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Phillip Harein, Ronald Gardner, and Harold Cloud*

In 1984, Minnesota was ranked fifth in corn production and seventh in wheat production on a national basis. Unfortunately, about 10 percent of this grain will be lost in storage as a result of insect damage. The U.S. Department of Agriculture surveyed stored grain from 27 states in 1978-81 and examined the samples for insects and damage (Storey et al. 1983). Based on Storey's report, wheat samples in Minnesota had the highest incidence (42.9 percent) of insects compared to all the other states. Of the six states that contributed most of the corn samples, Minnesota's corn also had the highest incidence of insect infestation (83 percent). These data (Storey et al. 1983) agree with those from another stored grain survey conducted in Minnesota during the same period. In that survey, 40 to 90 percent of all farm-stored wheat and corn inspected was infested with insects (Barak and Harein 1981). A more recent publication on damages in Minnesota from insects (Noetzel et al. 1985) estimated that the total annual dollar loss due to postharvest insects in corn, wheat, oats, and barley in Minnesota was $54.9 million.

To determine some of the reasons for high insect damage to stored grain, we developed a questionnaire on grain storage management in cooperation with the Minnesota Department of Agriculture and mailed it to 1,600 Minnesota stored grain managers (commercial and private). The following information is based on the data collected from the 300 completed questionnaires returned. It can be used to assist Minnesota corn and wheat managers in making future decisions regarding proper grain storage.

Based on the survey, about three-fourths of the storage was in round metal bins; wooden granaries and flat storage provided the remainder (table 1). Although a greater percentage of wheat than corn was stored in round metal bins (table 2), the average capacity of the corn bins was almost 8,000 bushels greater than that of the wheat bins. More bushels of corn than wheat were stored in wooden granaries. Flat storage was used to about the same extent for both crops.

Bin preparation is one of the key elements in getting ready for the next harvest. Cleaning the bin walls and floors of dust and grain residue is extremely important for reducing subsequent insect activity. Grain managers in Minnesota apparently agree; our survey showed that 90 percent followed this sanitation recommendation.

Bin loading (filling) practices also play an important role in successful grain management. Proper bin filling with a grain spreader reduces the formation of a dense cone of grain dust and fines in the spoutline area. Insect infestations in the spoutline area occur often and are difficult to control.

Screening the grain is also helpful in obtaining a uniform grain mass, as well as in reducing the number of storage insects. Based on the questionnaire responses, however, this practice was not used widely.

Filling the bin to the peak does not permit adequate stored grain inspection or treatment. Based on the survey, 63 percent of the corn and 55 percent of the wheat in storage was leveled as recommended. It may be necessary to overfill the bins at harvest, but it is important to remove enough grain soon afterwards to a level below the top of the vertical bin walls. Removing excess grain from the spoutline area also reduces the relatively dense core of grain fragments. Cleaning spilled grain from around the bins and removing grain from conveyers and other grain handling equipment were recommended practices followed by 78 percent of the corn managers and 71 percent of the wheat managers.

The average moisture content of the stored corn was 13.7 percent; for wheat it was 12.7 percent. Both levels of moisture are sufficient to support insect activity; however, it would not be

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economical to control insects by drying grain. Temperature is the important factor. Generally, the higher the temperature the shorter is the time that grain can be stored safely at any moisture level.

After the grain is in storage, periodic monitoring is necessary for determining its storability. Generally the longer that grain is stored the greater is the potential for losses from various stored grain insects. The quality of stored grain decreases constantly, but the rate at which it decreases depends on many factors, of which moisture and temperature are most important. Based on responses to our questionnaire, monitoring and inspecting the grain at regular intervals was practiced by the majority of storage managers (table 3). The time between inspections was often too long. Some respondents reported that five months would pass before they rechecked the grain. Also, the inspections usually consisted of just looking at the surface of the grain (table 4). Unfortunately, the condition of the grain below the surface may be entirely different from that of the grain that can be seen, particularly in regard to insect activity. The beetles that are currently infecting our stored corn and wheat are extremely small and their presence may not be apparent unless grain samples from various surface areas and depths are screened to separate out the insects. Based on the survey, removing grain samples from the bin was practiced less frequently than just visual inspection and most grain samples were just scooped from the surface (table 4). Grain probes to obtain samples below the surface were used only one-third of the time.

As stated earlier, the temperature and moisture of the grain are of primary importance in maintaining its storability. But, according to our survey, grain moisture or temperatures were checked only 20-25 percent of the time (table 4). When temperature was determined, it was done on the average of every two weeks for corn and every five weeks for wheat. Grain temperatures should be determined every week if the average is 55° F. or higher. The temperature should be determined near the grain surface if the air is pushed up by the aeration fan. Temperatures can be checked at the exhaust of the fan if the air is pulled down. Only average grain temperature can be obtained from the fan exhaust; however, surface temperatures taken from a number of areas provide more detailed information on the temperature differences within the grain mass.

The aeration of bulk stored grain during its time in storage is an important management tool in Minnesota. The temperature of grain can be reduced in the fall and winter and increased in the spring. In general, the temperature of the grain should be within 20° F. of the average monthly air temperature to prevent excessive moisture migration and condensation within the grain mass.

Aeration systems can either be included in storage facilities when the bins are erected or they can be added later. Based on our survey, too many (42.6 percent) of the round metal bins lacked aeration facilities (table 5). The remainder of the round metal bins either had duct aeration or they were equipped with both drying and cooling systems. About 50 percent of the flat storages were also without aeration, and only 14 percent of the wooden granary bins had aeration facilities.

Most aeration systems will move at least 0.1 cubic foot per minute per bushel. At this airflow rate the fans must run for about 150 hours (six 24-hour days) to obtain a uniform grain temperature throughout the grain mass.

The grain should be aerated as soon as it is delivered to the bin. Grain that has just been combined or dried will be warmer than ambient air temperatures, so immediate aeration will be beneficial. About 72 percent of the corn storage managers and 67 percent of the wheat storage managers followed the recommendation to start aerating as soon as the grain was binned (table 6). Of most concern were those managers (48-50 percent of the respondents) who practiced aeration sometime after the grain was stored and then by running the fan only for select periods of time. Our interpretation of select periods means something other than running the fan continuously.

The recommended grain storage temperature during winter in Minnesota is 25° to 35° F. Grain storage managers who responded to our survey reported, on the average, that they did not cool grain below 39° F. and did so with an average fan time of 66.7 hours (table 7). As stated earlier, it is necessary to run fans (0.1 cubic foot per minute per bushel) continuously for more than twice this fan time (150 hours) to aerate grain properly. The important thing to stress is that the fans must be run enough to change the temperature of all the grain in the bin and keep it uniform. The only way to know when this has been is accomplished is to monitor grain temperature.

Most (70 percent) of the corn managers and about 50 percent of the wheat managers aerated their grain in the spring, as documented in table 8. This warmup procedure should be followed by all grain storage managers unless the grain is to be removed from storage by July 1. Stored grain should be warmed up to 50°-60° F. in April and May if it is to remain in storage through the summer.

As indicated earlier, the most serious mistake in aeration management is not running fans often enough or long enough. The purpose of aeration is to maintain proper grain temperature and fans should be operated on that basis. Running aeration fans during periods of high humidity or during short rainy periods will not produce a high grain moisture problem. In fact, overdrying grain may occur if fans are operated only during periods of low relative humidity and if fan running time is excessive.

Turning stored grain periodically during prolonged storage may help in maintaining its quality if kernel breakage can be kept to a minimum. Perhaps additional kernel damage plus the lack of adequate grain handling systems on the farm are the primary reasons why no more than 27 percent of the stored wheat or corn managers who responded turned their stored grain.

Malathion is the most frequently used residual insecticide for application to stored grain. Based on our survey, 13 percent of the corn and 23 percent of the wheat received this treatment (table 9). Unfortunately many stored grain insects (especially the Indianmeal moth) are becoming resistant to malathion. An alternate treatment for controlling the Indianmeal moth is the insecticide pest strip. These strips contain 20 percent dichlorvos. They should be suspended in the overhead space of the grain bin in the spring just as soon as average overhead grain temperatures are 50° F. or higher. The dichlorvos vapors kill the adult moths before they can lay eggs. Based on our survey, only 7 percent of the grain managers reported using this application procedure to control moths (table 9).

The preventive practices to manage stored grain insects are expected to increase because of the loss of liquid grain fumigants from the market. These fumigant formulations, composed primarily of carbon tetrachloride and carbon disulfide, are no longer manufactured and current supplies will not last beyond 1985. As expected, and as documented in the results of our questionnaire, a low percentage (1.3 percent) of the stored corn and 2.6 percent of the stored wheat was fumigated (table 10). Most (82-93percent) of these grain fumigants were self-applied (table 10). Self-application will soon disappear, however, because of new safety requirements imposed by the Federal Environmental Protection Agency. These regulations will require fumigators to monitor gas concentrations at extremely low levels and to wear expensive safety equipment, a requirement that will be economically unfeasible for most farmers.

Most grain elevator managers either discount infested grain that comes to their elevator or require payment for fumigation procedures, as noted in table 11. The average discount for selling grain that was both moldy and insect-infested during 1984 was $0.17 per bushel for corn and $0.33 per bushel for wheat (table 12). The cost of treating the grain was believed to be considerably less than these discounts.

Based on the above information, it is apparent that stored grain management practices should be improved to prevent the significant losses that occur.

A compilation of the raw data generated via the questionnaire (appendix I) on stored grain and wheat management appears in appendix II. These data support the trends emphasized in this publication and the figures cited in tables 1-12. They also provide additional statistics on other grain storage techniques, policies, and problems.

Literature Cited

Barak, A. V., and P. K. Harein. 1981. Insect infestation of farm-stored shelled corn and wheat in Minnesota. J. Econ. Entomol. 74: 197-202.

Noetzel, D. M., L. K. Cutkomp, and P. K. Harein. 1985. Estimated annual losses due to insects in Minnesota. Univ. of Minn. Ag. Ext. Serv. AG-BU-2541. 48 pp.

Storey, C. L., D. B. Sauer, and D. Walker. 1983. Insect populations in wheat, corn and oats stored on the farm. J. Econ. Entomol. 76: 1323-1330.

Table 1. Percentage of Corn and Wheat in Different Storage Facilities

Storage Type	Number of Bins Reported	Percentage of Total Bushel Capacity
Round metal bins	1,564	77.3
Wooden bins (granaries)	610	15.0
Flat storage	151	7.7

Table 2. Storage Structure Types Used for Corn and Wheat

	Corn			Wheat		
Storage Type	Percent Corn Bins	Percent Bushels Stored	Average Bushel Capacity	Percent Wheat Bins	Percent Bushels Stored	Average Bushel Capacity
Round metal bins	58.9	72.3	22,437	71	77.3	14,788
Wooden granaries	33.9	19.5	4,660	21	12.9	7,382
Flat storage	7.2	8.2	54,176	8	9.8	53,111

Table 3. Grain Storage Inspection

	Corn	Wheat
Inspected grain	84%	82%
Average interval between inspections	3 wk	4 wk
Range of inspection intervals	1-20 wk	1-20 wk

Table 4. Inspection Techniques Used by Grain Managers

Technique	Percentage	
	Corn	Wheat
Looked at grain surface	63	61
Sampled grain with probe	31	38
Sampled grain at surface	45	49
Determined moisture of sample	25	20
Determined temperature of sample	22	23
Used temperature probes	19	21
Used temperature sensors	5	2
Utilized temperature monitoring systems	6	8

Table 5. Corn and Wheat Bins Equipped for Aeration

Storage Type	Percentage of Bins		
	No Aeration	With Aeration	Drying and Cooling Systems
Round metal bins	42.6	41.6	15.7
Flat storage	50.4	49.6	-
Wooden bins	86.0	14.0	-

Table 6. Aeration Practices

	Percentage	
	Corn	Wheat
Aerated the grain	79	50
Began aerating immediately after grain stored, continuously (day & night)	40	38
Began aerating immediately after grain stored, for selected periods of time	32	29
Began aerating later, continuously (day & night)	18	12
Began aerating later, for selected periods of time	48	50

Table 7. Temperatures for Cooling Grain

	Corn	Wheat
Average temperature of grain cooled	39° F.	41° F.
Percentage of managers who didn't aerate to a specific temperature	48%	62%
Average number of fan hours to get desired temperature	66.2 hr	67.2 hr

Table 8. Frequency and Months When Grain Temperature Is Increased in the Spring

	Percentage	
	Corn	Wheat
Warmed grain in spring:	70	52
March	18	23
April	40	37
May	21	37
June	2	3

Table 9. Frequencies of Insecticide Application to Stored Grain

Treatment	Percentage	
	Corn	Wheat
Applied insecticide to grain flow as being stored	13	23
Applied insecticide to grain surface after completing storage	16	19
Used insecticide pest strip	7	7

Table 10. Fumigant Application Data

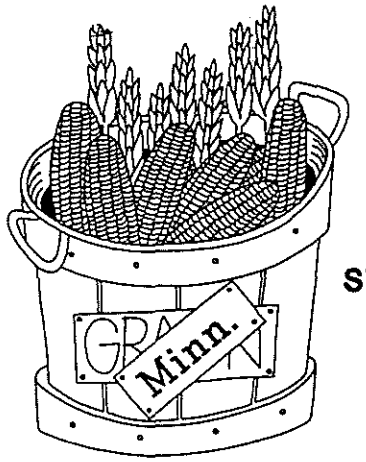
	Percentage	
	Corn	Wheat
Amount of stored grain fumigated	1.3	2.6
Fumigant self-applied	82.0	93.0
Fumigant commercially applied	18.0	6.0

Table 11. Elevator Practices When Receiving Insect-Infested Grain

Action Taken	Percentage	
	Corn	Wheat
Refused the grain	26	24
Fumigated the grain and charged accordingly	23	25
Discounted the grain	31	27
Received grain without discount	3	3

Table 12. Discounts for Insect-Infested or Moldy Grain

	Average Discount/Bushel	
	Corn	Wheat
Insect-infested grain	$0.08/bu	$0.11/bu
Moldy grain	0.09/bu	0.22/bu



A Survey by the
University of Minnesota &
Minnesota Department of Agriculture

STORAGE FACILITIES and INSECT MANAGEMENT PRACTICES IN FARM-STORED CORN and WHEAT

SECTION I. STORAGE STRUCTURES & EQUIPMENT

Please indicate below the type, number and capacity (bushels) of the farm structures you normally use for storing corn and wheat. Do not include those structures you normally use for storing other grain or unshelled corn.

	How Many	Total Bushel Capacity Of This Type
ROUND METAL BINS:		
1. Bins with no aeration.....		
2. Bins with duct or pad aeration.....		
3. Bins with other aeration types Explain_____.....		
4. Bins with full perforated floor (drying or cooling).		
5. Total round metal bins used for CORN.....		
6. Total round metal bins used for WHEAT.....		
FLAT STORAGE (Quonsets, Machine Sheds, Etc.) :		
7. With aeration.....		
8. Without aeration.....		
9. Total flat storage units used for CORN.....		
10. Total flat storage units used for WHEAT.....		
WOODEN BINS (Granaries, Etc.) :		
11. With aeration.....		
12. Without aeration.....		
13. Total wooden bins used for CORN.....		
14. Total wooden bins used for WHEAT.....		

15. OTHER STORAGE: Please describe any other structures you use for storage and indicate the bushel capacity.

Corn:_____

Wheat:_____

SECTION II: PEST CONTROL & STORAGE PRACTICES

The experienced producer is the best source of information about which pest control methods are the most appropriate for the farm storage situation. Please read the following list and check (✓) ONLY THOSE PRACTICES YOU ACTUALLY FOLLOWED the last time you stored grain on the farm. (✓ = yes)

During the 1983-84 storage season (or whenever you last stored corn or wheat on the farm) did you:

	CORN	WHEAT
26. Empty and sweep or otherwise remove residue from the bin before adding new grain?		
27. Spray or dust the bin with insecticide before filling the bin?		
28. Use a grain spreader when filling the bin?		
29. Clean the grain before storage?		
30. Apply an insecticide, spray, or powder TO THE GRAIN as a protectant as the grain was stored?		
31. Level the grain after the last load was added to the bin?		
32. Clean up spills around the bins and remove residue from the conveyor?		
33. Unload center after filling the bin?		
34. Fumigate grain as a precautionary measure (before major infestation was noted) to be safe?		
35. Hang an insecticide strip (No-Pest Strip, etc.) in the top of the bin?		
36. Apply an insecticide spray or powder to the surface of the grain in the bin? → IF YES GO TO:		

	Insecticide Used (Name & Formulation)	Amount Used
CORN.....		
WHEAT.....		

The moisture content and location of stored grain may also determine how easy it is to store without pest damage. Please answer the following questions pertaining to moisture content and location. Check (✓) either yes or no.

37. The last time you stored corn or wheat, what was the percentage moisture content when it was put in storage: → CORN [ ]% WHEAT [ ]%

	CORN		WHEAT	
	Yes	No	Yes	No
38. Did you have corn or wheat from previous years stored at the same time?				
39. Did you store corn or wheat from different crop years in bins close (less than 40 feet) to one another?				
40. Did you store corn or wheat in bins close to feed grains?				
41. Have you ever noticed musty or mold-caked grain developing in a bin?				

If YES to BOTH:

a. In what area of the bin have you found this condition:
___Northwest side ___Southeast side ___Other (_____)

b. What action have you taken, if any, to solve any existing mold problems?
___Aeration ___Turned grain ___Dried grain ___Other (_____)

The following questions relate to fumigation of farm-stored grain after an insect infestation has been discovered. If you did not fumigate your STORED GRAIN during the 1983-84 storage year, skip to Section III.

	CORN	WHEAT
42. Did you fumigate your stored grain during the 1983-84 storage year? → IF YES, GO TO:		

	No. of Bushels Fumigated	Fumigant Used (Name & Formulation)	Amount Used	Applied by: (check) Self	Applied by: (check) Commercial
CORN.....					
WHEAT....					

SECTION III: BIN INSPECTIONS

When grain is stored over long periods, many producers periodically check the condition of the stored grain. How often did you inspect your farm-stored grain and what techniques did you use to monitor its condition?

34. Did you inspect your stored grain at regular intervals?

CORN: ☐ No ☐ Yes → If yes, how often? Every ☐ weeks
WHEAT: ☐ No ☐ Yes → If yes, how often? Every ☐ weeks

35. How do you inspect it? Check (✓) as many as appropriate

	CORN	WHEAT
a. By looking at samples taken with a probe		
b. By looking at samples scooped from the surface		
c. By looking at the grain surface		
d. By taking the moisture content of samples		
e. By measuring the temperature of samples		
f. By taking the temperature of the bulk grain with a probe		

g. Other inspection methods: CORN (Explain)_____
WHEAT (Explain)_____

36. Do you have a temperature monitoring system (cables or sensors) in your grain storage area:

CORN ☐ No ☐ Yes If yes, how often do you check the temperature: Every ☐ weeks

WHEAT ☐ No ☐ Yes If yes, how often do you check the temperature: Every ☐ weeks

One of the major costs associated with quality deterioration in farm-stored grain is the price discount or fumigation charge applied when damaged or infested grain is sold. Please answer the following questions about price discounts for corn or wheat based on your experience and the elevators you normally trade with. If you've never received price discounts or don't know the answer, go to Section IV.

37. If the corn or wheat you sold contained live insects, what action is taken? Check (✓) as many as appropriate

	CORN	WHEAT
a. They refuse it till it's fumigated		
b. They receive it, fumigate it, and charge the cost of the fumigant		
c. They receive it but discount the price per bushel		
(How much? Corn_____/bu. Wheat_____/bu.)	XXXXXXXXXXXXXX	XXXXXXXXXXX
d. They receive it without discount or charge		
e. Their policy seems to vary		

38. Does the elevator you deal with discount the price because of odors or insect-damaged kernels IN ADDITION TO what's charged for live insects?

CORN: ☐ No ☐ Yes → If yes, how much per bushel? $☐

WHEAT: ☐ No ☐ Yes → If yes, how much per bushel? $☐

39. Does the elevator you deal with discount the price because of musty, or otherwise mold-damaged grain (for example, blue eye)

CORN: ☐ No ☐ Yes → If yes, how much per bushel? $☐

WHEAT: ☐ No ☐ Yes → If yes, how much per bushel? $☐

40. Based on your experience over a 5- to 10-year period, which costs more: the occasional price discount fc infested or damaged grain, or the cost of the chemicals or other measures you would have to apply to prev the infestation or damage?

CORN: ☐ The chemicals cost more ☐ The price discounts cost more

WHEAT: ☐ The chemicals cost more ☐ The price discounts cost more

41. Have you ever experienced livestock health problems if moldy grain was included in the ration?

☐ No ☐ Yes → → If yes, explain:_____

SECTION IV: AERATION AND TURNING OF STORED GRAIN

42. Do you aerate or turn your stored CORN? ☐ Yes ☐ No your stored WHEAT? ☐ Yes ☐ No
(If no to both corn and wheat, skip all remaining questions)

43. Do you aerate ALL stored CORN? ☐ Yes ☐ No ALL stored WHEAT? ☐ Yes ☐ No
If not, please explain how you determine WHICH should be aerated:

CORN: _____

WHEAT: _____

44. When do you usually BEGIN aerating? Check (✓) the appropriate one

	CORN	WHEAT
Immediately after storage, continuous (day & night).....		
Immediately after storage, selected periods of time.....		
Later, continuous (day & night).....		
Later, selected periods of time.....		

45. How many times during the year do you aerate a bin of grain to get it to the temperature you want?

CORN ☐ Times WHEAT ☐ Times

46. To what temperature do you usually cool grain?

a. CORN: ☐ Degrees F. ☐ I don't aerate to any specific temperature

b. WHEAT: ☐ Degrees F. ☐ I don't aerate to any specific temperature

47. How many hours per bin do you run the fan to get the entire bin to the desired temperature?

CORN ☐ Hours WHEAT ☐ Hours

48. If you cool your grain in the fall, do you also warm it again in the spring with aeration?

a. CORN: ☐ No ☐ Yes → If yes, when do you usually start warming it?

March ☐ April ☐ May ☐ June ☐ Other ☐

b. WHEAT: ☐ No ☐ Yes → If yes, when do you usually start warming it?

March ☐ April ☐ May ☐ June ☐ Other ☐

49. What information do you use to decide how many hours to run the aeration fans?
Check (✓) the source you use:

☐ State extension bulletins ☐ Your own experience

☐ Aeration equipment manufacturer's manual ☐ Neighbor's advice

☐ Other (Explain: _____)

50. Do you turn your grain as part of your storage strategy?

CORN: ☐ No ☐ Yes — WHEAT: ☐ No ☐ Yes →

IF YES, WHEN?

	CORN	WHEAT
January.....		
February.....		
March.....		
April.....		
May.....		
June.....		
July.....		
August.....		
September.....		
October.....		
November.....		
December.....		

WE APPRECIATE YOUR COOPERATION

ON THIS SURVEY

--THANK YOU!--

APPENDIX II
Data From Survey

	Bushels	Percentage Bushels
Total Storage Capacity	267,359,034	100.00
Storage Without Aeration	80,046,414	29.90
Storage With Aeration	187,312,620	70.06

Corn Storage	Number of Bins	Percentage Bins	Bushels	Percentage Bushels
Total Storage Capacity	1,223	100.0	154,514,062	100.00
Corn in Round Metal Bins	721	58.9	111,664,262	72.26
Corn in Flat Storage	88	7.2	12,673,600	8.20
Corn in Wooden Bins	414	33.9	30,176,200	19.52
Concrete Silo (note silo data not included in total storage figures above)	10		101,098,690	

Wheat Storage	Number of Bins	Percentage Bins	Bushels	Percentage Bushels
Total Storage Capacity	500	100	64,811,036	100.00
Wheat in Round Metal Bins	355	71	50,127,382	77.34
Wheat in Flat Storage	40	8	6,339,004	9.78
Wheat in Wooden Bins	105	21	8,344,650	12.87

Storage Types	Number of Bins	Percentage Bins	Bushels	Percentage Bushels
Total Round Metal Bins	1,564	100.0	202,131,130	100.00
No Aeration	667	42.6	40,719,010	20.14
Duct Aeration	651	41.6	126,818,970	62.74
Drying & Cooling Bins	246	15.7	34,593,150	17.11
Total Flat Storage	151	100.0	20,073,504	100.00
No Aeration	75	49.6	6,281,504	31.29
With Aeration	76	50.3	13,792,000	68.70
Total Wooden Bins	610	100.0	39,377,900	100.00
No Aeration	524	86.0	33,045,900	83.90
With Aeration	86	14.0	6,332,000	16.10

	Percentage		Frequency	
	Corn	Wheat	Corn	Wheat
Empty and sweep or otherwise remove residue from the bin before adding new grain.....	90	90	208	103
Spray or dust the bin with insecticide before filling the bin.....	35	41	80	47
Use a grain spreader when filling the bin.....	35	10	80	12
Clean the grain before storage.....	35	13	81	15
Apply an insecticide, spray, or powder TO THE GRAIN as a protectant as the grain is stored....	13	23	30	27
Level the grain after the last load is added to the bin.....	63	55	145	63
Clean up spills around the bins and remove residue from the conveyor.....	78	71	180	82
Unload center after filling the bin.....	31	14	71	16
Fumigate grain as a precautionary measure (before major infestation was noted) to be safe.....	8	14	19	16
Hang an insecticide strip (No-Pest Strip, etc.) in the top of the bin.....	7	7	16	9
Apply an insecticide spray or powder to the surface of the grain in the bin.....	16	19	38	22

Insecticide (Fumigant) Spray or Powder Applied to Surface of the Grain in the Bin

Insecticide	Number of Uses	Percentage of Use in Corn
Malathion	12	32
Malathion 6% Dust	4	11
Malathion 57%	9	24
Phostoxin	1	3
Vapona Strip	1	3
Unknown	2	5
Deepkill	2	5
Weevil-Cide	1	3
Farmland Ind. 6% Grain Pro	1	3
80-20	1	3
Vulcan Formula 82-h	1	3
Larvacide	1	3
Sevin 6	1	3

Insecticide	Number of Uses	Percentage of Use in Wheat
Malathion	12	55
Malathion 57%	4	18
Dipel	1	5
Vapona Strip	1	5
Phostoxin	2	14
Vulcan Formula 82-h	1	5

Average percentage moisture of corn when placed in storage 13.7%
Average percentage moisture of wheat when placed in storage 12.7%

	Yes		No	
	Percentage	Frequency	Percentage	Frequency
Did you have corn from previous years stored at the same time.....	55	127	42	98
Did you have wheat from previous years stored at the same time.....	46	53	61	70
Did you store corn from different crop years in bins close (less than 40 feet) to one another.....	49	114	41	95
Did you store wheat from different crop years in bins close (less than 40 feet) to one another.....	43	49	57	66
Did you store corn in bins close to feed grains.....	39	90	41	95
Did you store wheat in bins close to feed grains.....	40	46	50	58
Have you ever noticed musty or mold-caked grain developing in a stored corn bin....	52	121	34	79
Have you ever noticed musty or mold-caked grain developing in a stored wheat bin...	29	33	60	69

Mold Location and Action Taken

Mold Location	Percentage	Frequency
Northwest side	31	40
Southeast side	12	16
Top of mound	14	18
Southeast and center	2	3
Northwest center	2	3
Center	31	41
Northwest + southeast	1.5	2
Northeast	1.5	2
Access doors	1.5	2
Bin walls	1.5	2
North	0.7	1
Southwest	0.7	1

Action Taken For Mold	Percentage	Frequency
Aeration	20	27
Turned grain	19	25
Dried grain	0.75	1
Leveled grain	0.75	1
Removed top	0.75	1
Aeration + turned	27.0	36
Turned + dried	1.5	2
Aeration + dried	0.75	1
Removed	4.0	5
Aerated + dried + turned	8.0	10
Turned and removed	3.0	4
Aerated and removed	9.0	12
Aerated and Broke up	1.5	2
Fed it	1.5	2
Patched Bin	0.75	1
Sold it	0.75	1
Stirred it	1.5	2

Corn Fumigation

32 questionnaires showed fumigated corn. Total bu. = 1,954,510
1.3% of corn fumigated
35 records of corn fumigant used
15% of the managers who stored corn fumigated
82% self-applied
18% commercially applied

Fumigants Used

Fumigant	Percentage	Frequency
Phostoxin	8.6	3
Unknown Fumigant	14	5
Deepkil (CCl_4 + CS_2)	17	6
Tetrakil + Larvacide	2.8	1
Malathion 57%	11.4	4
Larvacide	17	6
Deepfume	2.8	1
Malathion	2.8	1
Lystads Farm Fumigant	2.8	1
Fumitoxin Coated Pellets	2.8	1
Phostoxin + Larvacide	2.8	1
Vulcan	2.8	1
Weevilcide	2.8	1
Tetrakil	2.8	1
Tetrafume	2.8	1

Wheat Fumigation

16 questinnaires showed fumigated wheat. Total bu. = 1,659,349
2.6% of wheat was fumigated
17 records of fumigants used
14.78% of the managers that stored wheat fumigated
93% self-applied
6% commercially applied

Wheat Fumigants

Fumigant	Percentage	Frequency
Deepkil (CCl_4 + CS_2)	17.6	3
Malathion	29.0	5
Tetrafume	6.0	1
Larvacide	6.0	1
Unknown Fumigant	6.0	1
Valcan	6.0	1
Lystads Farm Fumigant	6.0	1
Fumitoxin Coated Pellets	6.0	1
Tetrakil	6.0	1
80-20 Grain Fumigant	6.0	1

Bin Inspections

Corn-	Percentage	Frequency
Inspected corn at regular intervals	84	194
Average corn inspection interval		3 weeks
Range of corn inspection interval		1-20 wks

Wheat-	Percentage	Frequency
Inspected wheat at regular intervals	82	94
Average wheat inspection interval		4 weeks
Range of wheat inspection interval		1-20 wks

How Do You Inspect It?

	CORN		WHEAT	
	Percentage	Frequency	Percentage	Frequency
By looking at samples taken with a probe.....31		71	38	44
By looking at samples scooped from the surface..45		104	49	55
By looking at the grain surface.....63		145	61	70
By taking the moisture content of samples.....25		58	20	23
By measuring the temperature of samples.....22		51	23	26
By taking the temperature of the bulk grain with a probe.....19		43	21	24

Other Inspection Methods Reportedly Used For Corn

	Percentage	Frequency
Feeling with hand	1.3	3
By smell	3.0	7
By probe	0.8	2
Temperature sensors in bin	5.0	12
Stirring the top	0.8	2
Walking surface of grain	5.6	13
Metal rods inserted, pulled out and felt for hot spots	0.8	2
Hired a man to check	0.4	1
Removing portions of bins	1.3	3
Inspect while unloading	0.4	1

Other Inspection Methods Reportedly Used For Wheat

	Percentage	Frequency
Temperature sensors in bin	1.7	2
Removing portions of bins	0.9	1

Do you have a temperature monitoring system in your grain storage area:

	Percentage	Frequency
Corn	16.4	38
Wheat	7.8	9

How often do you check the temperature of your monitoring system:

	Average
Corn	every 2 weeks
Wheat	every 5 weeks

If the corn or wheat you sold contained live insects, what action was taken:

	Corn		Wheat	
	Percentage	Frequency	Percentage	Frequency
They refused it till it was fumigated.....26	31		24	14
They received it, fumigated it, and charged the cost of the fumigant.....23	27		25	15
Average discount price per bushel.....31	37		27	16
Corn, $ 0.08/bu Wheat, $ 0.11/bu				
They received it without discount or charge. 3	3		3	2
Their policy seems to vary.....18	21		20	12

Corn and Wheat Discounts

	Percentage of Total	Frequency	Average ($) Amount Discount
Corn, live insects	16	37	0.08
Wheat, live insects	14	16	0.11
Odors or insect-damaged corn	32	76	0.09
Odors or insect-damaged wheat	36	41	0.22
Musty or mold-damaged corn	41	94	0.08
Musty or mold-damaged wheat	33	38	0.17

	Percentage	Frequency
Corn pesticide chemicals cost more	25.9	28
Corn discounts cost more	74.0	80
Wheat pesticide chemicals cost more	21.4	12
Wheat discounts cost more	78.5	44

Livestock Health Problems Caused By Moldy Ration

	Percentage	Frequency
Lactating sows went dry, lost little pigs	21	3
Dairy cows go off production	14	2
Hogs slow down growth	7	1
Toxic reaction in cattle	14	2
Anesterous or continuous esterous in sows	7	1
Sows abort	14	2
Bad grain doesn't help livestock	7	1
Abortion	7	1
Go off feed; diarrhea	7	1

Aeration Practices

	Percentage	Frequency
231 Stored Corn 115 Stored Wheat		
Aerated stored corn	79	182
Aerated stored wheat	50	58
Aerated all stored corn	49	114
Aerated all stored wheat	24	28

How Corn was Determined to Need Aeration

Corn (out of 76 no answers to question 43)	Percentage	Frequency
As needed when checked	9	4
Extensive mold of moisture	1	1
Moisture on steel on outside of bin	1	1
Temperature	9	4
Moisture content	3	2
Temperature and moisture	3	2

Wheat (out of 58 no answers to question 43)	Percentage	Frequency
Moisture content	7	4
Moisture on steel on outside of bin	2	1

When do you usually BEGIN aerating: (percentage based on 182 corn aerators, 58 wheat aerators)	Corn		Wheat	
	Percentage	Frequency	Percentage	Frequency
Immediately after storage, continuous (day & night).....	40	72	38	22
Immediately after storage, selected periods of time.....	32	59	29	17
Later, continuous (day & night).....	18	33	12	7
Later, selected periods of time.....	48	88	50	29

How many times during the year do you aerate a bin of grain to get it to the temperature you want?

AVERAGE:
Corn - 4 times Wheat - 3 times

To what temperature do you usually cool grain?

	Average		
CORN	39° F.		
WHEAT	41° F.	67	39

How many did not cool grain to a specific temperature?

Corn		Wheat	
Percentage	Frequency	Percentage	Frequency
48	87	67	39

How many hours per bin do you run the fan to get the entire bin to the desired temperature?

AVERAGE:
Corn - 66.2 hours Wheat - 67.7 hours

Grain Aeration Practices

Warming Grain in the Spring

CORN (percentage based on 182 corn aerators)	Percentage	Frequency
Warms corn in spring	70	127
Month (percentage based on 127 responses)		
March	18	23
April	40	51
May	21	27
June	1.6	2
March-April	5.5	7
March-May	0.8	1
April-May	6.0	8
May-June	1.6	2

WHEAT (percentage based on 58 wheat aerators)	Percentage	Frequency
Warms wheat in spring	52	30
Month (percentage based on 30 responses)		
March	23	7
April	37	11
May	37	11
March-April	3	1

Information Sources
Used to Decided How Long to Run Aeration Fans

Information Source or Sources (percentage based on 191 who answered)	Percentage	Frequency
State extension bulletins	4	8
Own experience	69	132
Thermometer in air flow	1.6	3
Farm magazines	0.5	1
Aeration equipment manufacturer's manual	2.6	5
Temperature	3	6
Neighbor's advice	1	2
Extension bulletins and own experience	6.2	12
Own experience and equipment maker's manual	5.2	10
Extension bulletins, maker's manual, and farm magazines	0.5	1
Extension bulletins, own experience, and equipment maker's manual	0.5	1
Agricultural engineer and experience	0.5	1
Extension bulletins, own experience, and temperature in bin	0.5	1
Extension bulletins, own experience, maker's manual & neighbor's advice	0.5	1
Own experience and neighbor's advice	1	2
State extension bulletins, own experience, and father's advice	0.5	1
Grain company directions	0.5	1

Turned Grain as Part of Storage Strategy

(percentages based on 231 who stored corn, 115 who stored wheat)	Turned Grain	
	Percentage	Frequency
CORN (163 answered)	27	63
WHEAT (71 answered)	20	23

Month of Year When Grain Was Turned

(percentages based on 63 corn turners, 23 wheat turners)

	CORN		WHEAT	
	Percentage	Frequency	Percentage	Frequency
January	19	12	26	6
February	16	10	17	4
March	24	15	26	6
April	35	22	17	4
May	17	11	9	2
June	17	11	22	5
July	16	10	4	1
August	14	9	9	2
September	13	8	13	3
October	6	4	9	2
November	11	7	9	2
December	10	6	4	1