Stored Peanut Pest Management Strategic Plan

Prepared September 3, 2003

Dr. Dudley T. Smith, Professor dt-smith@tamu.edu
Texas Agricultural Experiment Station, Department of Soil and Crop Sciences
Texas A&M University, College Station

Dr. Rodney Holloway, Extension Specialist
Texas Cooperative Extension
Texas A&M University, College Station

Contents

Executive Summary

Six sheller firms handle 96% of the peanut crop in the southwestern U.S., which amounts to 26% of the U.S. production. Shellers go to great lengths to sanitize facilities prior to fall storage to avoid insect infestations later. But spring weather conditions favor the larvae of five species, which cause unacceptable losses in food quality, which necessitate chemical treatment. Weedy vegetation, avian pests, and vermin/rodents do not pose major problems and are easily handled with traditional pest management methods in and around peanut warehouses.

However, shellers highlighted four points, regarding current and future insecticide use:

1. The peanut hull provides natural protection for the raw peanut. Insecticides are not sprayed directly on raw kernels. Hence the pod resists invasion against insects, reduces insecticide needs, and keeps insecticide sprays off the nut.

2. In most years more than 80% of the southwest crop is not treated in storage. Only late-stored peanuts receive top dress, head space, or fumigation treatments, based on scouting.

3. Treatments are directed to pods in the upper 15 inch layer of the warehoused piles.

4. Shellers continue to need safe, efficacious, cost-effective insecticides to remain in business. They are concerned about continued available of present insecticides and the economic factors in getting new products labeled, even as many are bio-pesticides or reduced risk chemicals.

Critical Needs and Top Priorities for Pests in Stored Peanuts

Research Needs

1. Reduced risk insecticides - need to speed up development and data base.
2. Residual insecticides - continue research and development for pre-storage application.
3. Pheromones - develop highly effective pheromones for trapping and early detection.
4. Encourage USDA/ARS to include peanuts in the stored grain products research program.

Education Needs

1. Provide educational support for shellers and processors as new insecticides are developed.
2. Continue IPM education and demonstration work.
3. Educate consumers on the value of HACCP and GMP plans in assessing food safety.

Regulatory Needs

1. Speed up registration and labeling of reduced risk insecticides.
2. Please retain registration of dichlorvos, the last remaining OP available to shellers.

Background

Perspectives on the southwestern peanut industry. Peanuts are a main food crop in the U.S. Pests attack this crop at all stages: planting seed, the foliage and pods in the field, and in post-harvest storage. Pests and pesticide use has been summarized for the first two stages but not in the warehousing and processing stage. For example, peanut seedsmen were surveyed and documented that planting seed is treated with one or more fungicides at 1 to 2 ounces per acre at a cost of $2.60 and the economic assessment showed a net return of $130 per acre from this nominal pesticide protection (Smith et al., 2000). Today, 12 million pounds of planting seed in the Southwest are treated with 48,700 pounds of fungicide, to protect the seeds and seedlings. In field production, 1.01 million pounds of pesticide are applied to peanuts in Texas (on 314, 000 acres), Oklahoma (on 75,000 acres) and New Mexico (on 16,500 acres) (Smith et al., 1998).

All four types of peanuts (Runner, Spanish, Virginia , and Valencia) are grown and processed in the southwest, where erratic rainfall and low relative humidity prevail. After harvest, peanuts are dried and placed in warehouses until shelling is completed. The shelled commodity is shipped on demand to manufacturers for further processing into numerous food products. Peanut butter is the primary product. Several insects and other pests attack stored peanuts and losses can exceed those in field production.

Assessment Methods. Six member firms of the Southwestern Peanut Shellers Association, who warehouse and process 94% of the southwestern crop, participated in this pest management assessment, involving problem identification, pest management plans and needs. These firms operate predominantly in Texas, but also operate in Oklahoma and New Mexico, and store 26% of the U.S. peanuts. But little has been published recently on post-harvest pest management. One or more representative from each sheller organization participated in this plan (see participant list at the end). Representatives participated by teleconferences, site visits, reviews of draft documents. Inputs were solicited and consolidated three topics:

1. Pest identification and relative priorities
2. Current pest management practices (organized via the PAMS model that follows)
3. Identification of Research, Education, and Regulatory Needs.

Since shellers had participated in an assessment in 1998, data were included for comparisons in insecticide use over the past five years. It seemed prudent to review literature on stored pests to verify the relevance of current practices and future research needs. After researchers and shellers identified insecticide needs, registrants were contacted for information on potential insecticides. A list of sheller, research, and chemical industry participants is included. Now, here comes the report and assessment.

Insect Pests - identification and practices

Managers ID key insect pests. All peanut managers mentioned Indianmeal moth as the most serious pest and 67% mentioned the red flour beetle as another key pest at all locations in the southwest (see Table 1 for details on each pest). “Beetles in general” were mentioned by all participants. One operator, particularly skilled in pest identification, mentioned the sawtoothed

grain beetle as an occasional pest. The merchant grain beetle and or almond moth also damage peanuts. These pests were similar to those documented earlier by Redlinger and Davis (1995). The imported fire ant (*Solenopsis invicta* Buren) was mentioned by some shellers as a nominal problem around the exterior of some storage facilities; cockroaches (*Blatella germanica* and *Peripalneta americana* Linnaeus) were an occasional pest at one site, but none of these pests receive any particularly treatment.

Table 1. Key insect pests and priority ratings in southwestern peanuts.

Priority	Pest	Description
1	**Indianmeal Moth** (*Plodia interpunctella*)	**Behavior:** This moth exists in a wide range of climates and is found in many types of food processing and storage facilities. The larvae are general feeders and produce a dense webbing; the adults do not feed. **Life Cycle:** 26 days; 100 to 300 eggs/adult laid on produce. **Larvae:** Spin threads as they feed, forming webs; pre-pupal diapause particularly resistant to insecticide treatment. Pupae form in foodstuffs. **Adults:** Non-feeding; short-lived but live to lay more eggs.
2	**Red Flour Beetle** (*Tribolium castaneum*)	**Behavior:** A common pest of a wide range of grain, cereal, and other food products. Red flour beetle will fly under certain conditions; adults are very active, especially in the evening hours. These insects produce a foul odor and taste in the food products they infest, caused by pheromones and toxic compounds. **Life Cycle:** 23 days; up to 450 eggs/adult laid on foodstuff. **Larvae:** Prefer seed embryos. **Adults:** Can live for 18 months.
3A	**Almond Moth** (*Ephestia cautella*)	**Behavior:** Almond moth more common in warmer areas than the Indianmeal moth. Often found in concealed locations. **Life Cycle:** 25 days; up to 300 eggs/adult laid on or near product. **Larvae:** Move into & over products, spinning thick threads before pupation. **Adults:** Non-feeding; short-lived, but live to lay more eggs.

3B	**Lesser Grain Borer** *(Rhyzopertha dominica)*	**Behavior:** A small, highly destructive insect. Eggs laid outside the kernels and then young larvae bore inside. Both larvae and adults are voracious feeders and leave fragmented kernels and powdery residues. Larvae may complete their development in the residue. Leave a slightly pungent odor. **Life Cycle:** 25 days; up to 500 eggs per female **Larvae:** Eat into grain and feed on grain dust **Pupae:** Usually form inside grain **Adults:** Also feed on products; long-lived - compared to other stored pests
3C	**Sawtoothed Grain Beetle** *(Oryzaephilus surinamensis)*	**Behavior:** One of the most common grain and stored-product insect pests. Wide feeding range; active and crawls rapidly in search of food. **Life Cycle:** 20 to 25 days; up to 400 eggs per female **Larvae:** Develop rapidly, particularly in high moisture(greater than 14%) **Adults:** Can live up to 3 years and lay more eggs.

IPM Practices and the PAMS model

Shellers highlighted several control methods that involved IPM practices, including non-chemical and chemical methods. Since the PAMS model (Coble, 1998) is widely used by the USDA, we used it inventory pest management practices and identify research and educational gaps. **PAMS** includes four strategies: **P**revention, **A**voidance, **M**onitoring, and **S**uppression. Each strategy and related tactics are summarized as follows.

Prevention - in pre-storage

Strategies. Once peanuts are dried and placed in storage, accessibility to insects is restricted and control options become more limited. Heavy reliance is placed on pro-active sanitation methods before the commodity is placed in storage to minimize insect infestations later.

Tactics. HACCP (Hazard Analysis of Critical Control Points) programs are commonly practiced throughout the food processing industry. HACCP plans are used by nearly all (87%) peanut shellers and had been developed and implemented in cooperation with food manufacturers who purchased shelled peanuts to avoid insect contamination problems in processed and snack food products. Good Manufacturing Practices (GMP), outlined by USDA (Butts et al. 2002), explains procedures and compliance standards for all aspects of receiving, storing, and handling in-shell and shelled peanut products.

Research Needs

1. Shellers felt that present HACCP and GMP plans, as developed with food processors and USDA work well. No other needs are mentioned.

Educational Needs

1. Communication between various plant sites of each firm, across regions and linkages with

growers, shellers, and manufacturers work well. No other needs are mentioned.

Regulatory Needs

1. Since the FDA oversees food quality, no additional needs were envisioned.

Avoidance - in pre-storage

Strategies. Avoidance strategies were widely implemented by all firms. Prior to harvest, special attention is devoted to special cleaning efforts at receiving points, augers and conveyance devices, trailers, dryers, and central storage facilities to reducing insect re-infestations.

Tactics: Non-Chemical. Mechanical removal methods are widely practiced include brushing, sweeping, hand picking, compressed air, vacuums, high pressure/high volume wash downs with water to dislodge insect webbing and remove residual peanut material on equipment, flooring, walls, and rafters.

Intensive pre-storage sanitation procedures focus on eliminating all extraneous peanut kernels, hulls, plant debris or harborage, and eggs from the previous season that could re-infest the subsequent crop.

Degrees of pest infestations vary among warehouses, depending on geographical location, physical condition, or age of the facility. Warehouses with more southern exposures or intense solar heating, and other factors are more problematic. Most managers personally inspect each warehouse to insure complete sanitation and removal of foreign matter before any new peanuts were stored.

Tactics: Chemical. Chemical insect avoidance by prophylactic applications in and around storage facilities are widely practiced. Both general surface and "crack and crevice" treatments are applied before peanuts are placed in storage - to kill the adults and immature stages of insects. Surface treatments are applied with company-owned spray equipment under the supervision of an employee who holds a non-commercial pesticide applicator certification.

Pre-storage general surface insecticides are applied liberally to all internal surfaces, including walls, rafters, the lower roof line, and the outside perimeter of storage buildings to reduce early re-infestations of insects. General surface applications are applied two weeks or more in advance of peanut storage.

Bin Treatments. Some commodities may be treated as the product is being placed into storage so that a protective insecticide is blended throughout. However, this is not a common practice in southwestern peanuts for several reasons. Insects are not a problem until late spring or early summer in the following year and by that time most (usually 80%) of the crop has been processed and shipped - negating the need for treatment. Further, shellers prefer to leave farmer stock peanuts in storage facilities in west Texas/High Plains where fewer problems occur, due to

lower temperatures and humidity which naturally suppress insect development.

Discussion - pre storage use of insecticide use in 1998 and 2003

Insecticides for the complex of stored insect pests (as shown in Table 1) are highlighted below and summarized in Table 2, including shifts in insecticide use patterns since 1988.

Malathion - In 1998, 83% of the firms applied malathion as a general surface residual spray inside of warehouses. Some managers were aware of Indianmeal moth, red flour beetle, and almond moth resistence to malathion. By 1998, many operators were interested in alternative treatments, but expressed concern about future costs since continued registration of malathion for stored products was questionable.

Cyfluthrin - In 1998, one-third of the firms were applying cyfluthrin as a general surface treatment at one or more sites. The synthetic pyrethroid, commonly the "Tempo" formulation for storage facilities, was more costly than malathion but was particularly useful where severe pest outbreaks occurred in the past. "Crack and crevice" treatments were used by half of the managers prior to placing peanut into storage. Insecticidal treatments were applied by hand sprayer to small cracks and fissures in storage facilities where adult insects or eggs might be harbored and cause infestations later.

By 2003 nearly all operators had switched from malathion and routinely adopted cyfluthrin as a pre-storage treatment. "Crack and crevice" use of cyfluthrin nearly ceased because it was now being used as a general surface treatment.

Diatomaceous Earth (DE) - In 1998, there were no reports of this product being used, perhaps due to availability and efficacy of the finely ground diatoms. By 2003, at least one-third of the warehouse operators were using DE as a general surface treatment in one or more of their storage units. Many are still evaluating the usefulness in their various warehouses and were still in an experimental/trial use stage of adoption. DE is applied to walls and other surfaces as a pre-storage general surface treatment. DE is not used in southern areas of Texas where stored insect problems tend to occur earlier and are more severe.

Synergized pyrethrins (natural pyrethrins plus piperonyl butoxide) are labeled for pre-storage general surface treatment but there were no reports of use due to cost considerations.

Table 2. Pre-storage insecticides used in peanut warehouses in the southwestern U.S.*

Treatment and Pesticide	Extent of use (% of firms) 1998	2003	Comments on use patterns
Malathion	83	0	Use ceased due to insect resistance & non re-registration

Cyfluthrin	33	83	Use increased as O.P. insecticides were phased out
Diatomaceous Earth	0	33	Finely ground silica oxide sprayed on walls Shellers are gaining experience with the product
Pyrethrins	0	0	Effective but too costly for significant use

*****These insecticides are used to address the pest complex summarized in Table 1.

Research Needs for "Avoidance in pre-storage peanuts"

1. Major concern over lack of new insecticides and loss of old ones.
2. More research on the condition effecting DE efficacy.
3. Need USDA research at grain labs to consider peanut needs too.

Education Needs

1. Good awareness between shellers and registrants with products.

Regulatory

1. Loss of malathion was not viewed as a main issue since insect resistance was widespread.
2. Loss of bendiocarb (Ficam) certainly reduced options in resistance management since this carbonate was not re-registered in 2000 after FQPD review.
3. Peanut storage industry has fewer insecticides available, compared to grain (wheat, corn, etc.) due to smaller market potential. This 'erosion of tools" is a major concern.
4. May need IR-4 help after new products are cleared for other grains.

Monitoring - in-storage

Strategies. All managers have established routines for monitoring insect populations while peanuts are in storage. Scouting is conducted more frequently as the length of storage and ambient temperatures increase.

In fall months through January, piles are checked once a month, since storage conditions are relatively cool and insects are less active. In central and south Texas, inspections increase to twice a month during February to March. As ambient temperatures continue to increase in the spring and summer, monitoring is increased to weekly inspections and later to twice a week or more, depending on prior findings. Scouting in Oklahoma, the Texas High Plains, and eastern New Mexico follow similar frequencies but are initiated later since seasonal temperatures and lower humidity delay pest development in these northern regions and higher elevations.

Tactics. In 80% of the warehouses, coned piles of peanut are leveled at the time of storage to improve flow of forced air, visual inspections, and uniform insecticide treatment later. Each firm scouts for insects but employs slightly different procedures in checking for winged adults and crawling larvae. Actionable thresholds are variable but consider seasonal and location factors, prior histories, and facility features.

Inspections are initiated at specific sites where initial outbreaks occurred in the past.

Outbreaks tend to occur first near the tops of piles or where dirt or fine particles accumulate during storage. Employees scout from cat-walks in warehouses by looking for "flyers" or "millers" (winged adults) above the peanut pile. Perimeter areas near the floor are examined for Indianmeal moth larvae in loose shelled kernels, and warehouses are checked for larvae crawling on walls.

At least 67% of the operators use perforated grain probes or pitfall traps to monitor pests. Pitfall traps, consisting of 45 cm-long (18 inch) plastic tubes with perforations along the side, are inserted vertically in the upper surface of the pile at five to 20 locations in each warehouse. Larvae crawling through the surface layer of peanuts drop through perforations into the tube and are easily observed when traps are inspected. An actionable threshold of five larvae per tube was mentioned but chemical intervention varies with the seasonal outlook for additional pest emergence and storage temperatures.

At least one-third of the firms use pheromones (sex attractants) or glue boards to monitor adult insect populations. Lures are placed in hanging traps with a sticky surface or in perforated tube traps. Glue boards were placed at 10 to 20 feet distances along cat-walks to monitor for adults. One manager reported that quality assurance representatives from one food manufacturer periodically wore pheromone badges during site inspections to check for insects.

Research Needs for "Monitoring of in-storage peanuts"

1. Present monitoring methods are a combination of physical examinations from warehouse cat walks or use of pit-fall traps, and looking for "millers". No expressed needs for research on new methods.
2. Economic thresholds were well developed at each site with its own actionable threshold.
3. No real need for new monitoring methods.

Education Needs

1. Shellers are generally aware of and practice current technologies in monitoring.

Regulatory Needs No needs.

Suppression and control of in-storage peanuts

Strategies. Chemical control methods are implemented once actionable threshold populations of insects are noted in the storage pile. However, tactics vary depending on seasonal considerations and pest populations. For example, the presence of insects in the fall and the onset of cooler weather is of less concern, in contrast to insects found in the spring when populations could increase rapidly as ambient temperatures increase. There are no reports of applying protective insecticides when peanuts are being conveyed into storage.

Tactics - Non-Chemical. Identification and removal of localized infestations are important strategies in the fall in two operations.

1. "Hot spots" are hand-sacked to remove insect-infested spots to avoid premature use of chemicals and are followed by more frequent monitoring.

2. In the spring, chemical applications are deferred until economic thresholds are reached, as confirmed by monitoring programs. Chemical control is initiated sooner in southern areas than in northern or higher elevation areas.

3. Once insects are observed at actionable levels, top dress applications, head space treatments, and/or fumigation are initiated. In-storage insecticides and use patterns commonly practiced in the southwestern peanut industry are summarized in Table 3.

Tactics - Chemical

1. Top dress insecticides (treatments placed over the top and exposed surfaces of piles) are sprayed on in-shell peanut by workers on catwalks inside warehouses. These treatments protect the upper 15 cm surface layer where larvae are most prevalent. Managers prefer to apply insecticides to leveled surfaces. In 1998, **malathion** was the top dress treatment of choice since it was economical, easy to apply, and applied only when insect populations were noted in the late spring or summer.

By 2003, top dress use of malathion has disappeared due to lack of re-registration. During this five year period use of **syngergized pyrethrins** increased from 17 to 50% . However, the most notable change was in the trial use and partial adoption of **diatomaceous earth (DE)** as a top dress treatment. There was no mention of DE in 1998, but by 2003, 50% of the managers were using this inert insecticide to some extent. The product is being used in a limited number of warehouses, particularly those with a history of late season insect problems and in drier western areas. Operators indicate that they were still evaluating the overall efficacy and protection offered by DE and planned to experiment at various sites. Managers express concern over the four to five fold increase in the cost of DE, compared to previous options, and the increase dust in the warehouse and shelling plant.

2. Head space treatments are used to control winged adults and prevent infestation outbreaks. Applications are based on the volume of air between the surface of the peanut pile and roof line. Head space treatments are generally administered from pressurized canisters attached to automated fogging and misting devices that are mounted inside warehouses. Dispensers are timed to apply an insecticide during non-working hours, most commonly on alternate evenings. **Dichlorvos** is used in at least one-third of the operations. Managers did not express concern about potential loss of this OP insecticide. Impregnated strips containing dichlorvos have not been used in the past five years. **Resmethrin**, used nominally in earlier years, is being used in two-thirds of the operations in 2003, and use was particularly important in protecting shelled peanut. Use of **synergized pyrethrins** in head space increased nominally to cost considerations in bulk storage.

3. **Fumigation**. At least 83% of the shellers fumigate some facilities to control late

season outbreaks of insects. Managers consider fumigation as a treatment of last resort and used only after insect populations are no longer suppressed by top dress or head space treatments and further outbreaks pose serious economic threats due to increased temperatures and additional generations of insects. Fumigation is practiced in a limited number of warehouses in late spring and summer, near the end of the shelling period.

Managers indicate that fumigation is costly, time consuming, imposed down time, limited worker re-entry, and did not provide residual control.

4. Aluminum phosphide is the only fumigant available for shellers and is applied by warehouse employees who hold a non-commercial pesticide applicator license. Phosphine gas, liberated when pellets or tablets are exposed to atmospheric moisture, is applied using site-specific fumigation management plans. These plans contain provisions on sealing the facility to retain phosphide gas, protective clothing and other safety precautions for workers, placard notices, and building security to prevent re-entry. After application, phosphine concentrations are monitored with hand-held colorimetric equipment to assure that gas levels are adequate for pest control. After adequate exposure, industrial hygiene levels are checked before placards and security locks are removed. There was no mention of any exposure problems for employees or communities where storage facilities are located.

Summary notes on insecticide use

The amount of the southwestern peanut crop treated with an in-storage insecticide varies from 10 to 40% each year, depending on length of storage, seasonal progress in shelling, shipments, geographical location, and local environmental conditions. We estimated that an average of 18% of the total crop was actually treated with one or more in-storage chemicals; 82% is not treated due to earlier processing and shipment. Other than identifying the specific chemicals and times and conditions of use, we did not try to further quantify the amount of insecticide (pounds per ton of stored product) that was used (see Smith et al., 1998 and 2000, for qualification of pesticide use in planting seed and field production).

Table 3. In-storage use of insecticides for top dress, head space, and fumigation treatments in southwestern peanuts.

Treatments and Pesticides	Extent of use (% of firms) 1998	2003	Comments on use patterns
Top Dress Treatment			
Malathion	100	0	Sprayed on pile surface, based on scouting
Pyrethrins	17	50	Sprayed on pile surface at frequent intervals

Diatomaceous earth	0	50	Applied prior to insect build up; dusty, costly
Head Space Treatment			
Dichlorvos	33	33	Applied by timed foggers
Resmethrin	17	67	Fogged or mist sprayed as needed for adults
Pyrethrins	17	50	Spray directed toward ceilings for adults
Fumigation			
Phosphine gas	83	83	Costly; facility sealed and treated as a last resort

Research Needs - Chemical suppression

1. Shellers express concern on continued availability of currently-labeled pesticides and prospects for new products. Cereal grain markets are large and offer substantial economic returns for registrants while the peanut market is relatively small.

2. Bio-control agents such as **Bt** and **spinosad** (a fermentation product of *Saccharopolyspora spinosa*) and IGRs such as **methoprene** may offer shellers some alternatives. But most shellers felt that they had fewer options in chemical control.

3. Potential insecticides meriting research are summarized in Table 4.

New insecticides for stored peanuts

Table 4. New insecticides for stored peanuts: products useful to the industry and meriting additional research and regulatory consideration *	
Bio-pesticides	
Bt (Dipel and others) (a Reduced Risk insecticide)	- useful as a top dress treatment - interest by Valent.; 24(c) reg. is not a long term solution
Methoprone (Diacon II) (a Reduced Risk insecticide)	- potential “top dress” treatment for in-storage peanuts - EPA granted “freedom from tolerance” status - considerable literature published; Wellmark Int’al interested
Insect Growth Regulators	

Pyriproxyfen	- some USDA-ARS research as top dress treatment - product from Sumitomo and Valent U.S.A.
Pyrethroids	
Esfenvalerate	- broad spectrum of activity - head space potential ("stack penetration" needs research) - Sumitomo and MGK (Minn.) - labeled now for many horticulture crops
Others	
Spinosad (a Reduced Risk insecticide)	- top dress potential; high safety and efficacy in peanuts - interest by Gustafson and Dow AgroSciences

* Registrant representatives who provided information are summarized in Appendix 1.

Research Needs - New products for control of insect pests

1. Discussions with shellers and registrants indicated that several new products are being researched, generally with only moderate interest since the primary markets are in the grain crops (corn, wheat, etc). In general, most shellers had limited awareness of new products since most chemical firms did not consider peanut warehousing as a major market.

2. During this assessment, several warehouse operators and chemical representatives expanded discussions and some cooperative work was launched. However, expansion of labels to include peanuts would depend on regulatory costs vs market potentials.

3. A list of 'top prospects' was developed to include those insecticides that appeared to have good biological and economic potential as a commercial product. These included bio-pesticides, IGRs, and a pyrethroid (see Table 4).

Education Needs

1. Several warehouse operators were aware of registrant efforts to evaluate new products and are willing to help in small studies (EUP, etc.). Shellers can offer test sites in diverse regions.

3. The University of Georgia and other Extension specialists are interested in new products and methods of controlling stored insect pests.

Regulatory Needs

1. EPA should note that many new products are reduced risk and offer new hope on old pests. Shellers are concerned about loss of additional insecticides in the face of declining options. These products are listed in Table 4 of this report and include Bt (Dipel and others), Methoprone (Diacon II, a Reduced Risk insecticide), Pyriproxyfen (an IGR), Esfenvalerate, and Spinosad (a Reduced Risk insecticide).

2. IR-4 may have a role in guidance and assistance as new products (listed above) are developed for wheat and other large-volume grains. ("Peanuts" are relegated to a second tier consideration, compared to other grains, due the small volume.)

Other Pests affecting Stored Peanuts

Shellers reported other pest problems, in addition to insects. These included weeds, avian pests, and vermin but none of these posed serious problems since t hey could be controlled with currently-available pest management methods (both chemical and mechanical). A complete PAMS assessment was not developed but the following notes capture the main pests and management methods.

Weeds

1. Areas around warehouses are mowed to reduce weedy vegetation that provides harborage for insects and rodents.

2. Glyphosate is used to kill weeds to reduce harborage and fire hazards, but no residual herbicides are used around warehouses.

Avian Pests

1. Managers reported that losses from fecal contamination from commensal pests are far greater than physical losses from feeding. Feral pigeon (*Columbia livia* Gmelin) is cited by all managers as a major pest. English sparrow (*Passer domesticus* Linnaeus) is of nominal concern.

2. Bird infestation and contamination problems depend on warehouse age and construction design. Bird exclusion is more difficult in older storage facilities and those with numerous unsealed entry points.

3. Several preventive and suppression strategies are used, including wire netting on outside openings to restrict entry, placement of spikes or other exclusions of roosting or nesting sites, and use of live traps.

4. **Avitrol** (4-aminopyrine), a chemical frightening agent which causes birds to issue distress calls, is used outside of two operations. Carbide canons and other frightening devices are

not effective deterrents.

Vermin

1. The Norway rat (*Rattus norvegicus* Berkenhout) and, to a lesser extent, the roof rat (*Rattus rattus* Linnaeus) and house mouse (*Mus musculus* Linnaeus) cause losses in stored peanuts due to fecal contamination. These rodents are excellent climbers, have high reproductive capacities, vector several human diseases, and contaminate ten times more seed than they consume. Shellers mention that rat droppings are difficult to screen from peanuts, are not appreciated by food processors, and are highly undesirable in food products.

2. Since these vermin require food, water, and harborage, all of which are readily available around peanut storage facilities, preventative control measures are practiced. Externally, mowing, sanitation, rodent-proof construction, and netting are common preventive measures. One firm uses electric fencing with positive and negative wires placed 1 to 3 inches above paved surfaces to deter rodents. Population control measures are employed inside warehouses.

3. Rodenticides and traps are strategically placed near feeding sites and runways. **Warfarin**, an anticoagulant, is administered in food blocks or water baits at half of the sites. Water bait s stations are deemed to be particularly effective for rats in summer. Pellet formulations of warfarin are not used, to avoid physical contamination with similarly-sized peanut kernels. Entrapments include snap traps, glue boards, and multiple catch boxes, with and without baits.

4. Feral house cats (*Felis domesticus* Linneaus), present at some sites, help to suppress rodent populations

Shelled Peanuts

Strategies: Strict sanitation procedures and modified atmospheres are used in shelling plants and are based on HACCP and GMP plans to avoid contamination of the food product.

Tactics - Modified Atmosphere: In past decades, methyl bromide was a commonly used fumigant in the peanut industry. In this survey, one operator indicated that methyl bromide is used to a limited extent, based on requests from buyers. It was noted that:

1. Shelled peanuts are typically placed in refrigerated storage to avoid oxidation of fatty acids, preserve quality and flavor, and suppress insect development.

2. **Resmethrin** is dispersed during non-operating times in the shelling facility.

3. Shelled peanuts are frequently treated before shipment, usually at the request of the buyer to prevent insect contamination during transit. Resmethrin or synergized

pyrthreins are administered in some instances but most commonly containers were fumigated with aluminum phosphide. Fumigated shipping containers include boxed or packaged products, truck shipments, and rail cars.

Research Needs - Shelled Peanuts

1. Modified atmospheres, involving carbon dioxide, nitrogen, and other gases have been considered for peanuts but have not been cost effective (Redlinger and Davis, 1995).

2. While alternatives for methyl bromide are needed, these atmospheric displacements are not being considered by shellers at this time.

Acknowledgments

Special assistance from Dr. Roy Parker, stored product specialist with Texas Cooperative Extension, Riley Curb of Golden Peanut, Jim Burleson of Birdsong Peanuts, Greg Rich of Valent U.S.A., and Doug Vangundy of Wellmark International was appreciated in preparing the final summary of products and practices in the peanut industry.

Appendix 1. Participants: **Shellers, Research and Extension, and New Products/registrants**

A. Shellers

Birdsong Peanuts	Jim Burleson and Jack Simpson	Gorman, Texas
Borden Peanut	Russell Roberts	Portales, New Mexico
Clint Williams Co.	Tyson Walters	Madill, Oklahoma
Golden Peanut	Riley Curb	DeLeon, Texas
Lee County Peanut	Jonathan Socha	Giddings, Texas
Wilco Peanut	Byron Warnken	Pleasanton, Texas

B. Public Research and Extension Participants

Dr. Frank Arthur, Research Entomologist
USDA-ARS - Grain Research Center, Manhattan, Kansas. arthur@gmpre.ksu-edu.
Dr. Steve Brown, Extension Entomologist
Dept. of Entomology, Coastal Plains Station, Tifton, Georgia. Bugbrown@UGA.edu.
Dr. Roy Parker, Extension Entomologist Texas Cooperative Extension
Texas A&M Center at Corpus Christi, Texas r-parker@tamu.edu.
Dr. Dudley Smith, Agronomist, Department of Soil and Crop Sciences.
Texas A&M University, College Station, Texas. dt-smith@tamu.edu.

C. Registrant & New Product Participants (see Table 4 for insecticide potentials in peanut)

Bt

Greg Rich, Valent U.S.A. Memphis, Tennessee. Grich@valent.com.

Jeff Smith, Valent U.S.A. Memphis, Tennessee. Jeffery.smith@valent.com.

Dichlorvos
Bill Feider, AMVAC. Commerce, California. BillF@AMVAC-chemical.com.

Esfenvalerate
Don Sundquist, MGK/Sumintomo. Golden Valley, Montana. don.sundquist@MGK.com.

Methoprene
Doug Vangundy, Wellmark International. Dallas, Texas doug.vangundy@wellmarkint.com.

Pyriproxyfen
John Aleck, Valent U.S.A. North Carolina. Jalex@valent.com.

Spinosad
Gary Thompson, Dow AgroSciences GDThompson@dow.com.
Terry Pitts, Gustafson. Plano, Texas. Tpitts@gustafson.com.

Review of Literature (Appendix 2)

Numerous stored insect pests commonly infest peanuts (Redlinger and Davis, 1995). Key post-harvest pests in peanut are Indianmeal moth [*Plodia interpunctella* (Hubner)], red flour beetle [*Tribolium castaneum* (Herbst)], grain beetles (*Oryzaephilus* spp.), lesser grain borer [*Rhyzopertha dominica* (F.)], and almond moth [*Cadra cautella* (Walker)]. These insects invade peanut hulls or feed on damaged or loose shelled kernels. Economic losses occur from both physical destruction and contamination from frass and castings. Insect populations in stored products tend to be more prevalent in areas with higher ambient temperatures and humidity (Noyes et al., 1995).

Integrated pest management (IPM) in stored food products depends heavily on sanitation, population monitoring, and chemical control (Hagstrum and Flinn, 1995). Several non-chemical control methods have been explored to reduce losses to insects**.** Sanitation is an important strategy. Cleaning of farmer stock peanut at harvest to remove loose shelled kernels, foreign material, and other feeding sources may reduce insect damage during storage (Arthur, 1989).

Historically, insecticides, insect growth hormones (IGR), desiccants, and fumigants have been used to reduce insect damage. More recently biological control agents, have been partially effective against some pests. Diatomaceous earth (silicon dioxide as an inert dust) has been evaluated in laboratory-scale trials (Arthur and Brown, 1994). Finely ground diatoms ingested by larva of Indianmeal moth and almond moth result in insect dehydration from destruction of the epicuticle exoskeleton. Indianmeal moth and almond moth have exhibited highly variable responses to *Bacillus thuringiensis* (Bt) (Arthur and Brown, 1994 and Kinsinger et al., 1980). Trichogramma (*T. pretiosum* Riley) has shown potential as a biocontrol agent in stored crops

(Brower, 1983). Redlinger and Davis (1995) summarized the use of natural parasites, predators, and pathogens in post-harvest peanut but noted that commercial augmentation and introductions of viruses, bacteria, protozoans, and other natural enemies had not been adopted. Surveillance and control methods included the use of traps, pheromones, and other tactics. IPM practices and pesticide use in field production of peanuts have been summarized (Smith et al., 1998).

Literature Citations

Arthur, F. H. 1989. Effects of cleaning peanuts on insect damage, insect population growth and insecticidal efficacy. Peanut Sci. 16:100-105.

Arthur, F. H. 1995. Susceptibility of fifth-instar Indianmeal moth and almond moth (Lepidoptera:Pyralidae) to cyfluthrin resides on peanuts. J. Entomol. Sci. 30:318-323.

Arthur, F. H. and S. L. Brown. 1994. Evaluation of diatomaceous earth (Insecto) and *Bacillus thuringiensis* formulation for insect control in stored peanuts. J. Entomol. Sci. 29:176-182.

Butts, C., R. Crozier, J. Smith, and B. Willingham. 2002. Good agricultural practices for farmer stock storage and handling. Chapter 3. *In* R. Henning and D. Cowart (ed.) Amer. Peanut Council Good Management Practices Handbook, Alexandria, VA.

Coble, H. D. 1998. A new tool for measuring the resilience of IPM systems: the PAMS diversity index. *In* E. Day, (ed.) IPM Measurement Systems Workshop Proceedings. Am. Farmland Trust Ctr. for Agr. in the Environ. Chicago, IL. p.152-154.

Hagstrum, D. and P. Flinn. 1995. IPM in grain storage and bulk commodities. *In* Krischif, V., G. Cuperus, and D. Galliart (ed.) Stored Product Management. Oklahoma Agric. Ext. Serv. Cir. E-912. Chapter 27. p. 201-205.

Kinsinger, R. A., W. H. McGaughey, and E. B. Dicke. 1980. Susceptibility of Indianmeal moth and almond moth to eight *Bacillus thuringiensis* isolates (Leptidoptera:Pyralidae). J. Kansas Ent. Soc. 53(3):495-500.

Noyes, R. T., R. Weinzierl, G. W. Cuperus, and D. E. Maier. 1995. Stored grain management techniques. *In* Krischif, V., G. Cuperus, and D. Galliart (ed.) Stored Product Management. Oklahoma Agric. Ext. Serv. Cir. E-912. Chapter 12. p.71-84.

Redlinger, L. M. and R. Davis. 1995. Insect control in postharvest peanuts. *In* H. E. Pattee and C. T. Young (ed.) Peanut Science and Technology. Chapter 14. p. 520-570

Smith, D. T., M. J. New, and J. T. Criswell. 1998. Peanut pest management practices and chemical use - a survey of the southwest industry. 1998 Proc. Am. Peanut. Res. Educ. Soc. 30:52.

Smith, D.T., M.C. Black, W.J. Grichar, and A.J. Jaks. 2000. Economic assessment and fungicide use on peanut seed in the southwestern United States. Peanut Sci. 27:39-44.