V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

PLANT SCIENCES

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms	15%		25%	
205	Plant Management Systems	8%		0%	
206	Basic Plant Biology	8%		26%	
211	Insects, Mites, and Other Arthropods Affecting Plants	47%		32%	
212	Pathogens and Nematodes Affecting Plants	18%		14%	
215	Biological Control of Pests Affecting Plants	4%		3%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	8.0	0.0	30.0	0.0
Actual	8.0	0.0	29.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
227127	0	130881	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
443448	0	587013	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Issue

Properly tailored weather information can assist with important management decisions related to variety selection, planting dates, crop assessment, pest control, irrigation and harvest, particularly during times of prolonged drought. The Arizona Meteorological Network (AZMET) was developed in 1987 to provide weather data and information in near real time to the state's producers of agricultural and horticultural crops.

What has been done?

The AZMET network of 29 automated weather stations located across Arizona supplies meteorological data (air and soil temperature, humidity, solar radiation, wind speed and direction, and precipitation) from important agricultural production areas and selected urban locations. Data obtained by the stations are transferred to a Tucson-based data processing center nightly, where computers process the data into a variety of informational formats to assist in decision making. AZMET data and reports are available to the public free of charge via three Web pages.

AZMET data provide reliable information on heat unit accumulation, used to monitor general crop development, to time planting and harvest dates for melons, sweet corn and other horticultural crops, and to predict pest development. For example, the AZMET Southeast Arizona Crop Water Use Advisory provides corn, forage, chile and nut growers in Cochise and Graham counties with information on weather, water requirements and crop development. For cotton, AZMET generates weekly updates on heat unit accumulation, crop water use and current and projected weather conditions. The updates are distributed to nearly 500 growers each week as part of the Cotton Advisory Program. AZMET also provides daily updates on heat stress, which can significantly reduce cotton fruit retention and yield.

AZMET data on evapotranspiration (ET) are used to estimate the water use of vegetation, including field crops and turf. AZMET generates daily turf water use reports for the Phoenix area and distributes this information to the public via a turf water management web page and email; turf industry professionals may also receive this information via email daily. AZMET also generates a lawn watering guide published daily in major and regional newspapers in the Phoenix metropolitan area. AZMET's turf water management program includes weather stations in the low desert, and also in Prescott and Payson. A Web site offers information on landscape irrigation to residents of northern Arizona. AZMET provides reference ET data to the Bureau of Reclamation for use in the Lower Colorado River Accounting System (LCRAS). LCRAS represents a new and improved means of assessing water use along this portion of the Colorado River.

Impact

AZMET is widely accepted as an important (and often the only) source of meteorological information pertaining to the production of agricultural and horticultural crops in Arizona. Demand for AZMET information remains high based on hits, sessions and data downloaded. Users accessed AZMET web pages 1,638,000 times in 2010, and the total number of user sessions equaled 267,000 or 732 per day. The length of user sessions averaged about 10 minutes, while data transferred from AZMET's websites totaled 344 gigabytes. Phone calls, emails and face-to-face contacts indicate AZMET is viewed as a reliable source of meteorological data/information by a diverse clientele base. Demand for new weather stations remains high among rural clientele.

Of particular importance are the evapotranspiration (ET) data generated for irrigation management and for the Integrated Cotton Management Program (ICMP). Urban programs that utilize ET data include the web-based Phoenix and Tucson area turf water use reports, accessed 9,600 times in 2010 and the

Northern Arizona Turf Water Use Webpage, accessed 4, 323 times. Rural programs using ET include the Southeast Arizona Crop Water Use Report, accessed 1,468 times; cotton water use estimates, generated as part of the ICMP's weekly distribution of planting date and crop development advisories for 15 locations throughout southern and western Arizona, accessed more than 16,000 times; and the 20,000+ acres of farmland now irrigated using ET-based scheduling systems. The ICMP also uses AZMET data for online heat stress advisories that allow growers to monitor the impact of heat stress on boll retention. The heat stress reports were accessed approximately 10,800 times during the summer of 2010.

Issue

During the mid-90s, insecticide applications in cotton typically accounted for about half of all insecticide use in the United States. In 1995, nearly 100 percent of Arizona's cotton acreage was sprayed multiple times for pink bollworm Lygus bug and silverleaf whitefly. New technologies have enabled cotton growers to reduce their spray applications significantly while achieving among highest cotton yields worldwide. Behind only California and Australia, Arizona now produces the highest-yielding cotton in the world, nearly 1,500 pounds of fiber per acre, far exceeding the U.S. national average of about 800 pounds per acre. These technologies also help growers implement more ecologically-based, sustainable IPM programs and become less dependent on broadly toxic insecticides.

What has been done

An integrated pest management program (IPM) established in Arizona in 1996, refined in 2006 and continued through today uses insect growth regulators (IGRs--effective against whiteflies), transgenic cotton (with Bt--Bacillus thuringiensis--effective against pink bollworms), and a reduced-risk feeding inhibitor (effective against Lygus bugs.) Safe for humans, these tools kill only their target pests, allowing natural processes to play a larger role in the management of all other pest insects. Growers have been taught to deploy fully selective materials first and whenever possible. The UA College of Agriculture and Life Sciences initiated the program in collaboration with growers, USDA, Arizona Department of Agriculture, Arizona Cotton Growers' Association, Cotton Incorporated, Arizona Cotton Research & Protection Council, industry and others.

Impact

The fully implemented, collaborative cotton IPM program has registered significant gains since its inception in 1996:

· Statewide averages for cotton insecticide use patterns in Arizona from 1979 through 2010 show that insecticide use on cotton for all insects combined--including whiteflies, pink bollworm, Lygus bug and others reached a 32-year low over the last 5 years, while also reducing costs to all-time lows. The estimated cumulative savings in control costs and yield (from reduced losses to insects) from 1996 through 2010 was more than $223 million.

· Growers applied 4.15 pounds of active insecticide ingredient per acre of cotton in 1995. In 2009 and also in 2010 the amount of active ingredient applied per acre was reduced by 3.66 pounds, or 88.3 percent, to just 0.48 pounds per acre. This is the equivalent of applying less than a can of soda on an area the size of a football field just once over the cotton season (March to October).

· The last 5 years have shown the lowest insecticide use in cotton on record (32 years), at just 1.5 sprays season-long, reducing insecticide loads on the environment by more than 1.6 million pounds of active ingredient annually and saving growers over $10 million annually in combined control costs and yield savings.

· Compared to 10 years ago, the types of insecticides used now are much safer, with high selectivity and safety for beneficial insect populations. Specifically, there has been a 95 percent reduction in organophosphate use, comparing the last 5 years to an all-time high in 1995; a 98 percent reduction in pyrethroids; 80 percent reduction in endosulfan; and 92 percent reduction in carbamates; with an 85 percent reduction overall in cotton insecticide use. By 2010, 88 percent of all cotton insecticides used were either fully (61 percent) or partially (27 percent) selective, meaning they are safer to use and safer for the natural enemies in the cotton system. The total number of sprays applied in cotton has been reduced by 85 percent.

· For Lygus control, the percentage of cotton growers choosing reduced-risk insecticides over standard broad-spectrum options increased from 0 percent in 2005, 52 percent in 2007 and 75 percent in 2008 to 81 percent in 2009, the most recent year measured. One grower reported adopting this feeding inhibitor on 1,200 acres, resulting in 0 percent loss to Lygus in 2007 and again in 2010.

· For the first time in over 40 years, Arizona cotton growers did not apply a single spray against pink bollworm in the years 2008 through 2010. Through statewide grower-coordinated strategic uses of Bt cotton, sterile moth releases and pheromones, farmers are close to eradicating this pest from our borders.

· The percentage of cotton acres never sprayed for insects in 2010 was 29.3 percent, the highest level ever measured. Overall, cotton acreage in Arizona is expanding, from 150,000 acres in 2009, to 201,000 in 2010, and close to 250,000 acres in 2011 (projected), indicating a health in the industry that can be attributed at least in part to higher yields and lower pest control costs.

· The cotton IPM plans developed in Arizona have been exported for use in California, Texas, northern Mexico, Australia and Latin America.

Issue

The powdered roots and/or extracts derived from roots of the winter cherry plant--Withania somnifera (L.) Dunal--have been used for more than 3,000 years in India as a general tonic to build stamina, improve mental concentration, relieve stress and enhance health. Commonly known as "ashwagandha" in Ayurvedic medicine, scientific tests on the preparation have shown that it has anti-inflammatory, cardio-protective, antioxidant and antitumor properties, among others. Withania is widely cultivated for commercial use in its native India, and also in the Middle East and in North America. Ashwagandha is sold as a dietary supplement in the United States and Europe. The compound withaferin A, scientifically studied since the 1960s, seems to play the largest role in the plant's anticancer effects by reducing tumor mass and preventing the growth of blood vessels that make a tumor malignant. It also shows promise in treating Alzheimer's and Parkinson's diseases.

What has been done

University of Arizona scientists at the Southwest Center for Natural Products Research and Commercialization (or Natural Products Center), in collaboration with the Whitehead Institute at the Massachusetts Institute of Technology, have discovered a second form of withaferin that has identical functions in a less potent, slower-acting form that might be used as a "prodrug," or drug precursor in the pharmaceutical industry. The UA team used an entirely nontraditional method--aeroponics--to produce bulk amounts of withaferin A needed for biological evaluation. In aeroponics, plants are set over enclosed chambers where their suspended roots are misted with water and nutrients, instead of growing in soil. The UA College of Agriculture and Life Sciences provided funding for the project, along with the USDA.

Similarly, in a collaborative project with Nuvogen Research, a small Tucson-based company, a lead compound isolated from the Natural Products Center's library of extracts from Sonoran Desert plants has shown activity against prostate cancer. A provisional patent application has been filed for this discovery and the compound, called PCa (prostate cancer a), is currently being tested in animal models. The arid land plant containing this compound is rare and difficult to cultivate, however Natural Products Center scientists have been able to grow this plant in the greenhouse using the same innovative aeroponic technology as described for winter cherry. They are obtaining the promising compound in large quantities, toward the goal of yielding enough of the compound required for preclinical and clinical evaluation.

Withaferin A and PCa are just two of hundreds of such compounds the Natural Products Center has isolated, characterized and evaluated since its inception in 1996. The center searches for compounds in desert plants and their associated microorganisms that can improve human health and also be developed as potential industrial products in Arizona. The work focuses on economical methods for producing and structurally diversifying natural products from plants; natural products make up 60 percent of the anticancer agents that are commercially available or are in late stage clinical development.

Impact

Using the aeroponic system for cultivation yielded Withania plants with five times the biomass produced in soil-grown plants. The nontraditional method produced more than 20 grams of the active ingredient withaferin A in a single greenhouse operation in Tucson. Withaferin A normally costs about $195 for just 10 milligrams, thus the potential value of the test crop was about $390,000. And although Withania usually takes two to three years to mature to sizeable roots to be commercially viable, it took just six to nine months in this study.

Not only did the aeroponic method yield bigger plants faster, with more withaferin A than usual, it also unexpectedly stimulated the plants to produce large amounts of a new natural product--a water soluble sulfate form of withaferin A. Upon testing, this new form demonstrated the same bioactivity as withaferin A. The researchers found it was able to inhibit the proliferation and survival of tumor cells, disrupt tumor formation and induce the healthy cells' heat-shock response to reduce stress and increase survival. The difference is that the sulfate form of withaferin A is slower acting and water soluble, and can be converted to withaferin A in cell culture media. The researchers, expecting that this withaferin A analog will convert to its active form when metabolized in the body, are pursuing further testing in animal models. The patent will be held by the UA and MIT.

The work on the compound active against prostate cancer focuses on late stage Hormone Refractory Disease (HRD), for which no effective therapies currently exist. This stage kills more than 20,000 men per year in the United States alone. In addition to the potential for saving and/or prolonging thousands of lives, the direct target, a substance called PCa (prostate cancer a), represents a large market--greater than $3 billion--that remains focused on hormone ablation therapy. Many companies are active in this area and will be potential partners for commercial development.

2. Brief description of the target audience

Commodity groups, state agencies, pest management advisors, pesticide applicators, youth, ag ventures program.

V(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	17000	30000	5000	1000
Actual	18000	28000	5500	1300

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2010
Plan: 2
Actual: 3

Patents listed
Proteins and DNA Related to Salt Tolerance in Plants
Geraniol Synthase, Methods of Production and Uses Thereof

Pollen Tube Stimulants from Arabidopsis Pistils

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Plan	16	90	
Actual	16	90	106

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of individuals participating in educational programs

Year	Target	Actual
2010	17000	14500

Output #2

Output Measure

- Number of research projects conducted on all aspects of Plant Sciences

Year	Target	Actual
2010	60	65

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Adoption of better management practices for crop production
2	Adoption of alternative crop technologies
3	Adoption of more cost effective means for controlling plant diseases and insect damage

Outcome #1

1. Outcome Measures

Adoption of better management practices for crop production

Not Reporting on this Outcome Measure

Outcome #2

1. Outcome Measures

Adoption of alternative crop technologies

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	150	250

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Control of Pink Bollworm in Cotton plants

What has been done
Adoption of BT Cotton

Results
More than 95% of cotton farmers in AZ have adopted BT cotton. This resulted from the availability of the genetic material and demonstration by the University of AZ that this technology is effective and economical.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms

205	Plant Management Systems
206	Basic Plant Biology
211	Insects, Mites, and Other Arthropods Affecting Plants
215	Biological Control of Pests Affecting Plants

Outcome #3

1. Outcome Measures

Adoption of more cost effective means for controlling plant diseases and insect damage

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1000	1200

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Major insect damage to crops in Arizona costing significant dollars and utilizing major amounts of pesticides.

What has been done
An integrated pest management program (IPM) established in Arizona in 1996, refined in 2006 and continued through today uses insect growth regulators (IGRs?effective against whiteflies), transgenic cotton (with Bt?Bacillus thuringiensis?effective against pink bollworms), and a reduced-risk feeding inhibitor (effective against Lygus bugs.)

Results
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4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants
215	Biological Control of Pests Affecting Plants

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations

Brief Explanation

There is little that can be done to effect the above external factors.

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- After Only (post program)

Evaluation Results

Key Items of Evaluation