Boll Weevil Research Program Review and Planning Workshop

October 16 – 17, 2002

USDA, ARS
Southern Plains Agricultural Research Center
College Station, TX

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Meeting report prepared by D. W. Spurgeon, ARS, College Station, TX

The Boll Weevil Research Program Review and Planning Workshop was held on October 16 – 17, 2002, at the USDA, ARS, Southern Plains Agricultural Research Center, College Station, TX.

Introduction

Dr. James Coppedge, Associate Area Director, Southern Plains Area, opened the meeting by having participants introduce themselves. Participants included a private crop consultant, state Boll Weevil Eradication officials, a representative each from the National Cotton Council and the Texas Department of Agriculture, Texas A&M University and University of Arkansas research and extension scientists, APHIS personnel, and ARS scientists and administrators. Dr. Coppedge acknowledged that this would probably be the last meeting of this sort because the progression of eradication would limit opportunities for research unless special research needs arose that ARS could mobilize to address. General 'housekeeping' issues for participants were also addressed.

Overview and Objectives of Conference

Dr. Robert Faust, ARS National Program Leader for Applied Entomology, opened his comments by announcing that Ms. Kim Kaplan of the ARS Information Staff was in attendance and would be visiting with meeting participants in preparation for an article on the boll weevil research program. Dr. Faust welcomed the meeting participants, indicated the importance of the meeting to ARS, and thanked the attendees for their participation. Dr. Faust briefly reiterated the recent history of the ARS commitment to supporting the eradication effort beginning with the research planning meeting held in Memphis, TN in 1996, at which ARS and collaborators focused on establishing a set of high-priority research needs. A follow-up meeting was held in 1997 for development of a research action plan in response to identified research priorities. In 1998, the first review was held in College Station, TX, and a list of priorities as well as a revised action plan spanning from 1998 to 2002 was generated. This plan was published in a "green book" and is also available on the College Station ARS Boll Weevil Homepage web-site. A second progress review was held in College Station in 2000, featuring summary reports of research progress by ARS, APHIS, and Texas A&M University scientists, and future plans of ARS scientists. From that meeting, a list of 29 research priorities was established. This meeting represents the third, and possibly last, progress review depending on assessment of needs. Dr. Faust posed the question of how long ARS will be able to continue boll weevil research and requested that APHIS and eradication officials provide their insight into this question during the meeting. Dr. Faust indicated the meeting agenda contained the objectives of the meeting, including state eradication progress reports and anticipated research needs, research progress reports, and a period of discussion of reported research and new priorities. Dr. Faust invited participants to attend the Thursday meeting of ARS scientists where newly-evaluated priorities will be discussed and assigned to scientists.

Status of Boll Weevil Eradication in the U.S. – Plans and Research Needs

A report on the status of boll weevil eradication in the U.S. was provided by Bill Grefenstette, Senior Operations Officer, USDA-APHIS. Mr. Grefenstette began by reporting the approximate acreages and dates of completion of program areas from which the boll weevil has been eradicated:

Region	Year eradicated	Acreage
Virginia	1984	100,000
North Carolina	1987	925,000
South Carolina	1990	286,000
Georgia	1992	1,400,000
Florida	1993	121,000
Alabama	2000	589,000
Central Tennessee	2000	23,000
Kansas	2002	53,000
Texas (Southern and Central Rolling Plains)	2000/2002	950,000
Arizona	1991	360,000
California	1991	850,000
Northwestern Mexico	1993	60,000

In total, the boll weevil has been eradicated from 5,717,000 acres which represents 35.89% of the total U.S. cotton acreage.

Next, acreages under active eradication and the years of program initiation were reported:

Region	Year initiated	Acreage
Mississippi	1997	1,600,000
Western Tennessee	1998	512,000
Missouri	2001	388,000
Arkansas	1997	650,000
Louisiana	1997	600,000
Oklahoma	1998	300,000
Texas	1994	4,950,000
New Mexico	1998	72,000

The total area under active eradication is 9,072,000 acres which is 56.95% of U.S. cotton production.

New areas under eradication beginning in 2002 included the Upper Coastal Bend of Texas (270,000 acres) and the Chihuahua region of Mexico (80,000 acres). Program expansion for 2002 totaled 350,000 acres. The expansion into Chihuahua was credited to the hard work of Osama El-Lissy (APHIS).

Areas proposed for eradication in 2003 include the Northeastern Delta of Arkansas (350,000 acres) and the Northern Blacklands of Texas (100,000 acres) for a total of 450,000 acres.

Areas that have not formally pursued eradication include the St. Lawrence Valley (100,000 acres) and Lower Rio Grande Valley (200,000 acres) of Texas, and adjacent Tamaulipas, Mexico (40,000 acres). Hopes were expressed that the Chihuahua program would expand down the Rio Grande River into the Tamaulipas production region.

In summary, eradication is almost 40% completed nation-wide.

Future plans involve:
-Consistent application of technology in the various eradication zones recognizing the special differences among zones,
-Inclusion of the remaining areas not currently under eradication,
-Timely completion of active eradication programs within budget, and
-Efficient transition into post-eradication; a Boll Weevil Action Committee sponsored by the National Cotton Council is currently working with state and federal cooperators to develop a long-term post-eradication plan.

Mr. Grefenstette then presented examples of proven methodology that are necessary for successful eradication. These methods included complete acreage mapping, effective detection provided by the timely installation of traps, data management including timely triggering of treatments and accurate records, timely application of treatments after triggering, sound cultural controls including timely and effective stalk destruction, and active regulatory support from involved state agencies.

Expressed research needs included improved methods for crop termination (especially in no-till areas), increased understanding of the impact of ginning on survival of cotton pests relative to requirements for fumigation of cotton shipped overseas, reliable identification of boll weevils (especially to distinguish boll weevils and thurberia weevils), long-life pheromone lures, and Malathion resistance monitoring.

Dr. Faust inquired as to how long boll weevil research could be continued at the College Station and Weslaco locations. Mr. Grefenstette deferred to Dr. Charles Allen (Texas Boll Weevil Eradication Foundation; TBWEF) who described the new Texas Department of Agriculture regulations requiring permits for culturing non-commercial cotton (greenhouse and small-plot plantings) and the need to ensure that those permitted plantings are readily accessible to standard eradication control methods. After considerable discussion by the group Dr. Allen indicated that boll weevil research in the laboratory or greenhouse could likely be continued for the following year in College Station, and for two to five years at Weslaco, provided the research was neither causing nor giving the perception of causing re-infestation of treated cotton acreage.

Dr. Frank Carter (National Cotton Council) stated that in addition to the other proven methodologies previously indicated, successful programs needed continued technical support including periodic critical evaluation of program methods and progress.

Dr. Faust asked for a realistic projection for completion of eradication in the U.S. Discussion among Mr. Grefenstette, Dr. Allen, and Mr. John Norman (Texas A&M Extension Service, Weslaco, TX) produced a best-case estimate of 5 to 7 years.

Texas Status Report

A report on the status of eradication in Texas was provided by Dr. Charles Allen, Program Director, TBWEF. The Texas program now encompasses 12 active zones. The St. Lawrence area is not currently in eradication, but has a diapause control program except for the northern portion (20,000 – 30,000 acres) of the area. Weevil numbers in the area with the diapause program are low, but weevil numbers are high in the northern area and this area may be impacted by a quarantine in the next few years.

The Northern Blacklands area votes on an eradication referendum November 19. Traps in this area near the Red River have captured 80,000 weevils over several weeks and this area is close to some program acreage in Oklahoma. One problem with passing a referendum in this area is the large number of absentee landlords.

There is increasing interest in eradication in the Lower Rio Grande Valley but concerns remain there.

Dr. Allen provided a summary of year-to-date boll weevil trap captures by eradication zone and in reference to trap captures during the initial program year.

Region	2002 acreage	Year initiated	1st-year captures[a]	2002 captures[a]	% Reduction
El Paso/Trans Pecos	41,643	1999	0.13	0.00022	99.8
Northern High Plains	557,185	2001	1.124	0.005	99.5
Northern Rolling Plains	354,067	1999	24.21	0.002	99.99
Northwest Plains	523,325	1999	3.49	0.002	99.94
Permian Basin	735,404	1999	9.78	0.031	99.7
Rolling Plains Central	562,689	1996	19.22	0.0105	99.94
Southern Blacklands	61,915	2001	12.044	1.467	87.8
Southern High Plains /Caprock	1,197,506	2001	1.742	0.005	99.7
Southern Rolling Plains	208,329	1995	18.32	0.00003	99.999
South Texas/ Winter Garden	436,797	1996	13.86	0.14	99.0
Upper Coastal Bend	187,813	2002	30.64	--	--
Western High Plains	816,058	1999	14.15	0.002	99.98

[a]Trap captures are expressed as averages per weekly trap inspection.

Dr. Allen indicated the definition of "functionally eradicated" was no evidence of boll weevil reproduction combined with an average trap capture of less than 0.001 weevils per trap inspection.

In his report Dr. Allen indicated that several zones are ahead of schedule including the Southern Plains/Caprock and the Western High Plains zones, but problems were experienced in some other zones. Volunteer and re-growth cotton from failed plantings were problems in the Northern High Plains and other Plains zones. Volunteer cotton in corn was a problem in the Northwest Plains zone, and similar problems occurred in sorghum in the Permian Basin. The Permian Basin made no progress in 2002 because of migration from other areas and protocol issues regarding failed cotton overplanted with sorghum. Rolling Plains Central also made no progress in part because of migration from the Permian Basin. Good progress was made in the Southern Blacklands, and an increase in cotton acreage is expected next year. This year 7 weevils were captured in the Southern Rolling Plains, which was previously declared eradicated. These weevils may have moved in on equipment being transported through the area. The South Texas/Winter Garden area experienced problems on the north side because of weevil movement from the Upper Coastal Bend, and on the south side because of movement from the Lower Rio Grande Valley. The Upper

Coastal Bend zone began its initial diapause program this year but was plagued with problems of Malathion wash-off from rain, and thus weevil populations were very high. Weevil numbers were low in the new program in the Portales area of New Mexico, which is adjacent to the Western High Plains zone.

A brief summary of pink bollworm activities was provided. This year the program achieved an 88.5% reduction in pink bollworm populations, but will need to move towards season-long use of the rope formulation of the pheromone. The Pecos work unit had late-season problems that may have been caused by movement of moths from surrounding areas.

Challenges that face the Texas program include migration, timely location of all cotton fields, mapping, trapping, and treatment timeliness in the spring, re-growth and volunteer cotton, thorough stalk destruction and field clean-up, prevention of post-eradication re-infestation, secondary pests, and off-target pesticide concerns.

The Texas program has continuing needs for support in the following areas:
-Testing of pheromones, traps, insecticide strips, etc.,
-Insect identification, especially insects which may interfere with trapping such as the clerid beetle identified this year,
-Laboratory support in environmental monitoring, insecticide efficacy, and resistance monitoring,
-Quarantine protection in suppressed areas,
-Political, funding, program, and Technical Advisory Committee oversight and education,
-Regulatory support from EPA and the Texas Department of Agriculture,
-Advisory support from the Technical Advisory Committee, and
-Product development in the broad sense, including software development, remote sensing, and other technologies that may improve efficiency of eradication.

Dr. Allen ended his presentation by addressing the issue of research in eradication zones. Such research faces constraints regarding field-plots and importation of weevils, especially as weevil populations are suppressed. Also, research should focus on short-term objectives because of the limitations in development time to keep pace with eradication program progress.

Southeast Status Report
The report for the Southeastern Eradication Program was presented by Mr. Jim Brumley. At present, about 3.5 million acres in the Southeast are in post-eradication. Trap captures in the various states this year were: Virginia, 0; North Carolina, 12; South Carolina, 0; Georgia, 13; Alabama, 437; Florida, 0; and Central Tennessee, 0. The Southeastern Program also has about 2.5 million acres under active eradication in western Tennessee, Mississippi, and the Bootheel of Missouri. Of the 12 weevils captured in North Carolina during the past year, 11 were from the same county and 10 of those were caught in a single week. Reproduction was detected in that county. Eleven of the 13 weevils captured in Georgia were caught in Brooks County and reproduction was detected. That area was on the trial 3-wk trap cycle using the "super lure". In Talladega Co., Alabama, 101 weevils were caught and that area is being treated now. One weevil was caught in Escambia Co., and 61 weevils were caught in Mobile Co. Those weevils were carried over from an infestation last year and were caught at pinhead stage. Two weevils trapped in northern Alabama were caught close to the Mississippi state line. In Choctaw Co. 263 weevils were caught, and 8 weevils were caught in Marengo Co. No additional weevils have been captured in those areas in the last few weeks.

Post-eradication traps in the Southeastern Program are established in June and initially run in July. Mr. Brumley indicated the Southeastern Program was excited about the “super lure”. This lure contains 25 mg of grandlure plus 30 mg of eugenol, and it remains effective for about a month. At present, the Southeastern Program is using three trapping protocols for post-eradication: the standard two-week protocol using temporary personnel, a two-week protocol using only permanent employees, and a three-week protocol using permanent people and the super lure. The purpose of the 3-week cycle is to cut labor costs in post-eradication. The purpose of the trial is to see if the traps can be adequately maintained using only permanent employees.

Mr. Brumley then reported on the status of active eradication zones. Reported trap captures were expressed as weevils trapped per cotton acre. Trap captures in Region I of the Tennessee program have decreased from 1.38 in 1999 to 0.1503 in 2002, which is an 89% decrease. Migration from northeastern Arkansas has been a problem in this region. Trap captures have been reduced by 99.9% in the eastern portion of the region and only by 77.3% in the portion nearest the Mississippi River. Trap captures in Region II of the Tennessee program have decreased from 0.156 in 2001 to 0.0446 in 2002, which is a 71.5% reduction.

The program in Missouri began last fall with 4.5 diapause applications. The zone closest to the Mississippi River received 4.19 applications this year and averaged 0.10299 weevils trapped per acre. The zone closest to the ridge averaged 3.27 weevils trapped per acre and received 6.21 applications of Malathion.

The Mississippi program is divided into four regions. Trap captures in Region IV (eastern Mississippi) have totaled 0.0148 weevils/acre, 91.9% of fields have had zero captures ("zero fields"), and 0.26 applications of Malathion were applied per field. Some weevils are still being captured from a group of fields near Tupelo. Region III (extending from north-central to southeastern Mississippi) has three work units. The northern unit has caught 0.21 weevils/acre with 43.9% zero fields and 1.42 applications of Malathion per field. The central unit has caught 0.15 weevils/acre with 57.6% zero fields and 1.35 applications per field. The southern unit has caught 0.4 weevils/acre with 38.5% zero fields and 3 applications of Malathion per field. Region III and the Southern Delta zone (0.1669 weevils/acre, 40% zero fields, 2 applications per field) have lost some ground from last year. Part of this is related to weather and recently corrected personnel problems. The budget has been stretched to the point it may be "cracking", by going from 16 to 10 oz of Malathion and increasing trap spacing from 150 ft to 300 ft. These changes combined with light worm pressure (fewer producer-applied treatments) may have weakened the arsenal against the boll weevil. The technology has been bent to the breaking point. The northern work unit of the Delta zone has 54% zero fields and 1.41 applications of Malathion per field. The central work unit has 50% zero fields and 1.21 applications per field, and the southern unit has 61% zero fields and 0.8 applications per field. This zone is under budget.

From 1998 to 2002 we have not moved towards eradication as fast as we think we should have. Northeast Arkansas is part of the problem. There are 330,000 – 350,000 acres of cotton there that are outside the program. This area may be subsidized by the Southeastern and Arkansas programs to get these acres in the program and stop the migration problem.

Research needs of the Southeastern program are similar to those of the Texas program, and include development of a 30-d lure, better control of re-growth, and we need to know if weevils can fatten on re-growth cotton and survive the winter. Control of volunteer Roundup-Ready cotton is also a problem.

Arkansas Status Report

The Arkansas eradication status report was presented by Mr. Danny Kiser. Arkansas has four eradication zones. The Southwest zone was taken over from the Louisiana program in 1998, and has only about 3500 acres of cotton. This zone averaged 2.82 weevils per trap inspection in 1998 and has decreased to 0.0021 weevils per trap inspection, which is a decrease of 99.924%. A total of 52 weevils were caught in the zone this year. The Southeast zone includes about 281,000 acres, and there were some problems this year in two of the six field units. Field units 219 and 224 (about 25,000 – 30,000 acres) accounted for 75.53% of the weevils caught in the entire zone. Over the entire zone, trap captures averaged 0.130 weevils per trap inspection, which is a 97.71% decrease from the spring captures in 2000 (5.65 weevils per trap inspection). On average, of 6.44 applications of Malathion were made per field. The Central zone was started in 2000 and contains about 320,000 acres. Trap captures this year averaged 0.354 weevils per inspection, which is a 97.36% reduction compared with 13.42 weevils per inspection in 2000. The no-fly rule implemented after September 11 last year caused some problems for this zone, and the northern part of the zone is having problems caused by weevil migration from Mississippi County. Last week traps in Mississippi County averaged 461 weevils per trap. The program continues to make good progress in the Marvell District (southern portion of this zone). The Ridge zone is also experiencing problems with weevil movement from outside the zone. This zone, minus the eastern Poinsett area, averaged 0.802 weevils per trap inspection compared with 2.322 weevils per trap inspection in 2001. The eastern Poinsett area averaged 4.97 weevils per trap inspection. Statewide, trap captures in eradication zones were 98.47% lower than in non-eradication areas. The Mississippi County area contains about 350,000 acres of cotton and an eradication referendum is scheduled for this year.

Mr. Kiser also discussed new problems for the Arkansas program this year. When the program has discontinued diapause treatments early it has caused problems. Producers grazing cotton stalks and a great increase in no-till cotton in recent years have worsened this situation. This re-growth often reaches the squaring stage and as much as 25% of the eradication budget is used to treat this cotton alone. Bt cotton and new materials for worm control are also causing some problems because producers are treating less often for bollworms and the materials being used are killing fewer weevils. There is also a need for additional research to find effective ways to kill re-growth cotton in no-till systems.

Oklahoma Status Report

The Oklahoma status report was presented by Dr. Bill Massey. Oklahoma is the only boll weevil eradication program that is a state agency rather than a foundation. Weevil numbers in 2002 were very low. In the last five weeks weevil numbers have increased in the heavily irrigated acres in Jackson Co. Last year 227,000 acres were sprayed (1.12 applications per field) and so far about 40,000 fewer acres have been treated in 2002. Oklahoma has no regulations on stalk destruction but producers usually shred stalks and reform the beds shortly after harvest. There is some re-growth in dryland cotton that is not usually harvested until later in the season. About 600 acres of cotton are in the county adjacent to the Southwest Arkansas program, and about 40 miles from cotton outside an eradication program in Texas. In 2001 no weevils were caught there until October 15, and a total of 7 weevils were captured. One weevil was caught in the spring of 2002 until six weeks ago, and 77 weevils have been caught since. The Oklahoma program is concerned about quarantine issues and maintaining eradication in a situation where producers are growing cotton in both Oklahoma and across the border in Texas. This may become especially difficult because cotton is now being grown in the Oklahoma panhandle. This cotton will either be ginned in Kansas or the Hereford, Texas area.

New Mexico Status Report

The New Mexico report was presented by Mr. Joe Friesen. New Mexico has two active eradication zones; the South Central zone around Las Cruces, and the Pecos Valley. There is also a monitoring program in Hidalgo Co. (southwestern corner of New Mexico). Two zones on the Texas/New Mexico border are being taken care of by the Texas program through a cooperative agreement.

The South Central zone is currently in very good shape. Trap captures in 2002 averaged 0.0004 weevils per trap inspection compared with 4.1 weevils per trap inspection in 1998. This is a 99.99% reduction in captures. The Pecos Valley is in its second full season. Trap captures averaged 3.9 weevils per trap capture in 2000 and 0.26 weevils per trap capture in 2002, representing a 93.3% reduction. This year the New Mexico program was also involved in a pink bollworm eradication program in Chihuahua, Mexico, West Texas, and South Central New Mexico, and a 95% reduction in trap captures was achieved.

Summaries of Research on Identified Priorities

Dr. Faust introduced the research progress reports by describing their structure and emphasizing their focus on established priorities. Dr. Dale Spurgeon (ARS, College Station) moderated the reporting session, and began the reports by reiterating that not all research accomplished would be presented, but instead the reports would summarize only research that addressed established priorities. Because of overlap among the 29 priorities identified during the 2000 meeting, several related priorities were combined for the purposes of the research reports. Also, because of the limited time allotted for the presentations, and the need for sufficient time to discuss the reports and assess current and new priorities, Dr. Spurgeon asked that the participants record their questions on the provided presentation handouts so they could be addressed at the end of the reports. The research reports were organized by subject matter and were ordered according to the rankings established during the October 2000 meeting (Appendix A).

<u>*Cotton Harvesting, Storing, and Ginning (Research Priority 1)*</u>

The report on ginning research was presented by Dr. Thomas Sappington (ARS, Weslaco).
The report represented a collaborative effort with Dr. Alan Brashears (ARS, Lubbock), and Texas A&M University scientists Mr. Stan Carroll, Mr. Mark Arnold, Dr. Megha Parajulee, Mr. John Norman, and Dr. Allen Knutson. The two main components of the project addressed the transport of weevils to the gin on modules, and passage of those weevils through the gin, respectively.

Transport of Weevils to the Gin in/on Modules
-Adult weevils were present in defoliated cotton (up to 2300/acre)
-Live adults were packed in modules even when field populations were low (200 – 1200/module)
-A proportionate number will be packed on or near the module surface
-A field cleaner removes about 85% of harvested weevils
-Weevils of all stages can be packed in modules within infested bolls

-Mark-release studies indicated most (>90%) of weevils on the module surface disperse rapidly when temperatures or sunlight conditions are favorable for flight
-Mortality on the module surface under the tarp is high on warm sunny days
-The percentage surviving is low although a few weevils may burrow into the module
-Weevils are commonly observed walking (usually upward) on the module sides
-Weevil movement under the tarp is restricted and dispersal from under the tarp is unlikely

Conclusions of this aspect of the research were:
-During warm sunny weather almost all weevils on the untarped surfaces of the module disperse before the module is transported to the gin
-Weevils on the upper surface of the module, and under the tarp, suffer high rates of mortality and are unlikely to escape to the untarped module sides
-The greatest danger of weevil transport on modules occurs when the weather is cool and cloudy before and during module transport, and warm and sunny after the module arrives at the gin
-No evidence was discovered to suggest that modules are attractive to weevils; in fact, the module presents a hostile environment to the weevils

Survival of Weevils Entering the Gin
-Given that some weevils may enter the gin on modules, weevils marked with fluorescent powder were fed into the gin at various points in the ginning process to determine their survival

Before the Gin Stand – Seed Cotton Cleaning
-A few free adults (0.08%) and weevils in unopened bolls escaped alive into the rock/green boll trap
-There was no evidence that any weevils survived to reach the gin stand even in the absence of dryers
-With one dryer operating, 100% mortality of released weevils was obtained with an operating temperature of 300°F
-With two dryers 100% mortality was achieved at 185°F

Before the Gin Stand – Survival through Trash Fans
-No survival of free adult weevils or adults in simulated pupal cells (gelatin capsules) was observed in trash passed through a fan at tip speeds =183 ft/sec
-A small percentage of adult weevils inside green bolls survived passing through the fans at all speeds tested; the maximum tip speed tested was 269 ft/sec
-Mechanical cracking of the bolls was investigated as a method of increasing mortality of weevils in green bolls; cracking before passage through a fan increased mortality and no survival in cracked bolls was observed at tip speeds =199 ft/sec

At the Gin Stand
-Most of the released adults and simulated pupal cells were separated into the seed fraction, but survival was only 0.1 and 0.7%, respectively
-After separation into the seed, only 30 – 35% of the weevils survived passage through the seed conveyance system
-A small percentage (0.5%) of free adults were observed to pass alive through the gin stand in the lint

Past the Gin Stand – Lint Cleaners and the Bale Press
-There was no evidence that any weevils survived a single lint cleaner
-There was no evidence that weevils could survive tie-out densities in Universal Density bale presses at normal bale weights

Conclusions
-Weevil dispersal from the module surface presents a negligible threat under most weather scenarios
-Some live weevils are likely to enter the gin with the seed cotton
-The probability of weevil survival diminishes rapidly as the ginning process progresses; the probability of a weevil surviving to reach the gin stand is extremely small
-The greatest threat of weevil survival at the gin is through escape into the rock/green boll trap or passage through a trash fan in an unopened green boll

Diapause and Overwintering Survival (Research Priority 2)

The report on diapause research was presented by Dr. Spurgeon. The presentation summarized results of numerous diapause studies involving a number of collaborators and was organized according to experimental objectives.

Relationship Between Longevity and JHE Titer (D. Spurgeon, J. Raulston, R. Summy, ARS; M. Rankin, L. Hansen, T. Taub-Montemayor, University of Texas)

-This work was initiated because of a need for a diagnostic protein to indicate diapause; juvenile hormone esterase (JHE) was examined as a candidate for this purpose

-The work established a correlation between JHE titer and host-free longevity but JHE was of limited use as an indicator of diapause because a continuous range of titers was observed

-One of the most important findings was that among cohorts of weevils held outside no seasonal trend in JHE titers was observed. Thus the results did not indicate a diapause response to natural photoperiods from June through November

-Results also indicated a pronounced temperature-dependence of host-free survival

Seasonal Diapause Patterns in the Tropics (D. Spurgeon, J. Raulston, ARS)

-Dissections of trap captured weevils from a large-scale study in the Mexican state of Tamaulipas were consistent with the findings of the JHE experiment

-More than 22,000 weevils collected from 18 trapping sites were dissected

-Diapause characters were most prevalent when weevils were associated with a mature cotton crop and after harvest (December through February in southern Tamaulipas; August through October in northern Tamaulipas)

-No fully reproductive weevils were captured at sites more than 20 – 30 miles from cotton

-Times at which diapause characters were present were dependent on the cotton production schedule and were not related to photoperiod

-The results of this and the JHE study provided the impetus for expanding the diapause research program

Influence of Photoperiod and Temperature on Diapause Induction (D. Spurgeon, J. Raulston, ARS)

-A review of the literature indicated potential problems with methods that did not account for differences in physiological ages between diapause induction treatments

-Experiments were conducted using serial dissections to document changes in physiological status with increasing age

-Treatments of 11- and 13-h photoperiods, combined with constant (85°F) or fluctuating temperatures (85°F day, 50°F night) were compared

-Experiments were repeated five times in Weslaco and three times in College Station

-Photoperiod did not influence the incidence of diapause

-Temperature influenced the perception of diapause through its effects on reproductive development rate

-No inter-populational differences were observed between subtropical and temperate zone weevils

-Results indicated the diapause response was controlled by adult diet

Effects of Food Characters on Diapause (D. Spurgeon, C. Suh, J. Esquivel, ARS)

-Results of photoperiod experiments prompted increased interest in dietary factors

-All experiments used long-day (13-h photoperiod) conditions

-In general, the diapause response was stronger for large squares (>7 mm diameter) than for small squares (<7 mm)

-Bolls (20 – 25 mm diameter) generally produced more diapausing weevils than squares (6 – 9 mm)

-The diapause response to medium sized bolls (20 – 25 mm) was greater than the response to small bolls (10 – 15 mm)

-Diapause in males was not observed in response to feeding on small bolls and this diet provided substantial levels of reproductive development in both sexes

Influence of Feeding Period Duration on Survival (D. Spurgeon, ARS)

-The literature indicates a wide variation in the characters used to signify diapause

-This research was an effort to determine if the characters used were related to host-free longevity and to standardize feeding conditions and feeding period durations

-Weevils were fed a boll diet for 7, 14, or 21 d at 29.4°C (85°F) with a 13-h photoperiod

-Survival after the feeding period at 23.9°C (75°F) was monitored weekly

-On average, weevils fed for 14 d lived longer than those fed for either 7 or 21 d

-Extended host-free longevity was observed at all feeding period durations

Validation of Diapause Characters – Survival (D. Spurgeon, ARS)
-Having determined an appropriate feeding period duration, experiments were conducted to relate diapause characters to subsequent host-free longevity
-Feeding regimes (square size, numbers of squares per weevil) were varied to obtain a range in percentage of diapause (20 – 90%) after 14 d
-Weevils were fed at 29.4°C with a 13-h photoperiod
-Survival was monitored weekly at 23.9°C
-Survival was positively correlated with the diapause characters, especially fat body condition

Validation of Diapause Characters – Biochemical (D. Lewis, L. Keeley, Texas A&M University; D. Spurgeon, T. Sappington, ARS)
-Work was conducted in response to an expressed need for a diagnostic protein
-Experimental weevils were fed bolls at 29.4°C under either 11- or 13-h photoperiods
-A unique storage protein was identified, isolated, and sequenced
-The storage protein was associated with mature, dormant fat body; its occurrence was independent of egg production or presence of egg yolk protein
-The storage protein occurred similarly under the two photoperiods
-The storage protein can be detected with an antibody and Dr. Sappington is currently working on this aspect of the project

Flexibility in the Dormancy Strategy (C. Suh, D. Spurgeon, T. Sappington, ARS; D. Lewis, L. Keeley, Texas A&M University)
-Flexibility in the dormancy strategy was examined in diet-switching studies
-Female weevils were fed a reproductive diet for 5 d and oviposition was confirmed
-Beginning on day 6, weevils were switched to a dormancy-inducing diet for 18 d
-After the dormancy feeding period 22% (females) to 40% (males) were rated as diapausing, although most of the females (82 – 85%) contained the dormant type of fat bodies, showed signs of oosorption, and had the storage protein present
-Subsequent survival was monitored weekly at 23.9°C
-Males tended to live longer than females
-Some females known to previously oviposit survived =20 weeks without further feeding
-Results indicated dormancy could be induced in previously reproductive weevils by manipulating diet

Flexibility in the Dormancy Strategy (D. Spurgeon, B. Reardon, C. Suh, ARS)
-Given that reproductive weevils could be induced to develop the diapause characters, weevils known to overwinter naturally were examined for their ability to respond to diapause-inducing diets
-Overwintered weevils were trapped in areas away from cotton and divided between reproductive (square) and diapause (boll) diets
-Square-fed weevils generally committed to reproduction
-Many boll-fed weevils developed diapause characters and most developed the dormant type of fat body
-Boll-fed weevils held without food after a 14 d feeding period lived longer (up to 7 weeks) than weevils fed the square diet
-These results indicated the diapause characters could be re-induced in naturally overwintered weevils by manipulating diet

Effects of Temperature on Dormancy Development (D. Spurgeon, ARS)
-It is known that boll weevil reproductive development is temperature dependent
-Similar temperature dependence of the development of diapause characters has been assumed and provides the rationale for extending diapause spray intervals in the fall
-Weevils were fed the dormancy-inducing diet at temperatures of 18.3, 23.9, or 29.4°C (65, 75, or 85°F) under a 13-h photoperiod
-Development of diapause characters was evaluated by serial dissections
-Lower temperatures only slightly decreased the rates of diapause character development but greatly decreased the rates of reproductive development

-Studies of host-free longevity are in progress; to date, survival among the temperature groups is similar

Diet-Induced Termination of Dormancy (D. Spurgeon, C. Suh, ARS)
-Weevils were fed dormancy-inducing diet for 14 d, then switched to a reproductive diet
-A substantial proportion of female weevils were ovipositing or exhibiting ovary development by 12 d but few males fed on the reproductive diet
-Additional studies were conducted to examine the termination response in relation to starvation periods of 1, 3, or 5 weeks
-Both sexes exhibited a termination response, and the response in males was enhanced by increasing the starvation period
-Studies were also conducted to examine the role of flight in termination
-Both sexes exhibited a termination response after flight, and flight was the factor providing the most marked termination response in males

Major Conclusions from Diapause Studies
-The dormancy is not a classical diapause; it is most likely a quiescence controlled by the host
-The dormancy response is not amenable to modeling efforts because it is tied to development of the cotton crop
-Weevil reproduction on cotton re-growth is not restricted to a portion of the population
-Presence of eggs in female weevils does not preclude successful overwintering
-The results illustrate the potential for young reproductive weevils to enter dormancy on late-fruiting cotton
-Results suggest diapause spray intervals should not be lengthened in the late fall in response to lower temperatures

Trap Effectiveness, Placement, and Boll Weevil Movement (Priorities 3, 5, 7, and 15)
Dr. Charles Suh (ARS, College Station) and Dr. Thomas Sappington presented research summaries of trapping research from their respective locations. As with the previous reports, a diversity of objectives and investigators was represented. Dr. Suh initiated the report by addressing research on trap placement.

Trap Placement (D. Spurgeon, T. Sappington, J. Raulston, ARS)
-Studies of trap placement in relation to surrounding habitat indicated that captures were highest when traps were associated with prominent vegetation (brush lines, standing sugarcane, wooded areas)
-Brush lines also moderated wind speeds >6 mph, and afforded higher captures in traps placed on the downwind side under those conditions
-Results indicate weevil captures in eradication programs, and the probability of weevil detection during maintenance programs, can be maximized by establishing traps downwind of prominent vegetation

Trap Placement (J. Westbrook, C. Suh, D. Spurgeon, ARS)
-The influence of trap placement relative to distance from cotton was also investigated
-Traps within an extensive trap line in the Brazos Valley were grouped according to distance from cotton (<100 m; 100 m – 1000 m; >1000 m)
-Seasonal patterns of capture indicated highest captures during the fall harvest and spring seedling periods
-Traps at distances >1000 m from cotton captured fewer weevils than traps at other distances
-Trap captures at distances of 100 – 1000 m were less depressed during the period when cotton was squaring than traps <100 m from cotton
-Results suggest that weevil detection during the mid-season squaring period may be improved if traps are not established directly on field borders

Boll Weevil Dispersal (D. Spurgeon, J. Raulston, ARS)
-Long-range dispersal was examined in an extensive trapping study in the Mexican state of Tamaulipas
-Traps in Northeastern Mexico detected weevils at distances of about 100 miles downwind from the nearest cotton
-Trap captures documented the infestation of a new cotton production area about 70 miles from other cotton during the first production season
-Seasonal capture patterns at distant, downwind sites were similar to those nearer cotton but captures were smaller in magnitude
-Results illustrate the potential for weevil movement into the Texas Lower Rio Grande Valley from cotton production regions of Northeastern Mexico

Boll Weevil Dispersal (J. Westbrook, D. Spurgeon, ARS)
-Effects of wind patterns on weevil dispersal were studied using mark-recapture methods
-Captures of marked weevils indicated a net downwind displacement of dispersing weevil populations
-Spatial patterns of capture documented both a northerly displacement of weevils by prevailing winds and a southerly displacement following passage of a frontal system
-Changes in the direction of dispersal in relation to the release point often lagged one day behind the change in wind direction, presumably because of the time elapsed between displacement and capture
-Results indicate that southerly displacement of boll weevil populations can occur with frontal passage

Trap Capture Characterization (C. Suh, D. Spurgeon, J. Westbrook, J. Esquivel, ARS)
-Research was conducted to better understand the physiological condition of trapped weevils and thus the information provided by trap captures
-Weevils collected from an extensive trapping system in the Brazos Valley and from associated cotton fields were dissected to determine their physiological condition
-The morphology (fat body condition, reproductive condition, status of the midgut) of trapped weevils was often different from that of weevils collected from the standing cotton crop
-Weevils trapped in-season typically exhibited less reproductive development than weevils collected from cotton
-The morphology of early- to mid-season trap caught weevils suggested they originated from sources other than cotton (i.e., overwintering habitat)
-Results suggest the placement of traps on field borders may enhance weevil colonization of the cotton crop

Trap Capture Characterization (C. Suh, D. Spurgeon, J. Westbrook, J. Esquivel, ARS)
-Laboratory studies were conducted to examine selected morphological characters of weevils that may provide additional information in interpreting trap captures
-The presence of juvenile fat (fat body remaining from the pupal stage) was the best indicator of weevil age; this fat persists for 1 – 2 days after adult eclosion and can be considered sound evidence of weevil reproduction in the vicinity
-The presence of solid food in the midgut (especially cotton pollen) was a good indicator of recent association with cotton
-Ovaries containing oocytes with yolk showing no signs of oosorption, and well-developed accessory glands in males are evidence of association with cotton during the previous 1 – 4 days
-Results suggest that many of the weevils trapped were seeking rather than departing cotton, and that recent association with cotton can be detected

Dynamics of Pheromone Production (D. Spurgeon, ARS)
-The impacts of pheromone production by wild weevils on trap captures are poorly understood. Studies were conducted to improve understanding of the dynamics of pheromone production
-Pheromone production in the boll weevil is usually examined using groups of weevils; methods were developed to allow examination of pheromone production by individual weevils
-Pheromone production was observed at much higher levels and at earlier ages than previously reported
-Weevils produce primarily pheromone components I and II for the first few days
-Very little (<5%) pheromone was recovered from the frass although this has been the traditional measure of boll weevil pheromone production
-Production of large amounts of pheromone was associated with the presence of well-developed accessory glands
-Results suggest that boll weevil frass does not act as a slow-release medium as previously thought; estimates of pheromone production indicated the amounts of pheromone available to compete with traps in the field is much higher than previously reported

Trap Efficiency and Economics (C. Suh, D. Spurgeon, ARS)
-Eradication programs devote substantial resources to the use of kill strips in traps but the efficacy of these devices has not been evaluated
-Two types of DDVP-impregnated kill strips were evaluated out-of-doors in traps
-Both types of kill strip provided high levels of weevil mortality, but only after extended exposure times
-Use of kill strips did not prevent weevil escape from traps

-Results suggest costs associated with kill strips are not justified on the basis of preventing weevil escape, and particularly so in the later years of active programs or in maintenance programs when traps capture low numbers of weevils

Major Conclusions from Trap Studies
-Capture and detection of weevils can be maximized by placing traps downwind from prominent vegetation
-Detection of weevils by traps may be improved by placing traps away from field borders; traps placed on field margins may enhance colonization
-Many weevils captured in traps probably do not originate in the trapped field
-Use of kill strips to reduce weevil escape is of questionable value
-Southerly displacement of weevil populations can occur with frontal passage

Dr. Sappington continued the report with research summaries from the Weslaco location.

Large Capacity Boll Weevil Trap (A. Showler, ARS)
-The large capacity boll weevil trap is a board (1 ft X 3 ft) coated with adhesive
-Seasonal capture patterns relative to the foundation trap were evaluated
-Traps were convenient to operate and were =2-times more effective than the standard traps at low and moderate weevil population levels
-The sticky trap had a much higher capture capacity than the standard trap
-The sticky trap was less sensitive to wind orientation
-Captures by sticky traps were increased in proximity to brush, especially when traps were upwind of the brush line
-Captures by sticky traps were increased when the grandlure point sources were distributed over the trap surface

Boll Weevil Movement During Late-Season Field Operations (A. Showler, ARS)
-Disturbances of the cotton crop such as defoliation, harvest, shredding, and stalk pulling were associated with temporary increases in trap captures
-Trap captures suggested that substantial numbers of weevils persist in cotton fields even when the plants are being systematically destroyed
-Results suggest that higher than expected numbers of weevils remain in cotton fields at shredding and stalk pulling

Trap Interference (T. Sappington, ARS)
-Recently, questions have been posed about interaction between traps in trap evaluations and monitoring efforts so the effects of wind orientation in this regard were studied
-When traps were at 50 – 65 ft spacings, captures were affected by trap position unless wind direction was perpendicular to the trap line
-When wind direction was >23° from perpendicular, the upwind-most trap recorded the highest captures and the lowest captures were obtained from the trap in the 2^{nd} position (about a 2-fold difference)
-Comparisons of trap designs or pheromone formulations should feature position rotations and the use of outer buffer traps
-Trap spacings should be =100 ft to avoid positional biases in captures

Flight Behavior (T. Sappington, ARS)
-A better understanding of the effects of weevil age and physiological condition on flight behavior could provide valuable insights for better interpretation of dispersal studies
-Weevil flight behavior was studied on computerized flight mills
-Both the duration and speed of flight was similar between weevil sexes
-The duration of flight increased with weevil age to a peak at ages of 9 – 11 days
-The duration of flight per day was similar for reproductive and diapausing weevils at ages =11 days
-Weevils fed a diapause-inducing diet for 14 – 28 days flew 4.6-times longer per day than weevils fed a reproductive diet
-Results suggest feeding on late-season bolls is more likely to promote dispersal than in-season square feeding

Trap Capture Characterization (T. Sappington, D. Nelson, ARS)
-Eradication programs have requested development of methods to accurately age trap-captured boll weevils
-Age-related changes in the cuticular hydrocarbons of the outer wax layer of the insect cuticle were analyzed

-Quantities of eight components of the cuticular hydrocarbons changed with weevil age
-Cuticular hydrocarbon profiles can be used to reliably estimate weevil age
-Knowledge of the age of weevils trapped in eradicated zones may be of help in determining their source of origin
-Comparisons of age structures of field- and trap-collected weevils may help to better understand the timing and dynamics of dispersal

Survival of Trap-Captured Overwintering Weevils (S. Greenberg, T. Sappington, ARS)
-Trap captures, particularly during the non-cotton season, are difficult to interpret because the proportion of the weevil population that is sampled is unknown
-Host-free survival of trapped weevils in the Lower Rio Grande Valley was evaluated from September to March
-Fat body ratings of trapped weevils declined from initial ratings of fat to intermediate in September to ratings of extra-lean in March
-The maximum longevity of unfed weevils from any collection was < 3 weeks
-Weevils fed squares for 10 d after capture lived up to 3 months
-Results suggest traps become increasingly selective as the fallow season progresses and/or many weevils do not enter the fallow season with large fat reserves

Crop Termination, Cultural Controls, and Trap Crops (Priorities 4, 13, and 20)
Research summaries pertaining to crop termination, cultural controls, and trap crops were presented by Drs. Spurgeon and Sappington for their respective locations. Dr. Spurgeon began the presentation by indicating the research reports from College Station did not directly address cultural controls, but instead represented new biological information that was relevant to the design and implementation of cultural controls.

Early-Season Ecology (C. Suh, J. Esquivel, D. Spurgeon, ARS)
-The practice of uniform delayed planting that has been used to considerable advantage in the Rolling Plains of Texas is based on the premise that weevils denied fruiting cotton plants display limited longevity and reproductive development
-Experiments were conducted to examine these factors under controlled laboratory conditions (23.9°C, 12-h photoperiod)
-Ovary development and longevity of overwintered weevils fed either cotyledon-stage or 4-leaf stage cotton plants were evaluated
-Extensive plant damage by the weevils necessitated plant replacement each 2 – 3 days
-Both types of plants supported some egg development (including mature eggs), which was greatest on cotyledon-stage plants
-Maximum observed longevity was 157 d (cotyledon-stage plants)
-Average survival for weevils provided non-fruiting cotton plants was much greater (62 d, 4-leaf; 81 d, cotyledon) than that of unfed weevils (7 d), and much greater than in previous reports in which weevils were caged in the field and plants were not regularly replaced
-Results indicate that non-fruiting cotton plants are nutritionally adequate to support both limited egg development and extended longevity
-These findings suggest the mechanisms responsible for the effectiveness of uniform delayed planting may differ from those currently accepted

Early-Season Ecology (J. Westbrook, D. Spurgeon, ARS)
-Previous attempts to model boll weevil emergence from overwintering habitat have yielded inadequate results, yet the need for this information in relation to planting date remains
-Emergence profiles from cages in the Brazos Valley were studied in relation to micrometeorological factors for two years
-Weevils were fed the diapause diet for 2 – 3 weeks before installment in cages in November
-Recovery of installed weevils ranged between 60 and 70% for the two years
-Major emergence events were of short duration, and were associated with significant rainfall and temperatures =23°C
-Peaks in emergence did not align with trap capture patterns, although trap captures are commonly considered to indicate emergence activity
-Fat bodies of trapped weevils were generally much less well developed than those of weevils emerging from cages

-Results suggest degree-day based emergence predictions may not be appropriate because of the influences of short-term meteorological conditions on emergence
-Based on these results, dry spring conditions would be expected to prolong emergence from overwintering as was observed in the Brazos Valley this spring

Overwintering Ecology – Host-free Survival (D. Spurgeon, ARS)
-Although it is widely recognized that severe low temperatures produce considerable mortality of overwintering weevils, effects of more moderate temperatures typical of subtropical and southern temperate regions have not been adequately studied
-Weevils were fed the diapause (boll) diet for 14 d
-Host-free survival was assessed weekly at 12.8, 18.3, 23.9, and 29.4°C (55, 65, 75, and 85°F)
-Survival was highest at 18.3°C and lowest at 29.4°C
-Survival at 12.8 and 23.9°C were roughly similar
-Maximum length of survival was about 380 days
-Results suggest some level of chronic low temperature injury was associated with the lowest temperature (12.8°C); these results can be used to explain recent survival observations reported from field studies

Overwintering Ecology – Supercooling (C. Suh, D. Spurgeon, ARS)
-Recent studies of acute low-temperature boll weevil mortality have provided temperature regimes to discriminate between diapausing and reproductive weevils, but other potentially important factors were not controlled in these studies
-The supercooling ability of fed versus unfed, and diapausing versus reproductive weevils were examined in cold-bath studies
-The ability to supercool was influenced by gut content; weevils recently fed froze at around -10°C (14°F) while previously starved weevils froze at about -16°C (3°F)
-No difference in supercooling ability was observed between reproductive and diapausing weevils
-No difference in supercooling ability was observed between weevil sexes or among ages ranging from 55 to 125 days
-Results indicate that acute freezing is seldom a major mortality factor in the southern regions of the U.S. cottonbelt

Major Conclusions from Survival and Emergence Studies
-Available historical meteorological data should be sufficient to calculate a “do not spray before” date based on temperature dependent survival data
-Interpretation of survival and emergence data should consider that many late-season weevils enter the fallow season ill-prepared to overwinter
-Patterns of mortality, emergence, and early-season survival should be considered together in the context of region-specific short-season crop management

Dr. Sappington continued the report with research summaries from the Weslaco location.

Conservation Tillage and Weevil Survival (S. Greenberg, T. Sappington, J. Smart, J. Bradford, ARS; J. Norman, Texas A&M University)
-Natural mortality of boll weevil immatures in fruit on the soil surface is an important factor limiting population growth but effects of conservation tillage on this factor have not been studied
-Temporal patterns of natural mortality were compared in conventional and no-till dry-land cotton
-Plant canopies in conventional tillage fields closed earlier and thus reduced natural mortality compared with no-till fields
-Populations of adult weevils estimated by beat bucket were 1.3 – 5 times greater in conventional tillage fields compared with no-till fields
-Under the environmental conditions studied, no-till practices enhanced natural mortality and reduced weevil population recruitment

Insecticide – Defoliant Mixes (S. Greenberg, T. Sappington, G. Elzen, ARS; J. Norman, A. Sparks, Texas A&M University)
-Cotton that is spindle-picked is typically prepared for harvest with defoliants and other harvest aid chemicals

-Combinations of harvest aid chemicals and insecticides were evaluated for efficacy and to determine if one or more diapause sprays could be replaced by treatment in combination with defoliation
-Efficacy and potentiation of chemical mixtures were evaluated in topical and leaf assays at 72 h after treatment
-Half-rates of Guthion provided 100% mortality of boll weevils when mixed with a full or half-rate of Def or half-rates of Def plus Dropp
-Efficacy of treatments of one-half rate of Karate plus the full rate of Def was greater than for a full rate of Karate alone, but less than for a half-rate of Guthion plus defoliant
-The mortality of weevils collected from the field at 24 and 48 h after application was also assessed
-Efficacy of mixtures of one-half rate of either Guthion or Karate combined with the full rate of Def or half-rates of Def plus Dropp was equal to that of the full rate of Guthion alone, but was greater than for the full rate of Karate alone
-During the first year of the experiment the full rate of Def plus a half-rate of insecticide did not provide adequate defoliation
-Defoliation obtained with half-rates of Def plus Dropp equaled that obtained with two full rate applications of Def (97%)
-Results indicate the mixture of one-half rate of Guthion plus half-rates of Def plus Dropp can replace a standard diapause treatment with ULV Malathion

Late-Season Trap Cropping (T. Sappington, ARS)
-The feasibility of reducing late-season boll weevil populations using a late-fruiting trap crop flanking the field was assessed by mark-recapture methods
-Trap rows arrested =20% of weevils dispersing from the host field
-Trap rows also accumulated weevils dispersing from surrounding fields
-The duration of arrest was not determined
-Although weevil concentration in the trap crop was demonstrated, practical and economical methods of controlling those weevils have not been developed

Chemical Termination of Cotton Stalks (J. Norman, Texas A&M University; S. Greenberg, ARS)
-Inclement weather conditions and high fuel costs often deter producers from plowing cotton stalks promptly after harvest
-Various chemical termination treatments were evaluated as substitutes for conventional termination methods; evaluations were by direct observation and remote sensing
-Two applications of 2,4-D (Savage, 1.0-lb formulation) at 0 and 27 days after shredding provided 100% control of cotton re-growth
-After the 2nd application 100% root kill was observed in all 2,4-D treatments
-One pt. of Dicamba (Clarity) at 7 or 14 days after shredding followed by 2,4-D at 27 days after shredding provided 100% control of re-growth
-Dicamba applied 0 and 3 days after shredding did not prevent re-growth; live stalks and fruit were observed even after a follow-up treatment with 2,4-D
-Valor plus RoundUp, and Harmony Extra, did not control re-growth
-Harmony Extra allowed re-growth cotton to fruit regardless of application timing

Recommended Protocols
-One-lb formulation of 2,4-D per acre at 0, 3, 7, or 14 days after shredding followed by a second application plus any additional herbicides needed for weed control at about 1 month after shredding
-One pt of Dicamba per acre at 7 to 14 days after shredding followed by 1-lb of 2,4-D per acre at about 1 month after shredding

Post-Harvest Tillage and Survival (S. Greenberg, A. Showler, T. Sappington, A. Brashears, ARS; S. Carroll, M. Arnold, M. Parajulee, A. Knutson, Texas A&M University)
-In light of the increasing use of reduced tillage systems, knowledge of the fate of late-season boll weevils infesting fruit at the time of shredding in reduced tillage versus conventional tillage systems may be useful to eradication programs
-Studies were conducted to compare the fates of weevils infesting fruit that were left on the soil surface after harvest compared with those in fruit buried during tillage
-Mortality of weevils in infested fruit was high on the soil surface in warm sunny weather

-Burial of infested fruit under these weather conditions allowed adult survival = 10 d
-Buried weevils survived for longer periods and emerged sooner when soil conditions were dry
-Emergence of buried weevils was enhanced in loose, coarse, cloddy soils
-Few weevils emerged from field-buried bolls by mid-March
-Burial of infested fruit insulates developing weevils from high soil surface temperatures, but survival and emergence is reduced by wet, compacted, or crusted soil

Malathion Resistance Monitoring (Priority 6)
Ms. Terry Junek (Texas A&M University) presented a summary of research on Malathion resistance monitoring.

Susceptibility Status of Texas Boll Weevils (P. Pietrantonio, T. Junek, Texas A&M University)
-Responses of weevil collections reared from squares or obtained from traps at various locations were assessed by computing LC_{50} resistance ratios at 48 h versus the ARS susceptible boll weevil strain
-Among weevils collected in Burleson Co. in 1999, 2 – 3 d old weevils reared from squares exhibited a resistance ratio of about 8.3, while trapped weevils exhibited a resistance ratio of about 2.5
-Resistance ratios of weevils collected from Burleson Co. in 2001 ranged from about 0.6 (2 – 3 d old, reared from squares) to 0.9 (trap captured)
-Resistance ratios of weevils collected from Lubbock Co. in 2001 ranged from about 1.4 (2 – 3 d old, reared from squares) to 0.9 (> 3 d old)
-Resistance ratios of 2 – 3 d old weevils reared from squares collected in Wharton Co. in 2002 ranged from about 2 to 4
-The lower susceptibility previously observed (1999) in Burleson Co. weevils was not apparent in 2001 collections, suggesting changes in susceptibility among years and collections
-Results from Wharton Co. are of concern because these were the only collections yielding one or more weevils that survived the 60 µg/vial dose, and these collections exhibited the highest resistance ratios detected in 2002

Formulations and Application Parameters for Malathion (Priority 9)
Results of studies of Malathion formulations and application methods were presented by Dr. W. Clint Hoffmann (ARS, College Station).

Early-Season Boll Weevil Colonization (B. Reardon, D. Spurgeon, ARS)
-Producers and eradication programs have recently indicated interest in conserving beneficial arthropods and reducing insecticide costs by applying early-season boll weevil treatments only to field borders, but supporting information on boll weevil colonization patterns are not available
-Colonization patterns of overwintered boll weevils were studied by mapping collections of adults and fallen squares in the outer 70 rows of Brazos Valley cotton fields
-Samples were collected from the four-leaf stage until bloom
-Collections of adults or fallen squares did not indicate a consistent colonization pattern relative to the field edges
-Although the probability of collecting an adult weevil or infested square slightly decreased with increased distance into the field, patterns exhibited on individual sample dates were highly variable and substantial numbers of weevils were documented in the field interior
-Lack of an edge-oriented colonization pattern and presence of weevils in the field interior indicate border sprays are not appropriate for eradication efforts

Effects of Dew on ULV Malathion Efficacy (I. Kirk, ARS)
-Compliance with state regulations regarding wind speeds during pesticide application often necessitate field treatments in the presence of dew, but the influence of dew on efficacy of ULV Malathion is not well understood
-ULV Malathion was applied to fields in the presence of dew and chemical persistence was monitored for 14 days by residue analysis and bioassay against boll weevils
-Observed efficacy and leaf residues were not different between canopies that were wet with dew and those that were dry at the time of application
-Results indicate it is not necessary to delay the application of ULV Malathion until dew dries

Aerial Application of ULV Malathion Plus Cottonseed Oil (A. Showler, T. Sappington, ARS; R. Foster, T. Roland, O. El-Lissy, APHIS)
-Recent shortages of Malathion have renewed interest in reduced-rate applications but efficacy of those treatments must be maintained
-Efficacy of reduced rates of ULV Malathion in cottonseed oil (10 oz Malathion plus 8 oz cottonseed oil per acre; 12 oz Malathion plus 6 oz cottonseed oil per acre) were compared to a standard rate of Malathion (14.9 oz per acre)
-No differences were observed in field efficacy at 5 days after treatment
-No differences were observed among the treatments in laboratory bioassays
-Responses of non-target arthropods were similar among the treatments
-Results suggest the reduced Malathion rates studied were as effective as the standard rate

Reduced Rates of ULV Malation (W. Hoffmann, ARS)
-Additional studies compared the efficacy of 12 oz ULV Malathion to that of 6 oz ULV Malathion plus 6 oz cottonseed oil
-The 12-oz rate of Malathion provided significantly higher efficacy at 0 and 2 days after treatment compared with the reduced rate plus cottonseed oil; efficacy of both treatments were low at 5 days after treatment
-Efficacy of both treatments was much lower when evaluated by whole-plant cages than when evaluated by leaf bioassays
-Results indicate 6 oz of Malathion plus 6 oz of cottonseed oil was not as effective as 12 oz of ULV Malathion

New Pesticide Chemistries, Biologically-Based Technologies (Priorities 11, 12, and 14)
Results of studies of alternate or biologically-based control technologies as replacements for ULV Malathion or use in sensitive areas were presented by Dr. J. Lopez (ARS, College Station).

Kaolin Particle Film (A. Showler, ARS)
-Boll weevil responses to kaolin treatments were evaluated in field and laboratory studies
-Weevils were deterred from treated squares in the laboratory; observations suggested the deterrent effects of kaolin were based on color
-Kaolin treatments also reduced beet armyworm oviposition and larval survival in the laboratory
-Square damage by boll weevils in field plots was reduced by kaolin applications
-Field applications of kaolin also reduced the numbers of leafhoppers, but increased aphid numbers
-Kaolin shows potential as an alternate control for the boll weevil but adoption of this tactic will require improvements in cost-effectiveness and foliar persistence of the treatments

Neem (A. Showler, S. Greenberg, J. Aranson, G. Gordh, ARS)
-Four neem-based formulations (including three commercial products) were evaluated as possible alternate toxicants for boll weevil control
-Neem treatments caused limited deterrence of boll weevil feeding and oviposition in the laboratory
-Aging of treatments by exposure to direct sunlight reduced weevil responses
-Lack of strong efficacy of neem treatments suggests their potential for development as an alternate control tactic is limited

Guayule (A. Showler, F. Nakayama, J. Aranson, ARS)
-Guayule extract containing triterpine argentatins that inhibit acetylcholine esterase was evaluated for efficacy against boll weevil adults
-Assays are currently in progress to evaluate deterrent or toxic effects against the boll weevil and other cotton insects

Photoactive Bait (D. Spurgeon, J. Raulston, ARS)
-Insecticidal properties of photoactive dyes are well documented but these materials have not been evaluated for efficacy against adult boll weevils
-A simple, repeatable laboratory assay for the photoactive dyes was developed
-Dose/mortality responses to selected dyes were determined and Phloxine B and Rose Bengal demonstrated high levels of efficacy in the laboratory
-High levels of efficacy by Phloxine B were not demonstrated in a field test

-Lack of efficacy in the field and difficulties with application of the bait formulation suggest a low potential for further development of the photoactive bait as a practical boll weevil control tactic

Feeding-Based Adult Boll Weevil Control (J. Lopez, ARS)
-An attractant- and feeding-based control tactic for adult boll weevils was evaluated in the laboratory and field
-Insecticide concentrations for field studies were determined through feeding assays in the laboratory
-Three formulations of feeding stimulant were evaluated in combination with the standard pheromone attractant in field studies
-Results demonstrated the ability of feeding-based toxicants to kill weevils on pheromone-baited shrubs
-Continued evaluation of strip applications of feeding-based toxicants in combination with pheromone is warranted

Improvements in Efficacy and Drift Reduction of Aerial Applications (Priority 17)
Results of research addressing efficacy and drift of aerial applications were presented by Dr. I. Kirk (ARS, College Station)

Spray Deposition and Drift in Crop Canopies (W. Hoffmann, I. Kirk, ARS)
-Field studies evaluated the effects of crop canopies on downwind movement and deposition of sprays through paired comparisons of applications made over plant canopies and over pasture
-Crop canopies tended to increase spray deposition at the canopy top (probably because of increased air turbulence over the canopy) compared with deposition over pasture
-At distances from 25 to 300 m from the flightline, deposition on the soil surface under plant canopies was similar to that observed in the pasture setting
-Leaf area index and wind speed did not consistently influence deposition or movement of spray droplets as indicated by horizontal mylar cards, but the range of wind speeds evaluated was limited

Aerial Electrostatic Technology and Spray Drift (I. Kirk, W. Hoffmann, ARS)
-Previous work has indicated that electrostatic systems can be configured for enhanced spray deposition or reduced spray drift
-For deposition enhancement, recommended spray rate is 1 gpa with fine to very fine spray droplet spectra
-For drift reduction, recommended spray rate is conventional 3 – 5 gpa with medium to coarse spray droplet spectra
-Spray drift is not reduced when the system is configured for enhanced spray deposition

Electrostatic Aerial Application of Malathion (I. Kirk, W. Hoffmann, ARS)
-Efforts to adopt electrostatic application methods for ULV Malathion have not been successful because of the inability to charge Malathion
-Efficacy of an electrostatic application of an EC Malathion formulation was compared with ULV Malathion in aerially-applied treatments
-Efficacy measurements were based on mortality of GAST weevils in leaf bioassays
-Efficacy of the two treatments were similar on day 0 after application, but efficacy of the ULV treatment was higher compared with the electrostatic application at day 3 after application
-Results indicated residues of the ULV Malathion application were more persistent than those of the electrostatic application

Malathion Deposition on Various Plant Structures (W. Hoffmann, ARS)
-Deposition of Malathion on plant leaves, petioles and stalks by conventional or electrostatic applications were compared using GC residue analysis and oil-sensitive cards
-Conventional applications deposited more material on the upper and outer regions of the plants than did electrostatic methods
-Electrostatic methods deposited significantly more material to the interior portions of the plant canopy than did conventional application methods

Models for Droplet Spectra Classification (I. Kirk, ARS)
-EPA proposes that pesticide product labels contain specifications for application within certain droplet size ranges or Droplet Spectra Classification (DSC)
-DSC varies with aircraft operation parameters including angle of the nozzle in the airstream and air speed

-Atomization models were constructed for 18 commonly used nozzles (9 for fixed-wing and 9 for helicopters) and are available at:
http://apmru.usda.gov/downloads/downloads.htm
-USDA will publish a handbook for applicators without internet access

Molecular Fingerprinting of Boll Weevil Populations (Priority 18)
A summary of research efforts to develop methods of identifying boll weevil populations by molecular fingerprinting was presented by Dr. Sappington. This work was conducted in an effort to develop a DNA profile to aid in identifying sources of reinfestation of eradicated areas, and to obtain estimates of gene flow as an indication of migration events.

Population Differentiation (K. Kim, T. Sappington, ARS)
-Mitochondrial DNA (mtDNA) haplotypes were determined for weevil populations from Texas, New Mexico, Oklahoma, Louisiana, Arkansas, Missouri, Mississippi, Tennessee, and Mexico
-Significant differences in haplotype frequencies were observed among populations
-Marked differences in haplotype frequencies were observed between weevil populations in the Southeast (LA, AR, MO, MS, TN) and those in the Southwest (NM, OK, TX)
-Several weevil populations were found to exhibit distinctive haplotypes

Gene Flow (K. Kim, T. Sappington, ARS)
-Haplotype frequencies of respective weevil populations revealed a positive correlation between genetic and geographical distances among populations
-Genetic diversity was greatest in collections from Mexico, and generally decreased with increasing latitude
-Levels of divergence at regional scales so far examined suggest little net movement between sampled populations; a possible exception is that weevil populations in the Lower Rio Grande Valley may be receiving immigrants from the Tampico area of Mexico

Conclusions
-Certain haplotypes appear diagnostic of certain collection locations
-Results suggest long-range (> 100 miles) movement is a relatively rare event
-Genetic variation in weevil populations north of South Texas is relatively low
-Genetic structuring between populations on a finer geographical scale is likely and awaits further analyses

Discussion of Research Findings, Identification of New/Continuing Research Priorities
The group discussion of research reports and their application, and identification of new or continuing research priorities was moderated by Dr. Coppedge. This session began with responses by ARS scientists to questions from meeting participants.
Q: Is there any evidence of two seasons of overwintering (L. Brashear, APHIS)
A: Overwintered weevils allowed to accumulate dormant fat bodies lived a maximum of only 7 weeks. The longest survival on record is about 380 days (D. Spurgeon)
Q: What temperature and photoperiod conditions permitted the weevil to live 380 days (S. Carroll, Texas A&M University)
A: Photoperiod makes no difference; the temperature was held constant at 55°F (D. Spurgeon)
Q: You effectively indicated that temperature does not affect the metabolic rate of weevils in diapause; please elaborate. I would assume that overwintering weevils at higher temperatures would use fat body faster than at lower temperatures (J. Leser, Texas A&M University)
A: The statement was that temperature effects on reproductive development are much greater than on development of fat body; survival is temperature dependent and increases with decreasing temperatures to a point, beyond which survival begins to be limited by chronic deleterious effects of low temperature (D. Spurgeon).
Q: I gleaned from what you have said that diet essentially over-rules the effects of temperature on diapause (D. Hardee, ARS)
A: That has been our experience and we have a large quantity of data that shows this. You should also consider that earlier studies did not demonstrate that their results were repeatable, and results varied considerably among and within studies. The diapause response is quite variable, especially on the diets traditionally used and failure to repeat experiments has often led to misinterpretation of the results (D. Spurgeon).

Q: What you are saying is that if you have 55°F days and 8 hours of light and you have squares in the field those weevils will not go into diapause; this is totally opposed to everything else in the literature (D. Hardee).

A: If you consider the body of research we have conducted and compare that with the published literature you can begin to see how earlier investigators obtained their results. However, there is one small study reported in the literature in which the diapause response was examined for squares from young versus mature plants. Descriptions of plant maturity were not provided, but the conclusions were that plant maturity did not play a role in diapause induction. We have preliminary data to indicate that squares from plants with a heavy boll set will not produce the degree of reproductive commitment that can be obtained using squares from plants earlier in the fruiting cycle. In an earlier report the investigators changed the ratio of squares to weevils without changing the photoperiod and got a marked change in diapause response. In that paper they also reported caging weevils on cotton plants in the greenhouse without supplemental light and they observed no diapause. The boll weevil is not like many of the insects we work with in that you cannot feed them just anything and assume that is good enough (D. Spurgeon).

Q: I do not understand why all of these other diapause studies were not correct when there are so many of them; what is the one thing they were doing wrong? (D. Hardee).

A: If you look at the other studies and compare them to each other the results are not consistent, so at least part of the published literature is incorrect. There is so much contradiction in the published literature, even within a single paper, that the findings as a body contribute little to our knowledge of diapause (D. Spurgeon).

Q: The boll weevil evolved with the cotton plant and those plants are photoperiodic; are you saying the boll weevil is not photoperiodic but its host is? (J. Quisenberry, ARS)

A: The aboriginal host of the boll weevil is thought to be *Hampea*, and its fruiting pattern is driven by monsoon rains. Regardless, we cannot get a response from photoperiod. You should also consider that a wide diversity of criteria have been used to designate diapause and some of the criteria are questionable. Our studies have used very stringent criteria that leave little latitude in interpretation of the results (D. Spurgeon).

Q: All of your diapause studies were conducted under laboratory conditions; do you have information indicating what areas of the U.S. have weevils in diapause, dormancy, or in an active condition? (S. Greenberg)

A: Some of our research was conducted outside under natural photoperiods. I have seen no evidence to indicate that weevils at Tampico, Mexico are different from weevils at Lubbock, and we have examined weevils from both locations. Diapause does not imply that the weevils will be inactive, but that the animal will not resume development until the diapause period is satisfied. The evidence we have collected suggests the dormancy is most likely a quiescence (D. Spurgeon)

Q: When you refer to differences what do you mean? (O. El-Lissy, APHIS)

A: For instance, we have compared host-free longevity of weevils from the Lower Rio Grande Valley and Lubbock and induced dormancy using our diets. We see no differences between those populations in their responses, and the weevils in Central Texas has also responded similarly (D. Spurgeon).

A: We have compared longevity of weevils from the Lower Rio Grande Valley with that of weevils from the Northern Rolling Plains. Numerically there were some differences but had we conducted more replications I doubt there would have been a statistical difference (S. Carroll, Texas A&M University).

Q: In one of your conclusions you showed that we might be making a mistake in stretching these diapause treatment intervals; would you comment on that? (J. Brumley, Southeastern Foundation).

A: It is difficult to determine how long it takes a weevil to accumulate fat body because at the higher temperatures reproductive development occurs very quickly and at dissection these weevils are not rated as diapausing despite the enlarged fat bodies because the overall characters do not fit the diapause syndrome. If we consider the dormancy as a quiescence these fat weevils with some reproductive development now have biological meaning. Our point was that even at 65°F by 6 to 9 days the weevils can accumulate enough fat body to live for a long time. If they feed to that point in August they may not survive to the following spring, but if they feed to that point in November they do not need to survive as long. On re-growth cotton we cannot count on the low temperatures to slow fat body accumulation enough to prohibit survival to the following crop (D. Spurgeon).

Q: If there are squares in the re-growth it should make no difference because the weevils will commit to reproduction, right? (D. Hardee).

A: If there are enough squares and they are in good enough condition; many of these squares have been fed on or are not in good condition. We have monitored re-growth here and have seen it develop to the point of having squares and small bolls. Whether those squares are normal and would induce reproduction is not known, but I doubt it (D. Spurgeon).

A: Scientists at ARS, Texas A&M University, and Texas Tech University should be commended for their research on ginning and thanks to Dr. Sappington for sharing his data with the eradication program in Arkansas and the

Arkansas State Plant Board; this research has saved growers in Arkansas thousands of dollars (T. Teague, Arkansas State University).

Q: What type of weevils were used in the ginning evaluations? (J. Lopez, ARS).

A: For the ginning experiments the laboratory-reared weevil from the APHIS facility in Mission, TX was used because these experiments were not sensitive to weevil behavior; for the module experiments trap-collected weevils were used (T. Sappington).

Q: How far are we from having a "squash" test to determine if the weevils have enough fat body to support overwinter survival? (J. Coppedge).

A: We have tested polyclonal antibodies and now have a commercial company raising monoclonal antibodies. Given that we have these antibodies we have models based on other insects that show us how to develop the squash tests. If someone wanted to take over that research we have the antibodies necessary for development of a kit (T. Sappington).

Q: You indicated that flight by male weevils breaks the diapause? (C. Allen, Texas Boll Weevil Eradication Foundation)

A: It predisposes them to terminate the dormancy; they will still not terminate the dormancy without access to a reproductive diet (D. Spurgeon).

Q: If weevils in diapause in the fall take a long dispersal flight does this mean that they will not be able to survive the winter? (C. Allen).

A: Flight does not bear on survival, it pertains to their competence to terminate the dormancy once a reproductive host is located. If no host is located termination does not occur. Also, our dissections have indicated that even after 6 hours of flight the fat bodies are not visually depleted, so flight should not decrease the ability of the weevils to survive the winter (D. Spurgeon).

Q: How many weevils out of a thousand can fly for that long (6 hours)? (J. Norman).

A: The question is not how many can make the flight but how many will. Many of the weevils will not be inclined to fly for this long but in our Mexico studies we have caught weevils 100 miles downwind from the nearest cotton (D. Spurgeon).

Q: Data was presented a few years ago that indicated when the wind speed was greater than 12 mph weevils did not fly (D. Kiser, Arkansas Boll Weevil Eradication Foundation).

A: That data did not indicate that the weevils did not fly, but rather that they were not captured by the traps in those high wind speeds. Winds of that nature exceed the ability of the weevil to respond upwind to the pheromone, but do not necessarily impede their ability or willingness to fly (D. Spurgeon).

A: We need to consider that during migration weevils are not flying close to the ground (B. Massey, Oklahoma Boll Weevil Eradication Program)

Q: From your pheromone work are you saying the original estimate that 10 mg of pheromone was equivalent to a male boll weevil is incorrect and that one boll weevil would be equivalent to more pheromone than that? (J. Coppedge).

A: I have never understood how 10 mg of pheromone was calculated to be equivalent to a male weevil that produced 1 µg of pheromone in a day, but on average our experiments indicated daily pheromone production of 80 – 100 µg compared with earlier reports of 1 µg per day. This probably means the pheromone lure is actually closer to the "three-weevil equivalent" indicated by the earlier data (D. Spurgeon).

Q: When you look at all the pheromone components do you see ratios different from those in the pheromone lure? (J. Coppedge)

A: We do see differences in the pheromone produced by males compared with the lures and have conducted some limited evaluations. However, the component that needs to be increased to better mimic the pheromone produced by the weevil is component I, which is expensive. Considering the expense it is doubtful that trap captures would be increased enough to justify the cost of increasing the amount of component I (D. Spurgeon).

A: In laboratory bioassays we never observed evidence that performance of the current lure could be improved by addition of component I (D. Hardee).

Q: Your data suggested that weevil detection by traps may be improved by not placing traps on field borders; are you indicating that we need to set the traps away from the field? (D. Hardee).

A: Especially in maintenance programs where detection of small numbers of weevils is important, to place traps directly on the field border is to invite problems. Based on our observations, something less than half of the weevils responding to the pheromone actually land on the trap, and the remainder of these weevils will likely find the cotton. From a practical standpoint we are not recommending that traps be set at distances > 100 m from the cotton field, but we can at least get the traps off the outside row of plants (D. Spurgeon).

Q: We keep seeing more and more data that suggests we are wasting our money with the kill strips; please comment on this (J. Brumley).
A: The problem with the kill strips is that they kill very slowly. Our observations indicate that weevils are most likely to escape the trap within an hour or so of their initial capture. Thus, the kill strip will not reduce escape and its use is not warranted on that basis. Others have indicated the kill strip offers additional benefits such as simplified trap maintenance, however, if traps are maintained on a weekly basis the operator will normally find both live and dead weevils in the trap regardless of whether a kill strip is used. In a maintenance program, trap captures will be too low to justify use of the kill strips for simplification of trap operation (D. Spurgeon)
A: In research that was not recent, we observed boll weevil mortality induced by the kill strips in 20 minutes (D. Hardee).
A: In our research we observed only 3% mortality after 1 hour of exposure (C. Suh, ARS).
A: In our studies under field conditions mortality did not level off until the weevils had been exposed for 48 hours (D. Spurgeon).
Q: What about the effects of the kill strip on predation? (D. Kiser)
A: Based on our experience the kill strips do not act fast enough to reduce predation or plugging of the trap entrance by spider webs (D. Spurgeon, D. Hardee).
Q: In the Southeast program we have observed that cotton fields early in the morning are often dripping wet with dew. It has been our opinion that to treat those fields while they are wet is not warranted. Could whoever presented the data to the contrary comment on this situation? (L. Brashear, APHIS).
A: The data we collected in the Brazos Valley from fields sprayed when they were wet with dew indicated any efficacy lost to these conditions was not measurable (I. Kirk, ARS).
Q: It was indicated that as many as 2300 weevils per acre have been found to continue to infest defoliated fields, please comment on what happens to those weevils if the field is not sprayed (L. Brashear).
A: Most of those weevils are probably relatively newly-emerged and will eventually disperse. If they can locate food they may overwinter (T. Sappington).
Q: It was stated that if an older boll weevil is wetted it is difficult to distinguish it from a newly-emerged weevil; is this correct? (J. Brumley).
A: Wetting the weevil makes the weevil much redder than if it were dry and there is considerable variation in weevil color at different ages. For this reason we use the presence of juvenile fat to indicate weevil age because we know it disappears within 24 to 48 hours after the adult ecloses. Cuticle hardness is probably a better indicator of weevil age than is color (D. Spurgeon).
Q: You indicated that acute freezing is seldom a major mortality factor for the boll weevil; please explain what you meant by that (D. Hardee).
A: Temperatures sufficiently low to freeze a weevil outright (3°F) are much lower than we typically experience during the winter at this location and locations further south (D. Spurgeon).
Q: Please explain why we often see reduced boll weevil populations after a hard winter (D. Hardee).
A: We also get mortality from the chronic effects of low temperatures (D. Spurgeon).
Q: One of the conclusions stated was that available data should be sufficient to calculate a "do not spray before" date; please elaborate (O. El-Lissy).
A: Our survival data should allow us to use historical weather data to calculate, from different starting dates, the probability of weevil survival to a given point in the spring. If the cotton crop of a given year matures sufficiently early treatment of those weevils with diapause sprays before a certain date may not be warranted because the probability of their survival to the next spring is negligible. Instead, sprays could be concentrated on populations present on later dates when the weevils have a higher probability of overwinter survival. These data also have application to uniform delayed planting. We advocate the use of uniform delayed planting, but only when the crop is managed for earliness so the host-free period is maximized. If we understand the seasonal pattern of heat unit accumulations and their effects on weevil survival we can designate planting dates that will maximize the effects of the fallow period on boll weevil populations (D. Spurgeon).
Q: The suggested protocol for chemical termination of cotton stalks calls for two treatments. Can you give us some idea of the level of control that we could expect from a single treatment? (B. Grefenstette).
A: A single treatment applied at 0 to 24 h after shredding will probably provide 90% control, but 10% of those plants may survive to produce fruit and that is not acceptable (J. Norman).
Q: We also have to be concerned with volunteer seedlings and those will need to be controlled later; is there anything we can do to reduce the cost and increase safety of these chemical treatments? (R. Parker, Texas A&M University).

A: One thing that can be done is to band applications over the row of shredded stalks; that cuts cost by reducing the treated area and also helps to reduce drift (J. Norman).
Q: When you indicate the potential for 10% re-growth, is that squaring re-growth? (D. Kiser).
A: Those plants would eventually square, yes. We will need to test this technology in other areas with different fall temperatures (J. Norman).
Q: Have the effects squares grown during cold conditions have on the diapause response been examined? (C. Allen).
A: No, because of our pursuit of other objectives and the need for an exemption from crop destruction to undertake that research under fall conditions. Under the best of conditions you will likely get a percentage of weevils on re-growth that will develop the dormant fat bodies, and late in the year their chances of survival are considerably enhanced compared with weevils entering overwintering early. To assume that weevils will not enter the dormancy on squaring re-growth is extremely risky (D. Spurgeon).
Q: With the 2,4-D treatments would it be better to let the stalk "green-up" before treatment? (J. Coppedge).
A: When the 2,4-D was applied at 7 and 14 days after shredding control was much less effective than when applications were made immediately after shredding (J. Norman).

The discussion of research priorities was moderated by Dr. Coppedge. Previously existing objectives were reviewed to determine if additional research was needed. Dr. C. Allen and Dr. Hardee suggested the group should concentrate on more short-term research objectives that can be adequately addressed in the limited time available to continue research. Dr. Coppedge requested participants indicate their top 10 research priorities, in order of importance, on the provided list so those priorities could be tallied and discussed in the ARS Scientist meeting on the following morning.

Review of Research Priorities

The review of research priorities was presented by Dr. Coppedge. Priorities are listed in order of importance in Appendix B. Tentative research responsibilities were suggested as indicated below:

a) Scientists in Weslaco were encouraged to continue work on chemical termination of cotton (Priority 1), and other scientists were asked to conduct additional research at more northerly locations,

b) Dr. Sappington was requested to complete ongoing research addressing molecular fingerprinting of weevil populations (Priority 2) and cotton ginning (Priority 7),

c) Drs. Spurgeon, Suh (ARS), and Leser (Texas A&M University) agreed to conduct evaluations of the long-life pheromone lure ("super lure") (Priority 3), and were asked to combine this research with studies of pheromone dosage (Priority 9),

d) Dr. Pietrantonio (Texas A&M University) was encouraged to continue efforts to monitor for Malathion resistance (Priority 4),

e) Drs. Kirk, Hoffmann, and Fritz of the Areawide Pest Management Research Unit were asked to continue research on application parameters for ULV Malathion (Priority 5),

f) Drs. Westbrook and Spurgeon were requested to continue research on effects of wind speed and other weather factors on trap captures (Priority 6), and Dr. Spurgeon was asked to continue studies of boll weevil diapause (Priority 8),

g) Dr. Westbrook and the remote-sensing group at the Weslaco location were deemed the most appropriate to develop or demonstrate technology for the location of unmapped cotton (Priority 10), and

h) Dr. Greenberg and collaborators were requested to continue research on boll weevil cultural controls in conventional and no-till production systems (Priority 11).

Discussion of Post-Eradication Research Needs

Dr. Faust moderated a discussion of potential post-eradication research needs, and began by presenting a listing of potential pest problems he had prepared.

a) cotton aphids,
b) cotton fleahopper,
c) *Lygus* bug complex,
d) stink bug complex,
e) *Heliothis/Helicoverpa* complex,
f) beet armyworm, and
g) silverleaf whitefly.

Dr. Hardee was asked to relate his experiences regarding changes in research focus in Mississippi in response to boll weevil eradication. In particular, emphasis on *Lygus* and stinkbugs has increased. Dr. Hardee indicated that additional independent or collaborative research on these problems by the Texas locations would be welcomed.
Dr. Spurgeon reported the following:
-Dr. Suh has already initiated research to develop a monitoring system for the cotton fleahopper, and based on experience with the local production system problems with cotton aphids and stink bugs are anticipated.
-Although *Lygus* bugs in cotton have not been a problem locally, numerous wild hosts are present and the potential for development of problems with *Lygus* exist.
-The *Heliothis/Helicoverpa* complex and beet armyworms are problems locally but those pests are currently addressed in the Areawide Pest Management CRIS.

Dr. Spurgeon closed the meeting by thanking participants for their contributions and soliciting the input of presenters in the preparation and review of a meeting report.

Appendix A - Boll Weevil Research Priorities*

(ranked by participants at the 2000 Boll Weevil Research Progress Review, College Station, TX, 13 October 2000)

Rank	Research Area	Top-Ten Votes	Total Score
1	Cotton harvesting, storing & ginning. Impacts on movement & survival of boll weevils.	22	157
2	Studies of boll weevil diapause & corresponding models to help more precisely time sprays.	22	152
3	Improve monitoring and detection efficiency.	15	111
4	Chemical and mechanical terminations of late season cotton.	16	109
5	Study boll weevil movement & activity relative to meteorological events.	16	101
6	Monitoring for Malathion resistance.	12	84
7	Determine impact of pheromone dosage, trap density, & other parameters on capture of boll weevil in traps.	15	77
8	Improve accuracy & impact of mid-season triggers on boll weevils & beneficial insects.	15	76
9	Field studies on effects of formulations, additives, dosage, & application parameters on efficacy of Malathion.	12	75
10	Non-aerial treatment methods for irrigated cotton in rural or sensitive setting.	14	72
11	Identify & evaluate new insecticides for use in the boll weevil eradication program. Emphasis should be on those which can be applied ULV.	14	67
12	Develop & evaluate biological & biologically based technology for use in environmentally sensitive areas & other areas where the use of Malathion is restricted.	14	65
13	Evaluate cultural control methods of reducing boll weevil populations (i.e., shorter season cotton, limited fertilizer, irrigation) & determine how these practices will impact the boll weevil eradication programs.	12	49
14	Develop & evaluate new & softer methods of controlling boll weevils.	8	43
15	Compare traps near fields & those along roads for effectiveness in post eradication monitoring.	10	42
16	Develop use of GIS to find cotton not identified in program.	8	40
17	Design & evaluate new aerial application systems that improve efficacy & reduce drift.	7	38
18	Develop molecular methods of fingerprinting boll weevils with initial emphasis on separating boll weevils & thurberia weevils.	9	34
19	Investigate interaction of Bt cotton on boll weevil population dynamics.	5	28
20	Investigate cotton trap crops or “factitious” trap crops as an approach to reducing boll weevil populations over large areas.	10	26
21	Research the use of remote sensing & mapping for use in the eradication program.	5	21
22	Design & evaluate combined pink bollworm/boll weevil eradication program.	5	17
23	Determine effects of Bt cotton on boll weevil eradication.	3	17
24	Determine impact of strip spraying on boll weevil populations.	6	17
25	Conduct studies on the economics of boll weevil eradication in the mid-south & southwest.	4	14
26	Investigate the physiological interaction of Malathion & tobacco budworms, beet armyworms, & other secondary pests.	4	13
27	Develop models to establish treatment triggers during “45 day no treatment window” period of eradication.	1	3
28	Investigate mating disruption as an approach to boll weevil management.	1	1
29	Determine efficacy of *Catolaccus grandis* as a component of eradication program.	0	0

*Shaded areas represent research priorities with no significant progress to report.

Appendix B - Boll Weevil Research Priorities

(ranked by participants at the 2002 Boll Weevil Research Progress Review, College Station, TX, 16 October 2002)

Rank	Research Area
1	Chemical and mechanical termination of late-season cotton.
2	Molecular fingerprinting of boll weevils.
3	Improve monitoring and detection efficiency.
4	Monitoring for Malathion resistance.
5	Formulations, application parameters, and rain-fastness of Malathion.
6	Boll weevil movement and activity relative to meteorological events.
7	Cotton harvesting, storage, and ginning.
8	Factors controlling diapause.
9	Impact of pheromone dosage and other operational parameters on trap captures.
10	Remote sensing technology to locate unmapped cotton.
11	Cultural controls.