AGRICULTURAL

GUIDE

Published by the University of Missouri-Columbia Extension Division

Grain drying

Estimating airflow for in-bin grain drying systems

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One of the most often asked questions about in-bin grain drying is "How long will it take to dry the grain?"

It is virtually impossible to answer this question unless you can satisfactorily estimate the airflow delivered by the drying fan. This guide will help estimate that airflow. It will also help you compare performance of two or more fans under your conditions.

This guide can also be used to determine another important term, cubic feet per minute per bushel (cfm/bu) The cfm/bu level of your fan(s) determines how fast grain will be dried in your bin(s).

How much airflow you need depends on the application: aeration, in-bin cooling, dryeration, low-temperature drying, high-temperature drying, etc. Specific airflow recommendations for these applications are found in University of Missouri and Midwest Plan Service publications available through University Extension Centers.

Knowing the meaning of terms such as "airflow" and "static pressure" are essential for understanding fan performance. Airflow is measured in cubic feet per minute (cfm). Note that this is similar to the gallons per minute (gpm) used for measuring water flow. A fan will move a certain airflow (cfm) against a specified static pressure, just like a water pump will pump a certain amount of water (gpm) at a specified pressure (psi) or head.

In the bin, static pressure is created by the resistance of the duct(s), perforated drying floor and grain. Usually the ducts and drying floor create very little resistance to airflow, so they can be ignored. Static pressure is measured in inches of water.

Adequate airflow is most critical with low-temperature drying. Low-temperature drying includes drying with natural or unheated air and drying with air that has been heated, 10 degrees F or less, with gas, electricity or solar energy. Table 1 shows the recommended **minimum** airflow for low-temperature drying in Missouri.

When comparing two fans, the one with the higher airflow in cfm/bu will dry or aerate grain faster. For example, a fan that provides 10% more air will dry or aerate grain approximately 10% faster.

Fan performance

Most grain drying fans are rated for performance using standard testing procedures. The performance of a fan depends on its diameter, number and design of blades and speed (rpm). The performance data, air delivered (cfm) at various static pressures, should be available from the fan supplier or manufacturer. If the performance rating is not available, it is difficult to estimate fan performance on a given system.

Figures 3 and 4 at the end of this guide relate the airflow in cfm per square foot of bin floor area (cfm/sq ft), the static pressure in inches of water, and the grain depth in feet (solid lines) for corn/soybeans and wheat/milo, respectively. Also plotted are cfm/bu lines (dashed lines). The remainder of this guide explains in detail how to use these charts.

Step 1

Enter the fan performance data [airflow (cfm) vs. static pressure (inches of water)] in Table 2 for your fan. Static pressure is already entered in the left column; if your fan operates at higher static pressures than those shown, you will have to make your own table. If an airflow rate is not provided for your fan at a particular static pressure, leave that space blank.

Example figures are for a 7.5 horsepower axial fan. Space is provided in Table 2 for two additional fans. If you need more space, make copies of Table 2 or obtain additional copies of this guide.

Step 2

Determine the air velocity in cubic feet per minute per square foot through the bin floor for each fan and bin. This is done by dividing the cfm at each static pressure in Table 2 by the bin floor area. Put these figures in column 2.

Table 3 gives the floor area for several common bin diameters. For other diameters, the bin floor area equals the bin diameter in feet times the bin diameter in feet times 0.7854. A 24-foot diameter bin with a floor area of 452 sq. ft. (24 X 24 X 0.7854) is the sample bin.

The air velocity at 0 inches of static pressure for the example bin and fan is 27.5 cfm/sq. ft. (12,450 cfm 452 sq. ft.)

Step 3

On the appropriate chart for the grain in question (figure 3 or 4) plot the air velocity (cfm/sq.ft.) for each static pressure. This has been done in Figure 2 for the example fan. After all of the available points are located, connect the points using a straight edge or ruler (a smooth curve is more accurate, but a straight line between points is easier and adequate). This line or curve represents the performance curve for the specific fan and bin combination. It is possible for that fan to operate at any combination or air velocity and static pressure (or grain depth and cfm/bu) on the curve plotted.

Step 4

For low temperature drying, read the approximate depths of grain for the five specific airflow-per-bushel curves (dashed lines) from the chart. For the example, the fan performance curve crosses the 3.0 cfm/bu curve at about 9 feet of corn. Note that the actual point falls between the 8 foot and 10 foot depth lines so you will need to use judgment in completing this step. As you determine these values from the graph, enter the numbers in Table 4 as shown in the example.

Figure 1.

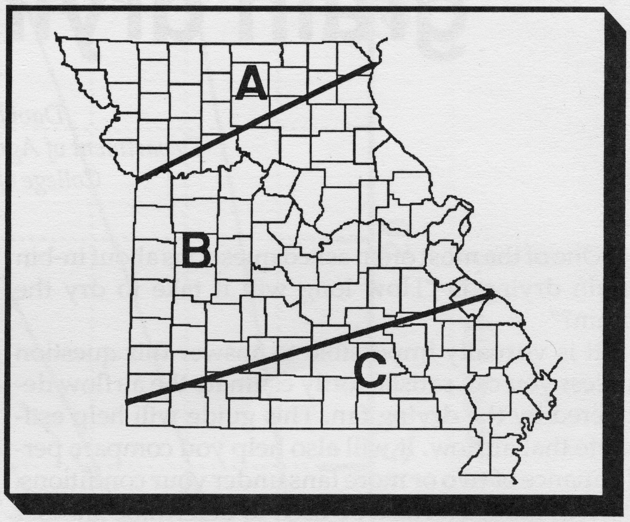


Table 1. Recommended airflow for low-temperature drying of shelled corn in Missouri

Zone (see Fig.1)	Minimum airflow (cfm/bu)	Sept.1	Sept. 15	Oct. 1	Oct. 15	Nov. 1	Nov. 15	Dec. 1
		Corn harvested on or after						
		Maximum moisture content (%)						
A	1.0	19	20	20	21	23	20	18
	1.25	19	20	20.5	21.5	24	20.5	18
	1.5	19.5	20.5	21	22.5	24	21	18
	2.0	20	21	22.5	23.5	25	21.5	18
	3.0	21	22.5	23.5	24.5	26	22	18
B	1.0	19	19.5	20	21	22	20	18
	1.25	19	20	20.5	21.5	22.5	20.5	18
	1.5	19.5	20	21	22	23.5	21.5	18
	2.0	20	21	22	23	24.5	21.5	18
	3.0	21	22	23.5	24.5	25.5	22	18
C	1.0	19	19.5	20	21	22	20	18
	1.25	19	19.5	20.5	21	22.5	20.5	18
	1.5	19	19.5	21	22	23	21	18
	2.0	19.5	21	21.5	23	24	21.5	18
	3.0	20.5	21.5	23	24	25	22	18

Table 2. Data for plotting fan/bin curves for ___-foot diameter bin. (24-foot diameter example)

Static pressure (inches of water)	Example 7.5 hp axial Col. 1 Total airflow (cfm)	Example 7.5 hp axial Col. 2 Air velocity (cfm/sq ft)	Your fan ___ hp Col.1 Total airflow (cfm)	Your fan ___ hp Col. 2 Air velocity (cfm/sq ft)	Your fan ___ hp Col. 1 Total airflow (cfm)	Your fan ___ hp Col. 2 Air velocity (cfm/sq ft)
0	12,450	27.5				
1/2	12,450	27.5				
1	11,900	26.3				
1 1/2	11,300	25.0				
2	10,600	23.5				
2 1/2	10,000	22.1				
3	9,300	20.6				
3 1/2	8,550	18.9				
4	7,750	17.1				
4 1/2						
5						
5 1/2						
6						
6 1/2						
7						

Note that in order to get the depth for 1 cfm/bu in the example, it was necessary to extend the fan curve slightly beyond the last point. You have to guess a little to extend the curve since we don't know the actual performance beyond the data provided by the fan supplier. Care must be taken in extending the curve this way since it can result in overestimating airflow and grain depths.

The data from Table 4 for your situation provides enough information to compare the performance of two different fans or to estimate the effectiveness of your current fan for low-temperature drying. When used in combination with Table 1 it can be used to determine depths of fill for layer or controlled-filling drying.

For instance, with the example fan/bin combination, what depth of corn could be safely dried if corn is harvested at a maximum moisture content of 21 percent on or after Oct. 1 near Hannibal, Mo.?

From Table 1 find that for a 10/1 harvest date in Zone B at an initial moisture content of 21 percent, the minimum airflow is 1.5 cfm/bu. From Table 4, the 24

Table 3. Floor area and estimated capacity (level-fill) of grain bins.

Bin Diameter (ft)	Floor area (sq ft)	Bin capacity (bu/ft)
18	254	203
21	346	277
24	452	362
27	573	458
30	707	566
33	855	684
36	1,018	814
40	1,257	1,005
42	1,385	1,108
48	1,809	1,448
60	2,827	2,262

Table 4. Estimated cfm/bushel summary

Estimated airflow (Low temp. drying) (cfm/bu)	Example 24-ft bin approx. depth (ft)	Your ___-ft bin ___-hp fan approx. depth (ft)	Your ___-ft bin ___-hp fan approx. depth (ft)
1.0	20	________	________
1.25	17	________	________
1.5	15	________	________
2.0	12	________	________
3.0	9	________	________

ft. bin and 7.5 hp fan will provide the required airflow (1.5 cfm/bu) at a depth of 15 feet of corn. Therefore, 15 feet of this corn could be safely dried in the bin.

High temperature drying

The following example will show how to use this guide to estimate airflow or evaluate fans for high temperature drying such as bin-batch or bin-continuous-flow methods where the airflow per bushel is higher than 3 cfm.

1. Using the 24-foot diameter bin and 7.5 hp axial fan from the previous example, find the air velocity from Figure 2 for the desired fill depth (6 feet). The velocity for the example is about 23 cfm/sq. ft.

2. Find the total estimated airflow in cfm by multiplying the air velocity times the bin floor area (Table 3). **Example: 23 cfm/sq. ft. x 452 sq. ft. = 10,396 cfm total airflow.**

3. Estimate bushels of grain in the bin by multiplying the desired grain depth times the bushels per foot (Table 3). **Example: 6 ft. x 362 bu./ft. = 2,172 bu.**

4. Estimate airflow per bushel by dividing total estimated airflow by total estimated bushels in the bin. **Example: 10,396 cfm ÷ 2,172 = 4.8 cfm/bu.**

Figure 2. Example of airflow worksheet

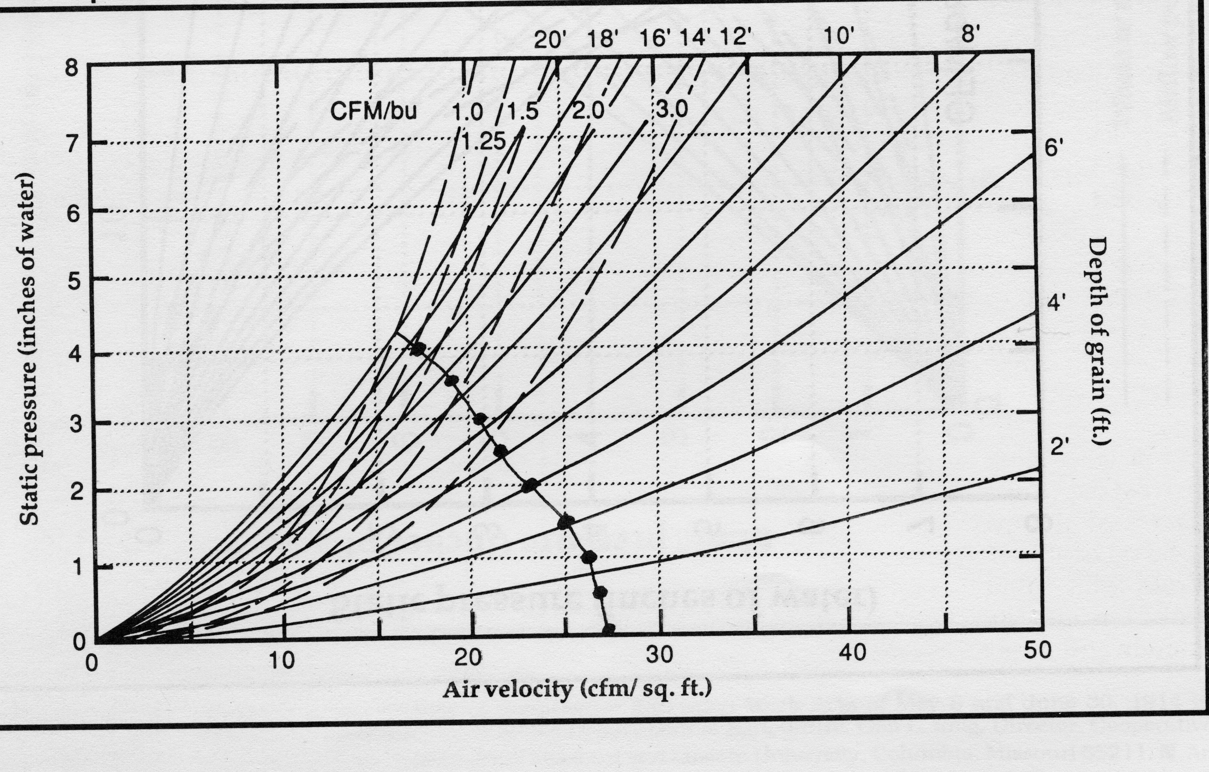


Figure 3. Corn or soybean airflow worksheet.

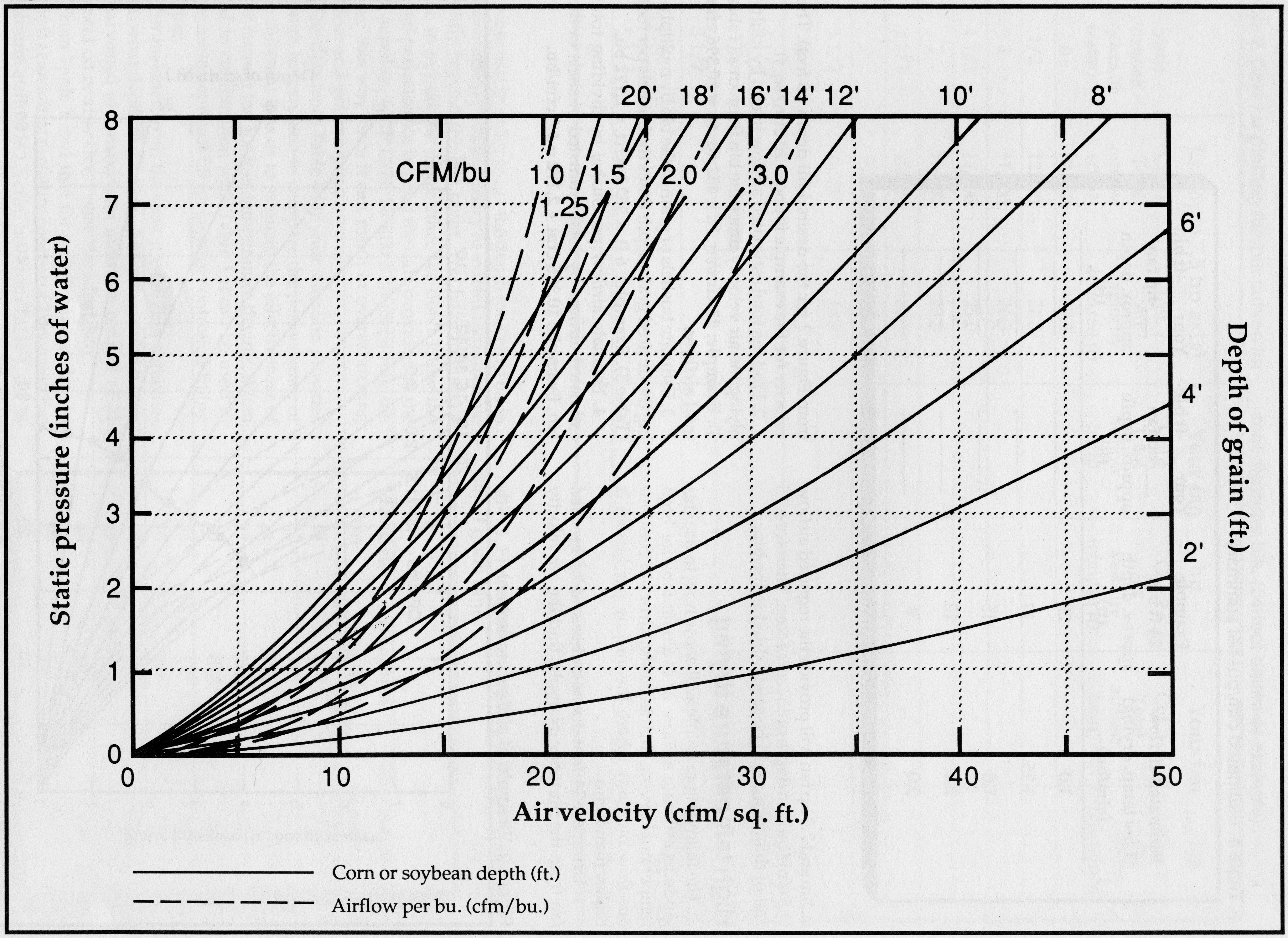
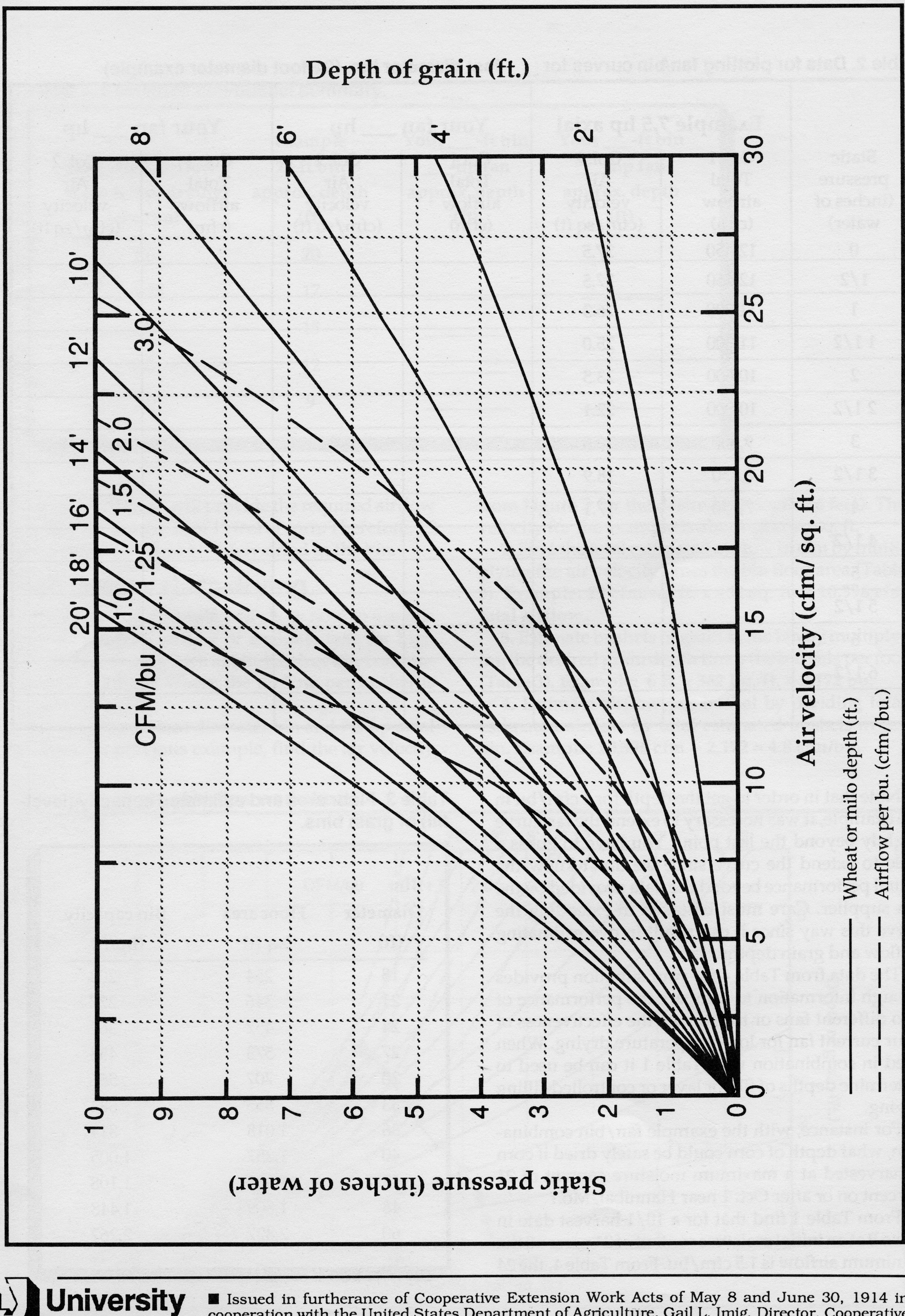


Figure 4. Wheat or milo airflow worksheet.



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