Natural Air Drying Corn

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Many small farmers prefer to dry crops using unheated or natural air drying in bins in layers 3 to 6 feet deep. It is desirable to have heat available on standby which will allow safe drying in any weather. Significant aflatoxin buildup can occur in 48 hours in grain if the air leaving the grain is between 55 and 105°F and relative humidity is over 85 percent.

Equilibrium Moisture Content

Grain can be dried in many areas (except along the coast) of our state using natural air if the drying layer is limited to three to four feet and a sufficient volume of air with the proper relative humidity and temperature is circulated through the grain. If, for example, corn is to be dried to 12 percent moisture, air must be circulated which will remove moisture from the corn rather than adding moisture. When the air circulating through the corn neither absorbs moisture nor adds moisture, the air and corn are said to be at the equilibrium moisture content. Table 1 shows 12 percent moisture corn to be in equilibrium with air at 50°F and 50 percent humidity. If the humidity increases to 60 percent and the air temperature remains at 50°F, it is not possible to dry the corn below 13.3 percent. If the relative humidity dropped below 50 percent and remained at 50°F, drying to 12 percent or below would be possible.

Table 1. Equilibrium moisture content of shelled corn at various relative humidity and air temperature.

Air Temperature (°F)	Relative Humidity (%)									
	30	35	40	45	50	55	60	65	70	80
30	10.3	10.8	11.3	12.2	13.1	13.8	14.6	15.5	16.4	18.7
50	8.8	9.7	10.5	11.3	12.0	13.0	13.9	14.8	15.7	17.9
60	8.5	9.3	10.1	10.9	11.7	12.5	13.3	14.2	15.1	17.2
70	8.1	8.9	9.7	10.5	11.2	12.0	12.8	13.6	14.5	16.6
80	7.8	8.6	9.3	10.1	10.8	11.6	12.4	13.2	14.0	16.0
90	7.6	8.3	9.0	9.7	10.5	11.2	12.0	12.7	13.6	15.5
100	7.3	8.0	8.7	9.4	10.1	10.9	11.6	12.4	12.2	15.1

A small amount of heat raises the drying air temperature and reduces the humidity which increases the drying capability of the air. A 20°F temperature rise reduces the relative humidity by 50 percent. For example, air at 60°F and 70 percent relative humidity heated to 80°F. (20°F temperature rise) reduces the relative humidity to 35 percent (50 percent of the 70 percent). With shelled corn, the original air (60°F and 70 percent humidity) would reach equilibrium at 15.1 percent while the 80°F and 35 percent relative humidity would reach equilibrium at 8.6 percent. This would result in more drying capability (Table 1). If the air were heated 10°F (one half the 20°F above), the relative humidity would drop only 25 percent or one half the above value to about 50 percent.

Airflow – the Key to Natural Air Drying

Table 2 gives the maximum quantities of grain that can be dried per batch per fan horsepower for minimum air flow rates and maximum depths using natural air under favorable conditions.

The air flow rate in Table 2 is the minimum flow rate with grain depth being the maximum for clean grain with little or no fines using unheated air. (Heat should be available on standby). The static pressure on the fan is given in inches of water.

Table 2. Estimated maximum quantities of grain that can be dried per batch per fan horsepower for minimum air flow rates and grain depths using natural air.

Grain	Air Flow Rate per Bushel (CFM)	Initial Moisture Content (Percent)	Grain Depths (Feet)	Static Pressure (Inches Water Gage)	Maximum Quantity That Can Be Dried Per Fan Horsepower (Bushels)
Corn (Shelled)	6	25	3	0.60	885
			5	1.50	360
			7	3.20	170
	5	22	5	1.00	635
			7	2.40	265
			8	3.40	190
	3	18	7	1.27	835
			9	2.14	495
			10	2.65	400
	2	15	7	0.81	1965
			9	1.33	1200
			11	1.95	815

The approximate drying time for shelled corn at different initial moisture contents (in Georgia) is shown in Tables 3-7 for unheated air. Unheated air is defined as air being pulled across an electric fan motor giving a 2.5ºF temperature rise. Notice drying is quite slow. For this reason, many farmers will not find natural air drying acceptable since faster methods will usually be needed. Drying rate can be increased by adding heat or increasing air flow rate, or both. Slow drying is not desirable to maintain grain quality and reduce risk from aflatoxin. Increasing airflow will decrease drying time as shown in Tables 3-7.

Table 3. Approximate drying time (days) for shelled corn at different initial moisture contents for 2.5ºF temperature rise and 2 CFM/bushel.

Final Moisture (%)	Drying Time (hours)							
	Initial Moisture (%)							
	20	19	18	17	16	15	14	13
20	0							
19	6	0						
18	13	7	0					
17	19	13	6	0				
16	25	19	12	6	0			
15	31	25	18	12	6	0		
14	37	31	24	18	12	6	0	
13	43	37	30	24	18	12	6	0
12	48	42	35	29	23	17	11	5
11	53	47	40	34	28	22	16	10
10	58	52	45	39	33	27	21	15

Table 4. Approximate drying time (days) for shelled corn at different initial moisture contents for 2.5ºF temperature rise and 3 CFM/bushel.

Final Moisture (%)	Drying Time (hours)							
	Initial Moisture (%)							
	20	19	18	17	16	15	14	13
20	0							
19	4	0						
18	9	5	0					
17	13	9	4	0				
16	17	13	8	4	0			
15	21	17	12	8	4	0		
14	25	21	16	12	8	4	0	
13	29	25	20	16	12	8	4	0
12	32	28	23	19	15	11	7	3
11	35	31	27	23	19	15	11	7
10	39	35	30	26	22	18	14	10

Table 5. Approximate drying time (days) for shelled corn at different initial moisture contents for 2.5ºF temperature rise and 5 CFM/bushel.

Final Moisture (%)	Drying Time (hours)							
	Initial Moisture (%)							
	20	19	18	17	16	15	14	13
20	0							
19	2	0						
18	5	3	0					
17	8	5	2	0				
16	10	8	5	2	0			
15	12	10	7	5	2	0		
14	15	12	10	7	5	2	0	
13	17	15	12	10	7	5	2	0
12	19	17	14	12	9	7	4	2
11	21	19	16	14	11	9	7	4
10	23	21	18	16	13	11	9	6

Table 6. Approximate drying time (days) for shelled corn at different initial moisture contents for 2.5ºF temperature rise and 6 CFM/bushel.

Final Moisture (%)	Drying Time (hours)							
	Initial Moisture (%)							
	20	19	18	17	16	15	14	13
20	0							
19	2	0						
18	4	2	0					
17	6	4	2	0				
16	8	6	4	2	0			
15	10	8	6	4	2	0		
14	12	10	8	6	4	2	0	
13	14	12	10	8	6	4	2	0
12	16	14	12	10	8	6	4	2
11	18	16	13	11	9	7	5	3
10	19	17	15	13	11	9	7	5

Table 7. Approximate drying time (days) for shelled corn at different initial moisture contents for 2.5ºF temperature rise and 9 CFM/bushel.

Final Moisture (%)	Initial Moisture (%)							
	20	19	18	17	16	15	14	13
20	0							
19	1	0						
18	3	2	0					
17	4	3	1	0				
16	6	4	3	1	0			
15	7	6	4	3	1	0		
14	8	7	5	4	3	1	0	
13	10	8	7	5	4	3	1	0
12	11	9	8	6	5	4	2	1
11	12	10	9	8	6	5	4	2
10	13	12	10	9	7	6	5	3

Adding low levels of heat (10 – 15^{o}F) allow faster drying and the drying process becomes less sensitive to the weather. A good method for controlling the supplemental heat is to install a humidistat in the blower discharge air stream or near the top of the storage bin. The humidistat, set at the desired humidity level, provides almost perfect control if three conditions are met. First, the heating unit should have a modulating valve so heat output changes will be gradual. Second, the humidistat must be able to operate in a dusty environment. Third, reaction time of the humidistat and heater should be such that there is little if any overrun of the heater.

Bin Capacity and Airflow Rates

Table 8 gives estimated capacities for various depths and bin diameters. One bushels equals 1.245 ft^{3}. The CFM/bushel can be calculated by knowing the amount of bushels and dividing by the fan CFM. Depth of grain should not exceed 4 feet. Figures 1 and 2 illustrate the amount of air available per bushel at different depths for a 15 foot diameter bin when drying grain.

Example: Corn is harvested at 17 percent moisture. A 30 feet diameter grain bin filled to a height of 18 feet holds 10,220 bushels (Table 6). The fan has a capacity of 20,000 CFM at 3.0 inches static pressure. Dividing the 20,500 CFM by 10,220 bushels gives us 2.0 CFM/bushel based on full bin. Natural air drying should only be for 4 feet or less. The number of bushels for 4 feet depth is 2,271 bushel. Now calculating the CFM/bushel equals 20,500 divided by 2,271 equals 9 CFM/bushel. Table 6 shows drying time for 17 percent moisture shelled corn at 4 days to achieve 14 moisture content. Higher moisture corn could then be added on top. Remember adding 4 feet will half the amount of CFM/bushel to 4.5. Drying the second layer to 14 percent will take over 7 days (Table 4).

Table 8. Capacities of level full round bins.

Based on 1.245 ft^3= 1 bushel does not involve test weight, moisture content or shrinkage.

Grain depth	Bin diameter (ft)												
ft	15	18	21	24	27	30	33	36	39	42	45	48	60
1	142	204	278	363	460	568	687	818	960	1,113	1,277	1,453	2,271
1.5	213	307	417	545	690	852	1,030	1,226	1,439	1,669	1,916	2,180	3,407
2	284	409	556	727	920	1,136	1,374	1,635	1,919	2,226	2,555	2,907	4,542
3	426	613	835	1,090	1,380	1,703	2,061	2,453	2,879	3,338	3,832	4,360	6,813
4	568	818	1,113	1,453	1,840	2,271	2,748	3,270	3,838	4,451	5,110	5,814	9,084
6	852	1,226	1,669	2,180	2,759	3,407	4,122	4,905	5,757	6,677	7,665	8,721	13,626
8	1,136	1,635	2,226	2,907	3,679	4,542	5,496	6,541	7,676	8,902	10,220	11,628	18,168
10	1,419	2,044	2,782	3,634	4,599	5,678	6,870	8,176	9,595	11,128	12,774	14,534	22,710
12	1,703	2,453	3,338	4,360	5,519	6,813	8,244	9,811	11,514	13,354	15,329	17,441	27,252
14	1,987	2,861	3,895	5,087	6,438	7,949	9,618	11,446	13,433	15,579	17,884	20,348	31,794
16	2,271	3,270	4,451	5,814	7,358	9,084	10,992	13,081	15,352	17,805	20,439	23,255	36,336
18	2,555	3,679	5,008	6,541	8,278	10,220	12,366	14,716	17,271	20,030	22,994	26,162	40,878
20	2,839	4,088	5,564	7,267	9,198	11,355	13,740	16,351	19,190	22,256	25,549	29,069	45,420
22	3,123	4,497	6,120	7,994	10,117	12,491	15,114	17,986	21,109	24,481	28,104	31,976	49,962
24	3,407	4,905	6,677	8,721	11,037	13,626	16,488	19,622	23,028	26,707	30,659	34,883	54,504
26	3,690	5,314	7,233	9,447	11,957	14,762	17,861	21,257	24,947	28,933	33,213	37,790	59,046
28	3,974	5,723	7,790	10,174	12,877	15,897	19,235	22,892	26,866	31,158	35,768	40,696	63,588
30	4,258	6,132	8,346	10,901	13,796	17,033	20,609	24,527	28,785	33,384	38,323	43,603	68,130
32	4,542	6,541	8,902	11,628	14,716	18,168	21,983	26,162	30,704	35,609	40,878	46,510	72,672
34	4,826	6,949	9,459	12,354	15,636	19,304	23,357	27,797	32,623	37,835	43,433	49,417	77,214
36	5,110	7,358	10,015	13,081	16,556	20,439	24,731	29,432	34,542	40,061	45,988	52,324	81,756
38	5,394	7,767	10,572	13,808	17,475	21,575	26,105	31,067	36,461	42,286	48,543	55,231	86,298
40	5,678	8,176	11,128	14,534	18,395	22,710	27,479	32,703	38,380	44,512	51,098	58,138	90,840
42	5,961	8,584	11,684	15,261	19,315	23,846	28,853	34,338	40,299	46,737	53,653	61,045	95,382
44	6,245	8,993	12,241	15,988	20,235	24,981	30,227	35,973	42,218	48,963	56,207	63,952	99,924
46	6,529	9,402	12,797	16,715	21,154	26,117	31,601	37,608	44,137	51,189	58,762	66,858	104,466
48	6,813	9,811	13,354	17,441	22,074	27,252	32,975	39,243	46,056	53,414	61,317	69,765	109,008
50	7,097	10,220	13,910	18,168	22,994	28,388	34,349	40,878	47,975	55,640	63,872	72,672	113,550
52	7,381	10,628	14,466	18,895	23,914	29,523	35,723	42,513	49,894	57,865	66,427	75,579	118,092
54	7,665	11,037	15,023	19,622	24,833	30,659	37,097	44,148	51,813	60,091	68,982	78,486	122,634
56	7,949	11,446	15,579	20,348	25,753	31,794	38,471	45,784	53,732	62,316	71,537	81,393	127,176
58	8,232	11,855	16,136	21,075	26,673	32,930	39,845	47,419	55,651	64,542	74,092	84,300	131,718
60	8,516	12,263	16,692	21,802	27,593	34,065	41,219	49,054	57,570	66,768	76,646	87,207	136,260

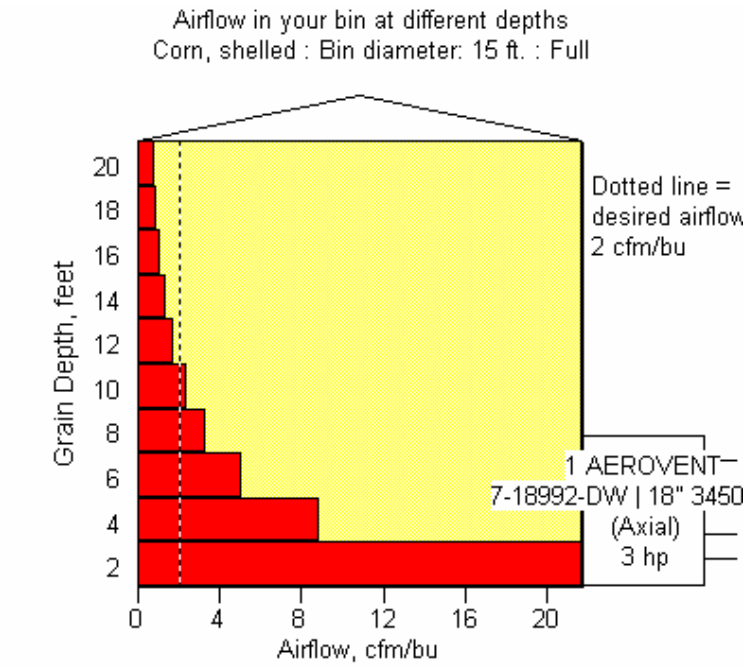

Figure 1. Airflow per bushel for a 15 ft diameter corn bin at different depths, total desired airflow is 2 cfm per bushel.

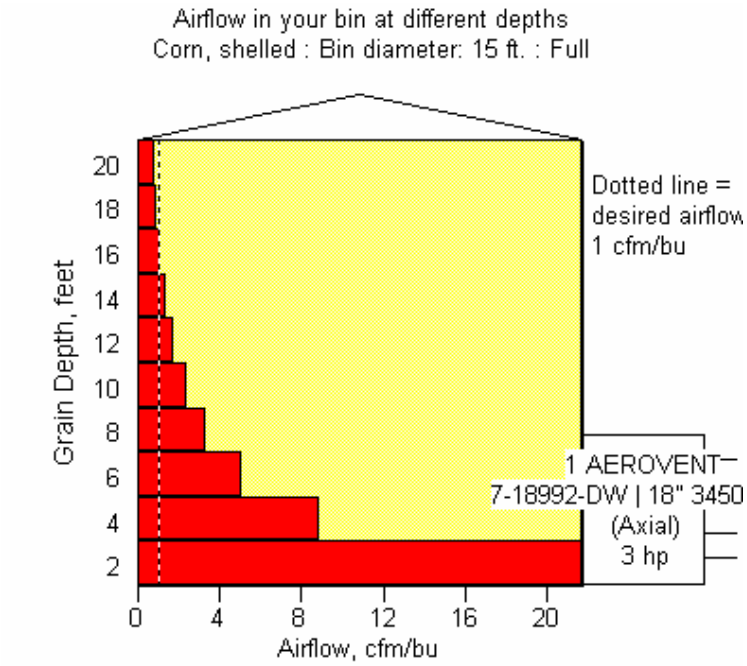

Figure 2. Airflow per bushel for a 15 ft diameter corn bin at different depths, total desired airflow is 1 cfm per bushel.

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