Crop Profile for On-Farm Stored Wheat in Kansas

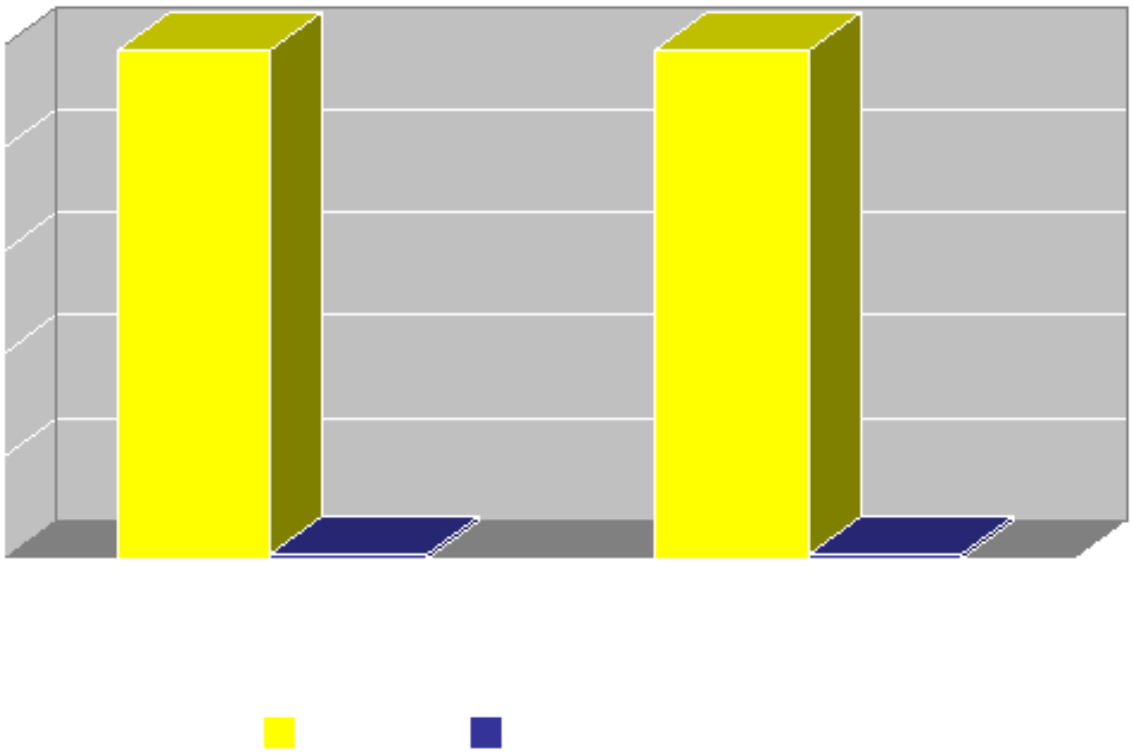
Prepared: February, 2005

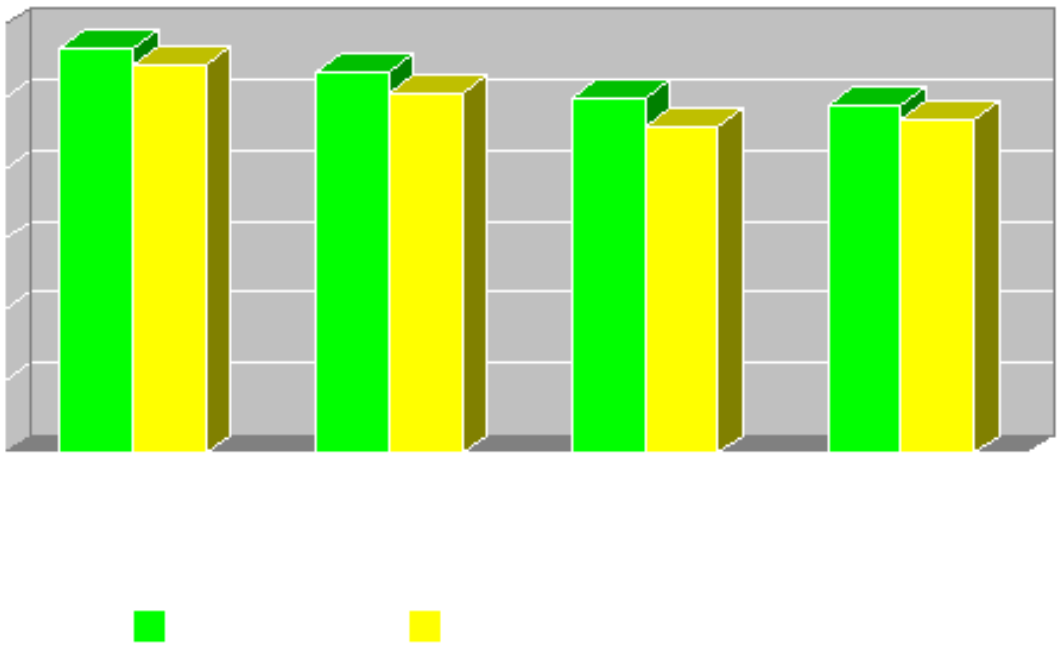
General Production Information

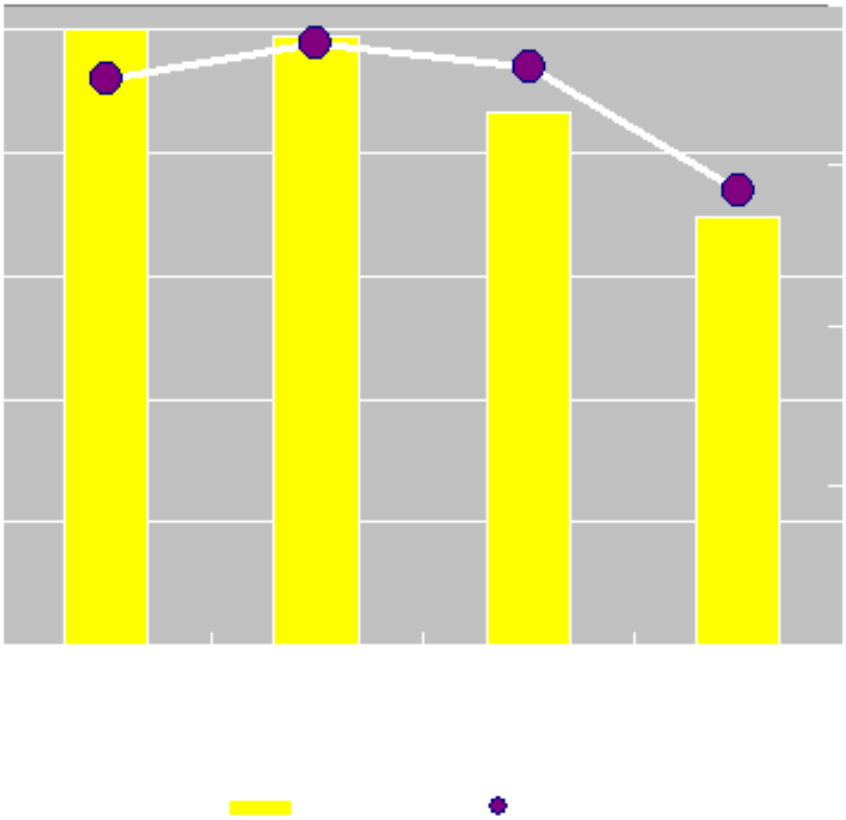
Data for figures 1-6 are extracted from the National Agricultural Statistics Service (NASS, USDA), Small Grain Summery, and US Grain Stocks.

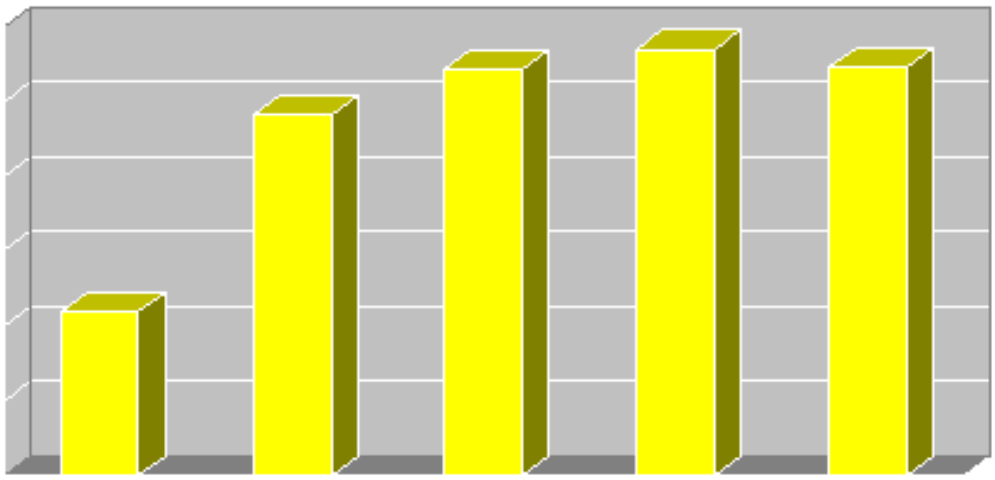
- Hard red winter (HRW) is the dominant wheat class in Kansas (Fig. 1). Winter wheat is used for bread, rolls and, to a lesser extent, sweet goods and all-purpose flour.
- Planted and harvested acres of winter wheat showed a steady decline since 1997 (Fig. 2). In 2000, 9.8 million acres were planted, down 200, 900, and 1,600 acres form 1999, 1998, and 1997, respectively. About 9.4 million acres were harvested in 2000, down 200, 700, and 2000 acres from 1999, 1998, 1997, respectively.
- Winter wheat production totaled 347.8 million bushels in 2000, down 20% from 1999 (Fig. 3). The decline was the result of both acreage and yield decreases.

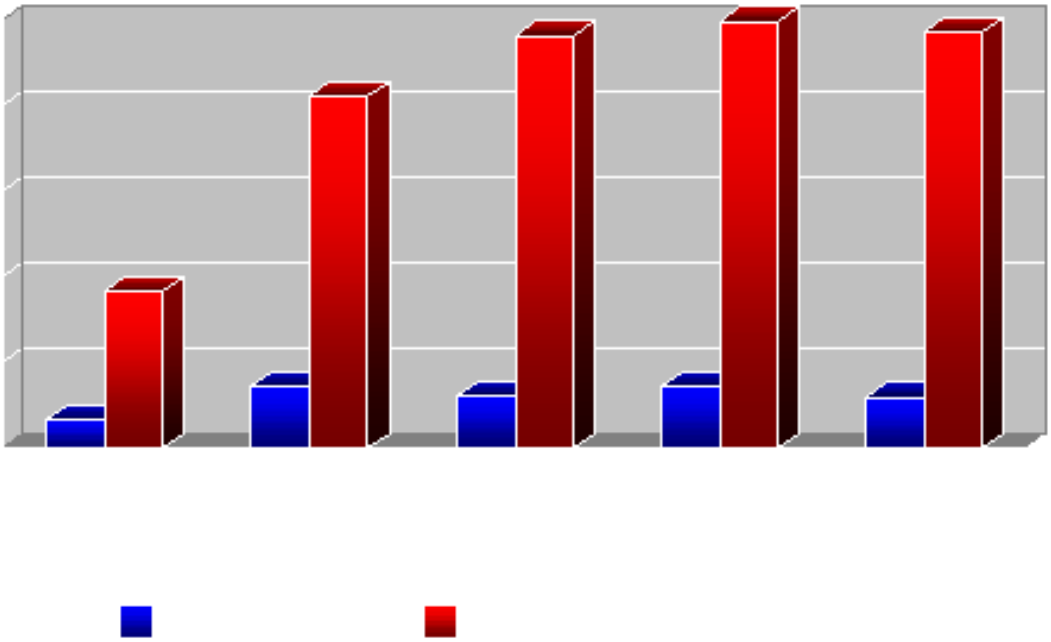
- In 1997, Kansas stored 121% more wheat than 1996. Ever since, wheat stocks in storage have been increasing except a 4% decrease was reported in 2000 compared to 1999 stocks (Fig. 4).
- Most of the wheat in Kansas is stored off-farm (Fig. 5). A significant increase was reported in 1997 (205.3 million), up 123% from 1996. Since 1997, steady increase off-farm wheat storage was reported, except 4% decrease in 2000 compared to 1999 stocks. On-farm wheat stocks show no significant changes since 1997 when wheat stocks were up 52% from 1996.
- Although, Kansas off-farm grain storage capacity in 2000 was 875 million bushels, up 12% from 1999, there were fewer facilities to store cereal grains in 2000 compared to 1999 (Fig. 6).











General Management Practices

PreHarvest Practices

On-farm wheat in Kansas is mostly stored in cylindrical metal bins, although a few farmers still store wheat in wooden facilities. Flat floor bins are non-aerated with flat concrete or metal floors. False-floor bins typically are rounded metal structure typically with a ground-level floor made of concrete and a metal, fully perforated floor located 12" above the concrete floor to allow air movement through the grain mass. Drying bins are false-floor bins with heaters to increase the temperature of the forced air. Hopper bottom bins that are mostly used in western Kansas are equipped for aeration. The system consists of fan and either air ducts or a false floor of perforated metal. Storage bins in central and eastern Kansas are much smaller than those of western Kansas and some lack aeration. The mean storage capacity per farm is between 11,000 bushels in central Kansas to more than 40,000 bushels in western Kansas. In general, farmers in the western one-third of Kansas who own large storage capacity manage most of the on-farm stored wheat in Kansas.

Sanitation:

Insect migration into stored grain bin can be limited using proper sanitation practices. Insects migrate from sites in the bin bottoms, through eaves of round metal bins, nearby stored grain, or other places where grain, grain dust, or grain based materials accumulate.

1. Bin and Handling Equipment Preparation

- Empty bins are cleaned thoroughly of old crop, garin residues, and dust before the newly harvested wheat is stored.
- Spilled grain and grain debris outside the bins are removed.
- Bins are repaired or replaced to prevent insects from entering the storage facility.
- Weeds and debris around the bin are removed.
- Temperature monitors are installed in bins.
- Augers, combines, and truck beds are cleaned before harvesting and unloading the grain from or to the bin. Also, equipment kept properly adjusted to minimize grain breakage.
- First few harvested bushels that are passed through the equipment are discarded.
- Grain is visually checked for the presence of stored-grain insects.
- Harvested grain is sprayed with an approved protectant as it is loaded into a bin.
- Dockage and fines are separated from the grain mass going into storage.

2. Bin Treatments

Bin is sprayed with residual insecticides two to three weeks prior to harvest. Walls, roof, and floor are sprayed to 'run off' with a chemical. If it is necessary, bin is fumigated two to four months before harvest to eliminate hidden infestations. In addition, if harvested crop has to be binned with the last- year grain, the latter is fumigated before bin is filled with the new crop. Several chemicals are approved for use in empty facilities.

Chemicals:

- Malathion 57% EC @ 8 fl. oz./2 gal water.
- Methoxychlor 25% EC @ 1 qt./2 gal water (not used, because of its availability)
- Methoxychlor 50% WP @ 1 lb/2 gal water (not used, because of its availability)
- Pyrethrins 6% plus piperonyl butoxide 60% @ 1 1/3 pt./3 gal water (surveys have shown that this product is not typically used in empty facilities)
- Chlorpyrifos-methyl (Reldan 4E) @ 4 fl. oz./3 gal water (should be used in facilities not intended for storage of corn)
- Diatomaceous earth dusts (Insecto, Protect-It and Dryacide) can be used at 1 lb/1000 sq. ft. and are highly recommended for bins with false floors.

Note: Malathion, methoxychlor, and chlorpyrifos-methyl (Reldan) have been registered as outside perimeter sprays and/or inner plus outer bin wall treatments. Malathion and methoxychlor treatments are labeled for structures in which barley, corn, oats, rye, sorghum, and wheat will be stored. Reldan is registered for structures where barley, oats, rice, sorghum, or wheat will be stored, not corn or rye.

Grain Treatment

Protectants
Protectant treatment consists of minimum bin treatment plus grain treatment with a protectant as grain is placed in storage. This is a prophylactic application, primarily intended to kill insects colonizing the grain surface. Kansas wheat is mostly treated with garin protectants, especially grain stored in large bins, to control stored-grain pests. The grain protectants, liquids or powders, are residual insecticides applied to the surface of grain intended for long-term storage. They leave a protective shield of toxic residue on the surface so that insects may come in contact as they colonize the grain. Invaded insects are killed before they can reproduce and cause serious damage. Protectants are most appropriate where summer harvested grain is stored into the next year. Malathion in several commercial brands and trade names, and chlorpyrifos-methyl, under the trade name Reldan, are the two insecticides mostly used on cereal grain in Kansas. However, malathion treatment of wheat is not recommended, because it is often ineffective under conditions of farm storage in Kansas. Reldan, so far, has proven to be more effective than malathion.

Chemicals:

Chlorpyrifos-methyl (Reldan 4E) @ 11.5 fl. oz./5 gal water per 1,000 bu. wheat. Effective against Indianmeal moth and many stored-grain insects

- Chlorpyrifos-methyl (Reldan 3% Dust) @ 10 lb/1,000 bu. grain loaded or turned into final storage. Effective against Indianmeal moth and many stored- grain insects.
- Premium grade malathion 57% EC @ 1 pt or malathion 80% EC @ 10 oz / 2-5 gal water per 1,000 bu. grain.
- Premium grade malathion wheat flour dust formulations that contain 1% malathion (60 lb./1,000 bu), 2% malathion (30 lb./1,000 bu), or 6% malathion (10 lb./1,000 bu).
- 6% Pyrethrins and 60 % Piperonyl Butoxide mixture @ 2 pt/5 gal water per 1,000 bu grain.
- Bacillus thuringiensis, @ 1.5 pt/100 bushels, is an insect pathogen derivative that will kill Indianmeal moth larvae but it is not effective against the adult moths, weevils, or other beetles. It is commercially available as Dipel 4L.
- Several formulations of diatomaceous earth dusts are registered for use on grain at 28-56 lb/1000 bu. Notable formulations include Insecto, Protect-It and Dryacide. These dusts affect grain flowability, and lower test weight, although 98% of the dust can be removed during cleaning of grain prior to milling. These dusts are exempt from a residue tolerance.

Note: As of December 31, 2004 all uses of Reldan have been revoked. It is now available for use only for seed

treatment in Storicide formulation, which contains 3 ppm chlorpyrifos-methyl and 2 ppm cyfluthrin. Synergized pyrethrins are not generally used on stored wheat. Dipel formulations are also rarely used because of development of resistance in Indianmeal moth larvae. Diatomaceous earth dusts are gaining popularity and can be used for organic stored wheat.

Surface Dressing

If grain protectant is not used on incoming grain, it is recommended to apply malathion, Reldan, or Bacillus thuringiensis to the grain surface as a "cap-out" treatment. Surface application with a protectant can be made only if the grain was not treated during bin filling (except for diatomaceous earth dusts as they are exempt from a residue tolerance).The chemical, split applications, is only applied to exposed surface of the grain mass down to 6 to 12 inches deep. The product is divided into two or three lots. The first lot is spread on the surface of the grain then mixed thoroughly to a depth indicated by the rate. The second lot is applied as the first one, third lot is applied evenly to the surface and further mixing is minimized, unless otherwise recommended on the label. Most protectants are not used as surface dressing if they have already been used as grain protectants about the same date on the same grain mass.

- Malathion 57%EC @ ½ pt./ 1-2 gal water; malathion 1% dust @ 30 lb; malathion 2% Dust @ 15 lb.; malathion 6% dust @ 5 lb. All surface dressing rates are calculated to treat 1,000 sq. ft. of grain surface. Surface dressing of malathion may protect against many insects except Indianmeal moth larvae.
- Chlorpyrifos-methyl (Reldan 4E) @ 3 oz./2 gal water per 1,000 sq. ft. of surface area. Effective against Indianmeal moth.
- Chlorpyrifos-methyl (Reldan 3% dust) @ 7 lb/1,000 sq. ft. of grain surface.
- Bacillus thuringiensis is an insect pathogen derivative that will kill Indianmeal moth larvae but it is not effective against the adult moths, weevils, or other beetles. It is commercially available as Dipel, Top-Side, and SOK-BT.

Fumigation

Grain protectants are not highly volatile and penetration into infested kernels is very limited, and has limited capability to destroy insect eggs and control internally feeding insects. Therefore, grain fumigants are more effective in killing all life stages but do not provide residual activity against reinfestation. In western Kansas, most producers depend on fumigation and aeration as the means of managing insect populations in their grain. In central Kansas, where most of the storage facilities are not equipped with aeration systems, producers use grain protectants for long-term control. Fumigation with phosphine is done to kill an existing infestation, although there is a misconception that the use of fumigant will prevent infestation. Fumigants produce penetrating, toxic gases when released. These gases readily penetrate into infested kernels and should eliminate all insect life stages in the grain mass and in the surrounding area. Fumigations usually are performed during the fall and winter. October and November, after the fall flight peak of the lesser grain borer, is the optimum time for fumigating on-farm wheat in Kansas. Before fumigating, all ground-level openings of storage facility should be sealed with tape and plastic sheeting. The grain surface is covered with plastic tarpaulins, after fumigation, to ensure even distribution of fumigant gas through the grain mass. Ground-level fumigation technique has been reported to be the most effective method to control insects. Phosphine gas quickly moves upward in on-farm stored wheat and distributes well when applied beneath the grain. Temperature, moisture, insect types, and storage facility affect the efficiency of fumigation. Fumigation is ineffective when grain or the structure temperature is below 50 oF or above 115 oF. As grain moisture increases, it becomes more difficult for the fumigant to penetrate the grain. Some insects are more susceptible during some stages of their life cycle than others. Generally, active insects are susceptible to fumigation, such as adults and larvae. On-farm wooden structures that are leaky do not retain the fumigant gas as well as sealed metal, plastic, or concrete structures. Bin is sealed tightly, especially at the doors, eaves, hatches, vents, and aeration/auger ports. The grain surface is leveled below the

storage sidewalls before fumigation.

Fumigation of Flat Storages

Several considerations are required using pellets or tablets to release phosphine gas into the flat storage.

- Fumigation should be conducted when grain temperatures are above 50oF.
- Doors, vents, aeration ducts, cracks of the flat bin should be sealed.
- To ensure a uniform distribution of gas in the grain mass, phosphine tablets or pellets are probed at intervals along the width and length of the flat storage or they can be applied into the grain mass by dropping them into the probe as the probe withdraw from the grain.

Fumigation of Vertical Storages

An automated system of fumigant application is provided in the concrete bins in which grain is rapidly transferred. Pellets and tablets are applied continuously by an automatic dispenser or by hand as the grain is turned or loaded into the bin. Also, the "closed loop fumigation" method is used to apply phosphine. Solid fumigants are placed on the surface of the grain using the headspace to generate the gas. The gas is then moved by the duct and fan to the bottom of the bin and up through the grain mass. Fumigated grain is covered with a gas-tight material. The tarps may be specially made for fumigation, such as impregnated nylon, or they may be sheet polyethylene.

Types of Fumigants

1. Aluminum and magnesium phosphides (Fumitoxin; Phostoxin), restricted use pesticide (RUP). Any form of aluminum or magnesium phosphide reacts with the moisture to release a garlic odor phosphine gas. The magnesium phosphide formulation releases gas at lower temperature than the aluminum phosphide formulation. The phosphine gas is toxic to humans, insects, burrowing pests, and other forms of animal life. In addition, the gas corrodes certain metals and may ignite spontaneously in air at concentrations above its lower flammable limit. The gas easily penetrates into the grain but can easily be removed by convection or other air currents.

2. Methyl bromide, RUP, is available in cylinders as liquid under pressure. At normal pressures and temperatures, it is an odorless, colorless gas. It penetrates deeply into the grain under normal atmospheric conditions and vapors dissipate rapidly after fumigation. Grain is generally not fumigated with methyl bromide.

3. Chloropicrin, RUP, is no longer registered for direct application to stored grain. It is used for empty bin treatment only. This fumigant is ideal to kill insects in the bin false floor area. Availability of this fumigant has been an issue for several years.

POST HARVEST OPERATIONS

Wheat intended for long-term storage are exposed to living creatures (insects, microorganisms, etc.) and environmental conditions (temperature, moisture) that can adversely affect grain quality. Therefore, postharvest monitoring and aeration are the management components necessary to preserve the quality and quantity of on-farm stored wheat.

Monitoring
The quality of stored wheat is checked frequently to monitor insect populations and activity that can cause

deterioration of the grain. Grain damage can be prevented by detection of infestation early. Stored wheat is inspected either by observing the grain surface or samples scooped from the surface, samples collected with a probe, or determining moisture content and temperature of the samples. Samples are taken bimonthly when grain temperature is 55o or 60oF and monthly when temperatures are higher. Samples are collected using a grain probe (trier or deep bin cup probe) in the bin center, bin periphery or any location on the surface. The probe is inserted into the grain and the sample from various locations is composited for insect and grain quality analysis. Each sample is carefully examined for insects, damaged grain, flour, or other signs of infestations. Besides insect sampling, grain temperature, using temperature cables, and moisture are recorded to detect rising in temperature in locations where insect populations are increasing. The optimum temperature for stored grain is below 50 oF. The optimum feeding and reproduction of stored grain insects occur between 80o to 90 oF. Insects can develop to serious levels if grain moisture is above 12% and mold activity may double with each 10 oF increase. Therefore, area within the grain that shows a 20 oF or greater difference from the average bin wide temperature should be intensively sampled to verify development of “hot spots” (areas of high insect/mold activity).

Aeration

The use of aeration to maintain isothermal conditions within the grain mass and also cool the grain using ambient air is an effective strategy to reduce insect and mold incidence. Most of the grain is aerated immediately after storage. The temperature to which farmers cool stored wheat is between 35o and 40oF. Aeration is forcing ambient air through the grain mass to remove heat from the stored grain. Cooling helps retain the potency of the protectants and retards insect growth. Most Kansas bins, especially the larger ones, are equipped with aeration systems that are operated either shortly after harvest or until fall. Aeration controllers are used to facilitate cooling of the grain. Grain temperatures can be lowered enough during the summer to slow insect development. Besides cooling the grain, aeration minimizes moisture migration through the grain mass, limits insect development, maintains grain quality, and reduces chemical usage. Wheat can be stored for more than 6 months in facility equipped with aeration system. The simple aeration controller has a thermostat that senses air temperature and must be periodically reset. A programmable controller is set at the beginning of the storage season, typically senses the grain temperature as well as the air temperature and relative humidity. The controller turns the fan on when the outside temperature falls below the set point, turns off when the temperature rises above the set point.

Surveys

1999

During October and November 1999, 650 farmers were asked about their on-farm grain storage practices and chemical applications made to stored wheat, corn, soybean and sorghum for the 1998 crop year. For wheat, the chemical application period was June 1, 1998 to May 31, 1999. This document presents only results for wheat. Corn, soybean, and sorghum information are beyond the scope of this profile. Of the 650 farmers, 418 reported storing grain on-farm during that period, 148 did not store grain and the remaining did not answer the questions. Of the 275 million bushels of grain stored on-farm, wheat represented 26% of the total. Wheat by far was the most common grain treated with chemicals (71%) and was the most commonly fumigated grain (40%). All of the treatments were with insecticides. A total of 16,000 pounds of chemicals were applied. Of the 16,000 pounds, 39% was malathion, 38% was aluminum phosphide, and 23% was chlorpyrifos-methyl. Although more malathion was used, 37% of the stored wheat was treated with aluminum phosphide compared to 22% with malathion, because the rate of application of malathion was 0.41 lb/1,000 bushels compared with 0.23 lb/1,000 bushels for aluminum phosphide. Nineteen percent of wheat was treated with chlorpyrifos at a rate of 0.27 lb/1,000 bushels. Stored wheat was mostly treated during bin loading (49%) and in storage (44%). The latter is generally applied to the grain surface or to grain during grain turning (that is moving grain from one bin into another). Only 7% of wheat was treated while in-bound to farm storage. None of the wheat was treated while out-bound from the farm to elevators. The most common method of application of protectants was direct spray (40%). Aluminum phosphide tablets or pellets (39%) were mixed with the

grain.

1984-1986 and 1991

Data are extracted from surveying farmers and producers in the northwestern, north central, western, central, southwestern and south central Kansas regions during 1984 and 1986. The questionnaire survey was repeated in 1991. Answers to many of the questions for both surveys were similar, unless otherwise reported.

- The average on-farm storage capacity for wheat was 22,118 bushels per farm. Wheat was produced at more than 88% of the surveyed farm sites. In the central region, around 53% of the producers stored wheat on-farm, followed closely by the northwestern region (50%) and the western region with 49% of the producers. In the southwestern and south central regions, only 38% of the producers stored wheat on the farms. By 1991, 28% indicated that they no longer stored wheat on the farms.
- The average storage-bin age is around 27 years. Thirty-three percent of the bins are 30 years or older, while 50% of the bins are less than 20 years old.
- The percentages of respondents that reported using a specific type of pest control were similar in both surveys (1984-1986, and 1991). Most of the farmers (97%) swept their bins before filling and 76% removed debris from auger and cleaned spills around bins. More than 78% sprayed the empty bins with insecticide, 54% treated wheat with grain protectant during binning, only 28% applied protectant to wheat surface as top dress treatment, and 27% used protective fumigation. More than half of the farmers leveled the stored wheat after binning
- Most Kansas farmers (75%) stored on-farm wheat for 6 months or more. Although, 37% of the framers indicated they had stored old- and new-crop wheat close together, only 8% stored wheat from two crop years in the same bin.
- Harvested wheat was stored with 11 to 12% moisture level, as indicated by almost 30% of the farmers.
  1984-1986: One-third of on-farm stored wheat in Kansas was not chemically treated. The pest control measures practiced include empty bin and surface treatment (minimum treatment), grain protectant, fumigation, or protectant plus fumigation treatments. Most of the producers used protectant treatment that consists of minimum treatment plus garin protectant during filling, 31% reported using only minimum treatment, more than 15 and 12% of the farmers used fumigation or protectant and fumigation treatments, respectively.
  1991: About 51% reported that their farm-stored wheat has been fumigated during previous storage season. Twenty-five percent of them fumigated the same grain more than once and 15% used preventive fumigation and grain protectant. The majority of respondents (71%) used gain protectant during binning. More than half of the 71% eventually fumigated their stored wheat. Sixteen percent used neither fumigant nor protectant.
- Producers reported that 71% and 73% of the aerated stored wheat was treated with protectant and fumigants, respectively.
- The majority of the respondents (81%) inspected their wheat on a regular basis. More than 64% inspected every month, 22% every 5 to 6 weeks, few reported checking wheat every 2 weeks. Inspection and observation was done by several methods. Sixty-five percent of the surveyed monitored the stored wheat surface, 60% collected samples from the surface, and 59% took samples with a probe. Grain temperature was recorded from samples collected for insect inspection.
- **1984-1986:** Fifty-one percent used corrective fumigation. Liquid fumigant was used by 62% of the respondents, whereas 24% used solid form fumigant.
  1991: Seventy percent of the respondents reported using a solid fumigant, 21% used a liquid, 12% used both, and 7% used a gaseous fumigant. The respondents self-applied the fumigant (69%), only 13% had a commercial applicator fumigate their stored wheat. The use of a liquid fumigant was markedly reduced in central Kansas by December 31, 1985.
- **1984-1986:** More than 62% of the respondents aerated all their on-farm stored wheat. Of those, 74% began aeration immediately after storage, while 27% aerated in the fall. Of the respondents who aerated immediately

after storage, more than 60% reported operating the fans continuously and more than 13% operated fans during cooler times of the day. Seventy-five percent of the respondents that cooled during the fall ran the fans 24 hours per day. Farmers with large storage capacity reported using 3 or more aeration periods than those with smaller capacity. Producers (48%) cooled the wheat to 34o-40oF. The majority of the respondents (57%) operated their fans for 60 hour or less to cool the wheat to the set point, 20% operated the fans for 30 hours or less, and more than 16% for 120 hours or more.

1991: More than 63% aerated their stored wheat. Some farmers did not aerate the grain because their bins lacked an aeration system (28%). Only 8% of the farmers, who do have aeration system, did not use it for wheat. Of the farmers that aerated, 65% began cooling immediately after harvest, 35% did not aerate until fall. Of the respondents that waited until fall, the majority (47%) aerated during October, 23% in November, and only 18% began aeration in September. The fans were run for 2 days, as 15% indicated, while 20% operated the fans for 3 days. Overall, only 21% reported that the cooling time was between 150-300 hours. Most respondents reported more fans hours in 1991 than they did in 1986. Compared to 1986 survey, percent of farmers reported running fans for 120 or more hours increased to 23%, while those who operated for 60 or less decreased to 45%. In 1991, the set temperature ranged from 0o to 65oF, with a mode of 35oF. About 50% reported that target temperatures were between 32o and 40oF. Western farmers (39%) depend on aeration and fumigation, while 39% of the central third of the state did not have bins equipped with aeration systems.

- Although empty bins were sprayed with insecticides, more than 20% of the bins had light live insect infestation, 8% had moderate infestation, and 13% had heavy infestations. Therefore, it was concluded that spraying empty bins before infestation reduced but did not completely control insect populations. The sources of infestations were the auger and the auger ports, and the high populations around empty bins where insects enter the sprayed bins after treatment.
- Fumigation plus malathion treatment of bins with long-term stored wheat increased significantly from November to May. Only 13% were treated in November compared with 67% in May. Insect density in the wheat mass was the highest during late fall, especially in November. The majority of the inspected bins (75-100%) contained *Cryptolestes* spp., followed by the *Tribolium* spp. and *Oryzaephilus* spp.

Pesticide Residues in Wheat

The Pesticide Data Program (PDP) was implemented by the USDA in May 1991 to collect data on pesticide residues in foods. Pesticides monitored by the PDP are insecticides, herbicides, fungicides, and growth regulators in fresh and processed fruits and vegetables, and grain. PDP is a critical component of the Food Quality Protection Act (FQPA) of 1996, which mandated the USDA to collect pesticide residue data on commodities highly consumed by infants and children. These data are used by the USDA-EPA for its risk assessment process, and for the registration and special review of pesticides.

Between 1995 and 1997, wheat samples were collected from selected states in the U.S. including Kansas and Oklahoma. Samples were collected from non-farm storage facilities (grain elevators and commercial storage facilities), excluding wheat already segregated for export. Analysis of the wheat samples was performed by the Grain Inspection Packers and Stockyards Administration (GIPSA) laboratory for multiple pesticide residues and metabolites/ degradates/ isomers. More information on PDP and sampling collection and testing processes can be accessed at http://www.ams.usda.gov/science/pdp/download.htm

Table 1. Chlorpyrifos-Ethyl Residues in Wheat Samples Collected from Selected States, Crop Year 1995- 1997

	Unit	1995	1996	1997
Total samples collected	No.	600	340	623
Samples with detection	No.	117	49	40
	%	19.5	14.4	6.4
Min. value detected	ppm	0.005	0.010	0.010
Max. value detected		0.021	0.042	0.040
EPA tolerance level		**0.5**	**0.5**	**0.5**

Table 2. Chlorpyrifos-Methyl Detected Residue in Wheat Samples Collected from Selected States, Crop Year 1995-1997

	Unit	1995	1996	1997
Total samples collected	No.	600	340	622
Samples with detection	No.	325	249	346
	%	54.2	73.2	55.6
Min. value detected	ppm	0.002	0.002	0.002
Max. value detected		3.3	1.5	1.8
EPA tolerance level		**6.0**	**6.0**	**6.0**

Table 3. Malathion Residues in Wheat Samples Collected from Selected States, Crop Year 1995-1997

	Unit	1995	1996	1997
Total samples collected	No.	600	340	623
Samples with detection	No.	426	239	425
	%	71	70.3	68.2
Min. value detected	ppm	0.002	0.005	0.005
Max. value detected		2.9	1.0	7.6
EPA tolerance level		**8.0**	**8.0**	**8.0**

Table 4. Methoxychlor* Residues in Wheat Samples Collected from Selected States, Crop Year 1995-1997

	Unit	1995	1996	1997
Total samples collected	No.	600	340	617
Samples with detection	No.	6	16	32
	%	1.0	4.7	5.2
Min. value detected	ppm	0.013	0.012	0.012
Max. value detected		0.13	0.064	0.73
EPA tolerance level		**2.0**	**2.0**	**2.0**

*Methoxychlor is registered for treating empty grain storage facilities.

The detected residues of the most commonly used pesticides in empty facilities or on stored wheat were well below the EPA established tolerance level (Table 1-4).

Table 5. Chlorpyrifos-Methyl Residues Detected in at Least 10% of Wheat Samples Collected from Selected States, Crop Year 1997*

	Unit	1997
Total samples collected	No.	623
Samples with detection	No.	346
	%	55.6
Lower-Upper	Mean	0.059-0.060
50^{th}	%	0.003
75^{th}		0.034
90^{th}		0.181
90^{th}/Tolerance		0.030

* No data available for wheat in 1995

Table 6. Malathion Residues Detected in at Least 10% of Wheat Samples Collected from Selected States, Crop Year 1997*

	Unit	1997

Total samples collected	No.	623
Samples with detection	No.	346
	%	68.2
Lower-Upper	Mean	0.146-0.147
50th	%	0.008
75th		0.038
90th		0.266
90th/Tolerance		0.033

*No data available for wheat in 1995

Table 7. Percent of Wheat in the U.S. Treated at Grain Elevators of Selected States, Crop Year 1997

Insecticides	Wheat treated (%)
Chlorpyrifos-methyl	1.35
Malathion	1.47

The agricultural chemical use estimates, based on surveys of pesticide applied at the grain storage facilities (Table 7), showed that only 1.35% and 1.47% of the wheat was treated with chlorpyrifos-methyl and malathion, respectively, while the PDP results showed more than half of the collected wheat samples from elevators (Table 5-6) contained chlorpyrifos-methyl and malathion residues. The PDP results indicate that wheat brought from the on-farm storage to the elevators was already treated with chlorpyrifos-methyl and malathion pesticides, which points out that more pesticides are applied to the on-farm wheat than at the elevator to protect the quality of the grain. Losing chlorpyrifos-methyl and malathion labels for use on stored wheat will negatively impact the quality of stored wheat in the U.S.

Outlook for New Registrations

1. **Spinosad (SpinTor 2SC, Dow AgroSciences LLC)**
   Spinosad is a naturally derived reduced-risk pesticide that is currently registered for over 250 crops in over 52 countries including the United States. Although, it is not registered for use on stored grains, an experimental use permit for testing Spinosad on stored grain was approved by the EPA in May of 2002. Under this permission, Spinosad was tested on stored barley, corn, oats, rice, sorghum/milo, and wheat in Arkansas, Georgia, Indiana, Kansas Minnesota, Montana, and Oklahoma. Laboratory and field tests have shown

Spinosad at 1 ppm to be stable on stored wheat for 1 year and effective in managing several species, including the lesser grain borer, Rhyzopertha dominica (F.), a devastating pest of stored wheat. Spinosad was approved as a grain protectant at 1 ppm in January of 2005. The tolerance level has been set at 1.5 ppm. Because international tolerances for Spinosad are not in place, this product is currently unavailable for use as a grain protectant. The product for use on wheat will be sold under the trade name, Secure, and this product may be available for use on stored wheat by the end of 2006 or early 2007.

2. **Methoprene**
   The insect growth regulator methoprene was labeled for use on stored grain in the 1980s, but was not extensively used and was removed from the market. Methoprene is registered for use on stored grains, and the trade name for the product is Diacon II. Expected application rates will be 1-5 ppm, depending on the target species (Arthur, personal communication). This product will not kill adults but will provide long-term population suppression of key species in stored wheat.
3. **Storicide I and II**
   Storicide I is a combination product consisting of 2 ppm cyfluthrin (a synthetic pyrethroid), and 3 ppm chlorpyrifos-methyl (Reldan). It was approved for use on stored seeds as of October 2002. It is effective against lesser grain borer and weevils and other species associated with stored wheat. Because there are no international tolerances for Storicide I it is primarily intended for use on seed wheat only. Recently, storicide II containing 2 ppm cyfluthrin and 0.5 ppm deltamethrin was approved as a grain protectant. Deltamethrin has international tolerances and this product can be used on stored wheat intended for food.

Insect, Vertebrate, and Mold Pests

In Kansas, insects are more serious problem for stored grain than molds. Wheat is harvested dry, thus molding occurs infrequently. Insects do not infest the grain in the field, therefore, infestation of newly harvested wheat occurs after storage from insects migrating from sites near the storage facility. Flat or rusty grain beetles, flour beetles, sawtooth grain beetles, and lesser grain borers are the most serious insects present in stored wheat. Lesser grain borer is found in increasing numbers through fall and early winter. Damages form storage insects include riddle kernels (insect damaged kernels or IDK), test weight reduction, presence of insect waste products and parts, etc. The two types of stored grain insects are internal-infesting and external-infesting insects. The internal insects feed and develop internally in the kernels of cereal grains. Most of the insect fragments found in processed foods are from the internal insects.

INTERNAL INSECTS

Insects that live and feed inside kernels and larvae bore holes through the grain. These species contribute to the IDK and thus are considered serious pests. The Defect Action Level for stored wheat intended for milling with respect to IDK is 32 IDK/100 g of sample. However, millers are conscientious and reject wheat having more than 5 IDK/100 g.

Lesser Grain Borers (*Rhyzopertha*)are commonly found in warm conditions, and can cause serious problem to the stored grain. Adults are small, shiny, dark brown to reddish, 1/10 to 1/8 inch long, cylindrical in cross section, 1/32 inch wide with the head pointed downward from under the prothorax. The wing covers have many small pits. Eggs are laid on the surface of the kernel either singly or in clusters. After hatching, larvae burrow into the kernel to feed and develop to adult stage. The adults chew their way out of the grain and continue to feed on the whole kernel. The adults and larvae have powerful jaws that are used to riddle the grain, creating large, irregular-shaped holes. Heavy infestation with lesser grain borer can be identified by a sweetish, musty odor in the storage. This insect is found soon

after the grain is in storage but populations tend to peak during fall and early winter. This species can tolerate low grain moisture and high temperatures. It is an excellent flier and has been captured outside grain bins and in several non-agricultural habitats. It has been reported that lesser grain borer is resistant to may insecticides including chlorpyrifos-methyl, but it is extremely susceptible to Spinosad.

Rice Weevil (*Sitophilus oryzae*) is a serious pest of stored grain, especially in off-farm storage facilities, and is rarely found in on-farm stored wheat. Rice weevil infests other grain besides rice. Adults can fly in warm conditions and cause serious damage to corn, wheat, and other grains before harvest. The insect is usually found in the whole grain of stored wheat, corn, rice, and sorghum. Infestations in storage occur from filling bins with infested grain or the already infested bins. Adult is 1/8 inch long, dark reddish to black, cylindrical body with large, red or yellow spots on the wing covers. Wings are fully developed under the wing covers. Head is elongated into a snout with strong teeth at the end. The larva is white, wrinkled and legless. Adult chews a hole in the kernel, deposit an egg and seals the hole with gelatinous material. After hatching, larvae feed and develop to adult stage inside the kernel before chew their way out and continue feeding on the grain. Life cycle of this insect may be completed in 27 or 35 days, depending on favorable conditions. Damage from rice weevil is caused from larvae feeding mostly within the kernels. Larvae can destroy 25-30% of the wheat kernel, which drastically reduces the market value of wheat.

EXTERNAL INSECTS

Insects which are unable to penetrate the whole grain, feed and live on broken kernels, grain dust, fungi, and milled grain products, causing less damage than primary insects. Although, they do not contribute to IDK, they contaminate the grain with their body parts. If two or more live of external feeders insects are found in the sample, grains are referred to as “infested grain”.

Rusty Grain Beetle (*Cryptolestes ferrugineus*) are common in Kansas stored grain. They are similar to the flat grain beetles except that the female and male antennae are the same length and only ½ the body length. The prothorax of the male is slightly longer than broad and tapers toward the posterior. Eggs are deposited in the cracks or furrows on the grain surface. After hatching, larvae feed in the germ layer of the wheat kernel. Rusty grain beetle feeds on the germ of kernels. Large numbers of this species are commonly found in stored wheat, but they do not cause extensive damage.

Flat Grain Beetle (*Cryptolestes pusillus*) is a tiny beetle that feeds on germs of the commercially stored grains, especially wheat. Adults are flattened, oblong, reddish-brown in color, and 1/16 inch long with long and slender antennae about ½ to 2/3 of the body length. The prothorax of the females is nearly square; while that of the male narrows slightly toward the posterior. Female deposit eggs on the surface of the grain, and the hatched larvae feed on the germ layer of the wheat kernel. The insects reproduce faster when broken kernels and fine materials are present in the stored grain. Although, this insect is the most common pest of off-farm stored wheat, it does not cause serious feeding damage to the grain.

Red Flour Beetles (*Tribolium castaneum*) are common in stored wheat. Adults are flattened, oval in shape, 1/7 inch long, shinny, and reddish-brown in color. The last three segments of antennae enlarge to form a club-shaped tip. Larvae are 3/16 inch long, cylindrical, whitish yellow with 2 small pointed-spines on the tail end. They reproduce faster when some fine material is present in the stored grain. Beetles can grow rapidly on undamaged grain, especially if grain moisture is more than 12%. A pungent, bad odor in the grain is a sign of high infestation with red flour beetles. Contamination also occurs from dead bodies and waste products.

Sawtoothed Grain Beetle (*Oryzaephilus surinamensis*) is one of the most common insects in Kansas on-farm stored

grain. The larvae develop in flour, cereal products, and many other dried products. Adults are flattened, narrow, dark-brown, 1/10 to 1/8 inch long, and the space behind the eye is greater than ½ the eye diameter. They are recognized by the sawtooth projections on the sides of the middle segment, while larvae are white to yellowish and reach 1/10 inch long at maturity. Eggs are deposited on cracks in the kernels. The adults and larvae feed on damaged kernels, on fines, and may attack germ of intact grain.

Vertebrates

Each year rodents and birds destroy or contaminate enormous amounts of stored grain. One rat eats about 50 pounds of grain per year, wastes twice that much, and contaminates much more. Inspection for rats and mice are an essential part of protecting stored grain from loss and contamination. Eliminating weeds, refuse piles, overgrown vegetation, and rubbish piles around the storage facility should always be practiced to limit places where rodents can hide and nest. However, generally in Kansas field rodents are not a problem in stored grains. Birds eat and contaminate large quantities of grain. Bird control, like rodent control, is important from a health as well as economic standpoint. All openings should be closed to prevent birds from entering the facility or grain should be stored in bird-proof facilities.

Mold

When insects and vertebrates are controlled, fungi are often the major cause of reduction in the quality of stored grains. The prevention of damage by storage fungi is by keeping stored grains under conditions that are unfavorable for fungi growth. The major storage fungi comprise only few species of *Aspergillus* that can live without free water:

- **Aspergillus restrictus** kills and discolors germs, giving them a purplish-black cast. The fungi are major cause of germ damage in wheat and corn stored at moisture level at or just above the lower limits for their growth. Aspergillus restrictus grows too slowly to cause heating, thus the damage may be done without detectable increase in temperature. The fungus is closely associated with the granary weevil and the rice weevil. If these insects are controlled by fumigation, Aspergillus restrictus development may continue.
- **Aspergillus glaucus** kills and discolors the stored cereal seeds. It causes mustiness, and caking, by which time molding is evident to naked-eye inspection. It can grow slowly but cause no damage between 36-41oF. Most cases of fungus-caused spoilage involve an increase in Aspergillus glaucus, especially in earlier stages.
- **Aspergillus canadidus** kills and discolors germs very rapidly and causes heating up to 131oF, by which time the grain is totally spoiled. Invaded and heated grain by Aspergillus canadidus will be susceptible to bacterial invasion as well.
- **Aspergillus ochraceus** kills and discolors germs and caused advanced spoilage. Some strains of this fungus produce ochratoxin. It thrives under the same conditions as Aspergillus canadidus and Aspergillus glaucus but can not compete effectively with them. Although, it is isolated from smaller percentage of spoiled seeds compared to seeds with Aspergillus canadidus and Aspergillus glaucus, its presence in even small percentage is evidence that spoilage is underway.
- **Aspergillus flavus** kills and discolors germs, decays and discolors whole kernels, and cause rapid heating up to 131oF. Some strains growing under some conditions produce aflatoxins. The presence of Aspergillus flavus is evidence that partly spoiled grain was mixed with the lot before the grain was loaded into the bin or that spoilage is under way.

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