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Effective Drying and Storage of Corn and Sorghum Seed

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EFFECTIVE DRYING AND STORAGE OF CORN AND SORGHUM SEED[1/]

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Seed drying and storage are separate but closely related phases in an overall seed operation. In both cases, seed moisture content and its control are the main considerations. Basically, drying of seed conditions them to a desirable moisture content while storage maintains moisture content at a favorable level and also protects the seed against injurious pests (rodents, insects) and high temperatures.

Moisture content is the single most important factor involved in the preservation and maintenance of seed quality. It not only controls the rate of physiological degeneration in seed but also the action of other detrimental elements such as heating, molds, and storage insects.

DRYING

Corn and sorghum seed attain physiological and functional maturity at seed moisture contents ranging from 32 to 40%. At that time the seed have reached maximum dry weight, germinability, and vigor. Therefore, during the interval from maturation to harvest, seed are - in effect - stored in the field, which seldom provides a favorable environment for storage.

Harvesting seed after maturation but while they are still high in moisture content poses an immediate and serious problem, for such seed will heat and deteriorate rapidly unless moisture content is quickly reduced to a safe level. The only practical and dependable way to reduce the moisture content of "high moisture" seed is by artificial drying.

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For the seed producer, artificial drying offers the following advantages: (1) permits earlier and more timely harvesting, thus, reducing the chances of losses in the field from weather, shattering, mechanical damage, insects and birds; and (2) facilitates storage operations by eliminating the hazard of high moisture.

Seed corn is usually harvested on the ear at moisture contents ranging from 20 to 32%. Thus, drying is always necessary. On the other hand, sorghum seed produced in the Southwest under relatively good field drying conditions are frequently allowed to dry in the field and only aerated after harvest. Nevertheless, most sorghum seed producers have facilities for artificial drying when and if it is needed.

Seed drying involves a two phase system consisting of air and seed. In order to understand the principles of drying, some knowledge of pertinent seed and air characteristics or properties is necessary.

Properties of Air:

Air consists of a mechanical mixture of gases and suspended solids (dust, pollen, etc.). The more important gases are oxygen (20%), nitrogen (79%), carbon dioxide (0.03%), and water vapor (0 to 4%). Within normal temperature ranges, the gaseous composition of air remains relatively constant except for the water vapor component.

The actual weight of water vapor contained in a given volume of air is referred to as absolute humidity. Absolute humidity is expressed in grains [3] or pounds of water vapor per cu. ft. of air. Absolute humidity does not indicate relative dryness or moistness of air - it only indicates actual moisture content.

Air is capable of holding moisture in an amount related to its temperature. If a given volume of air contains all the moisture that it can hold at a constant temperature and pressure, it has reached its maximum limit of absolute humidity and is said to be saturated and to have a relative humidity of 100%. Air that contains only 50% of its maximum capacity is only half saturated and has a relative

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3/ 7000 grains = 1 pound.

humidity of 50 percent. Thus, relative humidity is the ratio (expressed as percentage) of the amount of water that the air actually contains and the amount that it would contain under constant temperature and pressure if fully saturated. Relative humidity is, therefore, a measure of the relative moistness or dryness of air.

Three relationships among temperature, relative humidity and drying capacity of air are of paramount importance in seed drying. These are (see Table 1):

1. WHEN AIR IS HEATED, ITS RH DECREASES, AND ITS VOLUME EXPANDS.

   Example: Ambient conditions are 60^{O}F. and 80% R.H. If the air is heated to 100^{O}F., RH decreases to 21% and volume increases from 13.1 to 14.1 cu. ft./lb./dry air.

2. DRYING CAPACITY OF AIR INCREASES AS RH DECREASES.

   Example: 60^{O}F. - 80% RH air contains 62.05 grains moisture lb./dry air. At the same temperature it can hold 77.65 grains moisture at saturation (100% RH). Therefore, drying capacity is 77.65 - 62.05 = 15.51 grains/lb./air. If RH were lowered to 20%, the air would contain only 15.5 grains/lb. and drying capacity would be increased to 77.65 - 15.50 = 62.15 grains/lb. or approximately 4 times greater than previously.

3. DRYING CAPACITY OF AIR INCREASES AS TEMPERATURE INCREASES AT CONSTANT TEMPERATURE.

   Example: 60^{O}F. - 80% RH air has a drying capacity of 15.51 grains/lb./air. Air at 100^{O}F. - 80% RH has a drying capacity of 302.3 (content at saturation)-241.8 (content at 80% RH) = 60.50 grains/lb., or 4 times greater than the cooler air.

Table 1. Effect of temperature rise on relative humidity of air.

Natural Air Temperature Fahrenheit	Temperature Rise Degrees F.	Relative Humidity of Natural Air					
		100%	90%	80%	70%	60%	50%
	H_2O/lb. of Air*	15.06	13.55	12.05	10.54	9.04	7.53
20°	20	41	37	33	29	25	21
	30	28	25	21	20	17	14
	40	19	18	16	14	12	10
	50	14	12	11	10	8	7
	60	10	9	8	7	6	5
	70	7	6	6	5	4	3
	80	5	5	4	4	3	3
	90	4	3	3	3	2	2
	H_2O/lb. of Air*	24.18	21.76	19.34	16.93	14.51	12.09
30°	10	66	60	53	46	40	33
	20	45	41	36	32	27	23
	30	31	28	25	22	19	16
	40	22	20	18	15	13	11
	50	16	14	12	11	9	8
	60	11	10	9	8	7	6
	70	8	7	6	6	5	4
	80	6	5	5	4	4	3
	H_2O/lb. of Air*	36.49	32.84	29.19	25.54	21.89	18.25
40°	10	68	61	54	48	41	34
	20	47	42	38	33	28	24
	30	33	30	26	23	20	17
	40	23	21	19	16	14	12
	50	17	15	13	12	10	8
	60	12	11	10	8	7	6
	70	9	8	7	6	5	4

Table 1. Continued.

		100%	90%	80%	70%	60%	50%
	H_2O/lb. of Air*	53.62	48.26	42.89	37.53	32.17	26.81
	10	69	62	55	48	42	35
	20	48	44	39	34	29	24
50°	30	34	31	27	24	21	17
	40	25	22	20	17	15	12
	50	18	16	14	12	11	9
	60	13	12	10	9	8	6
	H_2O/lb. of Air*	77.56	69.80	62.05	54.29	46.54	38.78
	10	70	63	56	49	42	35
	20	50	45	40	35	30	25
60°	30	36	32	28	25	21	18
	40	26	23	21	18	15	13
	50	19	17	15	13	11	9
	H_2O/lb. of Air*	110.7	99.63	88.56	77.49	66.42	55.35
	5	84	76	67	59	50	42
	10	71	64	57	50	43	35
	15	60	54	48	42	36	30
70°	20	51	46	41	36	30	25
	25	43	39	34	30	26	22
	30	37	33	29	26	22	18
	35	31	28	25	22	19	16
	40	27	24	21	19	16	13
	H_2O/lb. of Air*	131.7	118.53	105.36	92.19	79.02	65.85
	5	84	76	67	59	51	42
	10	71	64	57	50	43	36
	15	60	54	48	42	36	30
75°	20	51	46	41	36	31	26
	25	44	39	35	31	26	22
	30	37	33	30	26	22	19
	35	32	29	25	22	19	16

Table 1. Continued.

		100%	90%	80%	70%	60%	50%
	H_2O/lb. of Air*	156.3	140.67	125.04	109.41	93.78	78.15
	5	85	76	68	59	51	42
	10	72	64	57	50	43	36
80°	15	61	55	49	43	37	30
	20	52	44	41	36	31	26
	25	44	40	35	31	26	22
	30	38	34	30	26	23	19
	H_2O/lb. of Air*	184.9	166.41	147.92	129.43	110.94	92.45
	5	85	76	68	59	51	42
	10	72	65	58	50	43	36
85°	15	61	55	49	43	37	31
	20	52	47	42	37	31	26
	25	44	40	36	31	27	22
	H_2O/lb. of Air*	218.3	196.47	174.64	152.81	130.98	109.15
	5	85	76	68	59	51	43
90°	10	72	65	58	51	43	36
	15	62	55	49	43	37	31
	20	53	47	42	37	32	26
	H_2O/lb. of Air*	257.1	231.39	205.68	179.97	154.26	128.55
	5	85	77	68	60	51	43
95°	10	72	65	58	51	44	36
	15	62	56	49	43	37	31
	H_2O/lb. of Air*	302.3	272.07	241.84	211.61	181.38	151.15
	5	85	77	68	60	51	43
100°	10	73	65	58	51	44	36

* The absolute moisture content for each temperature and relative humidity condition is given in grains/lb. of dry air. 7000 grains = 1 lb.

NOTE: The relative humidity values are given to the nearest whole percent.

These examples dramatically point up the reasons why heated air drying is used when seed moisture content is high and drying has to be rapidly accomplished. Yet, we did not even consider the total increase in drying capacity resulting from heating 60°F. - 80% RH air to 100°F. When this is done, drying capacity increases from 15.51 to 240.25 grains/lb./dry air.

Properteis of Seed:

Seed are hygroscopic. That is, they have the capacity to absorb moisture vapor, or to lose moisture as vapor. When seed and air are mixed, the vapor pressures of the moisture in the air and the mosture in the seed tend to equalize - and they will equalize if confined to a given space and sufficient time is allowed. As the vapor pressures equalize an equilibrium is established and there is no net change in seed moisture content of the seed or in relative humidity of the air. The moisture content that seed attain when subjected to a given level of relative humidity is referred to as the hygroscopic equilibrium value or equilibrium moisture content. The equilibrium moisture content of seed at a given level of relative humidity varies with chemical composition of the seed and temperature. In high oil content seed such as soybeans it is lower than that of starchy seed such as corn at all levels of relative humidity below 90% and at the same temperature. Equilibrium moisture content also increases slightly as temperature decreases and decreases in the same proportion as temperature increases. The equilibrium moisture contents of several important kinds of seed are given in Table 2.

Table 2. Equilibrium moisture contents of six kinds of seed. (Wet weight basis at 77°F.).

	Relative Humidity (%)					
Kind	15	30	45	60	75	90
Cotton	---	6.0	7.5	9.1	12.8	18.0
Corn, YD	6.4	8.4	10.5	12.9	14.8	19.1
Rice, rough	5.6	7.9	9.8	11.8	14.0	17.6
Sorghum	6.4	8.6	10.5	12.0	15.2	18.8
Soybeans	---	6.2	7.4	9.7	13.2	----
Wheat, soft red	6.3	8.6	10.6	11.9	14.6	19.7

Seed will lose moisture (dry) when their actual moisture content is higher than that in equilibrium with the relative humidity of the surrounding air. Conversely, they will absorb moisture when their moisture content is lower than the equilibrium value for the prevailing level of relative humidity.

Equilibrium moisture content sets the limits to which drying can be accomplished under a given set of conditions. Air at 100°F. - 25% relative humidity will dry corn and other grain seed to below 8% and soybean and cottonseed to below 6%, but air at 100°F. and 75% R.H. will dry the grains no lower than about 14% and cotton and soybeans no lower than 12.5 to 13.0%. Moreover, in the latter case, drying would be very slow.

Another most important property of seed should not be overlooked. Seed are alive and drying accomplishes nothing if viability is adversely affected by high air temperature. Generally, the seeds of corn, wheat, sorghum or similar grains are dried at air temperatures between 100-110°F. but no higher than the latter. High oil content seed such as those of peanuts, soybeans, etc. are dried at a somewhat lower air temperature.

The Drying System:

Drying is accomplished by moving air around the individual seeds or ears in a moving or stationary mass. In heated air drying the system required to dry seed consists of a bin to hold or confine the seed, a burner to heat the air, a fan to force the heated air through the mass of seed, and controls. For our purposes here a detailed discussion of the various components of the drying system is not necessary. Campbell's paper in this Proceedings thoroughly considers the total drying system. We will only say here that corn is most often dried on the ear in single or double circulation bins. The heated air is forced up through or down through the mass of ears, or alternately up and downward to achieve more uniform drying. Sorghum seed can be dried in bins or in a continuous flow type dryer.

Effective drying requires that the burner be able to deliver sufficient BTU's of heat to raise air temperature to 100 to 110°F., that the fan be able to deliver the required volume of air (10 to 30 cfm/bu.) against the static pressure developed by the depth of seed dried, and that temperature be accurately controlled within safe limits.

Rate of Drying:

Seed drying involves two transfers of moisture: (1) surface moisture to the air stream; and (2) internal moisture to the seed surface. The rate at which these transfers are accomplished determines the rate of drying. In turn the rate of moisture transfer is influenced by:

1. DRYING CAPACITY OF AIR
2. RATE OF AIR FLOW
3. PHYSICAL PROPERTIES OF THE SEED

Generally, rate of drying should be as rapid as possible without injury to the viability or vigor of the seed, and conspicuous and unnecessary waste of energy.

STORAGE

The properties of air and seed discussed previously are equally applicable in storage. The main purpose of storage is to maintain seed quality. This is best accomplished by storing high quality, well dried seed under conditions that will prevent any regain in seed moisture content and provide for reasonably moderate storage temperatures.

The general perscription for storage is that conditions should be dry and cool. A perscription such as this is meaningless unless specific levels or at least ranges of moisture content and temperature are given. And these can not be given unless the desired period of storage is known.

Corn and sorghum seed will store quite well for one season at a moisture content of 11 to 12% and normal warehouse temperatures. Storage periods longer than one season (carryover) require seed moisture contents of about 10% and some protection against high summer temperature for maintenance of viability and vigor. Long term storage of valuable seed stocks requires still more rigorously controlled conditions - relative humidity of 40% or less and temperature of 50°F. or less.

SUMMARY

Seed drying and storage both involve conditioning of seed moisture content. Drying rapidly and effectively removes moisture from seed harvested at the peak of quality and reduces moisture content to a safe level. The main objective of storage is maintenance of high seed quality by holding seed moisture content down to a desirable level (10-12% for corn and sorghum), and providing for moderate temperatures, and protection against rodents, and insects.