

Identification of Suitable Seed Storage Places in India on the basis of Temperature and Relative Humidity Conditions

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Seed science research in our country, has made tremendous progress over the past few decades and Seed Research journal has been instrumental in marking and documenting new milestones in our journey of discovering and seeking new knowledge. Dr. Malvika Dadlani suggested to consider re-printing classical research papers published in Seed Research. There are several papers that have been published in this journal decades ago which could be considered as classical papers, since they still continue to be standard reference papers for basic seed research experiments. Considering its relevance for the current younger generation of scientists and stakeholders, the editorial team has decided to publish one such paper in each issue of the journal. The paper on 'Identification of suitable seed storage places in India' was first published in this journal in 1976 and is being reprinted in this issue, as the first one in the series of classic papers.

ABSTRACT: The viability of seeds during storage may be affected by a number of separate, but interacting factors. However, seed moisture or relative humidity of the atmosphere and storage temperature are the two most important factors influencing seed viability. Therefore, data on mean relative humidity and mean temperatures for the last 30 years (1931-60) for few important towns in 14 states have been analysed. For short term seed storage (up to 8 months or one planting season) 70 per cent RH and 30°C have been considered as the upper limit for minimizing the loss in seed viability. Based on these informations, Delhi, Ludhiana and Jaipur have been classified as good Indore, Coimbatore, Poona, Varanasi, Bareilly, Hyderabad and Sonogaon as moderate; Patna, Bangalore, Bombay, Cuttack and Calcutta as poor and Trivandrum, and Gawhati as very poor places for short term seed storage. Experimental data on 9 crop seeds have been presented to show that Delhi is a good place for seed storage under ambient conditions.

The viability of seeds during storage may be affected by a number of separate, but interacting factors e.g. seed moisture (or relative humidity of the atmosphere), storage temperature, gaseous exchange, physical condition of the seed, stage of seed maturity, initial viability and vigour, microflora and insect infestation. Out of these, seed moisture and storage temperature are most important factors influencing seed viability during storage.

Temperature, Relative humidity and seed moisture:

Amount of moisture absorbed by seeds depends not upon the absolute humidity, but upon the relative humidity (RH). Each kind of seed will attain a characteristic moisture content at a given

RH at a particular temperature which is called equilibrium moisture content (Table 1). It is clear from the table that with the increase in relative humidity of the air the seed moisture increases. The equilibrium moisture content for a given relative humidity changes as the air temperature changes. Thus, a rise in temperature reduces the RH of the air. If there is no further addition of moisture, a reduction in temperature raises the RH.

At different temperatures the water holding capacity of the atmosphere will be different (Table 2). If a kg of air at 20°C contains 7.4 g of moisture, its RH is 50% (7.4/14.8). Raising the temperature to 40°C reduces its RH to 17.9% (7.4/41.4). Reducing the temperature of the air to 10°C increase the RH to 97% (7.4/7.6). Cooling it a little lower

Table 1. Equilibrium seed moisture (per cent) at various levels of Relative Humidity at 77°F (25°C)

Seed kind	Percentage Relative Humidity						
	15	30	45	60	75	90	100
Equilibrium moisture content (%)							
<i>Cereal seeds</i>							
1. Maize	6.4	8.4	10.5	12.9	14.8	19.1	23.8
2. Rice (Milled)	6.8	9.0	10.7	12.6	14.4	18.1	23.6
3. Sorghum	6.5	8.6	10.5	12.0	15.3	18.8	21.9
4. Wheat, hard red winter	6.4	8.5	10.5	12.5	14.6	20.1	25.4
<i>Oil Seeds</i>							
1. Cotton	-	6.0	7.5	9.1	11.5	18.0	-
2. Groundnut	2.5	4.0	5.5	7.0	10.0	13.0	-
3. Soybean	-	6.2	7.4	9.7	13.2	18.8	-
4. Sunflower	-	5.1	6.5	8.0	-	15.0	-
<i>Vegetable Seeds</i>							
1. Cabbage and Cauliflower	3.5	4.5	6.0	7.0	9.0	-	-
2. Carrot	5.0	6.0	7.0	9.0	11.5	-	-
3. Egg plant (brinjal)	4.7	6.3	8.0	9.8	-	-	-
4. Lettuce	4.0	5.0	5.9	7.0	9.0	-	-
5. Okra	7.5	8.0	9.5	11.0	13.0	-	-
6. Onion	6.0	7.0	8.5	10.0	12.0	-	-
7. Tomato	6.0	7.0	8.0	9.0	11.0	-	-

will increase the RH above 100% and moisture will condense on seed coat (Harrington, 1973). Therefore, with the increase in storage temperature, RH decreases and consequently the seed moisture

and vice-versa. The rate at which seed absorb or lose moisture varies with the type of seed and depends upon the RH of the air, the moisture content of the seeds, seed coat thickness and the depth of the mass of seeds.

Table 2. Moisture in air at saturation (100 per cent RH) (Harrington, 1973)

Temperature°C	g water/kg air
0	3.9
10	7.6
20	14.8
30	26.4
40	41.4

The main component which absorbs water, in seeds, is the protein. However, other components also absorb water. The mucilages, as well as cellulose and pectic substances also absorb some moisture. Starch does not add much to the water absorption, except at acidic pH or at high temperatures.

Consideration in deciding the places for seed storage:

Suitable seed storage facilities must be available with the seed producing organization. The storage

Table 3. Months in which the mean RH and mean temperatures exceeds 70% and 30°C respectively (Mean of 30 years, 1931-60)

State	City	Temp. exceeds 30°C		RH exceeds 70%	
		Months	No.	Months	No.
Union Territory	Delhi	May to August	4	August	1
Bihar	Patna	April to July	4	July to September	3
Maharashtra	Poona	May	1	July to September	3
	Bombay	-	-	May to October	6
	Nagpur	April to June	3	July to September	3
Punjab	Ludhiana	May to August	4	August	1
Rajasthan	Jaipur	May to July	3	August	1
U.P.	Bareilly	May to July	3	July to September	3
	Varanasi	April to June	3	July to September	3
M.P.	Bhopal	May to June	2	July to September	3
	Indore	May to June	2	July to September	3
	Jabalpur	May to June	2	July to September	3
Orissa	Cuttack	April to June and September	4	June to October	5
A.P.	Hyderabad	April to June	3	July to September	3
Kerala	Trivandrum	-	-	February to December	11
Karnataka	Bangalore	-	-	June to October	5
Tamil Nadu	Coimbatore	-	-	July, Aug. and October	3
West Bengal	Calcutta	May to June	2	May to October	6
Assam	Gwahatti	-	2	Jan, May to December	9

facilities may be for short term (one planting season), intermediate term (two planting seasons) or long term (more than two planting seasons). Requirements for all these kinds of storage will be different. In this paper, only short term bulk seed storage is discussed. After harvest, almost all kinds of seed have to be stored for 6-8 months before sowing.

Decrease in seed moisture or storage temperature or both increases the storability of seeds (Barton, 1961). During reduction of storage temperature to an extent beneficial for the maintenance of viability of commercial seed stores,

greater attention must be given to the control of moisture content by drying (Agrawal, 1975). Reduction of moisture content to the desired level will depend upon the temperature, the length of storage period and kind of seeds to be stored. For short term storage of cereal seeds, 10 per cent moisture content should be considered as a safe level (Table 6). In order to maintain seed moisture at this level, seed stores should be built in places where the RH does not exceed 70 per cent during the year (Agrawal and Kaur, 1975). In fact, it would be ideal if the seed stores are built in more drier places, but places where the mean ambient relative humidity is less than 70 per cent are difficult to

Table 4. Classification of places for seed storage under ambient conditions, only mean relative humidity and mean temperature have been considered (mean of 30 years, 1931-1960)

Good (RH limit* does not exceed one month and temperature limit** 4 months)	Moderate (RH and temperature limit does not exceed 3 months)	Poor (RH and temperature limit does not exceed 4-6 months)	Very Poor (RH limit does not exceed 7-11 months)
Delhi	Bhopal	Patna	Trivandrum
Ludhiana	Indore	Bangalore	Gauhati
Jaipur	Jabalpur	Bombay	
	Coimbatore	Cuttack	
	Poona	Calcutta	
	Nagpur		
	Varanasi		
	Baeilly		
	Hyderabad		

*Mean RH Limit, 70%

**Mean temperature limit, 30°C.

Table 5. Germination percentage of 9 species during storage under ambient conditions in Delhi

Kind and variety	Storage period (Months)							
	0	4	8	12	20	22	24	27
Wheat*	96.0	96.0	96.0	92.0	92.0	91.0	91.0	-
cv.K. S.								
Triticalse*	90.0	70.0	71.0	-	53.0	54.0	-	11.0
cv.S-71-154		(3)**	(7)**		(19)**			
Paddy*	87.0	88.0	91.0	91.0	92.0	88.0	-	82.0
cv.IR-8								
Soybean*	89.0	80.0	74.0	43.0	0.0			
cv.Bragg								
Moong		69.0***	91.0	98.0	-	-	92.0	98.0
cv.PS-16								
Lobia		91.0	86.0	89.0	57.0			
cv.E. Lobia								
Lentil	95.0	91.0	96.0	91.0				
cv.Pusa-4								
Pea	80.0	87.0	86.0	84.0				
cv.479-B								

*Varietal differences in the loss of germination has been observed.

**Figs. In parenthesis relates to the months of storage.

***Low germination because of the presence of 29% hard seeds.

Table 6. Fluctuations in seed moisture (Mean of varieties) during storage under ambient conditions in Delhi

Months kinds	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wheat	6.77	-	6.66	-	5.46	6.47	8.55	10.12	9.74	8.60	7.22	7.41
Triticale	6.77	-	6.58	-	-	6.49	-	10.01	9.60	8.42	6.67	7.41
Paddy	7.71	7.85	-	7.32	5.86	6.76	7.82	9.18	9.45	9.77	8.54	7.65
Soybean	7.42	6.78	5.08	3.88	4.50	5.26	6.28	9.00	9.97	8.60	5.43	5.23
Moong	7.00	9.30	-	5.60	4.75	7.07	8.77	10.55	10.39	8.48	7.31	8.35
Lobia	6.87	9.90	-	5.50	4.40	7.21	9.22	11.75	9.83	7.91	6.08	10.60

find. The RH limit of 70 per cent has been taken because the lower limit for the invasion of storage fungi has been reported to be 70 per cent (Christensen, 1972). Taking into consideration the average monthly maximum temperature of the various places in India, the temperature limit of 30°C would be reasonable.

The data on local climate conditions, particularly average mean temperature and relative humidity, for the last 30 years for some important towns in 14 states have been analysed and presented in Table 3. These places are then classified into good, moderate, poor and very depending upon the relative humidity and temperature conditions (Table 4).

It is evident that Delhi, Ludhiana and Jaipur have been considered as good for seed storage, but Patna, Bangalore, Bombay, Cuttack and Calcutta have been classified as poor (TABLE 4). Not all places in the country have been taken into consideration for such a classification, because reliable data on RH and temperature are not available for all the places. There is a very strong need to locate many more suitable places for seed storage and to conduct simple storage experiments to substantiate the above classification.

Storage experiments were started in Delhi in 1973-75 and data are presented in Table 5 and 6. Even soybean seeds which is considered to be a poor storer and which has been reported to be

difficult to have reasonable viability percentage at the time of planting (June-July) gave 74 per cent germination after 8 months of storage. Good storer like paddy and wheat gave about 90 per cent germination after 24 months of storage. The data presented in Table 5, provides a strong support to the classification given in Table 4 that Delhi is a good place for seed storage. The better storability of seeds under ambient conditions of Delhi was due to the low RH conditions. And that is why the seed moisture in various kinds of seed never exceeded 12 per cent. In majority of the cases the maximum seed moisture was in range of 9-10.5 per cent in the month of August (Table 6).

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