April 2021

Drying Soybeans for Seed in the Southern United States

A. H. Boyd

DRYING SOYBEANS FOR SEED IN THE SOUTHERN UNITED STATES

A. H. Boyd[1/]

Interest in soybean drying for seed and grain has increased greatly in the last several years, primarily because of the widespread wet weather at harvest time across the soybean growing areas of the United States. More often, soybean seedsmen are more concerned with seed too dry than those which are too wet. However, the past two years of wet weather across the southeast has been unusual only in the extensiveness of the area covered. Practically every year some areas experience poor conditions during harvest time which result in poor seed quality and sometimes localized seed shortages. The seedsmen in the affected area are more than academically interested in the fact that their seed will probably go to the oil mill while better quality seed from outside the affected area may be shipped in. To compete, he must be able to produce seed of reasonable quality even in the bad years.

Many seedsmen have dried soybean for seed and their experiences have varied from good to complete disaster. We are now generally in agreement that soybeans are more fragile than corn and that special methods or techniques must be used. This is not to infer that practically all grain drying methods are not adaptable to soybean seed drying; they are, but we must learn the restrictions on the use of heat and handling methods that result in loss of germination and cause mechanical damage. All the various systems of drying have their advantages and disadvantages which must be weighed against each other. In no case have we reached the ideal put forth

---

1/Assistant Agronomist, Seed Technology Laboratory, Department of Agronomy, Mississippi Agricultural and Forestry Experiment Station.
Journal No. 3230.

by one author that "What the farmer appears to need is a foolproof grain storage into which he can place any kind of grain at any season and make certain that it will not spoil". To do a good job of drying with any equipment, one must have a working knowledge of the interactions of equilibrium moisture content, relative humidity, and drying fronts.

Most of the on farm drying that is done across the southeast is in flat bottom storage bins so we will address our attention primarily to this type of equipment. Bin or deep bed drying without agitation is characterized by a high mechanical reliability, but there are certain factors that must be understood and compensated for. The dry air entering from the bottom of the bin through the perforated floor or ducts begins drying the seeds at that point first and a drying front is quickly established. As this drying front moves up there are seeds above (or ahead) of the front that are not drying; some in a drying zone behind the front; and below the drying zone are seeds essentially in equilibrium with the entering air (figure 1).

The moisture content that soybeans will reach when exposed to a given relative humidity varies slightly with temperature. Figure 2 shows the equilibrium moisture content for soybeans at 40°, 82 and 92°F over a range of relative humidity values. Notice that the moisture content is always lower at a given RH at the higher temperature. For example, at 92° F soybeans will come to equilibrium at 11.7% moisture with the RH of 75%. Had we begun operating our dryers in a heavy fog (100% RH) at 82° F and raised the temperature of the drying air with our burners to 92° F, we would obtain the conditions stated. Needless to say, we seldom have such poor drying conditions even in the hurricane season. A starting

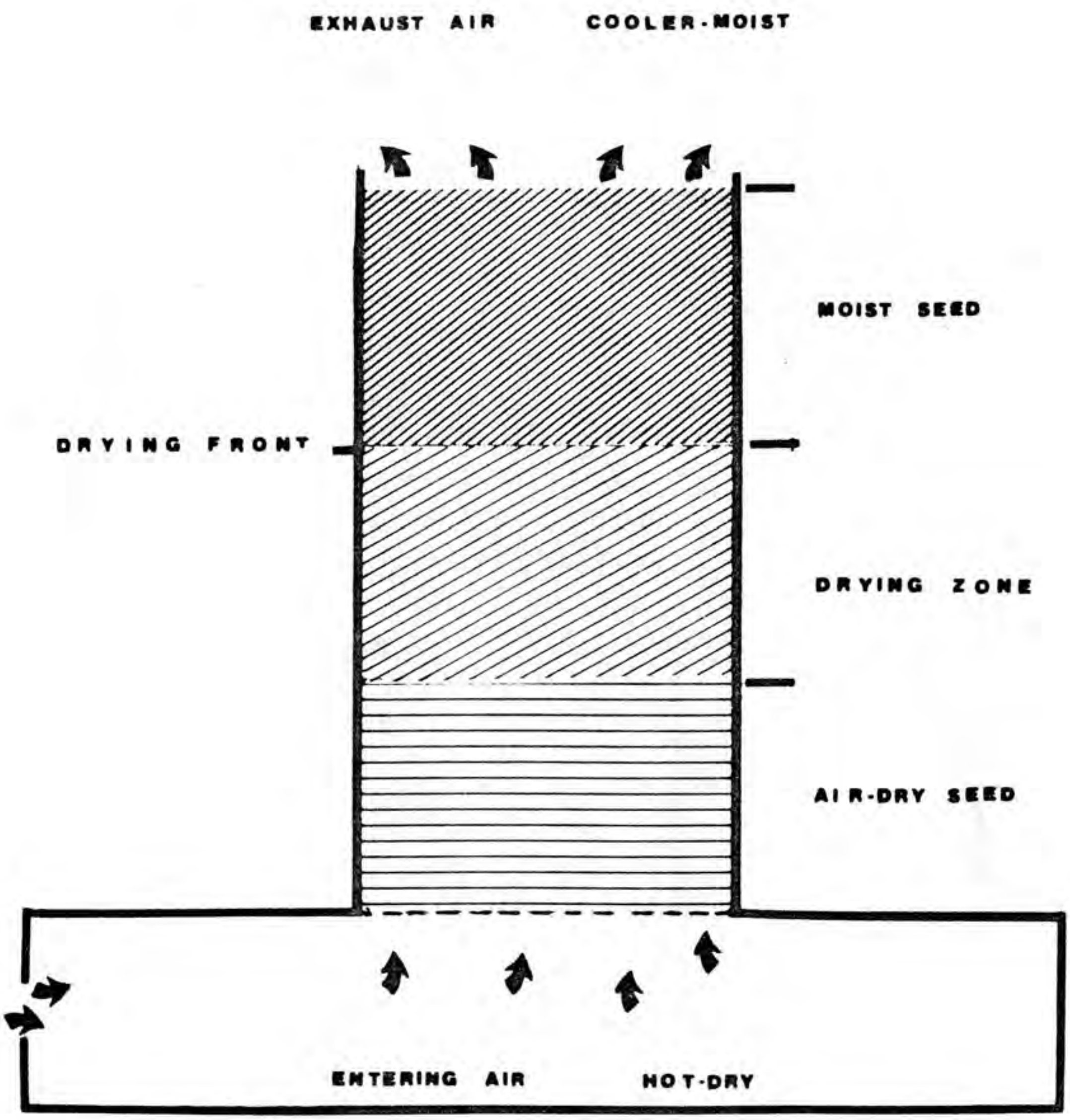
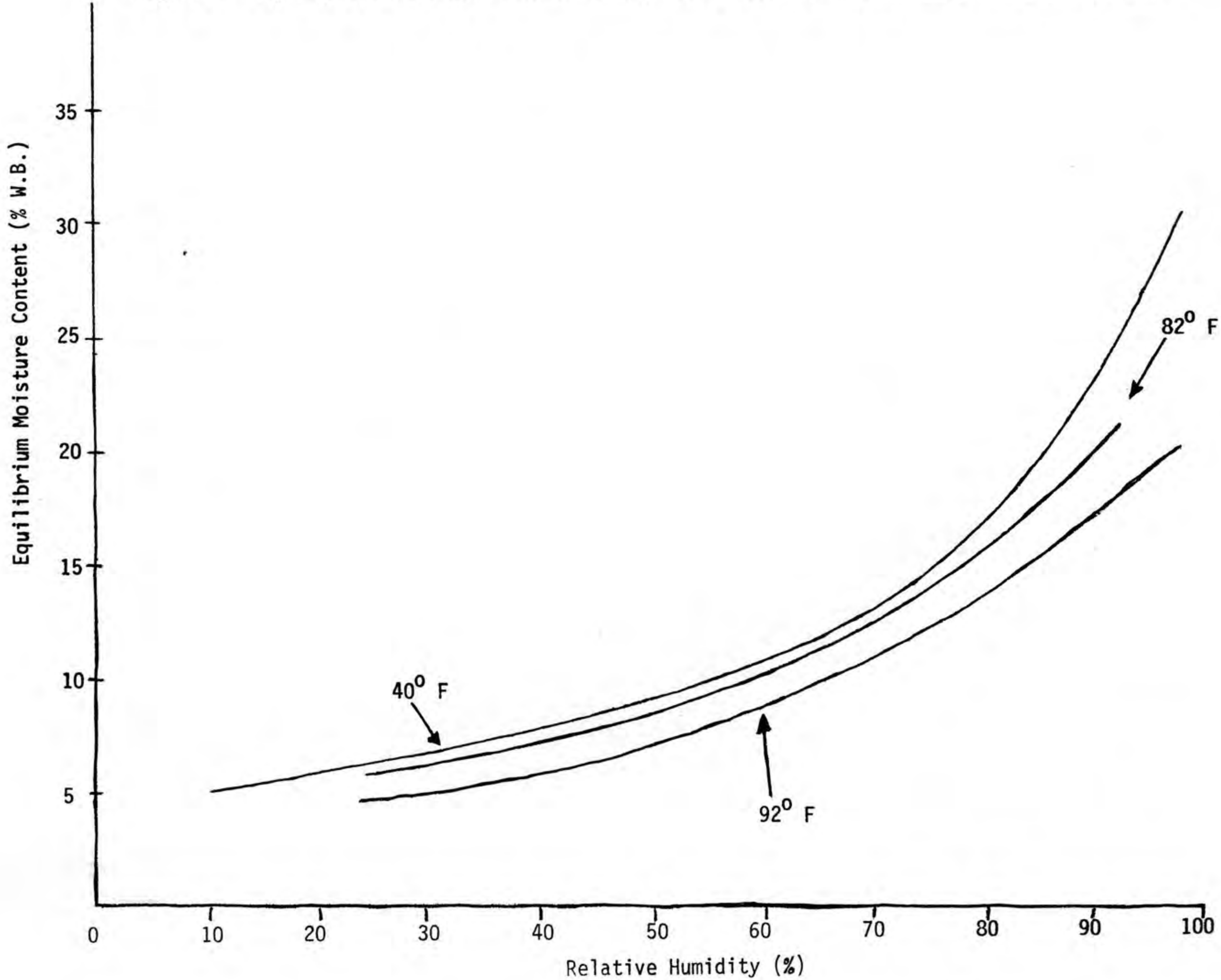


Figure 1. Diagram of deep bed drying.

Figure 2. Equilibrium moisture content of soybeans under different temperature conditions.



point of 100% RH at 70^{o} F would be a more reasonable early harvest season example. If we increase the drying air temperature to 92^{o} F in this case the RH will be 50% and soybeans will reach a moisture content of 7.4% if held in this condition. A moisture content of 7.4% while not detrimental alone, is not only uneconomical because of loss of weight that could be sold, but soybeans at such low moisture conditions are easily damaged when handled in conveying or processing equipment. This should indicate to us that generally we are too liberal with heat but too conservative with our drying operation when we consider the weather to be "bad drying weather".

Excessive drying can cause seed germination and damage problems even without mechanical handling. Table 1 shows the results of drying for a long period (as would the bottom portion of a bin) at 105^{o} F. The seeds eventually reached a moisture content of 6.7%. After these seeds were stored for 3 months they had a germination of more than 10% lower than seeds dried under the same conditions but for a shorter time so as not to reach as low a final moisture content. This was due primarily to a sharp increase in "baldhead" and "snakehead" seedlings but table 2 shows that the vigor ratings of the seeds were also sharply reduced. The primary damage appeared to be in the area of attachment of the cotyledons to the embryonic axis (figure 3).

The problem of overdrying in the lower part of the bin can only be alleviated by (1) Keeping the temperature low enough to prevent overdrying or; (2) Reducing time seed are held at the high temperature/low RH condition by increased air flow per bushel to affect more rapid drying of the upper layers. Relative humidity below 40% has also been reported to cause seed coat cracking.

Table 1. Mean numbers of soybean seedlings having fractured radicles or separated cotyledons. Source: Saisawat.

Initial Moisture %	Drying Time hrs. @ 105^{o} F	"Baldhead" and "Snakehead" Seedlings (%)
12.55	0	1.25 a
10.42	2:52	1.00 a
8.70	12:50	1.75 a
6.70	25:02	7.25 b

*Means not followed by the same letter differ significantly at the 5% level of probability as determined by DNMRT.

Table 2. Means of viability and vigor evaluations of soybean seed stored at 20^{o} C - 75% RH. Source: Saisawat.

Initial Moisture	Viability Tests		Vigor Tests	
	Std. Germ %	TZ. Germ Potential	1st Count Germ. %	TZ. Germ. Energy %
12.55	91.00 a	91.75 a	73.00 a	69.00 a
10.42	91.87 a	91.25 a	71.25 a	67.50 a
8.70	91.13 a	91.75 a	73.38 a	72.25 a
6.70	80.87 b	77.00 b	58.25 b	49.00 b

*Within each column, means not followed by the same letter differ significantly at the 5% level of probability as determined by DNMRT.

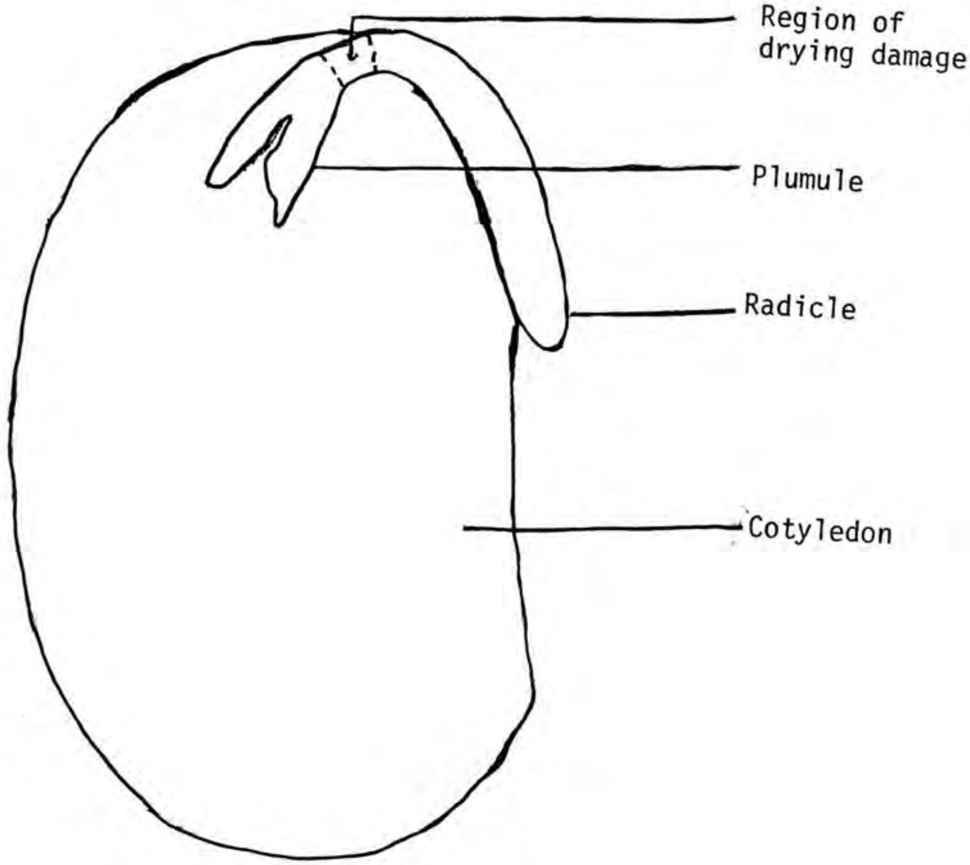


Figure 3. Region of drying damage revealed by TZ staining in soybean seed dried to 6.70% moisture.

Time of drying and seed quality.

The top layers of seed in a bin present another and more easily recognized problem. Since no drying is occuring above the drying front and under some conditions moisture content actually increases before arrival of the drying front, the seeds on top are held in warm moist storage. The quality of the seeds is reduced greatly if they are held for too long a time before actual drying is accomplished. How long is "too long" of course varies with the initial moisture content of the soybeans. Table 3 shows that soybeans harvested at 22.8% had dropped noticeably in germination if drying had not been completed within 36 to 48 hours. In table 4, soybeans at 14.8% moisture did not show appreciable drop in germination during the entire drying period which extended to a maximum of 58 hours.

We should be reminded at this point, that temperature also has its influence on seed deterioration. In a cooler climate than ours, somewhat longer periods could be used for drying.

Air Flow and Power Requirements.

Since we must limit the temperature rise because of the overdrying problem previously discussed, the only alternative we have for more rapid drying of the upper layers is increased air flow. Table 3 indicates that the best drying of high moisture soybeans occured at air flow of 9-12 cubic feet per minute per bushel (cfm/bu). This is 3 to 4 times as much as is generally quoted. The seemingly excessive air flow rate for bin drying is necessary since more air is the only means by which we can supply adequate energy for evaporation of the water given the temperature/RH limitations noted earlier.

Such air flow rates while low for continuous flow dryers are quite

Table 3. Standard germination of Dare soybean seed (original moisture 22.8%) after drying and time (hours) required for completion of drying under the conditions indicated.

R.H. of drying air	Bin No.	Airflow cfm/bu	Position				Mean
			1 ft.	2 ft.	3 ft.	4 ft.	
55%	9	1.5	+79.5	71.0	48.0	56.5	66.3
			++74	152	168	168	147
	1	3	+82.0	75.0	68.5	63.0	70.4
			++16	68	128	164	94
	2	6	+76.0	75.5	71.5	66.5	71.6
			++16	56	104	116	73
	3	9	+86.0	76.5	69.0	71.0	77.4
			++12	38	56	98	51
	4	12	+83.5	76.5	79.5	73.0	78.1
			++ 8	20	38	50	29
42%	8	3	+77.5	75.9	66.5	60.5	70.1
			++10	58	98	146	70
	7	6	+86.5	74.5	78.0	78.0	79.3
			++ 6	28	62	90	47
	6	9	+87.5	83.5	80.5	78.0	82.4
			++ 4	12	38	62	29
	5	12	+88.5	83.5	82.5	81.0	83.4
			++ 4	12	38	46	25

\+ Standard germination percent on these lines.
++ Hours to completion of drying on these lines.

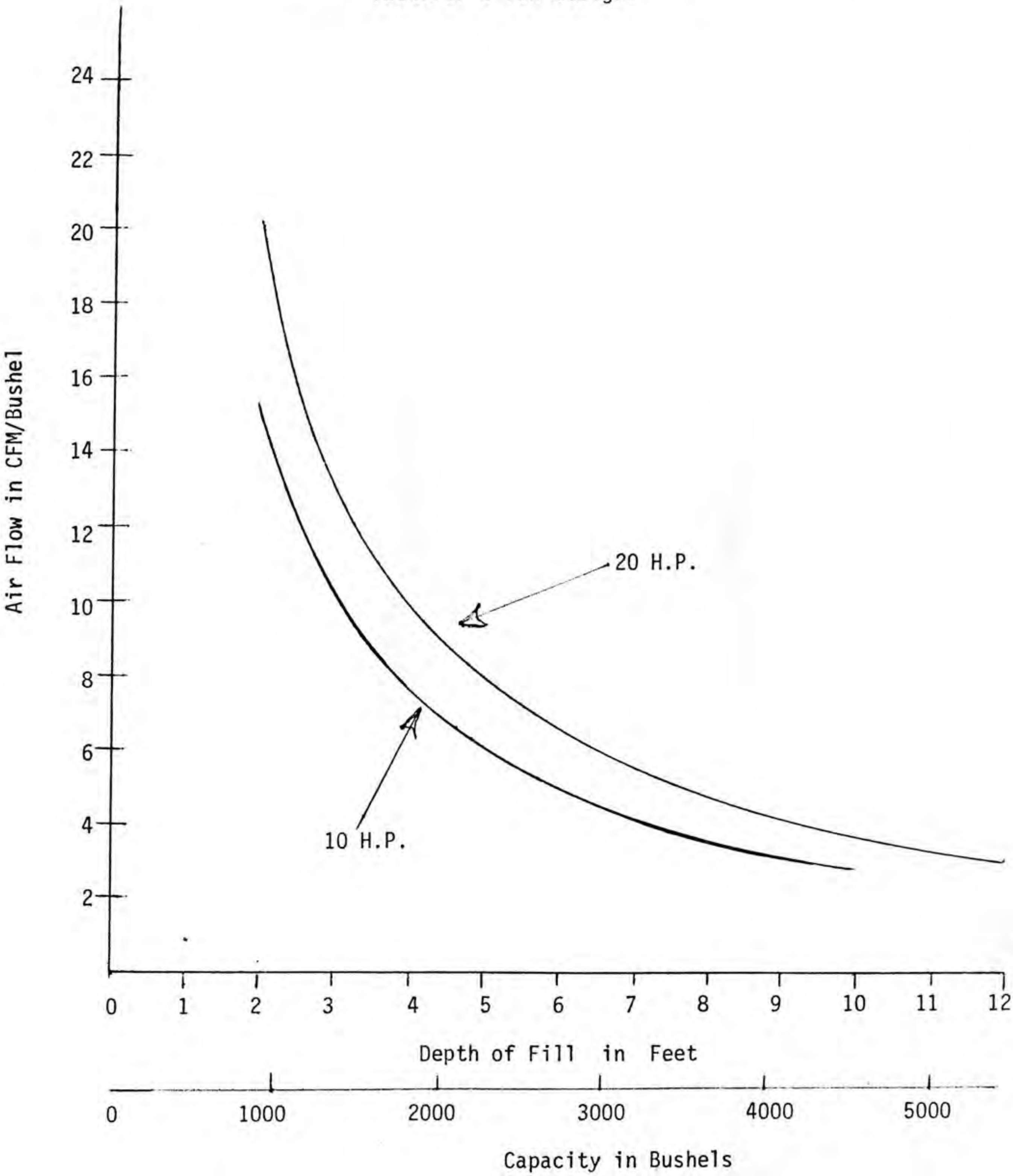
Table 4. Standard germination percentages of Lee 68 soybean seed (original moisture 14.8%) after drying, and time (hours) required for completion of drying under the conditions indicated.

R.H. of drying air	Bin No.	Airflow cfm/bu	Position 1 ft.	2 ft.	3 ft.	4 ft.	Mean
55%	1	3	+97.5	95.5	94.0	95.5	95.6
			++ 8	12	46	58	30
	2	6	+97.5	95.5	94.0	94.5	95.4
			++ 4	8	12	31	13
	3	9	+94.5	93.5	96.5	95.5	95.0
			++ 4	6	8	18	10
	4	12	+93.0	97.5	96.5	96.0	95.7
			++ 4	4	6	10	6
30%	8	3	+95.5	94.5	94.5	96.0	95.1
			++ 4	12	30	52	25
	7	6	+92.5	93.5	91.5	94.0	93.1
			++ 4	10	12	14	10
	6	9	+91.5	94.5	90.5	92.0	92.1
			++ 4	6	10	14	9
	4	12	+97.0	96.0	94.5	92.0	94.8
			++ 4	4	6	10	6

\+ Standard germination percent on these lines.
++ Hours to completion of drying on these lines.

Figure 4. Estimated air flow in cfm/bu. vs. seed depth for a 27 foot diameter drying bin of soybeans with 10 hp and 20 hp centrifugal fans.

NOTE: Exact curve will vary slightly with manufacturer's fan design.



Source: Calculated

large for bin drying. Horse power requirements increase rapidly as depth of seed increases or to state the reciprocal, air flow/bushel falls off rapidly as depth of seed increases. Figure 4 shows the estimated performances of 10 and 20 horsepower fans on a 27 foot diameter bin. Note that to obtain the recommended 9-12 cfm/bu air flow the depth of fill could be no more than 4 feet. To obtain the 3-6 cfm which was shown to be adequate for 14.8% soybeans (table 4) a depth of fill of 6 to 8 feet would be acceptable. Even the greater depth is much less than is generally encountered in the field. The temptation is to "fill it up" but for seed purposes this temptation must be resisted.

Summary and Recommendations.

1. High moisture soybeans can be harvested and dried with adequate seed quality on an emergency basis but the quick drying required will place maximum pressure on the drying system and management and the margin for error is very low.

2. Practically all grain drying systems can be used to dry soybean seed if precautions are taken to limit excessive drying and heat or mechanical damage.

3. An air flow of 9-12 cfm/bu is needed for sufficiently rapid drying for the top of the bins.

4. Temperature rise or heat applied should not result in a drying air RH less than 40%.

5. Too slow drying results in poor seed quality.

6. Too rapid or excessive drying results in poor seed quality.

7. No foolproof drying system exists. The operator must develop a working knowledge of the principles of drying and of his own drying system.

REFERENCES

Boyd, Albert H. 1974. Heated Air Drying of Soybean (Glycine max (L.) Merrill) seed. Dissertation (Ph.D.). Department of Agronomy, Mississippi State University, Mississippi State, Mississippi.

Chenault, Harvey. 1975. Personal Communication. Chief Engineer, The Reid Joseph Company, Greenville, Mississippi

McKenzie, Bruce A. 1972. Selecting A Drying System. The Farm Quarterly Crops (2), 1972.

Saisawat, Pranom. 1973. Storage of Soybean and Sorghum Seed as Influenced by Hysteresis Effect. Thesis (MS). Department of Agronomy, Mississippi State University, Mississippi State, Mississippi.

Shier, G.R., R.C. Miller, and W.A. Junnela. 1943. Forced Ventilation of High Moisture Grains. American Society of Agricultural Engineers Trans.

Walker, Robert J. and H.J. Bane. 1972. The Effect of Drying on Soybean Germination and Crackage. American Society of Agricultural Engineers. Paper 72-817, Chicago, Illinois. 1972.

Welch, G. Burns. 1967. Articles on Seed Drying. Reprinted from Seed Processing Clinic, Seedsmen's Digest, September, October, and November.