# STRATEGIC ANALYSIS & IMPLEMENTATION PLAN for TEXAS' CORN INDUSTRY

**Prepared by: Corn Advisory and Implementation Committee**

Texas A&M AgriLife, Texas A&M University System

- Texas AgriLife Research[1/]
- Texas AgriLife Extension Service[2/]
- Texas Corn Producers Board[3/]

**September 9, 2011**

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Texas A&M AgriLife, Texas A&M University System

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## ACKNOWLEDGEMENTS

The Corn Advisory and Implementation Committee greatly appreciates the efforts of the many faculty, unit heads, and corn producers who gave generously of their expertise and time in developing, writing, or editing sections of this report.

# Executive Summary

Corn is a $1 billion per year industry in Texas. From 2005 to 2009, NASS (2010) reported an average of 2.12 million acres of corn were planted annually in Texas. An average of 237 million bushels of corn were harvested with a farm gate value ranging from $520 million to $1.27 billion to Texas producers ($921 million/year average).

Research and Extension programs are conducted to address the grower's needs, advance scientific discovery, and assure technology transfer. The industry's needs are changing even as knowledge has increased.

The Corn Advisory and Implementation Committee was appointed by administrators of Texas AgriLife Research and Texas AgriLife Extension Service in May 2004. Research and Extension programs are conducted to address the grower's needs, advance scientific discovery, and assure technology transfer. The industry's needs are changing even as knowledge has increased. The Committee was charged with facilitating and monitoring implementation of the "2003 Strategic Analysis and Implementation Plan for Texas' Corn Industry". The Committee was comprised of selected research and Extension unit heads, faculty, and members of the Texas Corn Producers Board (TCPB), as shown in Appendix A. The initial 5-year "Corn Strategic Plan", adopted November 3, 2003, addressed major issues for Texas corn production and recommended actions that would position the research and extension corn programs among the nation's best.

In 2010-2011, the Committee and other selected individuals from Texas AgriLife and the TCPB reviewed the 2003 Strategic Plan and assessed progress toward meeting the recommended objectives and strategies. Of the priorities and/or actions recommended in the 2003 Corn Strategic Plan, most have been addressed (Table 1). However, much work remains to establish pre-eminent research and extension programs in addressing the evolving needs of the state's corn industry. Therefore, the Corn Advisory and Implementation Committee, together with TCPB Board members, have developed appropriate revisions and recommendations for future actions and program focus.

The purpose of this report is to convey a current analysis and Strategic Plan for addressing both scientific and industry needs as of 2010-2011. Actionable objectives and strategies are presented herein, as developed through a consensus of Texas Corn Producers Board members and selected Texas AgriLife Research and Texas AgriLife Extension Service personnel, identified in Appendix A. These team members have identified issues, needs and constraints to the corn industry in Texas. Out of the 2010-2011 re-assessment, the Committee and other participants have recommended several **major program areas** below. Within each Major Program Area, the high priority* program elements are listed below to be considered for short or long-range attention by researchers or extension personnel. Likewise, the current level of interest by TCPB board members was indicated from an industry perspective for comparison in the following listing (see also Appendix B), recognizing the changing needs of industry:

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## Major Program Issue Areas and Potential Research/Extension Program Elements

| | Current Priority for: | | |
|---|---|---|---|
| | TCPB | | Texas AgriLife Research and/or Extension |
| **CORN PRODUCTION AND MANAGEMENT SYSTEMS** | 2003 | 2011 | 2011 |
| • Integrated Pest Management/IPM | H | M | H |
| • Mycotoxins management/BMPs/systems (Appendix C) | H | H | H |
| • Cropping systems | H | L | M |
| • Efficient irrigation and crop water management | H | H | H |
| • Ground and surface water protection | H | H | H |
| • Irrigation and pumping system efficiency | H | H | M |
| • Atoxigenic fungi discovery/development (Appendix C) | N/A | VH | H |

| | Current Priority for: | | |
|---|---|---|---|
| | TCPB | | Texas AgriLife Research and/or Extension |
| **TARGETED STRATEGIC LIVESTOCK FEEDING APPLICATIONS** | 2003 | 2011 | 2011 |
| • Evaluate the feeding value & economics of distillers grains | H | L | M |
| • Mitigation of mycotoxins in animal feed production | N/A | H | M |

| | Current Priority for: | | |
|---|---|---|---|
| | TCPB | | Texas AgriLife Research and/or Extension |
| **ECONOMIC RESEARCH & POLICY ANALYSIS** | 2003 | 2011 | 2011 |
| • Farm Bill Implications polices | VH | VH | VH |
| • Water economics and water policy | H | VH | VH |
| • Impacts of alternative uses of corn | VH | L | L |
| • Master Marketer/price & production risk management | H | H | H |
| • USDA-FSA/NRCS rules & regulations | H | H | H |
| • Grain elevator sales and risk | N/A | H | M |
| • Crop insurance/education, insurance policies and rules | N/A | M | M |

| | Current Priority for: | | |
|---|---|---|---|
| | TCPB | | Texas AgriLife Research and/or Extension |
| **CORN BREEDING AND GENETIC IMPROVEMENT** *(Does not indicate funding priority)* | 2003 | 2011 | 2011 |
| • Drought tolerance | VH | H | VH |
| • Mycotoxin resistance/tolerance | VH | H | VH |
| • Heat tolerance | H | H | H |
| • Insect resistance | H | H | M |
| • Disease resistance/tolerance | H | H | M |
| • Better-yielding short season varieties | H | H | H |

| | Current Priority for: | | |
|---|---|---|---|
| | TCPB | | Texas AgriLife Research and/or Extension |
| **COMMUNICATIONS** | 2003 | 2011 | 2011 |
| • Research & Extension information exchange with industry | N/A | M | H |
| • Systematic external communications targeting growers & general public | N/A | M | M |

| | Current Priority for: | | |
|---|---|---|---|
| | TCPB | | Texas AgriLife Research and/or Extension |
| **EMERGING ISSUES** | 2003 | 2011 | 2011 |
| • Water policy and implementation | N/A | VH | H |
| • Crop insurance ratings, policies & education | N/A | H | M |
| • Grain indemnity fund development | N/A | VH | L |
| • Review action levels for Aflatoxin as pertaining to corn in livestock feed | N/A | H | M |

| | Current Priority for: | | |
|---|---|---|---|
| | TCPB | | Texas AgriLife Research and/or Extension |
| **RESOURCE COORDINATION AND LEADERSHIP DEVELOPMENT** | 2003 | 2011 | 2011 |
| • Congressional internship | H | H | L |
| • TALL program | H | H | M |

* Priority Designations: VH=very high; H=high priority; M=medium; and L=low.

The 2010-2011 Recommended Action Plan that can address needs of the Texas corn industry is provided in more detail in subsequent sections of this report. These sections were prepared by appropriate Texas AgriLife Research and Extension Service faculty or administrators, with substantial involvement of TCPB leadership including Board Members as well (Appendix A).

**Edited by:**
**J.M. Sweeten, David Gibson and Bill McCutchen**

**Table 1. 2011 Status of Fulfilling the 2003 Recommended Action Plan for the Texas Corn Advisory and Implementation Committee**

| | Timeline: | | Relative Cost: | | | |
|---|---|---|---|---|---|---|
| **Recommended Actions (2003)** | **Short Range** | **Long Range** | **Inexpensive** | **Expensive** | **Who (Agency*)** | **Status or Accomplishments, 2004-2010** |
| **Aflatoxin/Mycotoxin:** | | | | | | |
| ● State aflatoxin task force | X | | X | | TAES & TCE | Texas AgriLife established a Mycotoxin task force with Dennis Gross/George Latimer as co-chairs (2004-05). |
| ● Develop multi-university task force** | X | | X | | TAES & TCE | Texas and other states produced a federal initiative; FY11 request. |
| ● Congressional Initiative on Mycotxin | | X | | X | TAES, TCE, TCPB | Texas AgriLife Research has lead a federal initiative with TCPB input (FY11 request). |
| ● I.D. losses due to Aflatoxins/Mycotoxin | X | | X | | TAES & TCE | Handled by AgriLife Mycotoxin task force. |
| **State Legislative Initiative(s) (2005-2007):** | | | | | | |
| ● Cropping systems, including corn | | X | X | | TAES & TCE | State legislative initiative by AgriLife Research on Mycotoxin for FY06 & 07 was submitted to Texas Legislature, October, 2004. Not funded. |
| ● Irrigation water management | | X | X | | TAES & TCE | Legislative initiative by AgriLife Research on water conservation for FY08-09 was not funded; included irrigation water management. |
| **Capital equipment replacement plan:** | | X | | X | TAES | Not prepared; requires input from Corn Workers Group and sources of cost sharing (e.g. royalties). |
| **Focus on highest priority research needs:** | | | | | | |
| ● Farm bill implications/economics (continual ongoing analysis) | X | | X | | TCE & TAES | Agriculture & Food Policy Center team have conducted extensive trainings statewide; recurrent. |
| ● Alternative uses - new products/uses of corn economic impacts | | X | | X | TAES, IFSE, ARS | Main thrust to date has been distillers grains/cattle feeding research initiative. |

*** Agency names were changed January 1, 2008; so that TAES now refers to Texas AgriLife Research, and TCE refers to Texas AgriLife Extension Service.**

**** Includes: GA, MS, SD, KY, TN, NC, SC, LA, MO, TX**

| | Timeline: | | Relative Cost: | | | |
|---|---|---|---|---|---|---|
| **Recommended Actions (2003)** | **Short Range** | **Long Range** | **Inexpensive** | **Expensive** | **Who (Agency*)** | **Status or Accomplishments, 2004-2010** |
| • Mycotoxins | | X | | X | TAES, ARS, TCE | AgriLife Mycotoxin Task Force was expanded to include a multi-state initiative, viz. Aflatoxin Mitigation Center of Excellence (Appendix C). |
| • Water stress/irrigation $H_2O$ management | | X | | X | TAES & ARS | Research on irrigation efficiency, corn water use, and IWUE is ongoing at Etter, Halfway, etc.; superior corn breeding lines developed at Lubbock; also, corn variety trials and Extension demonstrations conducted annually statewide. |
| • Pest Management | | X | | X | TAES, TCE, TAMU | Corn rootworm models developed at Amarillo and ARS-Stillwater, OK linked to Texas High Plains Evapotranspiration (TXHPET) Network (Michels). Other R&E Entomologists and IPM agents stayed engaged in pest management R&D via demonstrations, collaboration with industry counterparts, field days, and newsletters (e.g. Panhandle Pest Management) .AgriLife Research and AgriLife Extension faculty are collaborating with counterparts in industry to screen new transgenic hybrids for control of pests that are unique to corn production in Texas in terms of species, severity of attack and timing of infestation. |
| **Enhance Technology Transfer to Seed Industry:** | | | | | | |
| • Improve value of Texas Corn variety tests | | X | | X | TCE & TAES | |
| • Breeders workshop | X | | X | | TAES & TCE | |
| • Multidisciplinary evaluation of tests | X | | X | | TAES & TCE | |
| • Include commercial hybrids | X | | | X | TAES & TCE | Extensive research toward developing improved breeding lines, germplasm, etc at Lubbock and CLL. |
| **Engage TAMU-Institute for Food Science and Engineering (IFSE):** | | | | | | |
| • Liaison | X | | X | | TAES & TCE | Initial efforts made to link IFSE with Corn Advisory & Implementation Team. |
| • Seed money, TAES | | X | | X | TAES | Cropping Systems Initiative funding available |

| | Timeline: | | Relative Cost: | | | |
|---|---|---|---|---|---|---|
| **Recommended Actions (2003)** | **Short Range** | **Long Range** | **Inexpensive** | **Expensive** | **Who (Agency*)** | **Status or Accomplishments, 2004-2010** |
| | | | | | | via competitive grants. |
| ● State legislative initiatives on cropping systems (see above) | | X | X | | TAES, TCE, ISFE | Texas AgriLife Research Cropping Systems Initiative established in 2005(?); composite of pre-existing state initiatives. |
| ● Mycotoxin initiative/multistate (above) | X | | X | | TAES, TCE, TCPB | Both state and federal Mycotoxin Initiatives were developed/proposed by Texas AgriLife Research (see Appendix C). |
| **Improve collaborations with USDA-ARS on Alternative Uses:** | | | | | | |
| ● Liaison | | | | | | Link was established to USDA-ARS Peoria research database. |
| ● Workshops | | | | | | Workshop(s) were piggybacked on Texas Feed & Grain Conference. |
| **Improve coordination of Corn R&E Programs:** | | | | | | |
| ● TCPB research funding priorities and projects | X | | X | | TCPB, TAES, TCE | Annual RFP for TCPB grants coordinated through Texas AgriLife Research; with annual review of proposals by Corn Advisory & Implementation Committee, with technical feedback to TCPB. |
| ● Access TCPB research reports | X | | X | | TCPB, TAES, TCE, ARS | No formal data base or report compilation established. |
| **Compilation of all corn R&E in Texas; One-stop shopping:** | | | | | | |
| ● Access existing report/data bases TARD, CRIS, TAES and TCE Impact Statements, etc.: | X | | X | | TAES, TCE, TCPB | Initial efforts to coordinate this through TARD and CRIS; not formalized nor continuing. |
| ● Interpretative summaries of the above reports | | X | | X | TAES, TCE, TCPB | Not established. |
| ● Compile consolidated research progress report in Texas | | X | | X | TAES, TCE, Soil & Crop Sciences | Not established. |
| **Extension Priority positions/coordination:** | | | | | | |
| ● State corn specialist - Coordinate various agencies | | X | | X | TCE & TAES | Dr. Brent Bean (Amarillo) named Interim State Extension Corn Specialist in 2004. |
| ● Regional corn specialists - High | | X | | X | TCE | |

| | Timeline: | | Relative Cost: | | | |
|---|---|---|---|---|---|---|
| **Recommended Actions (2003)** | **Short Range** | **Long Range** | **Inexpensive** | **Expensive** | **Who (Agency*)** | **Status or Accomplishments, 2004-2010** |
| Plains, Blacklands, Upper Coast/Coastal Bend, Low Coast,Valley, & Winter Garden | | | | | | |
| ● Corn workers group, inter-disciplinary | X | | X | | TAES & TCE | Initial efforts to organize (2005). |
| **Research position:** | | | | | | |
| ● Research/Extension entomologist/corn - High Plains or statewide | | X | | X | TAES & TCE | • A. Faculty position established at Lubbock (Dr. Christian Nansen).<br>• State chemist given partial research role, to include corn. |
| **Continued Involvement of Corn Advisory and Implementation Committee:** | | | | | | |
| ● Guide & monitor Strategic Plan implementation | X | | X | | TAES & TCE | • May 6, 2004 - Texas A&M AgriLife named Corn Advisory & Implementation Committee.<br>• Committee members with relevant Unit Heads (except faculty) reviewed proposals submitted to TCPB each fall, 2004-2009. Committee meetings held July 2004 and January 2005. |
| • Interact with Corn Workers Group, including Strategic Plan Implementation | | | | | TAES, TCE, TCPB | Initial efforts made (2005) to establish a Corn Workers Group (Bean, et al); organization was not finalized. |

# Introduction

## Texas Corn Production

Corn is a $1 billion per year industry in Texas. Over the five years from 2005 to 2009, NASS (2010) reported an average of 2.12 million acres of corn were planted annually in Texas, with an average of 237 million bushels of corn harvested with a farm gate value ranging from $520 million to $1.27 billion to Texas producers ($921 million/year average). Corn producers are represented by Texas Corn Producers Board, which administers the check-off funds for the state, and by the Corn Producers Association of Texas.

Corn planting begins in far south Texas in February and concludes in the northern panhandle in mid-May. Harvest season is normally from late July through November as it progresses from the south to the north. Conditions including natural resource constraints, management practices, and biotic/abiotic stress factors vary considerably among these major production areas. The distance from south to north presents corn producers many varied concerns such as insects, diseases, and weeds, and with moisture and heat stress being common across the whole state in most years. Water availability is a main factor in corn production, whether irrigated or dryland. Energy costs for irrigation are a major concern, as well as groundwater availability and policy, as affected by groundwater district rules and/or state policies.

Most of the corn that is produced in Texas is used for livestock feed with other uses including human food products, industrial usage of corn products, or export. A major growth area in the last 5 years has been grain-based ethanol production, which has expanded to 250 million gallons per year capacity (2% of U.S. total), with Texas ranking 13$^{th}$ in ethanol production capacity (USDA, 2010)* (Source: USDA, 2010. A USDA Regional Roadmap to meeting the Biofuels Goals of the Renewable Fuels Standard by 2022. USDA Biofuels Strategic Production Report, Washington, DC. June 23, 2010. p. 21). According to industry sources, an additional 100 million gallons per year of ethanol capacity is expected to open in Texas in 2011.

## Corn Advisory and Implementation Committee

In response to the 2003 plan, the Corn Advisory and Implementation Committee was established by memorandum(May 6, 2004) from the Associate Vice Chancellor, Texas AgriLife Extension Service; Deputy Director, Texas AgriLife Research; and Vice Chancellor and Dean for Agriculture and Life Sciences and Director, Texas AgriLife Research, Texas A&M University System (TAMUS). The administrative Charge to the Committee was stated as follows:

> *" A strategic plan was recently developed by a committee that included faculty, administration, and commodity leadership. We commend this group for their efforts and vision and feel that this document will provide the platform for charting future corn research and extension programs in Texas."*
>
> *"At this time, we would like to create an oversight committee to help with the implementation of the strategic plan for corn. The charge to this committee will be expanded to serve an advisory role to the Agriculture Program (currently Texas A&M AgriLife). It is anticipated that this committee will meet as needed to*

*develop an action plan with recommendations to aide Texas AgriLife Research and Texas AgriLife Extension Service in serving the corn industry in Texas.*

*Furthermore, please feel free to involve others in your deliberations as they are needed."*

Committee membership, leadership, and administrative liaisons were named in 2003. Appointed committee members represented the following categories (Appendix A):

- Resident Directors TAMUS AgriLife Research and Extension Centers (ARECs) in areas where corn is a significant part of a region's agricultural economy;
- Heads of TAMU Departments having significant disciplinary responsibility for corn;
- Selected members of the Board of Directors, Texas Corn Producers Board.
- Executive Director, Texas Corn Producers Board
- Faculty members with significant corn-related responsibilities.

As noted above, the charge included involving others from the above groups as needed; and this freedom has been liberally construed and used as indicated in Appendix A. In fulfilling the administrative charge, the Committee met 3 times (July 26, 2004 through June 24, 2010), and has produced this consensus report. When adopted by the Committee, this report will be presented to TAMUS AgriLife Administration and Texas Corn Producers Board with recommendations for modifications to the corn strategic plan and further action.

The Corn Advisory and Implementation Committee was organized and positioned to ensure current and future actions which include recommended resource allocations, careful consideration of the issues, and development of program elements articulated in this strategic plan. The committee's job is to ensure strong linkages with leadership of the Texas corn industry in identifying issues, challenges, needs, and opportunities; and assist in developing recommendations that will help foster, develop, and accelerate corn research and extension programs that meet the identified priority needs. Used to maximum advantage, the Committee can provide a forum for exchange of ideas which included developing and articulating a statewide vision and action plan for the corn industry. The Strategic Plan can be used to guide review and prioritization of program requests involving corn research and extension programs across the Texas A&M AgriLife, including Texas AgriLife Research and Texas AgriLife Extension Service in accordance with the identified needs and vision of the state's corn industry.

## Vision, Mission, and Major Program Areas

The Corn Advisory and Implementation Committee have developed the following consensus vision and mission:

1. Vision -- Interdisciplinary, multi-agency research and extension programs in corn development, production, management, and utilization shall be the premier source of new and applied knowledge that will help advance the corn industry in Texas.
2. Mission Statement -- Develop and deliver science-based information and knowledge related to improving corn development, production, management, and utilization in Texas, in accordance with the respective missions and program capacities of the Texas

AgriLife Research, the Texas AgriLife Extension Service, and closely-partnering universities (e.g., West Texas A&M University, Texas Tech University, etc.), federal or state agencies (including USDA-ARS), and the corn industry.

**3.** Major Program Areas -- The Corn Advisory Committee has identified several Major Program Areas that should be vigorously pursued in the next 5 years as resources permit to help meet the challenges of the corn industry in Texas:

A. Corn Production and Management Systems

B. Targeted Strategic Livestock Feeding Applications

C. Economic Research and Policy Analysis

D. Corn Breeding and Genetic Improvement

E. Communications

F. Resource Coordination and Leadership Development

Recommended Program elements, program actions or strategies that will substantially address these Major Program Areas are discussed and listed in subsequent sections. Several important new or emerging issues are mentioned or discussed within the context of the major program areas.

**Edited by:**

**J.M. Sweeten, Travis Miller, Charles Allen & Brent Bean**

# A. Corn Production and Management Systems

## Regional Differences

### Texas Corn Production

Over the five years from 2005 to 2009, an average of 2.12 million acres of corn were planted annually in Texas, with an average of 237 million bushels of corn harvested, which had a market value ranging from $520 million to $1.27 billion to Texas producers ($921 million/year average).

The key corn growing areas of Texas, as defined by the Texas field office of the National Agricultural Statistics Service (NASS)* for the 3-year crop period 2007-2009, were the Northern High Plains (880,000 acres), Blacklands (612,000 acres), South Central (189,000 acres), Upper Gulf Coast (268,000 acres), and the Southern High Plains (93,000 acres). These regions accounted for 90% of the Texas corn planted acres and 94% of the state's corn grain production, with 61% of corn grain produced in the Northern High Plains alone. The environmental conditions for growing corn vary considerably in these four regions. As such, farming practices have been developed to address regional corn production issues.

## Major Production Influences

The major factor in successfully producing corn is water availability during the season, and in particular, from anthesis through grain fill. Most of the corn grown in south and central Texas is produced under dryland conditions. In the Texas High Plains close to 100% of the corn acreage is irrigated. Cultural practices that improve water use efficiency in both dryland and irrigated production systems will have a major impact on yield and profitability. Those farming practices that impact production and water use efficiency include:

- Efficient crop water management and irrigation: timing, delivery systems and efficiency;
- Integrated pest management (IPM) of diseases, weeds, and insects;
- Soil fertility/nutrient management;
- Off-target losses of fertilizer and pesticides;
- Cropping systems;
- Hybrid selection(including hybrids with transgenic events);
- Tillage, including reduced tillage;
- Planting considerations: timing, population, and seed distribution.
- Refuge strategies for transgenic hybrids

The interaction of all these components greatly impacts the profitability of corn. The fundamentals of each factor should continue to be studied with particular interest in how they interact and fit into and overall corn production system.

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* SOURCE: NASS, 2010. Texas Corn for Grain. USDA-NASS, Texas Field Office, Austin, TX. February 2010. 1 p. (www.nass.usda.gov/tx)

## 1. Efficient Crop Water Management and Irrigation.

Increasing corn water use efficiency (amount of grain produced per inch of water) should be a major goal of all research and extension efforts as well as for producers. In the case of irrigated crops, this will lead to decreasing production costs and conserving water resources. Strategies for increasing crop water use efficiency may focus on one or more of the following: timing, amount, and method of irrigation water application; planting populations (seeding rates, row spacing and planting time); and hybrid selection (maturity and drought tolerance capability). Other production components such as pest management (weeds, insects, and diseases), crop rotations, reduced tillage, and fertilization can also affect corn water use efficiency. The pursuit of increased crop water use efficiency will also be facilitated by the development of accurate computerized crop management tools used to monitor soil moisture, crop growth and development, and crop water use.

## 2. Disease Management.

Corn diseases occur in all production areas of Texas, and several of these diseases can cause devastating losses. The greatest threat is from fungi that produce mycotoxins, which contaminate grain. Recurring droughts in Texas have predisposed most corn production areas of the state to aflatoxin contamination. Aflatoxin, occurs in corn produced on dryland, but has affected irrigated corn as well. The use of Bt corn and other transgenics has altered production and disease management practices. The labeling and use of atoxogenic stains of *A. flavus* is also impacting the management of aflatoxin. There is a great need for interdisciplinary efforts to develop new disease management systems and to develop innovative methods for improving disease resistance or pathogen suppression systems. Major disease problems that continue to be the focus of research and extension programs are described below.

*Mycotoxins*—Mycotoxins are toxic compounds produced by naturally occurring fungi in grains, nuts, and oil seeds. Aflatoxins are mycotoxins produced by the fungi, *Aspergillus flavus* and *A. parasiticus*. Numerous variations of aflatoxin occur with the most potent being aflatoxin B1. The use of products contaminated with aflatoxin is regulated by action levels established by the FDA. (Appendix C). Aflatoxin contamination of corn is the major problem for producers in Texas. It consistently results in annual losses across all Texas corn growing areas in the tens of millions of dollars, with losses exceeding $100 million during drought years. Aflatoxin is especially problematic in years when drought and heat stress occur during pollination or kernel maturation, affecting even irrigated corn produced under these conditions. Controlling the disease has been difficult. Collaborative efforts between pathologists and breeders has led to some progress in breeding as a control approach, but breeding alone is unlikely to solve the problem. There is a need for additional, coordinated research on other management practices. Soil inoculation with non-toxicogenic strains of the fungus may have promise.

An integrated and focused approach can hasten solutions to substantially reduce the outbreaks of aflatoxin contamination. An Aflatoxin Mitigation Center of Excellence was proposed to facilitate field deployment of solutions to aflatoxin in contamination in corn. Sponsors of the Center have identified the following as specific components of this proposed multi-disciplinary research program (Appendix C):

- Promoting and refining biological control and ecology,
- Developing resistance through breeding and genetics,
- Identifying best management practices, and
- Improving and obtaining approval of remediation procedures for contaminated grain.

Another important and emerging mycotoxin problem is fumonisin, produced by the fungus, *Fusarium verticillioides*. Factors affecting the preharvest accumulation of fumonisin in corn are not well understood. FDA has only recently established action levels for fumonisins in grain, and additional federal regulations are expected in the future because of the high toxicity of fumonisins to humans and animals.

*Other Diseases*--Other diseases also reduce corn productivity. There is no coordinated, intensive research effort on these diseases. These diseases are: charcoal rot, caused by the soilborne fungus *Macrophomina phaseolina;* head smut, caused by *Sporisorium reilianum*, and common smut, caused by *Ustilago maydis*, which can be found throughout the state, although serious problems occur mostly in the High Plains region of Texas; southern rust, caused by *Puccinia polysora*, and common rust, caused by *Puccinia sorghi*, which occur primarily in coastal and southern corn-producing regions of Texas; and viruses such as maize dwarf mosaic and the newly-recognized High Plains Disease. There is a need for epidemiological studies of these diseases, particularly smuts, in which the influence of weather and crop management practices is unclear, and High Plains Disease, which has a broad host range that, includes wheat, barley and several weedy grasses.

The corn pathology research and extension team should have expertise in mycology and mycotoxins, virology, disease resistance and breeding, and epidemiology. The team will address both applied and basic aspects of diseases, screening germplasm for performance in the field, and an educational program to ensure technology transfer to producers. To address these disease problems in Texas, the following research and extension activities have been identified:

a. Develop new approaches to identify resistance to aflatoxin-producing fungi, and support conventional breeding efforts aimed at incorporating aflatoxin resistance into corn germplasm.
b. Further investigate the potential use of non-toxigenic strains of fungi that suppress aflatoxin-producing fungi on corn.
c. Develop educational programs and publications that address the educational needs of growers, processors, and others potentially affected by aflatoxin.
d. Office of Texas State Chemist needs to evaluate the prevalence of fumonisins in the major production areas.
e. Develop hybrids with resistance or tolerance to fungal and viral diseases.
f. Determine how drought and other environmental stresses induce host susceptibility to charcoal stalk rot and mycotoxin-producing fungi.
g. Develop molecular gene markers to assist in selecting disease resistance genes for use in corn breeding programs.
h. Use molecular tools to understand resistance responses to pathogens and the strategies pathogens use to overcome field resistance.
i. Continue studies on cultural practices for managing corn diseases.
j. Increase support and incentives for collaborative multidisciplinary research teams to enhance crop and disease management practices.

## 3. Weed and Herbicide Tolerant Crop Management.

Weeds are a major challenge for corn producers in Texas. Glyphosate tolerant hybrids have simplified management of some previously problematic weeds, but weed complexes in corn fields and rotational crops are shifting. Weeds resistant to glyphosate and other herbicides such as atrazine have made weed control increasing complex and problematic. In addition, cotton with resistance to glyphosate when rotated to corn has posed significant problems with boll weevil eradication efforts, resulting in significant costs in either controlling the volunteer cotton or in added expense for boll weevil control in corn impacted with volunteer cotton.

Continued efforts are needed to respond to weed species shifts, availability of new herbicides, and changes in tillage and cropping systems. Staying ahead of weed resistance is an ongoing issue. For example, Johnsongrass resistance to popular sulfonylurea herbicides has been confirmed on farms in the High Plains and glyphosate tolerant tall waterhemp has been identified in the Upper Gulf Coast. Widespread tolerance to populations of horseweed, Plamer amaranth and giant ragweed have been identified in the mid-South. Intense pressure is being exerted on weed populations, as glyphosate use has increased due to the availability and widespread use of tolerant crop hybrids and varieties. Development of glyphosate resistance in major weed species would be a major setback in reduced tillage systems statewide as it is already causing such problems in the mid-South. More effort must be made to develop the most economical strategies for weed control and to integrate and implement strategies to prevent the development of weed resistance to herbicides.

## 4. Insect Management.

*Transgenic Corn*--Transgenic hybrids that provide protection against stalk borers, corn earworm, fall armyworm, and other lepidopteron species were first made available in 1996 as single toxin transgenic hybrids. This revolutionized how we manage lepidopteran pests in corn in Texas as well as in other crops that share the some of the same pest species. Fundamentally, we no longer rely on multiple applications of broad spectrum insecticides, e.g., pyrethroids for management of this suite of insect pests. Transgenic hybrids for corn rootworm were first made available in 2003 and while they provide good control of rootworm species affecting the northern High Plains (western corn rootworm) these transgenic hybrids are not as effective on southern corn rootworm that are important in the coastal production regions in Texas. What is currently available in transgenic hybrids are stacked hybrids that have multiple genes for lepidopteran pests and multiple genes for corn rootworms. The new hybrids will be stacked or pyramided traits, that is, hybrids with 3 to 5 or more genes expressing insecticidal toxins. These pyramided traits were developed as a way to manage resistance to these transgenic hybrids and to reduce the amount of land used to plant refuge corn (corn without the insecticidal genes). These transgenic events have increased cost of production substantially with seed corn prices approaching $350 per bu which is ca. $150 increase in price over non-transgenic seed corn. The economics of corn production has thus changed dramatically and most economic thresholds are based on input and price parameters that are no longer valid. Spider mites and other insects that were controlled by broad spectrum insecticides targeted for lepidopteran and corn rootworms are reaching damaging densities and work needs to continue on these pests not currently controlled by transgenic hybrids.

Transgenic hybrids that control Lepidopteran and corn rootworm pests provide significant economic returns to Panhandle growers through near-complete protection against southwestern and European corn borers. Continued educational emphasis on refuge requirements is needed

because seed companies continue to develop and make available new packages of Bt combinations, some of which have modified refuge requirements. As new Bt events become available, Research/Extension generated efficacy, agronomics and refuge information will be needed. Efforts to inform federal regulators of the scientific merit of less restrictive refuge requirements are also needed.

The next generation of transgenic corn will be those hybrids that require less water. What is unknown is whether or not less irrigation water may exacerbate the damage caused by corn rootworm larvae on corn roots. Typically, moderate corn rootworm damage can be overcome if corn is well watered. Water stressed corn may in fact loose yield to moderate root pruning. This interaction needs to be determined under Texas environments.

*Insecticides* -- As a consequence of the high seed corn prices, seed corn typically arrives with multiple compounds applied to the seed coat (fungicides plus insecticides). Research is needed on efficacy of these materials and recent work has shown that some of these insecticides might actually down-regulate genes that are involved in spider mite resistance suggesting that seed treatments may play a role in the increase in spider mite infestation. There are currently 3 registered miticides available on the market due to the work of AgriLife Research and Extension faculty and 2 additional miticides will likely be registered by 2012. Work will continue on treatment thresholds for spider mites as will educational programs that will highlight sampling and economic return on investment for mite treatment.

As with any insecticide whether applied to the seed, as a foliar application or as a transgenic event producing lepidopteran or beetle active toxins, resistance is a constant threat. AgriLife Research and Extension faculty are actively involved in collecting pest Lepidoptera for testing at various labs for susceptibility to various transgenic events. In the past bioassay data indicated high levels of insecticide tolerance in corn earworm to pyrethroid insecticides. As corn rootworm resistance or tolerance to transgenic hybrids expands in the U.S. Corn Belt (first identified in Iowa and Minnesota in 2011), we need to be vigilant and monitor for evidence of resistance in western corn rootworm to transgenic hybrids. Inherently transgenic hybrids for corn rootworms are not as effective as are the toxins for Lepidoptera. The corn earworm has been implicated in elevated aflatoxin levels, and is a major pest of cotton and vegetable crops. Therefore, we must continue to monitor these insects for resistance to the transgenic events and work with seed corn companies so effective hybrids will continue to be available to Texas growers.

*Corn Breeding to Improve Insect Resistance*--AgriLife Research corn breeders and entomologists have developed corn traits conferring drought tolerance and corn earworm and spider mite resistance. These lines are nearing commercialization and need to be evaluated locally by AgriLife personnel. If successful, these lines may increase net profit per acre or potential to expand the area where corn can be produced economically. In current corn production areas Successful introduction of these lines may also necessitate revision of economic thresholds for spider mites.

*Economic Thresholds* --Most of our economic thresholds were written 20 or more years ago and do not reflect the introduction of hybrids that are resistant to pests, changing market prices, or

costs of control. A few "dynamic" thresholds which alter the action threshold according to insect numbers, value of the crop, or the cost of control have been developed. More dynamic thresholds need to be developed, in part to help growers and consultants make reasonable control decisions with high-cost inputs and high-value corn (or low-value corn). This approach will also allow growers to adapt to changing policies regarding on-farm practices.

## 5. Soil Fertility

Soil fertility research on corn production in Texas has been limited in recent years. Nutrient management practices must be evaluated from both economical and environmental perspectives.

Amounts of N, P, and K required to optimize production are well documented. However, research is needed on how to most efficiently deliver nutrients with the least possible loss. Several U.S states have adopted aggressive environmental legislation related to fertilizers and soil test levels of nutrients. Data is needed to support current nutrient management practices. Additionally, research to develop soil test procedures that accurately quantify nutrient carryover are needed.

There has been much debate on the reliability and accuracy of soil test values for phosphorus with respect to crop response and to minimize nutrient runoff. Regulatory thresholds for phosphorus are based on extractable P levels, but have not been correlated with the environmental impact in many cropping systems or with differing soil test values. Studies are needed provide background data on soil test P levels, cropping systems and their impact on environmental fate of applied P.

Micronutrients or trace elements such as sulfur, iron, zinc, boron, and magnesium differ from the macronutrients in that they are needed in much smaller amounts. Spatial distribution of these elements between and within fields appear to be less uniform than that of macronutrients. Studies are needed to determine when, where, and how to apply these micronutrients to obtain a positive economic return.

## 6. Off target loss of fertilizers and , pesticides.

Off-target loss of pesticides and fertilizers is a major issue facing corn producers. The Texas Commission on Environmental Quality (TCEQ) listed six surface water impoundments and one river threatened by atrazine contamination from surface runoff of agricultural and urban landscapes. For instance, Lake Aquilla in Hill County is listed as impaired associated with atrazine contamination and a Total Maximum Daily Load for atrazine has been set for this reservoir. Alachlor has also been detected in Lake Aquilla at the threatened level. All of these water bodies serve to provide drinking water for each one's surrounding communities. Concerted efforts on the part of the part of AgriLife Research and Extension Service, the agrochemical industry, state and federal agencies with environmental responsibilities, and Central Texas farmers and ranchers have significantly reduced the concentration of atrazine in these water bodies resulting in the continued availability of atrazine for weed control and cleaner water supplies for Central Texas residents.

The TCEQ has also documented atrazine detections in public water supply wells supplying 6 or more cities in Texas High Plains in counties with significant corn production. The United States Geologic Survey (USGS) surveyed 48 sites covering 29,000 square miles of the Texas High

Plains to analyze drinking water wells in the Ogallala Aquifer. Preliminary results presented by USGS from this water quality study revealed pesticide detections in 15 of the 48 wells sampled (USGS WRI Report 02-4112, 2002).

Work must be done to develop and implement strategies for effective and sustainable corn growth and protection to reduce off-target losses of pesticides and nutrients. This effort must include on-site applied research projects that evaluate the use of best management practices (BMPs) that reduce off-target losses of pesticides and nutrients with minimal adverse impact on yield and net return per acre. A concerted effort must then be undertaken to transfer the results to the producer via field days, tours, CEU meetings, news releases, websites, news articles, videos, etc.

## 7. Cropping Systems

A cropping system is the sum total of all of the production practices on a particular field or farm. This may include the types of crops grown, their planting sequence, time, rate and pattern of planting, tillage, nutrient, irrigation, and pest control management strategies. For any cropping system to be successful it must be profitable and sustainable both in the short and long term. Much research in the past has been narrowly focused on refining individual production practices within a single crop, with little effort expended on developing profitable, whole farm cropping systems. In recent years economists, scientists and specialists across the state have made efforts to examine entire cropping systems. This effort must be encouraged to continue and expand, reaching across traditional commodity lines. Corn is an important rotational crop in Texas. Its use in farming systems allows for economical and effective management of diseases, weeds, and insects of other agricultural crops. Corn presents growers with important options for implementing economically viable cropping systems.

## 8. Hybrid Selection

Corn hybrids are constantly improving as new releases are developed by university and industry plant breeding programs. Texas AgriLife Research and Extension Service personnel conduct uniform corn hybrid trials around the state to provide seed companies and growers a fair assessment of current and newly released corn hybrids. Seed companies are invited each year to enter hybrids for a fee into these trials. The number of hybrids submitted by commercial companies has declined in recent years. Those submitted are often experimental and do not include the hybrids currently being sold in the local area. This reduces the value of AgriLife trials. A plan needs to be developed to improve the relevancy and dissemination of information from hybrid performance trials, to include hybrids with transgenic events that impact insect and herbicide resistance and drought tolerance, with cognizance of refuge strategies and associated costs.

Currently the Texas Corn Variety Test is primarily focused on yield. In the future, the Variety Test should include additional traits to help the corn producers in different regions to choose the most suitable hybrids. These additional traits include yield performance under different water treatments, husk coverage and tightness, physical and chemical characteristics of the seed pericarp, corn earworm, and grain molds or possibly the aflatoxin contamination levels. Variety Tests requires the collaboration of the scientists with different expertise to collect and report needed data.

**9. Tillage**

While the most obvious advantages to reduced tillage are reduced fuel costs, lower equipment requirements and reduced labor, tillage practices also strongly influence seedbed moisture storage and the condition of the seedbed at planting. Good seed to soil contact is critical for obtaining uniform stand emergence. Tillage systems that promote more uniform seed germination and seedling vigor, enhance weed control, and that preserve and improve water infiltration and storage are desirable. Optimum tillage practices will vary based on soil type, annual precipitation, crop rotations, the presence of weed, disease, and insect pests, and available equipment. Tillage practices vary considerably between regions of the state and even between neighboring farms. The development of new herbicide and weed control methods has enabled Texas farmers to rely on less tillage than was common in the recent past. While some producers have adopted no-tillage, most rely on a wide range of tillage methods and equipment. Research to develop profitable reduced tillage systems that address regional concerns are needed.

**10. Planting Considerations: Seeding Rate, Row Spacing, and Planting Date**

Response of corn yield to seeding rate, row spacing, and planting date vary considerably depending on the region of the state, and how a new variety affects these decisions. For example, studies on row spacing suggested a strong advantage to 20-inch rows over conventional 30 and 40-inch rows in central Texas. Less advantage was shown using 20-inch rows in irrigated production on the Texas High Plains. Although Texas agronomists have studied cultural practices, continued studies are needed as new hybrids are released and farming practices and equipment change. Interaction of cultural practices with the incidence of disease, insect, and weed pests need further study.

**Recommended Program Elements/Objectives and Program Actions/Strategies**

Program Elements (or Program Objectives) were identified within the Major Program Area of *Corn Production and Management Systems.* These Program Elements represent broad program directions or targets for statewide corn research and extension programs. Recommended Program Actions or Strategies for each Program Element are more specific, tangible and measurable activities that should be considered.

**Program Element/Objective 1. Efficient Irrigation and Crop Water Management:** Develop and disseminate best management practices that optimize water use efficiency and protect surface and ground water quality.

**Action/Strategy 1.1. Irrigation methods.** Development of irrigation application systems such as Low Energy Precision Application (LEPA), Low Elevation Spray Application (LESA), and subsurface drip irrigation have contributed greatly to increasing the efficiency of water application to crops and pursuing increased crop water use efficiency of irrigated corn in particular. There is a continuing need for educational efforts to encourage adoption and improve management of these high efficiency systems. Site-specific irrigation technologies currently being developed need to be tested to identify their effectiveness and feasibility for corn irrigation.

**Action/Strategy 1.2. Irrigation scheduling methods.** Proper timing and amount of irrigation applications will lead to increased water use efficiency. Timing irrigations based on water stress levels, stage of crop development, and production functions showing yield as percent of Evapotranspiration (ET) replaced by irrigation will be used to optimize crop water use efficiency as the knowledge base develops further and is transferred to producers.

**Action/Strategy 1.3. Tools for assisting irrigation scheduling**. The availability of computerized tools for assisting irrigation scheduling would help producers attain high water use efficiency, reduce irrigation costs, and conserve water. Such tools will focus on integrating weather, crop and soil information. Educational emphasis will be placed on utilization of irrigation scheduling tools such as evapotranspiration models, soil moisture monitoring, crop stress models, or cultural practices that affect crop water demand.

**Action/Strategy 1.4. Evaluation of drought tolerant hybrids**. Statewide corn production could be significantly increased and become more stable with the use of improved drought-tolerant hybrids, as this would reduce the negative impact of water deficits on yield and grain quality and the secondary effects of corn diseases associated with drought. The overarching efforts will focus on characterization of hybrids for drought tolerance and identification of plant traits controlling their water economy.

**Action/Strategy 1.5. Water quality protection.** Develop strategies for effective and sustainable corn production while protecting surface and ground water from off-target movement of pesticides and nutrients.

**Action/Strategy 1.6. Optimizing systems for water use efficiency.** Develop cropping systems and management practices that optimize water conservation and management by: a) expanding research and educational efforts to encourage the adoption of high efficient irrigation equipment, management, and cropping systems; and b) determining cropping systems that result in optimum water conservation and efficiency, and c) training producers in their use.

**Action/Strategy 1.**7. **Develop novel or improved systems/strategies for irrigation to include alternative energy sources (solar, wind, etc.) or improved water pumping systems.**

Current engineering knowledge in high-efficiency irrigation well design is under-utilized by contemporary water well drillers or pump installers. Advances in matching irrigation energy requirements with alternative energy sources, including a combination of wind and solar for instance, need to be packaged and placed in service. Novel advances in pump

design should be examined for applications to irrigation pumping plants for corn growers.

**Program Element/Objective 2. Integrated Pest Management (IPM).** Develop new strategies and disseminate updated information on IPM- based control of aflatoxin/mycotoxins and other diseases, weeds, insects, and pests Active management of pests, diseases, and weeds is critical to production of high quality corn in the variable field environments found in Texas**.** Many crop protection technologies are available to growers for their management. Best management approaches to pest management (IPM) are needed to optimize corn productivity and sustainability, based on understanding of pest/corn/environment/crop protection technology interactions.

**Action/Strategy 2.1. Integrated plant protection.** Develop integrated plant protection approach for management of endemic and emerging pests, diseases, and weeds. Several factors (e.g. changing weather patterns, different plant genetics, resistance development, pest expansion to new areas) affect the occurrence and severity of pests and influence the potentially significant interactions of pests, diseases, and weeds. Projects designed to produce integrated plant protection approaches are invited, including pest delineation/plant response assessment, management strategy evaluations, and understanding how production practices, drought and other environmental factors influence pest severity and vulnerability of plants to damage.

**Action/Strategy 2.2. Mycotoxin management.** Management of pathogen, environment, and host factors that collectively contribute to pre-harvest occurrence of mycotoxins will help mitigate a key constraint to the production of corn in Texas. A complex interaction of biological and environmental plant stresses and host response to those stresses have variable but significant effects on pre-harvest mycotoxin accumulation in corn. Production practices and associated pest management technologies including transgenic pesticide and herbicide traits can dramatically reduce plant stresses under some field environments. Projects are invited which seek to most efficiently utilize existing technologies and practices to reduce mycotoxin risk through sustainable management approaches readily integrated into existing major corn production systems in Texas. Research should include atoxigenics.(Appendix C).

**Action/Strategy 2.3. Disease management**. Characterize and mitigate effects of important corn diseases with a particular focus on mycotoxins, using interdisciplinary teams to develop: a) new methods for suppressing mycotoxin-producing fungi; b) new disease management systems in the field; and c) innovative methods for improving disease resistance or pathogen suppression.(Appendix C).

**Action/Strategy 2.4. Weed management.** Characterize effects of weeds on corn and develop IPM solutions by: a) developing specific economical weed control recommendations based on tillage practices and crop rotation considerations; and b) developing and disseminating information on weed control strategies that minimize development of weed resistance.

**Action/Strategy 2.5. Insect management.** Characterize effects of insects on corn and develop IPM solutions by: a) finding economically feasible methods to control corn pests; b) developing improved practices for managing spider mites; c) maintaining the viability of transgenic hybrids by continuing to monitor changes for tolerance or resistance to various cry genes; and d) developing and disseminating information on economic thresholds that take into account the insect numbers, value of the crop, and cost of control.

**Action/Strategy 2.6. Maximize efficacy and sustainability of genotypes with respect to chemical use in corn cropping systems**. Transgenic and traditionally bred hybrids and the use of agrochemicals have provided great benefits to corn production, and other crops have benefited from identical or similar technologies. With opportunity is also the challenge to most efficiently use and conserve all technologies and identify and address vulnerabilities associated with their use. For example, herbicide resistant weeds and pest/pathogen resistances are a constant threat; crop rotations to dissimilar crops that nevertheless have identical transgenic traits has posed various productions and associated agrochemical problems; and pesticide use to enhance crop growth in absence of a pest may pose a pest-resistance threat to the class of related pesticides. Multiple factors indicate the need to strategically deploy crop protection technologies in the most responsible manner within agricultural production systems that are economically viable and sustainable, and protect efficacy of all crop component factors. Projects are invited to: a) develop best approaches to utilize these technologies and resolve vulnerabilities within corn and associated rotational and neighboring crops; and b) maximize efficacy and sustainability of transgenic and traditionally bred corn and agrochemical use (pesticides, herbicides, and fungicides) within an integrated crop protection strategy for corn and associated rotational and neighboring crops.

**Program Element/Objective 3. Cropping Systems.** Develop and encourage adoption of cropping systems and management practices that maximize the economic return of corn production. Cropping systems refer to the integration of the production practices on a particular field or farm. These production practices include the types of crops grown, their planting sequences, time, rate and patterns of planting, tillage, nutrients, irrigation and pest control management strategies.

**Action/Strategy 3.1. Improved cropping system BMP's.** Develop and encourage the adoption of improved cropping systems and best management practices by:

a. Computerized crop management decision support systems**.** Crop models that integrate weather, soil, and crop information are useful tools for estimating components of crop production such as crop development, crop growth and canopy formation, crop water use, crop photosynthesis and crop yield. Such crop models can be packaged in a decision support system to assist crop managers make more informed crop management decisions before and during the cropping season. These management tools can be used to schedule chemical applications, water management, pest management and decisions on crop termination and harvest.

b. Crop rotation alternatives for corn. The choice of crop rotation has important implications to the subsequent crop in terms of residue management, fertility, soil erosion, soil water, insect management, disease management and weed control; crop rotations particularly influence the selection of herbicide to use.

c. Tillage methods. Developing profitable reduced tillage methods that address the current cost of fuels calls for a reevaluation of the intensity of tillage operation producers performs to produce a crop. Reduced or no till can improve the plant-soil environment, resulting in improve growth and yield and reduced production costs. Tillage methods modify the residue management, the soil infiltration and water retention capacity and improve soil fertility. Research stations needs to be up-to-date in methodology and equipment.

d. Soil fertilization. Fertilizer costs have drastically increased during the last five years. It is probable that prices will continue to increase in the years to come. Defining the type of fertilizer, method and rate of application are key variables defining the efficiency of uptake. Rotation and tillage system have a large interaction with soil fertility and yield.

e. Hybrid selection. Promoting extension activities that improve the quality and quantity of unbiased information on hybrid selection that emphasize maximize yield potential under local environmental and cultural conditions.

f. Soil fertility. Determining soil fertility management practices that reduce nutrient loss; better quantification nutrient carryover; utilizing the best identified phosphorus tests for the major soils in the state with respect to phosphorus fertilization; and identifying when, where, and how to apply micronutrients to obtain a positive economic return.

g. Soil management. Expanding research and extension activities to provide knowledge on soil management, reduced tillage, row spacing, seedbed preparation, optimum plant population and spacing, and planting date and rates.

**Action/Strategy 3.2. Off-site/off-target chemical losses.** Develop and implement strategies for effective and sustainable corn growth and production to reduce off-target losses of pesticides and nutrients. Strategies should include: a) on-site applied research projects that evaluate BMP's to reduce off-target losses of pesticides and nutrients with minimal adverse impact on yield and net return per acre; and b) transferring results to producers via field days, tours, websites, newsletters, CEU training meetings, and news articles.

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# B. Targeted Strategic Livestock Feeding Applications

**Livestock Use**

Corn has been a major feedstuff for U.S. livestock for many years. It is the most widely-used component in finishing diets for cattle and swine. Therefore, we often take for granted that the volumes of research that have been reported on corn as a feedstuff are sufficient for present and future understanding of its value. But, corn is a dynamic cereal and livestock feeding systems are ever-changing. New hybrids are being developed, new feeding roles are evolving, and new factors need to be considered in use of new hybrids as a feed, especially those concerning the environmental effects of feeding rations high in corn to animals concentrated in feedlots.

Research and extension faculty involved in animal nutrition, livestock production, and wildlife management have considered the current state of knowledge available to the industry. Corn has been shown to have negative associative effects when fed to cattle consuming protein deficient, high forage diets. Conversely, its value in high forage, high protein diets is not well understood.

In most corn hybrids, phosphorus in kernels is largely tied up as phytate. Phytate is poorly digested by swine and poultry (nonruminants). Phosphorus requirements of cattle have recently been shown to be 0.2%, whereas the phosphorus level in corn is about 0.3%. Phosphate-related water pollution from manure or effluent from concentrated animal feeding operations is a nonpoint source water pollution problem in some watersheds. If phosphorus or phytate in the diet can be reduced, for ruminants or nonruminants, respectively, the potential for phosphate-related nonpoint source water pollution can be reduced also, and the number of acres needed for environmentally-sustainable land application can be maintained at practical levels.

Some work has been done evaluating new hybrids such as high oil corn and high lysine corn. But many new corn hybrids are being developed and their feeding value must be assessed.

Corn has become a staple supplement for white tailed deer, but many other species consume the corn fed to these animals. Several reports indicate that the effects of supplementation of non-target species are often surprising and deleterious to the goals of the producer.

**Program Elements and Recommended Program Actions**

The Corn Advisory Committee has developed five (5) Program Elements and specific recommended Program Actions to meet identified industry needs. The fulfillment of these research and extension needs will help maintain corn's prominent role as an animal feedstuff in Texas and neighboring states.

**Program Element 1.** Evaluate the feeding value and economics of ethanol by-products including distillers grains (DGS) with solubles in wet (WDGS) or dry (DDGS) forms.

Action/Strategy 1. Determine the proper level of WDGS/DDGS in livestock diets, including overcoming challenges with feeding high levels with respect to sulfur content or other potential toxins.

Action/Strategy 2. Determine the nutrient availability of DDGS, including methods to enhance digestibility.

Action/Strategy 3. Determine the variation in nutritive value that exists in ethanol by-products and determine the variables associated with this variation with the goal of increasing the consistency and feeding value of the products.

**Program Element 2.** Determine ways to improve the feeding value of corn as a supplement to high protein, high forage diets for cattle or other livestock.

Action/Strategy 1. Evaluate the associative effects of corn when livestock graze high protein forages (e.g. small grains).

Action/Strategy 2. Compare the associative effects of feeding corn to cattle fed diets containing the most commonly fed high protein forages.

Action/Strategy 3. Determine the site of digestion and rate of passage of corn fed as a supplement to animals consuming high protein, high fiber diets.

Action/Strategy 4. Compare the associative effects of feeding corn to cattle, deer, goats, and sheep fed high protein, high fiber diets (including animals grazing or browsing rangeland).

Action/Strategy 5. Develop intensive, forage-based production systems utilizing corn-based supplements to produce consistently tender, juicy, flavorful, lean beef.

Action/Strategy 6. Determine the associated benefits of supplementing grazing livestock with WDGS/DDGS on subsequent feedlot performance and health.

**Program Element 3.** Develop low phosphorus and low phytate corn varieties for animal feeding purposes consistent with environmental nutrient management requirements for concentrated animal feeding operations.

Action/Strategy 1. Determine the optimum phosphorus requirement for livestock at different stages of growth, considering environmental quality goals.

Action/Strategy 2. Determine the minimum phosphorus level attainable in high yield corn.

Action/Strategy 3 Identify new parental lines with potential to develop hybrids of corn that are low in phosphorus and phytate.

Action/Strategy 4. Determine the effect of the new corn varieties in livestock diets on comprehensive nutrient management systems.

**Program Element 4.** Evaluate the feeding value of recently developed corn varieties.

Action/Strategy 1. Determine the nutritive value of new corn hybrids processed by steam flaking, to include energy value, protein characteristics (including site of digestion and rate of passage), and other value indicators.

Action/Strategy 2 Determine the feeding value of recently developed corn varieties such as high oil corns as to their relative feeding value to deer, goats and sheep fed high protein, high fiber diets.

Action/Strategy 3. Determine the feeding value of recently developed corn varieties/hybrids on feeding/nutritive value of resulting distillers grains.

**Program Element 5.** Determine the effects on target and non-target species when corn is fed to white tailed deer on rangeland.

Action/Strategy 1. Determine the distribution of corn consumption among animals of the targeted specie (e.g. what proportion of the white tailed deer population actually consumes the corn?).

Action/Strategy 2. Determine the non-target species consuming corn as fed as supplement to deer, and the effect on the behavior of these species.

Action/Strategy 3. Determine methods to increase the uniformity of consumption of corn among animals of the target species, while decreasing the consumption by non-target species.

Action/Strategy 4. Determine methods to use corn as an effective means of delivering animal health compounds (such as Ivomectin® to control fever ticks) to deer and other wildlife populations.

**Edited by:**

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# C. Economic Research and Policy Analysis

Corn is the second largest row crop in Texas with respect to cash receipts. Two-thirds of the production is irrigated and one-third is dryland. The major corn production areas in Texas are separated by more than 600 miles in distance, resulting in the need for different production and marketing approaches. These factors lead to a myriad of regional economic issues.

For example, dryland corn production systems account for the majority of corn produced in the Central Texas and Texas Coastal Bend. Over the last two decades, these regions have experienced large variations in yields and prices due to drought and disease problems, including mycotoxins. Mycotoxin (aflatoxin) continues to be a major economic issue.

The Texas AgriLife Research and Extension educational response to the need for economic management of risk resulting from variations in yields and crop quality must be addressed on several fronts. First, AgriLife Research and Extension education will address the risk management issues related to dryland corn production on a whole-farm basis. Second, Research and Extension education efforts are needed for evaluation of the impact of variability of corn yields and alternative production systems with respect to the provisions of the current US farm policy. Third, an analysis of and tenure (rental) issues related to corn production in light of alternative production systems and farm policy scenarios, given increasing number of tenant farmers, is needed. Fourth, there is a need to address marketing alternatives that capitalize on the early harvest and location advantages of corn producers in Texas. Fifth, Research and Extension education efforts should address advantages and disadvantages of biofuels production.

More than eighty-five percent of the irrigated corn production is located in the Texas High Plains. Irrigation and the characteristics of this region give rise to some unique economic issues. First, declining water tables result in a need to evaluate several alternatives to economically maximize water including: irrigation technologies; irrigation scheduling such as using region-specific evapotranspiration (ET) data; cropping systems; hybrid selection; water conservation systems and management strategies; production practices and water quality. Second, the increasing grain deficit characteristics of the region give rise to other issues that need to be evaluated such as: the impact of unit train facilities on local corn prices and the evaluation of alternative products, such as silage, for use in dairies on localized pumping of aquifers. Third, issues surrounding volatility in irrigation fuel prices need to be addressed including: feasibility of alternative irrigation fuel sources, including renewable energy alternatives; modification of crop lease agreements to combat the impacts of fuel prices volatility; and evaluation of methods to manage/control irrigation fuel prices.

A number of economic issues need to be addressed that cut across all corn production regions of the state. They include: the economic implications of the current US farm policy and subsequent changes impact analysis of changes in EPA regulations, including pesticide use with respect to water sources; improvements in marketing education allowing Texas corn producers to capture increased profits; improved corn basis information to assist in marketing and risk management efforts; and feasibility studies that evaluate community and producer impacts of attracting

alternative uses to Texas, such as ethanol plants; and potential impacts (positive or negative) of developing climate-change policies.

The overall goal of the economic and policy strategic planning is to provide research and continuing education programs that enhance Texas corn producers' ability to make improved economic decisions and maximize their net returns.

**Program Elements and Recommended Program Actions**

The Program Elements and recommended Program Actions identified by the Corn Advisory Committee are:

**Program Element 1.** Provide regional and farm level economic analysis and interpretation of federal and state policies affecting Texas corn producers.

Action/Strategy 1. Evaluate the economic implications of the various provisions of the current US farm policy and subsequent proposed modifications of the farm policy to Texas corn producers, by production region.

Action/Strategy 2. Evaluate and provide Texas corn producers with information concerning the impacts of changes in USDA-NRCS and EPA rules affecting production practices and chemical use, by production region.

Action/Strategy 3. Provide analysis and implications to Texas corn producers of changes in NAFTA, GATT, WTO/Doha, and other international agreements.

Action/Strategy 4. Evaluate potential policy changes that could enhance the comparative advantage of Texas corn producers.

Action/Strategy 5. Evaluate the impacts on Texas corn producers of potential greenhouse gas and/or carbon market legislation.

**Program Element 2.** Evaluate alternative marketing possibilities and develop educational programs that give Texas corn producers the skills/alternatives to maximize profits.

Action/Strategy 1. Enhance the intensive marketing educational system (eg. Master Marketer) already initiated to expand the use of improved producer marketing skills

Action/Strategy 2. Develop Research and Extension education programs that relate to the financial viability of on-farm grain storage and marketing strategies that utilize grain storage, both on-farm and commercial. These programs will help producers take advantage of strengthening basis levels after harvest and could increase value added opportunities through identity preservation.

Action/Strategy 3. Develop Research and Extension education programs related to marketing strategies based on the early harvest capability of Texas corn producers and potential for strong basis levels that may be available at harvest.

Action/Strategy 4. Develop, maintain, evaluate and disseminate corn basis information and trends as impacted by other regional production or constraints for the production regions of Texas to improve pre- and post-harvest marketing decisions.

Action/Strategy 5. Develop targeted and timely knowledge exchange with private or public policy developers that will improve the decision basics for crop insurance or grain indemnity decisions.

**Program Element 3.** Develop research projects and extension programs that address the critical financial and production risk management issues of Texas corn producers.

Action/Strategy 1. Develop Research and Extension education programs to examine how new risk management tools being developed by the USDA Risk Management Agency could be incorporated into the total risk management program for corn producers in Texas, to include influence of biotechnology or mytoxin mitigation endorsement on multi-peril crop insurance premiums.

Action/Strategy 2. Develop Research and Extension education programs related to changes in the total cost structure of alternative production systems under the current farm policy, including secondary impacts on rental arrangements and land tenure.

Action/Strategy 3. Develop Research and Extension education programs that evaluate the economic impact of alternative corn production technologies on the whole farm operation. For example, what are the impacts on fixed costs related to changes in the machinery complements due to the use of transgenic corn hybrids that offer alternatives to traditional pest management strategies. Another example could be the financial and capital impacts due to adoption of narrow row-spacing production technologies.

Action/Strategy 4. Evaluate improved irrigation technologies and water-pumping strategies to maximize the returns to irrigated corn producers; for instance, increasing use of drip irrigation and/or use of water-efficient corn varieties require economic analysis.

Action/Strategy 5. Conduct a feasibility study of alternative fuel sources for irrigation and identify methods to control fuel costs.

Action/Strategy 6. Develop economic studies that will indicate how Texas producers will fare under various alternatives involving proposed climate change policy.

Action/Strategy 7. Develop research and extension programs that target improved knowledge of water use, water requirements, advanced water conservation measures, and apply this knowledge in regional, state, or local water planning and policy, as well as guidelines to corn growers.

**Edited by:**

**Pete Gibbs; Mark Waller; Ron Lacewell; Dee Vaughan**

# D. Corn Breeding and Genetic Improvement

Major environmental factors limiting Texas corn production include drought, heat, insects (corn earworm, spider mites, corn rootworm, and corn borers), and diseases (aflatoxins and fumonisins). Texas corn producers need hybrids with high yield potential, resistance to biotic and abiotic stresses, and good product quality. Development of hybrids that are strongly adapted to Texas environments is crucial for sustainable and profitable corn production. The development of suitable hybrids is done through corn breeding, a process involving both the science and the art of genetically improving the crop plant. Breeding is a long and continuous process (Figure 1). Commercial corn hybrids are mostly single crosses between two elite inbred lines. Development of an inbred line starts creating a breeding population by crossing selected materials (lines, populations, testcrosses, hybrids, genetic stocks, etc.) with desirable traits. After five or more generations of selfing and selecting desirable plants, a pure and stable line is developed. The inbred lines are then crossed to produce experimental hybrids that are evaluated in multiple locations for 3-5 seasons. Superior experimental hybrids become commercial hybrids. Corn breeding goals and objectives are relatively constant; however, plant materials used in the program are continually evolving. In each crop season, new germplasm is introduced, new crosses are made, and promising materials (lines, hybrids, and populations) are advanced and selected. In this process only a small percentage of material screened meet the selection criteria.

Evaluation and selection of breeding materials are the most expensive and time-consuming part of a plant breeding program. Many important agronomic traits are complex in genetics and difficult to improve. Their physiological and genetic mechanisms are not well understood. To establish effective and economic evaluation and selection procedures, plant breeders rely on the expertise of interdisciplinary teams for scientific inputs (Figure 1). The recommended processes for release and licensing of new plant materials are discussed in Appendix D.

The commercial hybrids currently grown in Texas are mostly developed for the Midwest Corn Belt. Texas will benefit by greater breeding efforts specifically targeting Texas growing areas. The state corn breeding program has 1.25 FTE's. A group of scientists with expertise in plant physiology, pathology, entomology, molecular biology, molecular genetics, agronomy, agricultural engineering, and food science are also located throughout the major production areas in Texas. This distribution of resources was designed for breeding regionally-adapted corn that will maximize sustainable production in the high diverse geographical areas, environments, and production systems present in Texas. Introgression of genes from exotic corn germplasm (e.g. tropical and subtropical) offers a great promise for new sources of genes that can benefit Texas corn production. Texas is located in the transition zone between temperate and tropical environments, which facilitates crossing and gene introgression between temperate and exotic gene pools.

In recent years, the Texas AgriLife Research, Texas Tech University, and USDA-ARS have made a significant investment in plant molecular biology and genomics. Advances in these areas can help us understand genetic mechanisms of major corn agronomic traits, provide new tools for transferring desirable genes into elite germplasm, and make breeding more efficient.

Strong support and commitment from the Texas Corn Producers Board is especially important for the sustained success of the Texas AgriLife Research corn-breeding program.

**Program Elements and Recommended Program Actions**

**Program Element 1.** Develop germplasm with drought tolerance, heat tolerance, high yield potential and proper maturities for irrigated and rainfed areas of Texas.

Action/Strategy 1. Evaluate and select corn material under controlled moisture regimes in several environments across Texas. State of the art screening facilities (e.g., sub-surface drip irrigation systems) will be used to control stress levels.

Action/Strategy 2. Determine the genetic and physiological mechanisms of stress tolerance and major agronomic traits.

Action/Strategy 3. Enhance collaboration among breeders, plant physiologists, molecular biologists, and geneticists in conducting basic research to understand the physiological and genetic mechanisms of stress tolerance and quality.

Action/Strategy 4. Introgress genes from tropical and subtropical germplasm.

**Program Element 2.** Develop corn germplasm resistant to mycotoxin-producing fungi and other diseases and to insects (particularly corn earworm and spider mites). Currently effective chemicals and/or resistant commercial hybrids to control these pests are limited.

Action/Strategy 1. Employ effective screening methodologies to select resistant material for disease and insects by inoculating with target pathogens and pests or by evaluating plant materials in pest prone environments.

Action/Strategy 2. Introgress genes from exotic germplasm.

Action/Strategy 3. Establish a High Plains Mite Control Consortium to develop more effective control methods for spider mites, a major problem in the High Plains. The Consortium should actively seek federal funding to support the research for improved host resistance, more effective chemical and other control methods.

Action/Strategy 4. Establish a southern states consortium, Aflatoxin Mitigation Center of Excellence, focused on preventing health hazards and economic losses from aflatoxin contamination and sustaining corn production (Appendix C). The consortium should seek state and federal funds, facilitate research among multidisciplinary scientific teams to develop tools for reducing aflatoxins contamination in corn and sustaining corn production in the region, and provide a network of testing sites for aflatoxins resistant hybrids across the Southern states.

**Program Element 3.** Develop short-season corn with a good yield potential that can save water and irrigation cost and avoid drought stress in the late growing season.

Action/Strategy 1. Select early- and photo-period insensitive plants.

**Program Element 4.** Develop corn lines and populations with value added traits, including improved nutritional or processing properties for foods, feeds, and industrial products.

Action/Strategy 1. Collaborate with processors, food scientists, nutritionists and end users in defining desired characteristics in raw material and in selecting most suitable hybrids.

**Program Element 5.** Develop silage corn to meet the expanding dairy and beef cattle industries in Texas.

**Program Element 6.** Discover new genes from exotic materials to enhance productivity and quality.

Action/Strategy 1. Integrate biotechnology into applied breeding programs to identify genes and gene functions that are important for Texas and to increase breeding efficiency.

Action/Strategy 2. Introgress exotic material to increase the genetic base of germplasm used by U.S. corn-breeding programs. The characterization and combination of subtropical/tropical and temperate sources of germplasm will be emphasized.

Action/Strategy 3. Preserve, characterize, and enhance the genetic diversity of corn.

**Program Element 7.** Enhance technology transfer to the seed industry

Action/Strategy 1. Establish and improve cooperation with seed companies; Texas AgriLife Research breeding program and Texas AgriLife Extension Service agronomists should develop improved relationship with local seed companies to test new products under diverse environments.

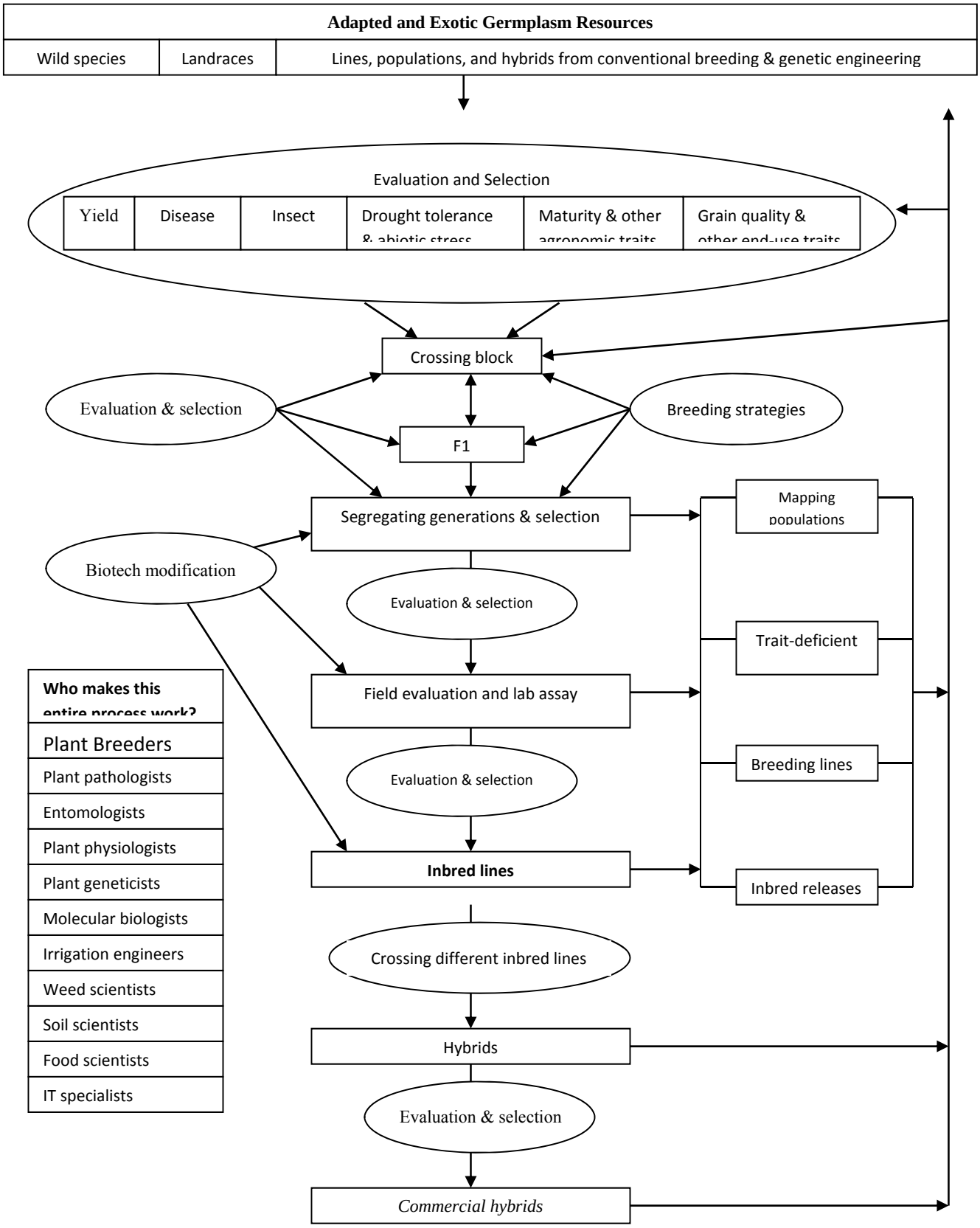
Action/Strategy 2. Establish a multi-location testing program across key Texas locations representing the main growing areas in the state; this will allow more accurate selection for regional adaptation, as the environments in Texas are highly diverse.

Action/Strategy 3. Upgrade research equipment and facilities to handle larger numbers of research plots and to train students.

**Edited by:**

**Charles Allen; Wenwei Xu; Seth Murray; Steve Brown and Leland Pierson**

Figure 1. Components of a successful corn breeding program.



# E. Communications

Effective communications between growers and AgriLife Research/Extension faculty with responsibilities for improving corn production, marketing and use are essential. Regular opportunities for growers and Texas AgriLife Research/Extension professionals to interact can: 1) improve grower abilities to communicate the issues that they feel need to be addressed, 2) focus Research/Extension project planning, 3) improve AgriLife Research/Extension's ability to communicate the impacts of their work on corn, and 4) improve mutual misunderstanding and communication. Industry needs include short, simple, rapid messages by professionals/experts for day-to-day management, as well as more robust information for seasonal planning. This information needs to be targeted and timely to meet grower's needs.

This document – the Strategic Analysis and Implementation Plan for Texas Corn Industry – provides the background and framework for the necessary communication. It also provides a basis for programmatic planning and decisions involving resource allocations within Texas AgriLife agencies.

**Program Elements and Recommended Program Actions**

**Program Element 1.** Develop robust communications through Corn Research and Extension Information Exchange Meetings.

Action/Strategy 1. Texas Corn Producers Board (TCPB) Research Priorities Meeting. Each year, the TCPB Research Committee will meet in April/May to discuss research/extension needs. The TCPB Research Committee Chairman would then prepare a report defining the specific research/extension proposal topics fitting the current needs of the industry. This report would then be shared with/within AgriLife.

Action/Strategy 2. Corn Research and Extension Information Exchange Meeting. The breadth, depth and specificity of the research/extension effort and the urgency of research topics changes from year to year. The precise topics are, by nature, difficult to capture in a strategic plan and are best addressed on a yearly basis at a Corn Research and Extension Information Exchange Meeting. Guidelines include:

a) The meeting should be held in the fall, prior to the TCPB Call for Proposals, and the Corn Advisory Committee would attend.
b) The TCPB Research Committee Chairman would present the report of the TCPB Research Priorities Meeting. The purpose of this presentation would be to provide clear guidance to research/extension faculty regarding Texas corn growers' current priorities.
c) Reports from grant supported research/extension projects from the past year would then be presented by research/extension representatives. These reports would provide AgriLife faculty the opportunity to interpret and share the valuable information obtained in their studies to the stakeholders.

d) This process would give the TCPB Research Committee an opportunity to see and assess the value of the research/extension programs. And it will give the AgriLife faculty insight about the research and program needs of the corn industry.

Action/Strategy 3. Develop and Maintain Internal Research Database.

Subject to the availability of funding; AgriLife will assist the TCPB by:

a) Maintaining a database of what research is being done across the state, to include research on various core-related topics such as aflatoxin, water, breeding/genetics, etc.
b) Providing TCPB with a point person to contact to obtain this information on behalf of their growers;
c) Provide online links to TCPB-sponsored research summaries and progress reports, to allow TCPB to link to the research from their website, and allow for easier grower access to research.

Action/Strategy 4. Establish and Maintain Event and Information Coordination.

a) AgriLife and the TCPB office shall work together as feasible to provide information about upcoming events, published research, TCPB-sponsored programs, and other matters pertinent to Texas corn growers.
b) AgriLife will designate a point-person for each of these programs and events. This person is responsible for communicating information to the TCPB executive director and communications director, so that it may be communicated to corn growers.

**Program Element 2. Develop Systematic External Communications.**

Action/Strategy 1. State Communicators Meeting.

Each year AgriLife conducts a meeting with the communications staff for selected state commodity and federal and state agencies. This meeting could also be used to discuss and develop plans to disseminate AgriLife Research and Extension information to growers. This meeting will assist TCPB communications staff in communicating AgriLife Research and Extension outputs to corn growers across the state. TCPB and AgriLife will jointly or independently communicate the research to growers via various communications channels, including, but not limited to: News releases, newsletters, E-newsletters, website, electronic media (facebook, twitter, etc.), or tradeshows.

Action/Strategy 2. AgriLife Field Days and Presentations

AgriLife will host corn field days and presentations each year. At these events, researchers will present recent research pertinent to corn growers and others in the industry. AgriLife will provide advanced promotion, as well as communicate information to the TCPB executive director and communications director. This will provide an opportunity for corn growers to learn more about and better understand recent research, and take the knowledge back to their farming operations.

Action/Strategy 3. General Public Information

Agriculture industry has faced a major challenge in reaching consumers and tomorrow's leaders about the value of agricultural products relative to price value and human health considerations. Extension programs can help further the outreach needed.

**New Section Prepared by:**

**Charles Allen; Kay Ledbetter; TCPB (David Gibson, Scott Averhoff & Stephanie Pruitt); J.M. Sweeten**

# F. Resource Coordination & Leadership Development

**Resource Benchmarks: TAMU Agriculture Program**

Resources devoted to corn-related research and Extension programs (Texas AgriLife Research) and extension (Texas AgriLife Extension Service respectively), Texas A&M University System, was estimated through a mid-2002 internal survey. The 2002 survey involved appropriate Department Heads; Resident Directors at Texas AgriLife Research and Extension Centers ; and Colleges of Agriculture at West Texas A&M University, Tarleton State University, Texas A&M University-Commerce, and Texas A&M University-Kingsville. The results provided a reasonable estimate of identifiable resources of faculty, scientific support staff, special-use facilities, land, and equipment along with salaries/wages and operating costs that were targeted for research and extension education related to the corn industry. Specific reporting categories were: breeding, genetics, physiology, production and management, entomology, pathology, quality end-use, economics, and "other." More recent data is not available.

*Corn Program Survey Results, 2002*

The following units provided data on corn-related research and extension programs, personnel, and resources:

- Texas AgriLife Research and Extension Center (ARECs) -- Amarillo, Temple (Blacklands), Corpus Christi, Lubbock, and Uvalde.
- Texas AgriLife Departments -- Entomology, Forest Science, Plant Sciences (PLPM), Soil and Crop Sciences, and Biological and Agricultural Engineering.
- Other TAMUS Universities -- WTAMU Division of Agriculture.

Several Centers or Departments contacted reported no significant R&E efforts related to corn.

Faculty and technical staff resource levels and funding support from Texas AgriLife Research and Texas AgriLife Extension Service, including grants were aggregated for faculty and staff according to: number of individuals involved; scientific years or full time equivalents; prorated salaries or wages; operating funds provided by units; greenhouses and seed processing; facilities (square feet); land (acres); and major equipment/ major dollar values.

*Findings & Discussion of Survey Data.* The 2002 results indicated that very significant resources were being devoted to corn research and extension programs. According to the survey, the greatest resources were devoted in the major corn growing areas of Texas -- High Plains (Lubbock), Panhandle (Amarillo), Coastal Bend (Corpus Christi), Winter Garden (Uvalde), Blacklands (Temple), and central/southeast Texas (College Station). The corn breeding program has two established Centers of Excellence: -- TAMU Soil and Crop Sciences Department and Texas AgriLife Research-Lubbock --wherein the corn breeders and their scientific support staffs expend virtually 100% of their efforts on corn. By contrast, faculty and support staff not associated with the breeding/genetics Centers of Excellence statewide generally devoted less than 100% of their efforts on corn, having direct responsibilities for other crops as well. This included the faculty in agronomy, irrigation engineering/water management, entomology, integrated pest management, and economics -- many of whom are located at the aforementioned ARECs. West

Texas A&M University in partnership with Texas AgriLife Extension Service and Texas AgriLife Research-Amarillo has developed integrated pest management (IPM) training and research programs dealing with grain production systems in the Texas High Plains. Value-added research is being conducted in the TAMU Soil and Crop Sciences Department, whereas there was little or no acknowledged involvement identified with the TAMU Institute for Food Science and Engineering.

The 2002 survey data showed approximately 13 faculty scientific years involvement (29 individuals) in corn programs estimated dollar total of $777,000. About 14 FTEs technical support staff (divided among approximately 37 individuals) represented an estimated $389,000 in salaries and wages. Reported faculty FTEs were slightly greater for Texas AgriLife Research, whereas the majority of support staff were employed by Texas AgriLife Research. Operating costs allocated to faculty from state or other sources for corn research and extension programs were reportedly $324,000/year, while prorated equipment costs are $339,000 or greater. Facilities included 9,375 $ft^2$ of greenhouses 1,686 $ft^2$ of seed processing, and over 260 acres of Texas AgriLife Research-owned or operated farmland were used for experimental purposes for on-station corn research, with most of the acres being devoted to breeding or production research.

As shown in Table 2, total research grant requests approved by the Texas Corn Producers Board (1998-2011) totaled $2,853,280 in support of Research and Extension programs. These grant totals have averaged $203,806 per year for the last 14 years (Table 2). The amount is proportional to corn production in Texas. Accordingly, grant totals have ranged from a high of nearly $353,000 for 1998 to a low of $109,700 in 2004. The grants provided by TCPB have been considered seed money for leveraging other grants in most cases. Formal progress reports or final reports are required from grant recipients each year of the grant.

Table 2. Texas Corn Producers Board, Total Research Grants Approved, 1998-2011.

| **1998 -2011.** | | |
|---|---|---|
| **Year** | **No. of Grants** | **Amount$** |
| 1998 | 26 | 352,748 |
| 1999 | 16 | 171,000 |
| 2000 | 18 | 244,886 |
| 2001 | 26 | 235,175 |
| 2002 | 22 | 220,738 |
| 2003 | 12 | 220,738 |
| 2004 | 10 | 109,700 |
| 2005 | 10 | 116,000 |
| 2006 | 12 | 129,500 |
| 2007 | 12 | 128,288 |
| 2008 | 14 | 260,400 |
| 2009 | 14 | 247,000 |
| 2010 | 12 | 172,107 |
| 2011 | 13 | 245,000 |
| TOTALS | 217 | 2,853,280 |
| Average | 15.5/yr | 203,806/yr |

The considerable investments being made in corn research and extension programs by TCPB, Texas AgriLife Research, and Texas AgriLife Extension Service need to be properly coordinated and responsive to the needs identified by the corn industry in Texas and/or supportive of longer range strategic objectives. These needs and opportunities are identified and discussed in previous sections of this report.

**Program Funding and Guidance for the Statewide Corn Strategic Plan**

To fully implement the Major Program Elements and recommended Program Elements in this Strategic Plan, resources will need to be identified and coordinated to the extent feasible to leverage additional resources. Funding sources, resources, or opportunities that should be considered include the following:

- State Legislative Initiative—Corn research and/or extension programs have been included in broad-based cropping systems or natural resources state Initiatives (exceptional items) over the last 10 years and this trend is likely to continue pending results of future Legislative Sessions. A new corn-related state initiative directed at cattle feeding with wet distillers grains was strongly supported by TCPB, funded by the Texas Legislature for FY08 – FY11.
- Potential Federal Initiatives—An aflatoxin federal initiative has been developed for Congressional consideration with other states. This initiative is currently requested for FY11 and FY12.
- Partnerships with other institutions and agencies, e.g., USDA-ARS, West Texas A&M University Texas A&M University-Kingsville, Texas Tech University, University of Georgia, and other major institutions. For instance, approximately $200,000/yr seed money from ARS was used to launch wet distillers grains research funded to Texas AgriLife Research for FY08 – FY11.
- Redirected resources within Texas AgriLife Research, Texas AgriLife Extension Service departments, agencies, and other specific units, or other agencies. The Soil and Crop Science Department re-established corn breeding at College Station, and a research Entomologist position was established at Texas AgriLife Research-Lubbock.
- Industry including the Texas Corn Producers Board and National Corn Producers Board.
- Contracts and grants from product user groups, private industry, and public sector (USDA-NIFA, USDOE, or USDA-ARS).
- Royalties from intellectual property including releases of improved plant materials or traits.

As alluded to above, significant new funding might occur through a proposed multi-state/multi-university Congressional Initiative on aflatoxin/mycotoxin, which is identified as a priority issue. Similar Congressional Initiatives on water management have likewise generated some resources that have relevance to corn production and management in the Rio Grande River basin and the High Plains (e.g. the USDA-ARS Ogallala Aquifer Program). As new or redirected funding

becomes available to Texas AgriLife Research or Texas AgriLife Extension Service, the recommendations of this Corn Strategic Plan should be considered.

Future allocations of resources statewide should strongly consider Major Program Areas and Program Elements that are recommended in this Corn Strategic Plan. Policies regarding retention or distribution of royalties from corn industry-related intellectual properties should be reviewed as needed to determine potential revenue to help underwrite key elements of the state Corn Strategic Plan herein.

The Corn Advisory and Implementation Committee should be reorganized with new leadership, and revitalized to remain engaged with the industry and the Texas AgriLife Research and Texas AgriLife Extension Service administration as a coordinating mechanism in the development and review of project proposals and programs. Systematic selection of members and committee leadership should be established. The Committee will be in a position to supply strong leadership and recommendations in program direction including resource allocation with industry priorities articulated in this state Corn Strategic Plan. The Committee's role should also involve assisting the TCPB in annual proposal review from a science-based perspective, and consistent with priorities articulated in this state Corn Strategic Plan. A Corn Workers Group comprised of faculty and scientists engaging in corn related research and Extension projects and programs might be a useful coordinating and communication mechanism internally and externally with the industry.

**Program Elements and Recommended Program Actions**

**Program Element 1.** Improve coordination and cooperation of research and extension programs in concert with industry and partnering agencies.

Action/Strategy 1. Develop methods that will optimize the efforts of university, industry, and partnering agency personnel by enhancing communication and encouraging interdisciplinary, multi-institution projects between individuals.

Action/Strategy 2. Identify and prioritize key research and extension issues and address those issues in a coordinated effort.

Action/Strategy 3. Provide a science review process for research and Extension proposals submitted to the TCPB.

Action/Strategy 4. Establish a Corn Workers Group composed of faculty and scientists in Texas with corn-related research, with the goal of fostering communications and coordination of research and Extension efforts within and external to Texas AgriLife Research and Texas AgriLife Extension Service.

**Program Element 2.** Allocate resources in substantial support of the statewide Corn Strategic Plan.

Action/Strategy 1. Maintain corn program coordination and cooperation through an ongoing Corn Advisory and Implementation Committee.

Action/Strategy 2. Provide a coordinated process for guiding development of research and extension grants toward achieving Program Elements and many of the recommended Program Actions established in the Corn Strategic Plan.

Action/Strategy 3. Foster development of federal and corporate grants that will contribute to expansion of resources available for corn-related research and Extension projects.

**Program Element 3.** Develop new resources where appropriate**.**

Action/Strategy 1. Develop or encourage Congressional or State Legislative Initiatives that support new funding for priority Program Elements and Actions of the Strategic Plan.

Action/Strategy 2. Guide resource allocation decisions that relate the corn industry toward priority Program Elements of the Corn Strategic Plan.

**Edited by: J.M. Sweeten and David Gibson**

# Summary and Action Plan

Corn is a $1 billion per year industry in Texas. Corn is produced on just over 2 million acres annually in Texas. Four regions account for 90% of Texas' corn production—High Plains, Central/North Central, Coastal Bend/Upper Coast, and South Central. About 48% of the total corn acreage is irrigated which accounts for 68.5% of the corn production. Statewide harvest value of the harvested crop exceeds 900 million/yr. Most of the corn is used for livestock feed, with human food usage and export also significant. Production challenges vary with region/sub-region and include biotic and abiotic stress, resource limitations, and management practices.

The Corn Advisory and Implementation Committee was organized by Texas A&M AgriLife administration leadership to work with industry in addressing current and emerging issues and to provide recommendations that will position the corn research and extension program in Texas as among the leaders in the U. S. According to a 2002 survey, several research and extension centers and academic departments within Texas A&M AgriLife contribute significant resources to corn research and extension—for instance, 13.1 scientific years faculty involvement, 14.0 FTE's technical support staff, which at that time translated to $1.5 million recurring personnel and operating costs, and $ 0.33 million non-recurring costs, not including research farm acres. Likewise, the Texas Corn Producers Board has contributed another $203,806/year (14-year average) or $2,853,280 total to corn research and extension projects (1998-2011). These recurring public and private investments are represented geographically at AgriLife Research and AgriLife Extension Service Centers in major corn production regions and in appropriate academic departments on the TAMU campus. Cohesion and statewide coordination within the TAMU System and with other universities and agencies outside the TAMU System, together with a more direct means of communicating with corn industry leaders and members regarding technical progress made, is needed.

Major Program Areas together with key Program Elements identified by the Corn Advisory and Implementation Committee are as follows:

A. Corn Production and Management

   Develop and encourage the adoption of production and management systems for reducing mycotoxins; protection and efficient use of groundwater and surface water resources; implementing advanced cropping systems; integrated pest management (IPM) strategies; hybrid selection; and adopting best management practice for soil fertility, tillage, row spacing, and planting rates.

B. Targeted Strategic Livestock Feeding Applications

   Accelerated research to evaluate ethanol by-product (DDG) utilization; adapt to changing livestock feeding programs, uses and requirements including supplemental feeding of livestock (high forage/high protein) and wildlife; environmental nutrient management (especially phosphorus); and feeding values of recently-developed corn varieties.

C. Economic Research and Policy Analysis

   Determine implications of changing farm policy, including the Farm Bill and subsequent polices; develop economic analysis, and marketing strategies; manage risks to assure viability of corn production in Texas; and help farmers interpret and take advantage of USDA-NRCS rules and policies for implementing conservation practices.

D. Corn Breeding and Genetic Improvement

Develop superior plant materials including traditional breeding and biotechnology that maintains an emphasis on drought and heat tolerance, mycotoxin, insect and disease resistance better-yielding short-season varieties, end-user quality/value added traits, and silage production.

E. Communications

An improved system for two-way communication of priorities and technical progress needs to be developed. Several proposed actions will address these needs, both within Texas AgriLife and with the Texas corn industry.

F. Resource Coordination and Leadership Development

Provide in-depth training and education to develop future industry leaders; provide closer cooperation, resource coordination, and leadership development among research, extension, and industry and other partnering agencies and organizations; and focus limited resources on the highest priority needs and develop new resources.

G. Emerging Issues

Emerging issues identified by Texas Corn Producers Board members included: water policy and implementation; crop insurance ratings; policies and education; grain indemnity; and alternative marketing arrangements.

The Prioritized Program Elements and recommended Program Actions were provided within the report sections above describing each Major Program Area. A summary of prioritized Program Elements is shown in Appendix B, in which the priority ratings/rankings were provided entirely by the members of the Texas Corn Producers Board (TCPB) in 2011. They are also shown in the Executive Summary, which compares the ratings/rankings of TCPB with those of Texas AgriLife Research and Extension faculty and administrators.

**Edited by:**

**J.M. Sweeten & Steve Amosson**

# Appendix A

## CORN ADVISORY AND IMPLEMENTATION COMMITTEE MEMBERS AND CONTRIBUTORS

- **Appointed Committee Members, per May 6, 2004 memo from Drs. Chester Fehlis, Edward A Hiler, and Robert E. Whitson.**
- **Additional Contributing Unit Heads, Faculty and Corn Producers, 2004-2011.**

# Table A-1. Corn Advisory & Implementation Committee and Other Contributors, 2004-2011

| Title | First Name | Last Name | Organization** | Address | City | State | Zip | Office Phone | E-mail |
|---|---|---|---|---|---|---|---|---|---|
| **Originally Appointed Committee Members, per May 2004 Memo from Vice Chancellor and Agency Directors:** | | | | | | | | | |
| Dr. | Brent | Bean | TCE/TAES | TAMU-AREC, 6500 Amarillo Blvd West | Amarillo | TX | 79106 | (806) 677-5600 | b-bean@tamu.edu |
| Dr. | Bobby | Eddleman | TAES | TAMU-AREC, 10345 Agnes St. | Corpus Christi | TX | 78106-1412 | (361) 265-9201 | b-eddleman@tamu.edu |
| Dr. | Tom | Fuchs | TCE West Central (District 7) | TAMU-AREC, 7887 US Highway 87 N | San Angelo | TX | 76901-9714 | (325) 653-4576 | t-fuchs@tamu.edu |
| Mr. | David | Gibson | TCPB | 4205 North I-27 | Lubbock | TX | 79403 | (806) 743-2676 | tcpb@texascorn.org |
| Dr. | Dennis | Gross | TAMU, Plant Pathology & Microbiology | 120 L.F. Peterson, 2132 TAMU | College Station | TX | 77843-2132 | (979) 845-8288 | plpm-head@ppserver.tamu.edu |
| Dr. | Kevin | Heinz | TAMU, Entomology Dept. | 412 Heep, 2475 TAMU | College Station | TX | 77843-2475 | (979) 845-2510 | kheinz@tamu.edu |
| Dr. | Gary | Odvody | TAES | TAMU-AREC, 10345 Agnes St. | Corpus Christi | TX | 78406-1412 | (361) 265-9201 | g-odvody@tamu.edu |
| Mr. | Quinton | Raab | Retired Corn Breeder BH Genetics | P.O. Box 620 | Moulton | TX | 77975 | (361) 536-4087 | graab@gvec.net |
| Mr. | Joe | Reed | TCPB | P.O. Box 196 | Dress | TX | 79052 | (806) 684-2640 | reedfarm@amaonline.com |
| Dr. | Lloyd | Rooney | TAMU, Soil & Crop Sciences Dept. | Heep Center, 379 Olsen Blvd MS 2474 | College Station | TX | 77843-2474 | (979) 845-2925 | lrooney@tamu.edu |
| Dr. | John | Sweeten | TAES, Resident Director - Amarillo | TAMU-AREC, 6500 Amarillo Blvd West | Amarillo | TX | 79106 | (806) 677-5600 | j-sweeten@tamu.edu |
| **Administrative Liaisons appointed per May 2004 Administrative Memo:** | | | | | | | | | |
| Dr. | Mark | Hussey | TAMU, Soil & Crop Sciences Dept. | Heep Center, 379 Olsen Blvd MS 2474 | College Station | TX | 77843-2474 | (979) 845-8795 | mhussey@tamu.edu |
| Dr. | Ed | Smith | TCE, Director | 103B JKW Administration Bldg, 7101 TAMU | College Station | TX | 77843-7101 | (979) 862-3932 | egsmith@tamu.edu |

| Unit Heads or Faculty Contributing Subsequently, including replacements* for some of the above: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Dr. | Steve | Amosson | Regents Professor, TCE | 6500 Amarillo Blvd West | Amarillo | TX | 79106 | (806) 677-5600 | samosson@ag.tamu.edu |
| *Dr. | Charles | Allen | TCE, West Central (District 7) | TAMU-AREC, 7887 US Highway 87 N | San Angelo | TX | 76901-9714 | (325) 653-4576 | ctallen@ag.tamu.edu |
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** Denotes replacement for a 2004 named member or administration advisor of the Corn Advisory and Implementation Committee.*

*** Agency names were changed January 1, 2008, such that TAES now refers to Texas AgriLife Research, and TCE now refers to Texas AgriLife Extension Service.*

**Edited by:**

**J.M. Sweeten**

# Appendix B

**PRIORITIZED RANKINGS OF MAJOR PROGRAM AREAS AND PROGRAM ELEMENTS**


## Texas Corn Producers Board

**4205 North IH-27**
**Lubbock, TX 79403**

**800-647-2676**


December, 2010
**Revised March 10, 2011**
**Revised April 8, 2011**
**Revised July 18, 2011**

**Table B-1. Corn Advisory Committee's Major Program Areas* and Program Elements as ranked** within the 6 Major Program Areas by the Texas Corn Producers Board, 2011.**

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**ECONOMIC & POLICY ANALYSIS**

Implications of the Farm Bill and its policies (VH)
Water economics & water policy (VH)
Impacts of alternative uses of corn (L)
Master Marketing/ price & production risk management (H)
USDA-FSA/NRCS rules & regulations (H)
Grain elevator sales and risk (H)
Crop insurance/education on insurance policies and rules (M)

**CORN PRODUCTION AND MANAGEMENT**

Integrated Pest Management/IPM (M)
Mycotoxins management/BMPs/systems (H)
Cropping systems (L)
Efficient irrigation and crop water management (H)
Ground and surface water protection (H)
Irrigation and pumping system efficiency (H)
Atoxigenic fungi discovery/development (VH)

**CORN BREEDING AND GENETIC IMPROVEMENT**

*(Does not indicate funding priority)*

Drought tolerance (H)
Mycotoxins resistance/tolerance (H)
Heat tolerance (H)
Insect resistance (H)
Disease resistance/tolerance (H)
Better-yielding short season varieties (H)

**TARGETED STRATEGIC LIVESTOCK FEEDING APPLICATIONS**

Evaluate the feeding value & economics of distillers grains (L) ***
Mitigation and/or remediation of mycotoxins in animal feed products (H)

**COMMUNICATIONS**

Research & Extension information exchange with industry (M)
Systematic external communications targeting growers & general public (M)

**EMERGING ISSUES**

Water policy and implementation (VH)
Crop insurance ratings, policies & education (H)
Grain indemnity fund development (VH)
Review action levels for Aflatoxin as pertaining to corn in livestock feed (H)

**RESOURCE COORDINATION AND LEADERSHIP DEVELOPMENT**

Congressional internships (H)

TALL program (H)

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*****Assumes a 5 to 8 year planning horizon.

**Ranking Notation: VH=very high; H=high; M=medium; and L=low.

*** TCPB supports this research through a distiller's grains/cattle feeding State Legislative Initiative to Texas AgriLife Research.

**Revised/Edited by Texas Corn Producers Board, David Gibson and J.M. Sweeten**

# Appendix C

# Aflatoxin Mitigation Center of Excellence:

# Preventing Health Hazards and Economic Losses from Aflatoxins

# AFLATOXIN MITIGATION CENTER OF EXCELLENCE

Preventing Health Hazards and Economic Losses from Aflatoxin

*Auburn University, Louisiana State University AgCenter, Mississippi State University, North Carolina State University, Texas AgriLife Research, and University of Georgia*

## Aflatoxins: Potential Health Threat to Humans and Animals

Mycotoxins are toxic compounds produced by naturally occurring fungi in grains, nuts, and oil seeds. Aflatoxins are mycotoxins produced by the fungi, *Aspergillus flavus* and *A. parasiticus*. Numerous variations of aflatoxin occur with the most potent being aflatoxin B1. The use of products contaminated with aflatoxin is regulated by action levels established by the FDA.

Corn, cottonseed, peanuts, tree nuts and their products can be contaminated by aflatoxin. Corn is the most widely grown crop that can be affected by aflatoxin contamination in the U.S. Heat, drought, high humidity and insect infestation predispose corn to infection by aflatoxin-producing fungi which often results in aflatoxin contamination of the grain. Every year these conditions occur somewhere in the U.S. with resulting aflatoxin contamination exceeding action levels which start at 20 parts per billion (ppb). While aflatoxin contamination of corn more commonly occurs in the South, under certain environmental conditions, its distribution can expand to negatively impact a significant portion of the total corn crop:

- Aflatoxin in Georgia corn ranged from 6 to 622 ppb and averaged 97 ppb in a survey conducted over a 28-year period.
- In Texas, recent aflatoxin surveys showed that more than 50 percent of the counties had one or more corn samples that exceeded action levels.
- Alabama, Louisiana, Mississippi and North Carolina as well as States in the Mid-South have experienced periodic severe aflatoxin contamination in their corn crop.
- As recently as 2007, aflatoxin contamination on corn was prevalent in the Corn Belt where widespread heat and drought occurred.

### Aflatoxin is a potential health threat to:

- humans
- livestock
- poultry
- pets
- game birds
- trout
- deer
- other wildlife

### Aflatoxin may cause:

- low rates of weight gain
- impaired immune systems
- reduced vigor
- death

## Food and Feed Safety

Aflatoxin contamination endangers the food supplies and health of both people and livestock. This threatens the economic livelihood of crop producers, livestock producers, commercial feed users, and numerous feed and food industries.

Milk from cows that consume contaminated feed can transfer the toxins to humans. People can also consume the toxins through common foodstuffs derived from contaminated sources.

As recently as 2006, a national pet food manufacturer had to recall 18 products from over 20 states that were tainted with aflatoxin. U.S. corn exports are being rigorously tested by importing countries to insure their freedom from aflatoxin. Economic losses are borne by grain producers and handlers, distributors and shippers and feed manufacturers and sellers. Farmers, ranchers and commercial feeders also bear the economic burden

because of poor animal performance, death following immune system damage, and litigation. Aflatoxin occurrences in the South limit the increased production of corn where it is otherwise well adapted.

Wild animals and birds (including large mammals such as white-tailed deer) consuming contaminated feeds purchased by the public as wildlife feed can suffer liver damage, reduced reproductivity, and impaired immune system function, which can cause death from secondary illnesses.

## Economic Losses

The economic impact of aflatoxin contamination is difficult to measure, but the following losses have been documented. From 1990 to 1996, litigation costs of $34 million from aflatoxin contamination occurred. In 1998, corn farmers lost $40 million as a result of aflatoxin contaminated grain. In 2002, 30 million bushels of corn were discounted more than 25 percent. Millions of dollars are paid annually from crop insurance to corn growers who are adversely affected by having aflatoxin contaminated grain. In 2008, more than $15 million was paid out for crop losses due to aflatoxin contamination in corn. Every year where stress environments more frequently occur, corn is rejected at elevators because of the high level of aflatoxin contamination. As of now, the average direct loss is estimated at

*Deer and other wildlife can become ill after eating contaminated feeds offered by well-meaning humans*

*Meeting the goal of an ample, affordable and safe food supply.*

$200 million annually for corn. Indirect losses because of contaminated byproducts, such as distillers' grain, compound these losses. Ultimately, all contribute to increased costs to consumers.

## Solving the Problem of Aflatoxin Contamination

Reducing the adverse impacts of aflatoxin in human and animal diets will have wide-ranging economic benefits. Research investments made today will reduce direct losses to corn growers, indirect losses from contaminated byproducts of corn bio-energy and the food and feed industry, and result in less expenditure for crop loss by crop insurance providers when solutions are deployed.

An integrated and focused approach can hasten solutions to substantially reduce the outbreaks of aflatoxin contamination. An Aflatoxin Mitigation Center of Excellence is proposed to facilitate field deployment of solutions to aflatoxin contamination in corn. Sponsors of the Center have met, reviewed the research conducted to date, and identified the following as specific components of this proposed multi-disciplinary research program:

- promoting and refining biological control and ecology,
- developing resistance through breeding and genetics,
- identifying best management practices, and
- improving and obtaining approval of remediation procedures for contaminated grain.

Due to the complexity of the aflatoxin problem and the diverse geography involved, it is important to investigate efforts on all four fronts to be able to attack the problem with a control package rather than relying on a single control factor.

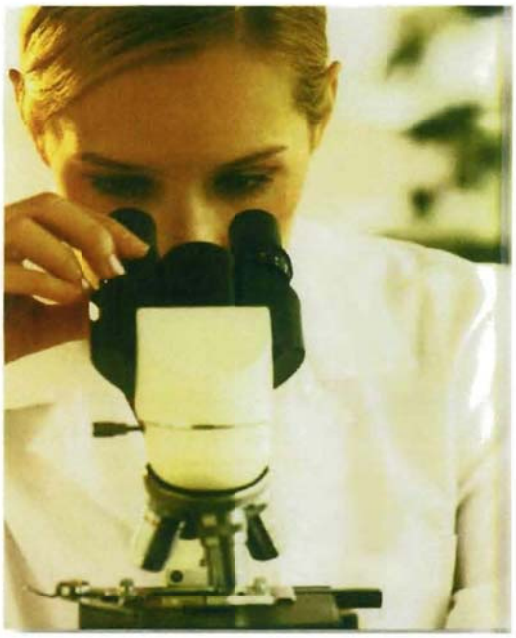
## Biological Control and Ecology

Biological control of aflatoxin is approved and is being used for peanuts and cottonseed. A specific bio-control has just been extended to include com. The control works by applying a naturally-occurring atoxigenic (non-toxin producing) strain of the fungus to displace the toxigenic (toxin producing) strain of the same fungus, thereby greatly reducing the probability of contamination of the grain. The approval for use on com comes from positive results obtained from controlled conditions. Optimum criteria for rearing substrate to use, application timing, dosage, strain selection, management options and a measurement of efficacy need to be determined and refined for the com crop working with suppliers and the farming community. This co-evolving research needs to involve stewardship combing stakeholder input and extension outreach before the technology will be able to establish itself in the marketplace.

## Resistance through Breeding and Genetics

Some very good sources of resistance have been developed but are agronomically unacceptable for commercial production. When the genes responsible for resistance have been idertified, they must

*Inoculations to measure resistance are very labor intensive.*



*Researchers can identifY atoxigenic fungal strains which can be used as biocontrol agents.*

be recombined with superior germplasm to make them agronomically competitive. Successful breeding relies upon exploiting numbers and probabilit es. This effort will require an increase in number of genetic combinations and environments sampled so that the best recombined material can be identified and released for use. Ultimately, these resources vrill allow the private sector to incorporate higher levels of resistance to aflatoxin accumulation into their own germplasm and develop better adapted com varieties to combat aflatoxin contamination. This will allov for increased acreage of corn in the U.S. to contri )Ute to an ever increasing demand for com.

## Best Management Practices

The goal is to develop a Com Aflatoxin Risk Index (CARI). Since the initial work in this area was conducted, the landscape has changed requiring a possible reprioritization of factors that can influence aflatoxin contamination. These factors include: planting date, varietal maturity, varietal resistance, husk coverage, insect resistance, drought resistance, kernel composition, specific transgenic traits, row

spacing, irrigation, rotation, tillage, use of other controls, harvest procedures, drying and handling methods, commonly used control methods, and novel biocontrol methods. This index will be made publicly available to corn growers and handlers so they can determine the best management practice procedures available to minimize aflatoxin contamination. The CARI will be updated as needed to acknowledge changing agronomic or managerial options.

## Remediation of Contaminated Grain

Research conducted in areas where aflatoxin is chronic has shown that certain clays, when mixed at low rates with grains, can bind aflatoxin and greatly reduce aflatoxin's effect on animals and humans. The remedy is inexpensive and easily disseminated. Analyses of the molecular structure of the toxin and the clay-specific lattices that can bind the toxin molecules have shown scientists how to extend the technology to a range of toxins and clay binders. However, extensive testing and refinement of the technology is needed to identify safe, effective clays, and the rates and methods of mixture for each food and feed with a cost-effective delivery and utilization system. Data on feed additives and best detoxification methodology needs to be developed to be able to promote an approved regional solution to aflatoxin contaminated grain that is accepted nationally.

Multistep processes used in the manufacturing of many corn products need investigation to determine the potential for site specific fractionization and elimination of aflatoxin from contaminated grain during the product's manufacturing.

## Partners in Aflatoxin Mitigation Research

Alabama Farmers Federation
Alabama Soybean & Corn Association
American Farm Bureau
Arkansas Corn and Grain Sorghum Board
Arkansas Farm Bureau
Corn Producers Association of Texas
Delta Wildlife
Georgia Agribusiness Council
Georgia Corn Growers Association
Georgia Farm Bureau
Louisiana Farm Bureau Federation
Louisiana Cotton and Grain Association
Louisiana Soybean and Grain Research and Promotion Board
Mississippi Corn Growers Association
Mississippi Corn Promotion Board
Mississippi Farm Bureau Federation
Mississippi Feed and Grain Association
National Corn Growers Association
North Carolina Corn Growers Association
North Carolina Farm Bureau
Southern Ethanol Council
South Texas Cotton & Grain Association
Southwest Council of Agribusiness
Texas Association of Dairymen
Texas Cattle Feeders Association
Texas Corn Producers Board
Texas Farm Bureau
Texas Grain and Feed Association

## Resource Needs

Growers invest $1 million in public aflatoxin mitigation research projects seeking commercial solutions annually. Funding this Center compliments and extends the existing effort to bring aflatoxin mitigation solutions to the field. Annual funding of $5 million for five years from the National Institute of Food and Agriculture (NIFA) is requested to bring the benefits of biocontrol, resistant varieties, best management practices, and remediation technologies to address aflatoxin contamination in corn.

# Appendix D

**PROCESSES FOR RELEASE/LICENSING OF NEW PLANT MATERIALS,**

**TEXAS AGRILIFE RESEARCH**

## Processes for Release/Licensing of New Plant Materials, Texas AgriLife Research

### Types of Releases Made in Corn

Four main types of releases are considered for corn material: germplasm, parental inbreds, genetic stocks, and mapping populations.

1. ***Germplasm***: This type of releases includes populations and synthetics with specific distinct characteristics (e.g. resistant/tolerance to abiotic and biotic stresses, exotic material adapted to temperate areas, grain quality attributes, etc.) created by recombining corn genotypes selected for those traits. Inbred lines are those that have shown potential for specific traits, or have performed well in preliminary hybrid evaluations, but have not been extensively tested over environments and/or testers could be included in this category.

2. ***Parental Inbred Lines***: Highly homozygous uniform inbred lines that can be used directly as parental lines in corn hybrid combinations. These lines have been extensively tested as lines per se and in hybrid combination potentially having direct commercial value.

3. ***Genetic Stocks***: Genotypes with one or more morphologic or physiologic traits whose inheritance is described (isogenetic lines, aneuploid lines, etc.). Genetic stocks are useful to determine the mode of inheritance or specific traits, transferring genes and gene mapping. They are not normally used directly as source of genes for breeding improved cultivars.

4. ***Mapping populations***: Groups of reproducible genotypes obtained from common parents that segregate for the expression of one or several trait(s) of interest. This set of genotypes can be used to map genomic regions known as Quantitative Trait Loci (QTL) or genes regulating the expression of the trait(s).

Texas AgriLife Research corn releases use the prefix 'Tx' for parental inbreds. The corn breeding program at College Station uses 100, 600, 700 and 800 series: 100 series are white grained inbreds, 600 & 700 series are yellow grained inbreds, 800 series are high-lysine inbreds with even number being yellow and odd numbers being white. The corn breeding program at Lubbock uses 200-500 series. We do not have a designation system for germplasm (synthetics and populations), genetic stocks and mapping populations.

### Evaluation of Release

The ultimate contribution of Texas AgriLife Research corn material in farmer's fields relies on use of these materials by the private seed industry either directly as hybrid parents or indirectly as parents of new breeding populations to derive new improved proprietary lines. Evaluation of potential releases by interested private seed companies facilitates identification of the most promising material.

A multistage process of evaluation across different locations is as follows: Initial evaluation and selection is conducted by the Texas AgriLife Research corn breeding programs. The most promising material is considered for advance testing with involvement by other public institutions and private companies. Texas AgriLife corn breeders invite private industry to observe and test this material. Material Transfer Agreements (MTA) will be used to share breeding materials with potential industry partners. MTAs will be developed as needed between Texas AgriLife Research and interested companies to allow commercial evaluation or breeding activities prior to release.

**Release Documentation and Distribution**

- ***Documentation.*** Texas AgriLife Research breeder develops a release proposal and registration, and submits this documentation to the Texas AgriLife Research Plant Release Committee for recommendation to release. At the time of submission, the breeder notifies the Texas A&M University System (TAMUS) Office of Technology Commercialization (OTC) and Texas Foundation Seed Service (TFSS) of the potential for a licensing and royalty agreement. At release Texas AgriLife Research and TFSS notify public and private corn breeders of the availability of the material. Information about available material will be posted on the TFSS web-site.

- ***Seed Handling.*** Requests for seed will go directly to the appropriate plant breeder who then is responsible for distribution seed to public workers, or to companies. Prior to seed distribution, appropriate MTAs and financial arrangements must complete. Breeder seed will be maintained by the originating breeding program for distribution to interested parties in small amounts. A small quantity of breeders seed will be deposited at the TFSS for storage and germplasm preservation. The most likely use of corn material released by Texas AgriLife Research will be as parent lines for use in breeding crosses. The originating breeding program should be responsible for this material, assuring proper seed increase and distribution by providing small quantities of seed to interested parties. The TFSS will be informed of all distributions to the seed companies, and available to facilitate transfer and licensing. Some corn materials released could be used directly for commercial products (i.e., hybrids) increasing substantially the potential commercial demand. TFSS would have the option to increased and distribute seed for these latter materials.

- ***TAMUS/OTC and Royalty issues.*** OTC and TFSS will cooperatively develop licensing agreements with interested parties for all releases. Unless otherwise specified, breeders employed by public agencies and institutions will be allowed unrestricted use of Texas AgriLife Research releases. However, Texas AgriLife Research will reserve the right to restrict use of its products consistent with the need to achieve maximum utilization of the product, or to prevent other public agencies from restricting use of genes identified, isolated, or characterized by Texas AgriLife Research through subsequent royalty agreements.

**Edited by:**

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