Texas'; 'Strawberry Crown and Root Rot Control'; and Recovering Strawberry Buds and Crowns from Cold Injury'. Our total outreach was approximately 500 contacts. Total estimated face-to-face contact hours is 1,275.

DATA COLLECTION

Explain what data was collected, how it was collected, the evaluation methods used, and how the data was analyzed to derive the quantifiable indicator.

Data was collected using selected methods based on the need of collection. Plant stress was analyzed by collecting leaf samples from multiple plants in the shade, fertilizer, and irrigation trials at selected times during the season. Leaves were cut from selected areas of plants within treatments and placed immediately into the chamber of the LiCor gas exchange system. Data was collected electronically on the machine. Leaf greenness (chlorophyll content) was collected on the leaves using a hand-held chlorophyll meter. Plant canopy data was collected using a cell phone app called 'Canopeo' which assessed percent green matter (whole plant leaf area). Following a snapshot of the selected area, the app converted it to a percent area of green leaves, stems, etc. Visual vigor ratings, where needed, were collected by an experienced researcher. Climate data (moisture, humidity, temperature in the air and soil) was collected continuously using a solar-powered data logger system. Plant biomass and berry yield were collected by hand. Berries were harvested into baskets and taken to the lab for grading, counting, and weights. Sugar content was collected using hand-held Brix meters of 3 – 5 randomly selected berries. Replicated data was analyzed and summarized using appropriate statistical and analytical programs.