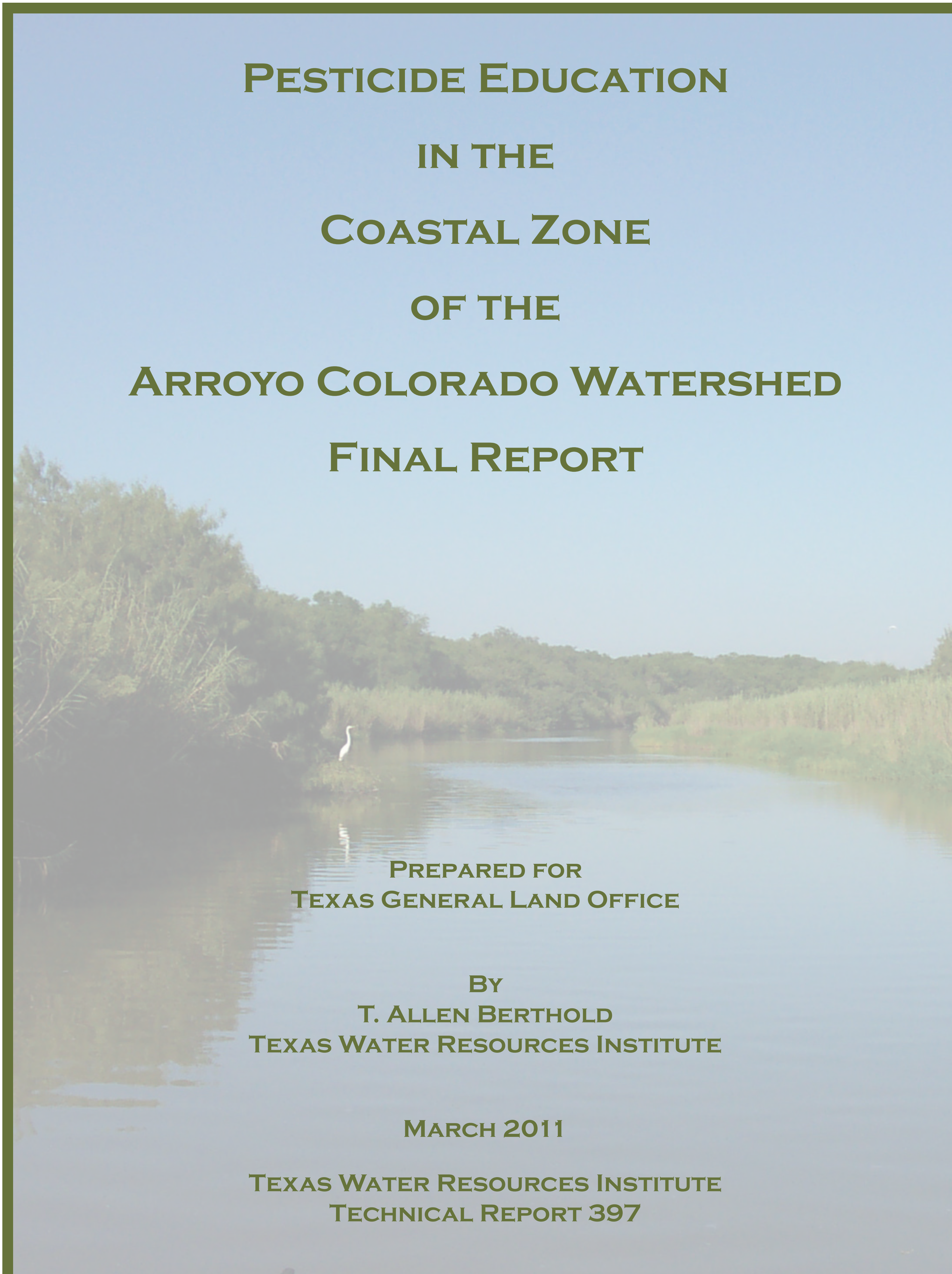

Pesticide Education in the Coastal Zone of the Arroyo Colorado Watershed Final Report

Prepared for
Texas General Land Office

By
T. Allen Berthold
Texas Water Resources Institute

March 2011

Texas Water Resources Institute
Technical Report 397

List of Acronyms

ACWPP – Arroyo Colorado Watershed Protection Plan

BMP – Best Management Practice

CNRA – coastal natural resource area

EPA – Environmental Protection Agency

IPM – Integrated Pest Management

NRCS – U.S. Department of Agriculture Natural Resources Conservation Service

SAFE – Sports Athletic Field Education

TCEQ – Texas Commission on Environmental Quality

TWRI – Texas Water Resources Institute

Funding provided by General Land Office as part of the
Coastal Management Program.

Texas Water Resources Institute
make every drop count

Executive Summary

The Arroyo Colorado is an ancient channel of the Rio Grande River that extends eastward for about 90 miles from near the city of Mission, Texas through southern Hidalgo County to the city of Harlingen in Cameron County, eventually discharging into the Laguna Madre near the Cameron-Willacy County line. The tidal segment of the Arroyo Colorado, as classified by the Texas Commission on Environmental Quality (TCEQ), is between the confluence with Laguna Madre in Cameron/Willacy County to a point 100 meters (110 yards) downstream of Cemetery Road, south of Port Harlingen in Cameron County. This part of the river is also defined as a coastal natural resource area (CNRA) and a coastal wetland in the Coastal Coordination Act.

Water quality monitoring over the past decade has confirmed low oxygen levels and escalated ammonia and nitrate concentrations that have contributed to multiple fish kills in the tidal segment. These sub-optimal aquatic conditions resulted in this portion of the Arroyo Colorado being placed on the *Texas Water Quality Inventory and 303(d) List* for high aquatic life use impairment in 2002. Numerous urban sources, such as point source wastewater discharges, have contributed to this impairment; however, according to the Arroyo Colorado Watershed Protection Plan (ACWPP), nonpoint source agricultural runoff accounts for much of the water quality issues in the tidal segment.

These coastal issues and other water quality issues in the watershed have been addressed by the more than 715-member Arroyo Colorado Watershed Partnership in the ACWPP. The plan identifies needs specific to water quality protection and improvement for the agricultural community as well as addressing nonpoint source pollution from the urban environment such as landscapes. In response to the ACWPP, Texas Water Resources Institute (TWRI) proposed to work with the Texas AgriLife Extension Service to implement an educational program aimed at agricultural producers, which included turfgrass producers and local independent school districts that manage athletic fields. The agricultural effort was an integrated farm management program focused on pesticide education and proper nutrient management for Cameron and Willacy counties to address water quality issues related to agricultural production in the tidal segment of the Arroyo Colorado. While the turfgrass and athletic field managers were invited to the educational programs provided through the agricultural effort, a separate educational workshop was held for turf producers and managers to increase awareness of how nutrient, pesticide and irrigation management can reduce the amount of nonpoint source pollution.

This education plan helps fulfill two goals of the Texas Coastal Management Program. First, agricultural and turfgrass producers and managers in Cameron and Willacy county were educated on water quality issues and how the proper application of pesticides meets current laws and regulations, and can improve the water quality and fish community in the Arroyo Coastal Natural Resources Area (CNRA). Second, the producers and managers were taught that implementing proper pesticide application practices will reduce the potential for nonpoint source pollution, which will improve the water quality in the Arroyo CNRA. This project also enhances the area's ability to continue to support valuable aquatic life and meet water quality goals outlined in the ACWPP. An additional environmental success for this area, given the over-allocation and availability of clean surface waters, will be the added water savings attributed to the irrigation management educational program provided through this effort.

Project Description

The overall objective of this project was to implement components of an integrated farm management program to educate agricultural and turfgrass producers about laws and regulations and better management of their land through safe use of crop protection chemicals, nutrients and irrigation management. By implementing these practices, the potential for nonpoint source pollution can be reduced. AgriLife Extension used its network of resources and delivery system to enhance its programs and educate producers on pesticide laws, use regulations, and management and application techniques. The Pesticide Applicator Safety Training and Continuing Education program addresses the following topics: principles of integrated pest management, nonchemical alternatives, pest features, ground and surface water protection, laws and regulations, pesticide labels, endangered species protection, Worker Protection Standards, record keeping, personal protection, application equipment, and calibration. The Sports Athletic Field Education (SAFE) Program addresses the following principles: effective and economic nutrient applications; reduced pesticide management techniques including proper soil and plant management; maintained turf health for proper playing surface; reduced water use and efficient irrigation management; and continued support for program implementation to ensure sustained success of the program.

TWRI and AgriLife Extension hosted educational workshops and produced educational materials for producers on the importance of proper pesticide application and use of integrated pest management practices to protect water quality in Cameron County. Funds to support the development and delivery of the educational programs were provided by the Environmental Protection Agency (EPA) Strategic Agricultural Initiative Program. In addition, the EPA program covered the delivery of an Integrated Pest Management

(IPM) and Best Management Practice (BMP) Newsletter, and a fact sheet directed at implementing BMPs for proper natural resources management. TWRI and AgriLife Extension documented project participation at all events and meetings. Programs had pre- and post-assessment surveys where knowledge gained was gauged. Follow-up surveys were used to quantify implementation of BMPs. Overall success was measured by the number of individual producers the project reached and estimates of BMP implementation.

Through this program, TWRI and AgriLife Extension supplemented the agricultural educational programs and field days with outreach and educational materials that address specific practices to reduce the potential for nonpoint source pollution from pesticides, nutrients, irrigation, and sediment. These materials should encourage the adoption of proper IPM practices. An example of outreach and educational materials distributed were signs that producers can use on-farm to designate areas of pesticide mixing, clean-out, and the proper disposal of used pesticide containers. Additionally, growers participated in soil-testing campaigns to encourage proper nutrient applications. Finally, a *Soybean Production in the Rio Grande Valley* booklet was produced, which can be used outside of the Arroyo Colorado Watershed to address water quality issues in other coastal areas impacted by agricultural nonpoint source pollution.

A targeted turfgrass educational program was also included in this project. Extension coupled the already successful SAFE Program with its resources for turfgrass producers to present proper management techniques through an educational conference, hands-on learning techniques, soil testing campaigns to encourage proper nutrient applications, and on-site visits to ensure proper implementation of the suggested practices. The SAFE Program offers turf management assistance for sports field maintenance personnel and turfgrass producers who operate within the Arroyo Colorado floodplain. Thus, a program targeting both turfgrass managers and producers has great potential to reduce nonpoint source pollution to the Arroyo Colorado.

Task 1: Project Coordination

TWRI facilitated this educational program through communication and consistent, timely reporting as well as active involvement with the Arroyo Colorado Watershed Protection Plan implementation process. A detailed listing of activities related to project administration can be found in Appendix A.

Specifically, TWRI provided project coordination that included technical and fiscal oversight to ensure tasks and deliverables were acceptable and completed as scheduled and within budget. Fiscal oversight consisted of submitting reimbursement forms per the schedule that was established in the request. TWRI frequently visited with project partners via teleconference as well as in-person meetings to ensure that issues, if any, could be resolved in a timely manner as not to affect the project timeline, and project personnel remained on task.

TWRI submitted quarterly progress reports to the General Land Office and all reports can be found on the Arroyo Colorado website (http://arroyocolorado.org/projects/coastal-zone-pesticide-education). Quarterly reports contained an overview of project activities completed during each quarter, an overview of activities to be completed in the next quarter, and highlighted related issues or problems associated with the project.

In addition to TWRI efforts, an update of the project was provided to the Arroyo Colorado Watershed Partnership Steering Committee during its quarterly meetings and to the Arroyo Colorado Agricultural Issues Workgroup, which meets bi-annually. At these meetings, TWRI provided participants with a summary of the programs that were held as well as other activities related to the project.

Task 2: Supplement Integrated Farm Management System Education Programs

The ***Pesticide Education in the Coastal Zone of the Arroyo Colorado Watershed*** project used several avenues of educational distribution (Appendix B contains a list of activities conducted). First, educational materials such as pesticide disposal signs were created and 300 were printed for producers' use. These signs are given to producers to place at their primary location of pesticide storage and disposal. Also, 500 bumper stickers were printed to be placed on water/ chemical transportation equipment such as "nurse tanks" to remind producers to dispose of the empty containers properly (See Appendix C for graphics of the Pesticide Disposing Sign and Sticker). Since soybeans are a relatively new crop to the Rio Grande Valley, a *Soybean Production in the Rio Grande Valley* booklet (See Appendix D) was produced to help producers understand the proper use of chemicals (fertilizers, pesticides) for the most effective and environmentally safe production of soybeans. The *Soybean Production in the Rio Grande Valley* booklet also contains information about growth and development, variety selection, planting practices, fertility, irrigation, weeds, insects, diseases, harvest aids, harvesting, and budgets.

A soil testing campaign was conducted to provide agricultural producers scientific data of nutrient levels present in the soil and recommendations on fertilizer levels needed to produce a sustainable crop. Soil samples were received by the county offices through the campaign (samples included only those that went through the AgriLife Extension office and does not include those that go through (US Department of Agriculture Natural Resource Conservation Service (NRCS)). The soil testing campaign started in October 2008, but because the award did not come through until January 1, 2009, AgriLife Extension had to use other funds to cover the soil testing campaign and related expenses. Therefore, funds originally budgeted for the 2008-2009 campaign were not used, which resulted in excess funds. To resolve this, the project was extended through March 31, 2011 to cover a third year of the soil testing campaign (2010-2011).

Table 1: Total Number of Soil Samples per County (*not within the coastal zone and not paid for through this project)

Year	County	# of Soil Samples
08/09	Cameron Willacy Hidalgo*	141 67 267
09/10	Cameron Willacy Hidalgo*	282 128 155
10/11	Cameron Willacy Hidalgo*	94 80 154
Total 2008 - 2011	All	1,368

Task 3: Conduct Turfgrass Production and Management Education Program

A Turfgrass Education Conference was planned and held on April 16, 2010 at the La Feria Independent School District. AgriLife Extension held a one-day course on irrigation auditing for athletic fields to diagnose potential problems, improve efficiency, and conserve water. The course included practical information on: 1) how to estimate the water needs for your grass; 2) how to set up a proper irrigation schedule to conserve water while maintaining quality turfgrass; and 3) management aspects of athletic fields. The course was designed for anyone interested in irrigation management and water conservation, anyone already using a sprinkler system, or anyone planning on having one installed. In this program, participants gained knowledge and hands-on experience on how to calculate plant water requirements based on evapotranspiration and rainfall and how to conduct an irrigation audit to evaluate their irrigation system's application depth and uniformity. In addition, three irrigation audit kits were purchased and AgriLife Extension used them while conducting irrigation audits for the school districts and turfgrass producers. (Appendix E contains the agenda for the SAFE program). According to the survey conducted at the SAFE program, the majority of respondents plan to take actions or make changes to their practices. In adopting these new management practices, the majority of the respondents anticipate to benefit economically as a direct result of what they learned during the program. Specific results can be found in Appendix F.

So many of the attendees were satisfied with the program that they said they would attend another program if it was held and recommend it to others. At this request, another program will be held within 6 months of this project's end date.

Conclusion

The Pesticide Education in the Coastal Zone of the Arroyo Colorado Watershed project was a great success. TWRI and AgriLife Extension worked closely in completing the tasks of the project. As a result, other programs were enhanced and resources were distributed and shared amongst producers and turfgrass managers throughout the Arroyo Colorado Watershed.

The development of the pesticide disposal sign and sticker, soybean fact sheet, and soil testing campaign were crucial steps in implementing the Arroyo Colorado Watershed Protection Plan and making progress in the agricultural community toward meeting the goals outlined in the AC-WPP. The soil testing campaign has proved to be a useful tool for producers to save fertilizer. This, in turn has reduced the amount of nutrients entering water bodies.

Lastly, the turfgrass education task was an innovative way to help reduce nutrients within the watershed as well as reduce the amount of water wasted through auditing.

Projects such as this are why accomplishments are being made in the Arroyo Colorado Watershed. The need for such projects in the future is crucial for continued success.

Appendix A

Task 1

Subtask 1.1

- TWRI worked with AgriLife contracts and grants division to ensure the correct budget as allocated per the agreement. When a discrepancy was discovered, TWRI worked with GLO and submitted a budget amendment request, which was approved on April 6, 2009.

- Upon receipt of correct budget, TWRI developed subaccount notifications for AgriLife Extension District 12 to provide the County Extension Agents with their funding and deliverables per this award.

- TWRI maintains contact with AgriLife Extension and GLO regarding project activities and deliverables.

- Realizing project activities are behind due to delay in project start date, TWRI discussed possible extension of the project with GLO especially considering a large budget item was the soil testing campaign and the 2008-09 campaign only had 1 month left when this project started. While other funds covered the campaign and allowed it to take place, the delay in this project left additional funds in the project budget that will need to be spent or the project could be extended to cover a soil testing campaign in 2010-11. It is doubtful a 2010-11 campaign can happen as GLO was only able to agree to a 3 month (6 month at most) project extension. The extra funds and meeting our deliverables in a timely manner will be addressed as project continues and deadlines get closer.

- TWRI requested and was granted a 6 month No Cost Extension, which will move the end date of the project to 9/30/2010.

- TWRI requested and was granted a 6 month No Cost Extension, which will move the end date of the project to 3/31/2011.

Subtask 1.2

- AgriLife did not submit an invoice for the quarter (January 1, 2009 through March 31, 2009). Due to initial contractual budget issues, no funds were expended during this quarter. Funds will be charged to the project during the next quarter.

- AgriLife submitted three monthly invoices on this project. Invoice #R017226 for April 2009 was for $1,567.94; Invoice #R017282 for May 2009 was for $702.08; and Invoice #R017371 was for $334.45. A delay in spending has occurred while project personnel initiate activities.

- AgriLife submitted three monthly invoices on this project. Invoice #R017683 for October 2009 was for $1,257.11 and Invoice #R017757 for November 2009 was for $2,035.28.

- AgriLife submitted three monthly invoices on this project. Invoice #R017848 for December

2009 was for $2035.27, Invoice #R017948 for January 2010 was for $2,039.24, and Invoice #R017998 for February 2010 was for $2,039.24.

- AgriLife submitted three monthly invoices on this project. Invoice #R017226 for April 2009 was for $1,567.94; Invoice #R017282 for May 2009 was for $702.08; and Invoice #R017371 was for $334.45. A delay in spending has occurred while project personnel initiate activities.

- AgriLife submitted three monthly invoices on this project. Invoice #R018504 for July

- 2010 was for $3,484.50, Invoice #R018574 for August 2010 was for $4,393.00.

Subtask 1.3

- TWRI held project planning meetings with project participants (County Extension Agents in Hidalgo, Cameron and Willacy counties) as well as the district extension administrator for District 12 on December 17, 2008. Meeting discussion included the upcoming start of this project and what activities will be required per this award (e.g. soil testing campaign, turf education conference, promotion of SAFE field day, etc.)

- TWRI held project planning meetings with project participants (County Extension Agents in Hidalgo, Cameron and Willacy counties) as well as the district extension administrator for District 12 on April 27, 2009 in Weslaco. Meeting discussion included the development of a steering committee for the turf conference as well as the development of the fact sheet. The soil testing campaign results were also discussed and were provided to TWRI.

- TWRI held project planning meetings with project participants (County Extension Agents in Hidalgo, Cameron and Willacy counties) as well as the district extension administrator for District 12 on October 22, 2009 in Weslaco. Meeting discussion included the developments of the turf conference as well as the development of the fact sheet. Future soil testing campaigns were also discussed.

- TWRI held project planning meetings with project participants (County Extension Agents in Hidalgo, Cameron and Willacy counties) January 21, 2010 in Weslaco. Meeting discussion included the developments of the turf conference as well as the development of the fact sheet. Future soil testing campaigns were also discussed.

- TWRI held project planning meetings with project participants (County Extension Agents in Hidalgo, Cameron and Willacy counties) as well as the district extension administrator for District 12 on April 27, 2009 in Weslaco. Meeting discussion included the development of a steering committee for the turf conference as well as the development of the fact sheet. The soil testing campaign results were also discussed and were provided to TWRI.

- TWRI held project planning meetings with project participants (County Extension Agents in Hidalgo, Cameron and Willacy counties) August 25 in Weslaco. Meeting discussion included the finalization of the pesticide disposal signs as well as the development of the fact sheet.

- TWRI maintains regular contact with the County Extension Agents in Hidalgo, Cameron, and Willacy counties regarding project deliverables.

Subtask 1.4

- TWRI submitted the first quarterly report on May 7, 2009. The first quarter report was late. Future reports will be on time.

- TWRI submitted the first quarterly report on July 15, 2009.

- TWRI submitted the second quarterly progress report on July 10, 2009.

- TWRI submitted the fourth quarterly progress report on January 8, 2010.

- TWRI submitted the first quarterly report on July 15, 2009.

- TWRI submitted the seventh quarterly progress report on October 8, 2010.

- TWRI submitted the eighth quarterly progress report on January 14, 2011.

Appendix B

Task 2

Subtask 2.1

- AgriLife Extension began discussion on the type and use of pesticide disposal signs.

- Extension also discussed the fact sheet for the project. Soybean production is a new crop in the Arroyo Colorado Watershed and producers do not understand proper use of chemicals (fertilizer, pesticides) for the most effective and environmentally safe production. A general fact sheet on soybean production including safe use of pesticides, fertilizers and irrigation will be developed. Other fact sheets were also discussed and AgriLife Extension is still deciding what will be the most effective fact sheet for this program.

- Signs and Education Materials (300 pesticide disposing signs and 1 Fact sheet) Extension further discussed the fact sheet at the April 27 meeting that is to be developed for the project. Soybean production, given soybean is a new crop in the Arroyo Colorado Watershed and producers do not understand proper use of chemicals (fertilizer, pesticides) for effective and environmentally safe production, is still likely to be the highlight of the publication. TWRI is working to identify a specialist to lead the effort on developing this general fact sheet on soybean production including safe use of pesticides, fertilizers, and irrigation.

- The pesticide disposing sign was drafted (see Figure below) and bids will be sought during the next quarter.

- AgriLife Extension further discussed the fact sheet at the October 22 meeting that is to be developed for the project. Soybean production, given soybean is a new crop in the Arroyo Colorado Watershed and producers do not understand proper use of chemicals (fertilizer, pesticides) for effective and environmentally safe production, is still likely to be the highlight of the publication. TWRI has identified a specialist to lead the effort on developing this general fact sheet on soybean production including safe use of pesticides, fertilizers, and irrigation.

- The pesticide disposing sign was drafted in the last quarter and AgriLife Extension has decided to redo the design. This will be completed within this quarter and the signs will be ordered.

- TWRI in collaboration with AgriLife Extension further discussed the fact sheet in March 2010 during various email and phone conversations. Soybean production, given soybean is a new crop in the Arroyo Colorado Watershed and producers do not understand proper use of chemicals (fertilizer, pesticides) for effective and environmentally safe production, is still likely to be the highlight of the publication. TWRI has identified a specialist to lead the effort on developing this general fact sheet on soybean production including safe use of pesticides, fertilizers and irrigation.

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- The pesticide disposing sign was drafted and bids will be sought during the next quarter.

- TWRI in collaboration with AgriLife Extension further discussed the fact sheet in August 2010 during various email and phone conversations. The fact sheet will cover Soybean production, given it is a new crop in the Arroyo Colorado Watershed and producers do not understand proper use of chemicals (fertilizer, pesticides) for effective and environmentally safe production, is still likely to be the highlight of the publication. TWRI has identified a specialist to lead the effort on developing this general fact sheet on soybean production including safe use of pesticides, fertilizers and irrigation.

- The final Pesticide Disposal Sign Design submitted for approval to GLO is attached as an appendix.

- TWRI has been in contact with Dr. Dan Fromme regarding the status of the fact sheet that will cover Soybean production. The fact sheet is anticipated to contain various topics as follows: soybean stages of growth, photoperiod, land preparation, planting, variety selection, inoculation, fertility management, weed management, insect management, disease management, harvesting, crop quality, and budgeting.

- Bids are currently being taken for printing of pesticide signs.

Subtask 2.2

- Due to the delay in the start date of the project, the soil testing campaign for 2008/2009 was already started when this project began. Therefore, project funds budgeted to cover soil testing were not entirely used this year.

- The soil testing campaign conducted to provide ag producers scientific data of nutrient levels present in soil and recommendations on fertilizer levels needed to produce a sustainable crop was completed and a total of 337 samples were processed. Soil samples received by county through the campaign (includes only those that go through the AgriLife Extension office and does not include samples that go thru NRCS) was as follows: Cameron County – 67 samples; Hidalgo County – 167 samples; Willacy County – 98 samples; Starr County - 5 samples.

- The soil testing campaign was conducted for the 2009/2010 season and collected a total of 565 samples. Willacy County had 128, Cameron County had 282, and Hidalgo County had 155. Hidalgo County is not paid for under this project. This brings a running total of soil samples to 940.

- In the 2010/2011 soil testing campaign, 328 samples were collected. 80 were collected in Willacy County, 94 in Cameron County, and 154 in Hidalgo County. Again, Hidalgo County is paid for under another project. This brought the running total of soil samples up to 1,368.

Appendix C

Pesticide Disposal Sign

Pesticide Disposal Sticker

Appendix D

Soybean Production in the Rio Grande Valley Booklet

Soybean Production in the Rio Grande Valley

Soybean Production in the Rio Grande Valley

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TWRI EM-108

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Introduction

During the past several years, interest in growing soybeans in the Rio Grande Valley has increased. In 2010, approximately 12,900 acres were planted in the Rio Grande Valley with most of those acres in Cameron and Willacy counties. Soybeans have proven to be a viable crop for the Rio Grande Valley. One of the main reasons for planting soybeans is the low input cost associated with them when compared to corn, grain sorghum, and cotton. When compared to cotton, spending less time managing the crop during the season is another advantage of soybean production.

Uses of Soybeans

Soybeans are used in livestock feed, food for human consumption, and many nonfood (industrial) products. Soybeans are high in protein (38%) and are a major ingredient in livestock feed. More than half of the soybeans processed for livestock feed are fed to poultry and about one quarter is fed to swine. The remainder is used in beef and dairy cattle feed and pet food. For human consumption, soybeans are used for cooking oil, soy milk, soy flour, soy protein, and tofu. Biodiesel can be produced from soybean oil, which burns cleaner than petroleum-based diesel oil. Other industrial products that soybeans are used in include cleaning solvents, lubricants, soy-based foams for use in coolers, refrigerators, and automotive interiors.

Growth and Development

Seed

A viable soybean is a living organism that carries on metabolic processes (even in storage). The shape of soybean seeds may vary but is generally oval. The soybean seed consists of a seed coat, which encloses the embryo. The embryo consists of two cotyledons, which upon germination produce a plumule with two simple or unifoliate leaves and a hypocotyl. The hypocotyl will be green or purple depending upon whether the variety produces white or purple flowers. The embryo will also have a radicle, which is the root. Located on the surface of the seed coat will be a hilum or seed scar and is readily identified by being either black, imperfect black, buff, or clear. A very small hole called the micropyle will be located near the hilum. The hilum, which is formed during seed development, accounts for nearly all of the gaseous exchange between the seed and its environment. Water is absorbed through the entire seed coat surface.

Germination

The germination process begins with a viable soybean seed having access to moisture and proper temperature (>50 °F). Moisture and proper temperature enable the plant to complete a normal life cycle. At the initiation of germination, water is absorbed by the seed, which in turn, doubles in size. A soybean seed must absorb 50% of its weight in water to germinate, compared to only 30% for corn. Within two days the root or radicle becomes visible and the first branch of the developing root occurs when the radicle is about 1 inch long. The hypocotyl (green or purple in color) is the structure that enables the seedling to break through the soil surface, exposing the cotyledon to sunlight. This process usually will take 3–7 days. Seed emergence can be as long as 10–17 days when it is planted in temperatures less than 55 °F. The cotyledons are the structures that provide immediate food reserves for the developing seedlings. The next structure to appear, between 5 and 10 days, is the unifoliate leaves (one leaf per petiole). These two leaves are located opposite each other on the main stem at the unifoliate node. During this entire time period, root development is rapid, with root nodules appearing within 7–14 days after emergence. Nodules are responsible for fixing nitrogen for the plant. The root system consists of a branched taproot. Bud development occurs at the axil or the junction of the main stem and the leaf. Flowering buds (auxiliary buds) develop normally at the fourth node.

Vegetative Development

During vegetative development, root development increases faster than shoot height when environmental conditions are good. However, the dry weight of the above ground parts does exceed the root dry weight.

As vegetative development continues during the season, there will be an increase in the number of nodes along the main stem with each one having trifoliate leaves. Each node or trifoliate leaf will be alternately arranged along the main stem. As each new trifoliate unfurls up the main stem, this event is used to determine the plant's current vegetative stage.

Table 1. Vegetative Stages

Stage No.	Stage	Description
VE	Emergence	Cotyledons above the soil surface
VC	Cotyledon	Unifoliate leaves unrolled sufficiently so the leaf edges are not touching
V1	First Node	Fully developed leaves at unifoliate nodes
V2	Second Node	Fully developed trifoliate leaf at node above the unifoliate nodes
V3	Third Node	Three nodes on the main stem with fully developed leaves beginning with the unifoliate nodes
V_n	n^{th} - node	n number of nodes on the main stem with fully developed leaves beginning with the unifoliate nodes

Plants in a field will not all be at the same stage at the same time. When staging a field of soybeans, each specific V stage is defined only when 50% or more of the plants in the field are in or beyond that stage.

Growth Habit

Determinate and indeterminate growth habits are used to describe the development of soybean varieties. The determinate growth type is defined as completing over 80% of vegetative growth prior to bloom and is further characterized by a terminal raceme and normally blooms over 2–3 weeks. A mature determinate soybean plant often has between 15 and 20 nodes. Determinate varieties are generally associated with maturity groups 5–10; however, there are exceptions. Indeterminate varieties continue vegetative development while they bloom and set pods, and they have an obvious terminal raceme and may bloom for up to six weeks. Mature indeterminate soybean plants often will have 22–24 nodes. Indeterminate varieties are typically associated with maturity groups 0–4; however, there are exceptions. Also, many varieties have been developed that exhibit characteristics of both indeterminate and determinate and are referred to as semi-determinate varieties.

Reproductive Development

There are several factors that affect the length of each stage of development (vegetative and reproductive). These factors include temperature, maturity group, and day length (number of hours of darkness).

Reproductive stages of development are based on flowering, pod development, seed development, and seed maturation. When a flower appears on a soybean plant, this signals the beginning of the reproductive (R) growth phase. Reproductive stages beginning at flower are described in Table 2. There are several factors that affect the length of each stage of development (vegetative and reproductive). These factors include temperature, maturity group, and day length (number of hours of darkness). Flowering is induced in soybeans by day length. Soybeans are referred to as short-day plants because short days (long nights or dark periods) initiate flowering. Severe moisture or temperature stress can impact or influence the photoperiod effect on blooming, making it very difficult to predict date of blooming. Blooms under these

Soybean flowering

abiotic stresses normally do not result in significant pod set. Stages R1 and R2 occur almost simultaneously in determinate varieties because flowering begins at the upper nodes of the main stem. Stages R1 and R2 are approximately three days apart for indeterminate varieties. Flowering will begin in the lower portion of the main stem and progress up the plant. Pod length is measured for R3 and R4 from the base of the calyx to the tip of the pod. Once pods have reached ¾-inch long or R4, the pod cavity in which each seed will develop is outlined by a white membrane. At R6 the seed has enlarged enough to cover the entire membrane.

Table 2. Reproductive Stages

Stage No.	Stage	Description
R1	Beginning Bloom	One open flower at any node on the main stem
R2	Full Bloom	Open flower at one of the two uppermost nodes on the main stem with a fully developed leaf
R3	Beginning Pod	Pod 3/16 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf
R4	Full Pod	Pod 3/4 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf
R5	Beginning Seed	Seed 1/8 inch long in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf
R6	Full Seed	Pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf
R7	Beginning Maturity	One normal pod on the main stem that has reached its mature pod color
R8	Full Maturity	95% of the pods have reached their mature pod color; 5–10 days of drying weather are required after R8 before the soybeans have less than 15% moisture

Plants in a field will not all be at the same stage at the same time. When staging a field of soybeans, each specific R stage is defined only when 50 % or more of the plants in the field are in or beyond that stage.

At the end of the season when the plant is mature, the ideal situation is simultaneous leaf and pod yellowing. However, in some situations leaves may remain green after the pods have reached maturity. Leaves and stems remaining green after the seed and pod mature can interfere with harvest.

Green soybeans and soybeans ready for harvest

Mature pods for most varieties are brown or tan in color; however, a few lines have black pods.

Factors that Influence Days Between Growth Stages

Factors that can influence soybean development include temperature, water, day length, variety, and other factors. Consequently, there can be considerable variation in the number of days between stages.

Temperature is the major factor affecting vegetative development. For example, the number of days for seedling emergence to occur can range from about 5 to 15 days. The effect of temperature becomes less important after the V5 stage. A new node is produced on the main stem about every three days after V5.

Temperature, day length, and variety can impact the beginning of flowering and subsequent reproductive development. High temperatures and short days will speed the beginning of reproductive development.

Listed in Table 3 are the time intervals (average number of days and range in number of days) in days between stages that scientists have reported. The information in the following table is only averages and should only be used as estimates of what may occur in any particular growing season.

Table 3. Number of Days Between Stages of Development		
Stages	**Average Number of Days**	**Range in Number of Days**
Vegetative Stages		
Plant to VE	10	5–15
VE to VC	5	3–10
VC to V1	5	3–10
V1 to V2	5	3–10
V2 to V3	5	3–8
V3 to V4	5	3–8
V4 to V5	5	3–8
V5 to V6	3	2–5
V6 and later	3	2–5
Reproductive Stages		
R1 to R2	0*, 3	0–7
R2 to R3	10	5–15
R3 to R4	9	5–15
R4 to R5	9	4–26
R5 to R6	15	11–20
R6 to R7	18	9–30
R7 to R8	9	7–18

**Stages R1–R2 generally occur simultaneously in determinate varieties. For indeterminate varieties the time interval between R1 and R2 is about three days.*

Photo credit: Ruben Saldaña

Soybean plants in the Rio Grande Valley

Variety Selection

Selecting a variety to plant is one of the most critical management decisions that a producer will make throughout the year. Obviously, finding a variety that will yield the most is important but there are other factors to consider when selecting varieties to plant.

Lodging resistance is important when selecting a variety. Lodging reduces yields and increases harvest losses. There are varieties that stand better than others. Shatter resistance is another factor to be considered when selecting a variety. This is especially important when selecting a variety for droughty soils, where shattering can be more of a problem.

Other factors to consider include the variety's sensitivity to iron chlorosis and chlorides. Iron chlorosis is a problem in high pH and calcareous soils. Often in fields, chlorides in irrigation water can increase chloride levels greatly. If a field has a history of iron chlorosis or being high in chlorides, then it would be wise to find a variety that is less sensitive to iron chlorosis or to high chloride levels.

In the Rio Grande Valley, soybean yields have been acceptable as long as supplemental water (irrigation) is provided. A few of the varieties that are currently being planted in the Rio Grande Valley are Vernal, Hornbeck 7200, Hornbeck C5941, and Hornbeck R5425.

- Vernal has a determinate growth type and is considered to be less sensitive to the photoperiod. This conventional soybean was developed by the Agricultural Research Service, U.S. Department of Agriculture, in cooperation with the Mississippi Agricultural and Forestry Experiment Station. Vernal was released in 1992 and it can be planted beginning in the middle of February.
- Hornbeck R7200 has a relative maturity group of 7.2, which contains the Roundup Ready® trait. It is an indeterminate growth type that is planted in the middle of March.
- Hornbeck C5941 is a conventional soybean that has a relative maturity group of 5.9. R7200 is an indeterminate growth type that is planted at the beginning of March.
- Hornbeck R5425 contains the Roundup Ready® trait and has a relative maturity group of 5.4. R5425 is an indeterminate growth type and is recommended to be planted no earlier than the middle of March.

Photo credit: Enrique Perez

Soybean plants in the Rio Grande Valley

Also in the Rio Grande Valley, once a spring crop, such as grain sorghum, has been harvested it is not uncommon to plant a fall crop of soybeans. These soybeans are usually planted during June, July, and August.

Planting Practices

The optimum soil temperature for soybean germination is around 95 °F; however, a soybean seed will germinate between 37 °F and 109 °F. For spring plantings, a soil temperature of at least 50 °F is recommended for a uniform stand establishment. Obtaining quality seed for planting is important in establishing an optimum stand of vigorously growing seedlings. Seed with a standard germination test of 80% or better generally results in adequate stands. In the Rio Grande Valley, soil temperatures are usually between 55–75 °F for the recommended spring planting dates.

Proper placement of seed and good seed-to-soil contact is critical in obtaining a good stand. The optimum planting depth in most soils is 1–1.5 inches. However, certain planting conditions may dictate otherwise. For example, a shallower planting depth would be desirable when a significant rainfall event is predicted after planting. This would allow the seed to emerge more readily through crusted soil.

Conversely, a deeper depth of planting is desirable when moisture availability is at a deeper depth. Most people agree that a seed should never be planted deeper than 2 inches in most soils. Adequate soil moisture is important to complete the germination process. If enough moisture is not present, the seed could only swell and stop before the germination process is complete. A soybean seed must absorb 50% moisture by weight to germinate.

Proper placement of seed and good seed-to-soil contact is critical in obtaining a good stand. The optimum planting depth in most soils is 1–1.5 inches.

At planting, soybean seed will need to be inoculated if the field has not been planted in soybeans in recent years or if previously grown soybean plants did not have adequate nodulation. Additional information related to this topic is presented in the fertility section (p. 13). The cultural practice of planting on beds will help reduce harvest losses. Planting on a high-shaped bed allows the combine header to cut lower on the plant, thereby reducing potential harvest losses.

Most producers prefer a plant population of 100,000–120,000 plants per acre on conventional row spacings of 38–40 inches. Studies in Texas have shown that there is little yield difference in plant populations of 65,000 and 130,000 per acre. The reason for this is that soybeans have the ability to compensate for variation in plant populations. At low populations, soybean plants usually are bushy and set pods on long lateral branches near the ground. As populations increase, pods are set closer to the plant's main stem and higher up from the soil line. However, if plant populations are too high lodging can become a problem. Also, varietal differences have an impact on the amount of lodging that may occur. Often, under droughty conditions many plants are weeds or barren soybean plants, reducing the amount of available soil moisture for the productive plants.

Soybeans planted in a row spacing of 30 inches or less will often show a yield increase over soybeans that are planted on 38–40 inches, but this yield increase is not always consistent over years and/or environments. Reduced or narrow row spacings affect the growth habit of the soybean plant similar to reduced plant populations on wide row spacings. Pod height may be lower and lateral branch length may increase when row width is greatly reduced. Harvest loss may be reduced on narrow or broadcast soybeans by increasing the plant population 25–50% over that used on conventional row spacings.

Rows of soybean plants

Fertility

The best way to determine fertilizer needs is with a reliable soil test. Investing in a good soil testing program is one of the most cost-effective ways to increase profits in soybean production. A good soil test can either save money by eliminating unnecessary fertilizer or make money by increasing yields when fertilizer is recommended. More information on soil sampling can be obtained at your local Texas AgriLife Extension Service county office. Nutrients most critical to soybeans are phosphorus, potassium, and molybdenum. Iron deficiencies can be a problem on high pH and calcareous soils. Liming is important if soil pH becomes acidic.

A good soil test can either save money by eliminating unnecessary fertilizer or make money by increasing yields when fertilizer is recommended.

Phosphorus is critical in the early stages of soybean growth. It stimulates root growth, is essential in the storage and transfer of energy, and is an important component of several biochemicals that control plant growth and development. Phosphorus deficiencies are not easily observed. Usually no striking visual symptoms indicate phosphorus deficiency in soybeans. The most common characteristic of phosphorus-deficient soybean plants is reduced growth and yields. Phosphorus rates should be based on soil test results. The Texas AgriLife Extension Service recommends phosphate as shown in Table 4.

Table 4. Recommended amounts of P_2O_5 (Mehlich III ICP only) at different soil test levels for soybeans

Soil Test Level	Soil Test P (ppm)	P_2O_5 (lbs/A)
Extremely Low	0-4.99	80
Very Low	5-9.99	70-60
Low	10-19.99	55-45
Moderate	20-49.99	40-5
High	50-99.99	0
Very High	100 or >	0

While 5–40 pounds of P_2O_5 per acre is recommended on moderate testing soils, this is primarily a maintenance application. Soybeans usually respond to phosphorus only when the soil test P level is low or very low.

Phosphorus availability in the soil is largely controlled by soil pH. When the soil pH is highly acidic, phosphorus becomes tied up in very insoluble compounds with iron and/or aluminum. When the soil pH is alkaline (pH> 7.0), phosphorus becomes tied up in insoluble compounds with calcium. Phosphorus is most available to soybeans when the soil pH is between 6.0 and 7.0.

Banded applications of phosphorus are sometimes preferable to broadcast applications, especially if the soil pH is either strongly acidic or alkaline, and soil test phosphorus levels are very low. This is because there is less soil:fertilizer contact in a band, and thus less chance of soil being able to tie up the phosphorus.

Potassium is essential in the growth and development of soybeans. Potassium is indirectly related to many plant cell functions. Some 60 enzymes require the presence of potassium. Plants with adequate amounts of potassium are better able to fight diseases than potassium-deficient plants. Many of our clay soils along the Texas Gulf Coast have sufficient potassium, so potassium fertilization may not be necessary. If soil test potassium levels are 180 ppm or greater, K_2O applications are not recommended. Potassium does not chemically tie up in the soil as phosphorus does.

Potassium deficiency symptoms are fairly easy to diagnose when they are severe enough to be seen visually. Potassium deficiency symptoms usually occur on the lower leaves. The deficiency symptom will usually occur during bloom or pod fill. The margins (edges) of the leaves are necrotic (dead and brown).

Potassium is essential in the growth and development of soybeans. Plants with adequate amounts of potassium are better able to fight diseases than potassium-deficient plants.

Nitrogen requirements of soybeans can be obtained from the atmosphere. They accomplish this with the aid of the bacteria *Rhizobium japonicum*. These bacteria use soybean roots as a livable environment to complete their life cycles. They form nodules on soybean roots to secure a better environment and to protect themselves from predators. They capture nitrogen from the atmosphere and fix it in a usable form. When cut with a knife, productive nodules are pink inside while non-fixing nodules will appear greenish to gray or white. The *Rhizobium japonicum* bacteria will use available soil nitrogen before fixing their own from the soil atmosphere. Many tests have been conducted to determine if nitrogen fertilization pays in soybean production. The only time a benefit in yield might be seen is if there was not a supply of *Rhizobium japonicum* bacteria in the soil and the seed were not properly inoculated with the bacteria, or environmental conditions during the early nodulation were so severe the bacteria could not survive. Examples include very cold weather or extremely wet or dry weather.

Photo credit: Ruben Saldaña

Soybean plants in the Rio Grande Valley

Molybdenum is a nutrient needed by soybeans in small quantities. Molybdenum is required for the synthesis and activity of the enzyme nitrate reductase. This enzyme system reduces nitrates to ammonium in the plant. Molybdenum is vital for the process of symbiotic nitrogen fixation by *Rhizobia* bacteria in legume root nodules. Symptoms of this deficiency resemble those of nitrogen deficiency and are probably caused indirectly by reduced nitrogen use rather than directly by lack of molybdenum. Leaves are pale green or yellow, necrotic, and twisted. Usually there is enough molybdenum in Rio Grande Valley soils for optimum growth, but molybdenum becomes less available to plants as the soil becomes more acidic. When soil pH is higher than 6.2, additional molybdenum is not needed as a seed treatment or fertilizer.

Iron is a catalyst to chlorophyll formation and acts as an oxygen carrier. It also helps form certain respiratory enzyme systems. Iron deficiency symptoms show up as a pale green leaf color (chlorosis) with a sharp distinction between green veins and yellow interveinal tissues.

Iron chlorosis can be problem on high pH and calcareous soils, which reduce the availability of soluble iron in the soil. In some cases, iron chelate sprays should be used to prevent chlorosis expression.

Various environmental, climatic, and cultural factors can affect formation of acid soils. Lime applications will need to be made when soil pH drops below 5.5. The most important benefit of liming acid soils is a reduction of the potentially toxic elements hydrogen, aluminum, and manganese. These elements can become toxic to plant root growth and as pH drops below 5.5, nutrients are not as readily available to the plant.

Irrigation

Total seasonal water needs for a 40–50 bushel per acre soybean crop can be as high as 20–25 inches, depending on planting date and maturity. For each inch of water, this usually equates to about two bushels of soybeans being produced. Average water use is about 0.18 inches per day for soybeans. Peak water use is about 0.20–0.25 inches per day during the reproductive stages when full canopy is obtained. The effect of irrigation on soybean yields can vary from year to year because of weather conditions, soil type, and management practices. Including wet, dry, and "normal" years, the best estimate based on limited research and observations shows expected yield increases of 5–20 bushels per acre with irrigation.

Usually irrigation of soybeans is not needed prior to bloom if the soil moisture profile is completely full prior to planting. If the soil profile is not carrying a full amount of moisture before planting, a preplant irrigation may be required. Adequate soil moisture must exist from beginning bloom until the beans are fully touching in the pods.

Including wet, dry, and "normal" years, the best estimate based on limited research and observations shows expected yield increases of 5–20 bushels per acre with irrigation.

After the soybeans have reached the flowering period, irrigation should begin when the available soil moisture drops to about 50%. Experienced producers can estimate the 50% available moisture level by squeezing the soil in their hand. A sandy loam will not form a ball; loams and silt loams forms a ball that crumbles easily; clay loams form a ball which is pliable but shows cracks.

Another method to determine irrigation is the use of Watermark® sensors, which measure soil moisture tension. This method involves placing the sensors in the field at two to three different depths to measure moisture throughout the soil profile. The number of sensors placed in the field will depend on the size of the field and the number of different soil types. Soil moisture tension readings will need to be taken from each of the sensors 1–2 times a week by using a handheld meter. More information is available from the Texas AgriLife Extension Service publication B-6194, *Irrigation Monitoring with Soil Water Sensors*.

Once the decision has been made to irrigate, the goal should be to apply enough water to penetrate at least 2 feet in sandy soils and 1 foot in finer textured soils.

Growers frequently ask when to make the last irrigation for the season. A general rule of thumb is if 50% or more of the pods have seeds that are touching within the pod and if there is good soil moisture at this point, then irrigation can be terminated for the season. However, if soil moisture is not adequate, then an additional irrigation may be required to finish up the crop.

Photo credit: Enrique Perez

Soybean plants in the Rio Grande Valley

Weeds

Soybeans, like most crops, are sensitive to weed competition. Weeds compete for water, sunlight, nutrients, and space. The major objective of a weed control program should be to control weeds that emerge at or about the same time as the soybeans. In general, the first four weeks after planting is the most critical time period to keep soybeans weed-free. At harvest, weeds create problems by causing foreign matter dockage, reducing yield and harvest efficiency, and increasing moisture levels in the grain.

The first step in weed management is to identify the weed correctly in the seedling stage. Proper weed identification is needed to apply the proper herbicide when an application is warranted. Also, any management practice that promotes a rapid soybean stand establishment, recommended seeding rates, and rapid canopy closure will increase the ability of soybeans to compete with weeds. Field scouting is important during the season to determine what weeds are present, their density levels, and where they are located. This information is necessary to decide if a treatment is needed and which postemergence herbicide should be used. If you apply the wrong herbicide, adequate weed control will not be achieved.

Soybean growers have a choice of many different herbicides and herbicide combinations. The selection of herbicide is based on what weed species are present and the method of application. The methods of herbicide application include: burndown, preplant, preemergence, or postemergence.

Burndown encompasses the chemical removal of existing weeds prior to planting. Instead of mechanical removal of weeds, a herbicide or combination of herbicides is used. This method is used frequently in no-till and minimum tillage operations. Preplant is used when the herbicide is applied prior to planting the crop. The application of herbicide can be either incorporated into the soil or surface applied. Incorporation of a herbicide is less dependent on rainfall for activation. Preemergence involves herbicides being applied before weeds emerge from the soil and usually before the emergence of the soybean crop.

The main disadvantage of preemergence weed control is its dependency on rainfall within a relatively short time after application. Herbicides vary in their solubility but at least .5–1 inch of rain is needed within a week or two to move most herbicides into the soil. Therefore, good soil moisture conditions are needed for proper activation of preplant incorporated herbicides.

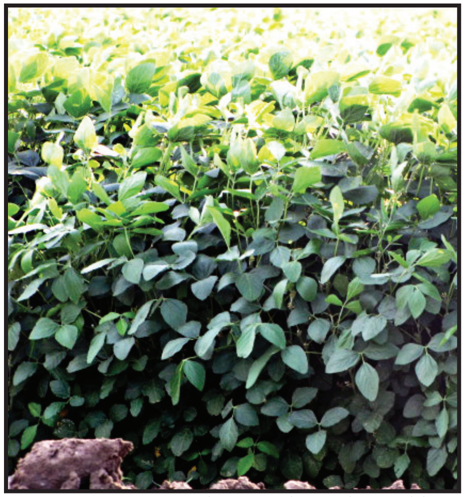

Photo credit: Ruben Saldaña

Soybean plants in the Rio Grande Valley

To select the proper herbicide, growers must know the weed history of the field since no weeds are visible. Postemergence is easier in determining which herbicide to use since the weeds are visible for identification. However, application timing is the critical factor. Weeds can become too large for the selected herbicide to be effective. Applications to weeds stressed by insufficient moisture may result in unsatisfactory control. Also, cultivation of weeds 7 days prior to or within 7 days after application may reduce percent control.

The use of herbicides is not the only tool available to control weeds. Cultural practices along with herbicide applications are the key to weed management. Cultural practices that should be considered include proper crop rotation, good seedbed preparation, good stands, and timely cultivation.

The number of resistant weeds is continuing to increase throughout the United States and Texas. Relying on one herbicide or one mode of action is a recipe for resistant weeds to develop. Management practices to avoid weed resistance should always be considered in a weed control program.

- Practice crop rotation when possible.
- Use preemergence and postemergence herbicides with different modes of action.
- Avoid sequential applications of the same herbicide or herbicides that have the same mode of action.
- Control weeds on fallow land.
- If you suspect resistance after herbicide application, attempt to eradicate escapes with alternative herbicides or cultural methods. Do not let them go to seed.

Insects

There are many insects that feed on soybeans and have an impact on yield and/or quality. The frequency and severity of insect damage varies considerably between production areas, within and between fields, and from season to season.

The cornerstone of managing insect pests is integrated pest management (IPM). IPM is the use of multiple control tactics to effectively keep pests from reaching population levels that will cause economic crop injury. These tactics include cultural control, biological control, host plant resistance, and chemical control.

Cultural control of insects includes practices such as crop rotation, planting dates, tillage practices, row patterns, etc., which help control an insect pest. However, such agronomic practices must not affect maximum economic yield.

Biological control is the conservation and use of natural enemies of insect pests to keep them from reaching damaging levels. The goal is to allow natural enemies to control pests without any disruption from pesticides. When insecticides are applied only when needed, the full economic advantage of natural enemies is realized.

Integrated pest management (IPM) is the use of multiple control tactics to effectively keep pests from reaching population levels which will cause economic crop injury. These tactics include cultural control, biological control, host plant resistance, and chemical control.

Chemical control or an insecticide application should be the last option to prevent insect damage after cultural and biological controls have failed. Correct insect identification is important to ensure the effective use of a labeled insecticide. Insecticide applications are made when insect pest levels reach economic thresholds and action must be taken to avoid an economic loss.

The only way to determine if the economic threshold has been reached is by scouting the field. Never base a decision to treat all fields based on what is found in one field. Differences in planting date, growing conditions, stage of maturity, and other factors often influence pest population levels. All fields should be scouted individually.

Insect populations can change rapidly in soybean fields. Therefore, growers should scout fields at least once and preferably twice a week to observe the species present, the pest density, and the amount of damage. Plant damage estimates are useful in making management decisions. Beginning at the onset of bloom (R1–R2) through physiological cutout (R7) is a very critical time for insect scouting. Random sampling should be conducted at four or more locations in a field. Sampling should be taken from each side of the field to adequately detect early insect infestations entering the field. Grasshoppers, stinkbugs, and other insects often feed on wild hosts adjacent to nearby soybean fields.

There are two tools used to sample soybean insect pests: (1) the drop cloth or shake sheet and (2) the sweepnet.

There are three different types of insect pests in soybeans: (1) foliage feeders, (2) pod feeders, and (3) stem, root, and seedling feeders.

Insects considered to be economic pests on the above ground portion of the plant include corn earworm, stinkbugs (green, southern green, and brown), green cloverworm, Mexican bean beetle, soybean looper, cabbage looper, velvetbean caterpillar, bean leaf beetle, beet armyworm, fall armyworm, grasshoppers, three-cornered alfalfa hopper, cutworms, garden webworm, saltmarsh caterpillar, and blister beetles.

For more information on soybean insects, labeled insecticides, and economic thresholds can be found on Texas AgriLife Extension Service publication B-1501, *Managing Soybean Insects*.

Diseases

By itself, a plant pathogen cannot cause disease. It must occur in combination with a susceptible host plant under environmental conditions that favor infection and subsequent pathogen growth. Furthermore, a plant growing under optimal conditions can withstand the effects of a pathogen. Good root development and regeneration greatly reduce severity of fungal root rot. An abundance of leaves diminishes the impact of foliar pathogens on yield. Healthy plants often grow to compensate for neighboring plants killed by diseases.

Diseases of soybeans are managed through the use of resistant varieties, fungicides, and crop rotation. Crop rotation is most useful for managing foliar diseases caused by fungi, but won't eliminate root-infecting fungi from soil. Fungicides can be applied to seed to manage seedling diseases, but may not work well with extended cool, wet soil that favors damping-off and seedling diseases.

Although soybeans are susceptible to a multitude of diseases, only a handful of those diseases are ever seen in the production of soybeans in the Gulf Coast and Lower Rio Grande Valley of Texas. Only three diseases may affect yield and for this to occur rainy weather is needed during the course of the season. These three diseases are Asian soybean rust, purple seed stain, and frogeye leaf spot. If conditions are humid and rainy during the growing season, one application of a foliar fungicide after flowering may be necessary to control these diseases, particularly if the field is used for seed production. For the most economical application, a fungicide should be applied to prevent disease, rather than treat it, using the timing and rate on the label. Fungicides should not be used for other purposes (e.g. yield enhancement), as indiscriminant use can result in pathogens becoming resistant to it.

The proper diagnosis of the disease is the first, necessary step to managing it.

Disease: Asian soybean rust (also known as rust)
Cause: a fungus, *Phakopsora pachyrhizi*
Symptoms: The undersides of leaves have raised, brownish, circular to irregularly-shaped areas. Under some magnification, these raised areas have openings in the center and resemble volcanoes. On the upper surface of the leaf, there may be yellow areas with circular brown spots just above affected areas on the undersides. A large amount of rust on leaves results in defoliation. The disease is favored by rainy weather, but since the fungus does

not survive from season to season in Texas, spores must be blown in from elsewhere to start the disease. Similar symptoms may be caused by drought and nutrient deficiencies related to drought, but a rust diagnosis can be confirmed by microscopic examination or a strip test kit (www.envirologix.com).
Control: Rust can be controlled by a fungicide application, which should only be made between R1 and R5. If a small amount of rust is already detectable on plants, then a triazole or triazole/strobilurin mixture should be used. If there is no rust in the field, a strobilurin fungicide can be used. Currently, the decision to apply a fungicide can be assisted by a tracking and forecast network (www.sbrusa.org). Texas-specific rust control information can be found at soybeanrust.tamu.edu or sickcrops.tamu.edu.

Disease: Purple seed stain
Cause: a fungus, *Cercospora kikuchii*
Symptoms: The upper sides of leaves have a purple coloration. Seeds have pink to purple discoloration. The infection originates from spores from infected seed or residue from a previous soybean crop. Disease development is favored by high temperatures and humidity.
Control: In areas where it is consistently a problem, a fungicide application can be made from R2–R5, especially if the crop is used for seed. Strobilurin fungicides tend to give better control than triazole fungicides. Crop rotation and changing varieties is also recommended.

Disease: Frogeye leaf spot
Cause: a fungus, *Cercospora sojina*
Symptoms: Leaves have circular spots with light brown centers and a darker brown edge. The infection originates from spores from infected seed or residue from a previous soybean crop.
Control: Some varieties may be resistant. Residues from previous soybean crops should be deep plowed and 2-year rotations used. In areas where it is consistently a problem, a fungicide application can be made from R2–R5, especially if the crop is used for seed. Strobilurin fungicides tend to give better control than triazole fungicides.

Other Diseases

Other noticeable foliar diseases that are a low risk for causing yield loss include downy mildew, aerial web blight, target spot, anthracnose, and mosaic. Soilbourne diseases that generally don't cause yield loss include seed decay, seedling disease, cotton root rot, charcoal rot, and southern blight.

Harvest Aids

Harvest aids in soybeans are used in fields when weeds are present at the end of season. At this time, weeds are not competing with the crop but they do pose problems at harvest. Weeds that are still growing in the field can cause excessive green material to interfere with an efficient harvest. Green weed seed and plant parts contribute to a higher seed moisture and foreign matter, which impacts the price that producers receive for soybeans.

Gramoxone Inteon (paraquat dichloride), Aim (carfentrazone-ethyl), and sodium chlorate are three desiccants or harvest aids that are labeled for soybeans. The primary objective of these products is to desiccate weeds. Several formulations of these three harvest aids are sold as harvest aids. Labels should be consulted for rates of application since active ingredients vary between formulations.

Timing of applications is important because yields can be affected if harvest aids are applied too early, causing pod-fill to be cut short. If applied too late, growers will have to wait for the weeds to dry down and watch their yield be reduced by pod shatter losses. For best results, harvest aids should be made at physiological maturity. Physiological maturity signals that the transport of photosynthate into the seed has stopped. At this time, seed moisture will be about 30–35%. When this occurs, the seed has reached its maximum dry weight. All that remains is for the excessive seed moisture to be removed. For indeterminate varieties, 65% of the seed pods should be a mature brown or gray color. On determinate soybean varieties, 50% of the leaves will have dropped and the rest will be yellow.

Desiccants will not accelerate harvest or kill soybean plants that are still green or immature. However, they are a valuable tool in early maturing soybean systems where indeterminates are grown and where grass and weeds come through the canopy prior to harvest.

Harvest

Weather conditions such as moisture fluctuations, changing fields, and crop conditions, which include weedy or droughty areas require that combine adjustments be made during most days to maintain combine efficiency. A skilled operator can return a significant increase in profit per hour of harvest. Also, harvesting is the single most costly operation of soybean production.

If dryer facilities are not available, harvest at a moisture content of 13%. When the moisture content is 10% or below, shatter losses become excessive. If drying facilities are available, harvest beans at moisture contents up to 20%.

Minimizing Field Losses

The following adjustments to the combine at harvest will help keep yield losses to a minimum, reduce damaged or split beans, and assist in a cleaner harvest.

- A sharp, well adjusted cutterbar is vital to speeding harvest and minimizing gathering loss. Four items need to be checked; ensure that
  - all sickle sections are sharp,
  - all sickle hold downs are gapped properly,
  - all guards are in alignment,
  - the sickle is in correct guard register.
- Operate the cutter bar as close to the ground as possible.
- Use a ground speed of 2.8–3.5 miles per hour.
- Run the reel tip speed 10–25% faster than ground speed.
- Reel axle should be 6–12 inches ahead of cutter bar. For short, low yielding beans, the reel axle may need to be moved directly over the cutter bar. Reel bats should leave beans just as they are cut. Reel height should be just low enough to control the beans.
- Set fan speed to remove chaff and straw, but not to blow beans into the tailings or out of the rear of the combine.
- To reduce over-threshing, start by narrowing the thresher to concave or rotor grate spacing to the position recommended in the operator's manual and then reduce it further if some unthreshed pods are leaving the rear of the combine. Cylinder speed must be adjusted for threshing conditions. When beans are above 13% moisture, they are usually tough and cylinder speed may have to be increased to 700–750 rpm. Reduce to 500–550 rpm for dry soybeans (8.5–13% moisture).

Soybeans ready for harvesting

Estimating Field Losses

Companies that sell combines consider the maximum combine capacity to be the feed rate (weight) at 3% field loss. However, experienced producers can keep field losses between .5 and 2 bushels per acre. The desired field loss should be .5 bushels per acre under normal or good growing conditions and 1.5 bushels per acre under extremely droughty, low-podded soybeans or muddy fields. However, when harvest is delayed, excessive shattering or severely lodged soybeans can cause field losses up to 2 bushels per acre.

When checking for field losses, an average of 4–5 beans per square foot equals about one bushel per acre loss. To obtain a good sample, soybeans in 10 square feet should be counted. Take several random samples and average them to find the average and divide the average by 50. For example, if an average of 75 beans is found within the 10 square feet, the field loss is 1.5 bushels per acre (75/50 = 1.5).

A combine harvesting soybeans

Table 5. Estimated costs and returns per Acre
Soybeans-GMO Seed-12 Row Conventional Till-Dryland
Upper Coastal Bend, 30 bushel Yield Goal, 2011, District 11

ITEM	UNIT	PRICE	QUANTITY	AMOUNT	YOUR FARM
		dollars		dollars	
INCOME					
Soybeans	bu	10.50	30.0000	315.00	________

TOTAL INCOME				315.00	________
DIRECT EXPENSES					
CUSTOM					
Scout - Soybeans	acre	5.00	1.0000	5.00	________
Custom Haul Grain	cwt	0.30	18.0000	5.40	________
HERBICIDE					
Glyphosate (gal)	gal	13.00	0.5625	7.31	________
2,4-D Amine	pt	1.50	1.0000	1.50	________
Surfactant	pt	1.21	0.0417	0.05	________
Soybean-PreEm-Herb	pt	9.46	1.0000	9.46	________
Roundup	pt	2.09	0.5000	1.05	________
Soy Desiccant/Defol	pt	4.23	1.0000	4.23	________
INSECTICIDE					
Beans-Stinkbug Cntrl	lb	5.25	1.5000	7.88	________
SEED/PLANTS					
Soybean Seed/RR	bag	48.00	1.0000	48.00	________
OTHER					
Inoculants	bag	5.00	1.0000	5.00	________
Crop Ins - Soybeans	acre	6.25	1.0000	6.25	________
OPERATOR LABOR					
Tractors	hour	13.75	0.2709	3.73	________
Self-Propelled	hour	13.75	0.1755	2.44	________
HAND LABOR					
Implements	hour	7.50	0.1000	0.76	________
Self-Propelled	hour	7.50	0.1200	0.90	________
DIESEL FUEL					
Tractors	gal	2.45	2.7899	6.84	________
Self-Propelled	gal	2.45	1.3600	3.35	________
REPAIR & MAINTENANCE					
Implements	Acre	1.59	1.0000	1.59	________
Tractors	Acre	1.50	1.0000	1.50	________
Self-Propelled	Acre	5.98	1.0000	5.98	________
INTEREST ON OP. CAP.	Acre	4.42	1.0000	4.42	________

TOTAL DIRECT EXPENSES				132.67	________
RETURNS ABOVE DIRECT EXPENSES				182.33	________
FIXED EXPENSES					
Implements	Acre	5.85	1.0000	5.85	________
Tractors	Acre	6.91	1.0000	6.91	________
Self-Propelled	Acre	14.07	1.0000	14.07	________

TOTAL FIXED EXPENSES				26.83	________

TOTAL SPECIFIED EXPENSES				159.50	________
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				155.50	________
RESIDUAL ITEMS					
Management Charge	%	315.00	0.0500	15.75	________
Land Charge	acre	40.00	1.0000	40.00	________
G&A Overhead	acre	10.50	1.0000	10.50	________

RESIDUAL RETURNS				89.25	________

Websites of Interest

agrilifeextension.tamu.edu
sickcrops.tamu.edu
soybeanrust.tamu.edu
twri.tamu.edu

Texas Water Resources Institute
make every drop count
AgriLIFE EXTENSION
Texas A&M System

EM-108
500 copies, March 2011

Appendix E

Task 3

Subtask 3.1

- AgriLife Extension is seeking input from local turfgrass producers regarding the turfgrass education conference and will put together a steering committee to guide the conference. The conference, likely to be a one day event with one half of the day dedicated to turfgrass producers and the other half dedicated to turfgrass managers, is tentatively scheduled for spring 2010.

- Outside speakers/experts on the various subjects will need to be brought in and some educational materials will need to be produced for the conference. Given the delay in the start of the project, the possibility to push the conference to next spring (2010) was discussed and AgriLife Extension requested TWRI to inquire about the possibility of such extension for the turfgrass education conference and the project.

- The SAFE Program was delivered on April 16, 2010 in La Feria.

- Irrigation Audit Kits were purchased and given to the Texas AgriLife County Extension Agents to conduct irrigation audits or to lend to schools to conduct their own audit.

ATHLETIC FIELD IRRIGATION AUDIT WORKSHOP

Staff Development Center (Curriculum/lnstruction Office)-La Feria ISD
400 West Street, La Feria, TX

April 16, 2010

The Texas AgriLife Extension Service is pleased to offer a one-day short course on irrigation auditing for athletic fields to diagnostic potential problems, improve efficiency, and conserve water. The course will include practical information on: 1.) How to estimate the water needs for your grass; 2.) How to set up a proper irrigation schedule to conserve water while maintaining quality turf grass; and 3.) Management aspects of athletic fields. This course is designed for anyone with an interest in irrigation management and water conservation, who is already using a sprinkler system, or who is planning on having one installed. Participants will gain knowledge and hands-on experience on how to calculate plant water requirements based on evapo-transpiration and rainfall, and how to conduct an irrigation audit to evaluate their irrigation system's application depth and uniformity.

AGENDA

8:00 a.m.	**Registration** – Breakfast
9:00 a.m.	**Welcome and Introductions**, *Dr. Ruben Saldana, District Extension*
	Overview and Objectives, *Dr. Enrique Perez, County Extension Agent-AG*
	Concepts in Irrigation Auditing, *Dr. Juan Enciso, Extension Ag. Engineer Specialist*
	Results of the Irrigation Auditing, *Xavier Peries, Extension Associate*
	La Feria lSD, Rio Hondo, lSD, Santa Rosa, lSD, Santa Maria, ISD
	Break
10:45 a.m.	**Athletic Field Management**, *Dr. James A. McAfee, Extension Turf Specialist*
	Lunch
12:00 p.m.	**Educational Tour** – Athletic Field
1:00 p.m.	**Adjourn**

AgriLIFE EXTENSION
Texas A&M System
Improving Lives. Improving Texas.

Participant Satisfaction Results

Activity Title: Cameron County-Athletic Field Seminar

Activity Date: April 16, 2010

Activity Description:

Number of Participants: 20

Percentages based on 14 respondents to the survey (Response rate = 70%).

Overall:

- 100% of respondents were mostly or completely satisfied with the activity.

Content:

- 100% of respondents were mostly or completely satisfied with the information being what they expected.
- 93% of respondents were mostly or completely satisfied with the information being accurate.
- 93% of respondents were mostly or completely satisfied with the information being easy to understand.
- 100% of respondents were mostly or completely satisfied with the completeness of information given on each topic.
- 93% of respondents were mostly or completely satisfied with the timeliness of information given on each topic.
- 100% of respondents were mostly or completely satisfied with the helpfulness of the information in decisions about your own situation.
- 93% of respondents were mostly or completely satisfied with the quality of course materials.
- 100% of respondents were mostly or completely satisfied with the relevance of the examples used.

Instructor(s):

- 93% of respondents were mostly or completely satisfied with the instructor's knowledge level on the subject.
- 100% of respondents were mostly or completely satisfied with the instructor's speaking / presentation abilities.
- 100% of respondents were mostly or completely satisfied with the instructor's organization / preparedness.
- 100% of respondents were mostly or completely satisfied with the instructor responses to student questions.

Facilities:

- 93% of respondents were mostly or completely satisfied with the physical setting's contribution to ease of listening and participation.

Anticipated Changes & Economic Impact:

- 71% of respondents plan to take actions or make changes based on the information from this activity.
- 77% of respondents anticipate benefiting economically as a direct result of what they learned from this Extension activity.

Value of Activity:

- 77% of respondents said that the information and programs provided by Extension were quite or extremely valuable to them.
- 100% of respondents would recommend this activity to others.
- 93% of respondents would attend another subject offered by Extension if it addressed a specific need or interest of theirs.

Demographics of Participants:

- 0% female
  100% male
- 0% Black
  93% Hispanic
  7% White
  0% Other
- 14% under age 30
  50% ages 30 to 49
  36% ages 50 to 69
  0% age 70 or older