

## Effects of Long-term Storage on Seed Viability and Vigour of Wheat Germplasm under Ambient Conditions in Western Himalayas

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**ABSTRACT** A seed bank is a repository, where seeds are stored at low temperature and relative humidity to maintain their viability for longer durations without affecting their genetic integrity. A study was conducted at DWR, Regional Station, Dalang Maidan, Lahaul-Spiti (Himachal Pradesh) to explore the possibility of storage of wheat germplasm under ambient conditions. Investigation showed that germplasm stored for the last 12 years under ambient conditions maintained germination up to 81.9 per cent and high seedling vigour. The present paper deals with preservation of wheat germplasm for longer durations under ambient conditions of alpine climate of the Western Himalayas.

**Key words:** Wheat germplasm, long-term storage, ambient conditions, germination, vigour

Wheat [*Triticum aestivum* (L.) em Thell] is an important food crop of the world, occupying approximately 20 per cent of world's cultivated land. It is the most important commodity in the international trade. India is the second largest producer of wheat in the world. It occupies an area of 27.4 m ha with a mean annual production of 73 MT [1]. During 2007-08, record production of 78.4 MT was achieved [2]. Wheat germplasm during long-term storage lose the viability and vigour and is infested by a large number of microbes (including *Aspergillus* spp. and *Penicillium* spp.). Christensen (1955) reported that wheat stored in commercial bins at 13.5-14 per cent and 14.5-15 per cent moisture content recorded presence of *Aspergillus restrictus* and *A. repens*, respectively. Seed germination is most easily measurable parameter of seed quality, whereas vigour index is an important attribute of seed quality which reflects the capability of seeds to emerge and establish under the unfavourable conditions in the field. Extent of

ageing (before and after harvesting) during storage is the major determinant of germination and vigour of the seed. Differential storability of various species has been attributed to its genetic and varietal characters, and also the storage environment and provenances [6].

In this paper, we look forward to new opportunity of storage of germplasm which are not only expected to be more economical but also technically sound. The purpose of this exercise is to cut down the exorbitant costs of installation and maintenance of artificial and conditioned storage rooms for germplasm conservation. Therefore, an attempt was made to store wheat germplasm under ambient conditions, characterized with low relative humidity and low temperature round the year at regional station, Directorate of Wheat Research, Dalang Maidan in Lahaul-Spiti district of Himachal Pradesh (Fig. 1). The oldest seed lot available was 12 years old. The main objectives of this study were: i) to

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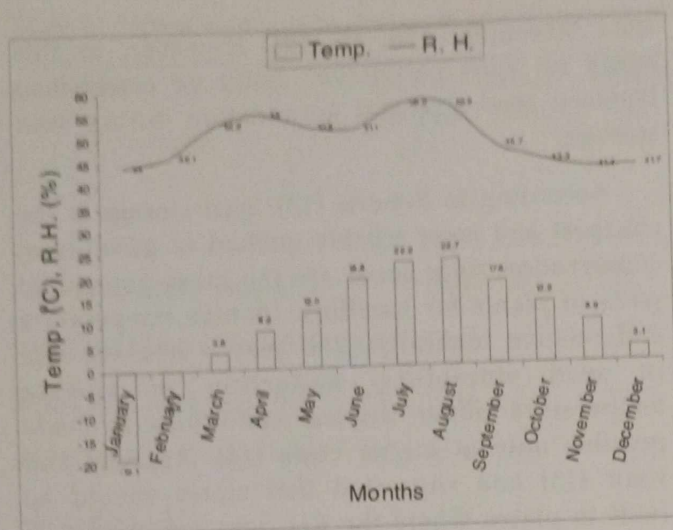


Fig. 1. Climatic pattern at Keylong of Lahaul Valley (mean value of daily data recorded from 1996 to 2007)

identify germplasm with better potential of seed storability under long-term ambient storage conditions, and ii) to examine the potential of Lahaul Valley as a site of natural long-term storage or low-cost seed bank.

## MATERIALS AND METHODS

The investigations were conducted at Directorate of Wheat Research Regional Station, Dalang Maidan in Lahaul-Spiti district of Himachal Pradesh, during 2007-08. The experimental materials consisted of 87 exotic lines of wheat belonging to *Triticum aestivum*, *T. dicoccum* and *T. durum* conserved by DWR at Dalang Maidan. Germination test was carried out using the guidelines of ISTA [7]. Total seedling length and seedling dry weight on 08 day of seed germination were recorded. A crop of all these lines was grown during 2007-08 and freshly harvested seeds were put to germination test immediately after sun-drying for assessing the dormancy levels in these lines. All fresh ungerminated seeds were classified as dormant seeds. The experiments carried out in laboratory conditions were laid out in completely randomized block design with four replications.

## RESULTS AND DISCUSSION

### Seed germination

All the lines met the Indian Minimum Seed

Certification Standards for germination, i.e. 85 per cent at the beginning of storage. Even after 12 years of storage under ambient conditions, three varieties, viz. LIN CALEL M.A., THATCHER/RESCUE and 1953/LEE B52-91 PI 13242 were able to maintain germination percentage above 80 (81.9, 81.3 and 80.3%, respectively). Germination per cent of 36 lines were between 70 and 80, whereas of 43 lines the germination per cent were between 60-70. Only 5 germplasm lines recorded the germination below 60 per cent. The lowest germination recorded was 55.1 per cent (YAQUI 54).

### Total seedling length

A great variation in seedling length among the lines was observed. It ranged between 2.2 cm (DGV.II/RODESIA 17A-54) to 26.1 cm (PI 94675). However, there was no significant correlation between germination ability and length of seedlings (Table 2). A positive and highly significant correlation between seedling length and dormancy was observed.

### Seedling dry weight

This trait was not found to have any effect on seed germination. Varieties varied much for seedling dry weight, the lowest being 0.066 g (MELANOPUS 2B) and the highest 0.312 g (GRIFONI 235) Table 1.

### Seedling vigour index-I

It is a function of seed germination and total seedling length. It showed non-significant correlation with seed germination. On the other hand the total seedling length influenced vigour index-I. Lines DGV.II/RODESIA 17A-54 and FROCOR/KT.II-2463-2B-2B-IT showed the lowest values for total seedling length (2.2 and 2.5 cm, respectively) and seedling vigour index-I (19.14 and 20.25, respectively). Similarly, PI 94675 exhibited the highest total seedling length (26.1 cm) and ranked first for vigour index-I (216.63). However, in case of some lines the seed germination was low to moderate, but vigour index-I was higher owing to more seedling length and *vice-versa*. Lines 1953/Lee B52-91 PI 13242, Celebration and Lignee 53 AD-3 although had

higher germination but were low on vigour index-I, because of smaller values for total seedling length. On the other hand, varieties Yaqui 48//Kenya 58/Newthatch and Supermo (W-175) showed higher vigour index-I, inspite of low germination. This was due to their more total seedling growth.

#### *Seedling vigour index-II*

The line Melanopus 2B showed the lowest value for the seedling dry weight (0.066 g), whereas Girfoni 235 recorded the highest values for seedling dry weight (0.312 g) (Table 1).

Although the lines AUSTRALIAN No. 459, KENYA GOVERNOR (W-171), NA485/3/MIDA/CADET C.I.1244//2\*GIZA 39 and Reliance had higher seed germination, they showed low vigour index-II because of very low seedling dry weight. On the other hand, lines Lusitano, Australian No. 204 and Supermo (W-175) exhibited higher vigour index-II inspite of low germination value on account of high seedling dry weight (Table 2).

#### *Seed dormancy*

The dormancy of seeds in any of the lines had not affected the germination of seeds under long-term storage. However, a significant positive correlation coefficient between seed dormancy and seedling dry weight was found. Seed dormancy was also found to have positive correlation with vigour index-II (0.234). This may be attributed to higher activity of enzymes, which are able to mobilize more of the stored food.

It was observed that 32 lines (nearly 40 per cent of the total) showed no dormancy, whereas 16 lines had dormancy levels between 0 and 10 per cent, 27 lines (about 31 per cent of total) exhibited dormancy ranging between 10 and 50 per cent, whereas rest 12 lines had a higher dormancy starting from 53 per cent up to maximum of 80 per cent.

#### *Test weight*

Several workers had reported 1000-seed weight (an indicator of seed size) to be correlated with

seed storability [10, 11, 12]. However, in this study no such correlation could be established between seed size and germination during seed storage.

According to Roberts [13], seed storage is the cheapest and most reliable method of germplasm conservation since seeds are the most convenient parts of plants for handling. Storage temperature and relative humidity (RH) play a decisive role in seed storability. Reduction of storage temperature under tropical conditions is made possible only at higher costs [14]. Agrawal and Kaur [15] had suggested that stores should be built in places where the RH does not exceed 70 per cent during the year. The RH limit of 70 per cent has been considered because it was reported to be the lower limit for invasion of storage fungi [16].

Artificial seed storage chambers are in vogue in many parts of the world, in which possibility of human errors, failure of electricity supply etc. always have room. In light of these, a place where RH never goes above 55 per cent during the year and mean temperature remains below 23°C throughout the year offers an opportunity for safe seed storage. From this study, it can be inferred that it is a technically sound option to have the medium term and long-term storage sections of gene banks in temperate areas like Lahaul-Spiti or locations with similar climatic conditions in any part of the globe. Besides being an economical alternative, it offers protection from possible manual errors or equipment failure that may cause loss of precious germplasm.

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Table 1. Effects of long-term storage on wheat germplasm quality under natural conditions at Lahaul Valley (HP) India

Genotype	Germi- nation (%)	Tillers/ plant	Height (cm)	Grains/ ear	Test weight (g)	Dorm- ancy (%)	Seed- ling length (cm)	Seed- ling dry weight (g)	Vigour Index -I	Vigour Index -II
AUSTRALIAN No. 459	77.4 (8.8)	3.1	69.1	11.4	14.5	0.00	19.3	0.090	169.84	0.79
AUSTRALIAN No. 204	63.2 (7.9)	2.9	62.8	16.6	25.5	0.00	18.8	0.173	148.52	1.37
AUSTRALIAN No. 90	73.3 (8.6)	2.9	76.5	18.6	28.3	0.00	7.2	0.203	61.92	1.75
AUSTRALIAN No. 190	56.8 (7.5)	3.2	78.5	13.6	22.0	0.33	21.7	0.151	162.75	1.13
AUSTRALIAN No. 14488	6.9 (8.8)	4.0	68.4	28.1	30.5	0.00	17.3	0.198	152.24	1.74
AF 3A-1	78.7 (8.9)	2.7	66.3	13.0	25.5	0.00	7.5	0.142	66.50	1.26
MIDA/CADET	64.8 (8.1)	3.1	70.2	18.3	37.5	1.33	5.0	0.094	40.50	0.76
MIDA/1529	60.3 (7.8)	3.1	74.2	17.3	18.7	0.00	16.4	0.196	127.92	1.53
TIMSTEIN/THATCHER	66.3 (8.1)	3.1	80.1	24.2	25.5	0.00	19.5	0.079	157.95	0.64
KENYA/GULAR/ PILOT/3/KENYA/NEWTATCH	67.9 (8.2)	3.4	33.4	18.8	23.5	0.67	7.8	0.186	63.96	1.53
EGYPT No. 95	71.7 (8.5)	2.9	80.7	24.6	17.7	0.00	22.8	0.154	193.80	1.31
H 544	63.0 (7.9)	3.3	85.2	24.0	31.0	0.33	12.2	0.134	96.38	1.06
ATLAS 50	71.8 (8.5)	3.6	56.0	19.9	26.5	4.00	19.8	0.173	168.30	1.47
MOSIDA	60.3 (7.8)	3.4	82.6	17.9	35.5	0.67	12.9	0.069	100.62	0.54
RENOWN	71.2 (8.4)	2.9	70.7	15.2	24.5	5.00	14.9	0.148	125.16	1.24
PI 58789-2	68.6 (8.3)	3.1	62.6	23.9	33.5	8.00	15.6	0.114	129.48	0.95
KENYA/FLORENCE/ DUNDEE	70.1 (8.4)	3.6	72.9	22.3	29.5	0.33	12.5	0.188	105.00	1.58
W 51/W.R. 48	72.2 (8.5)	3.9	68.7	14.6	19.5	1.33	13.5	0.138	114.75	1.17
KENYA GOVERNOR (W-171)	70.8 (8.4)	2.5	60.0	24.8	30.3	10.00	15.6	0.082	131.04	0.69
SUPERMO (W-175)	63.5 (8.0)	3.6	78.3	20.9	34.5	10.00	24.7	0.142	197.60	1.14
MOKHTAR/2*HIND 162	65.8 (8.1)	3.3	67.3	14.0	26.0	1.33	25.2	0.205	204.12	1.66
SUPERMO 51 (W-327)	69.7 (8.3)	2.9	85.5	14.2	41.5	2.33	15.1	0.189	125.33	1.57
220/39	65.1 (8.1)	2.7	67.3	13.8	28.5	0.00	4.7	0.184	38.07	1.49

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ONAS C.I. 6221	67.2 (8.2)	2.5	78.1	23.6	31.5	3.33	7.2	0.071	59.04	0.58
LIGNEE 53 AD-3	65.8 (8.1)	3.3	78.1	25.0	30.5	0.67	9.8	0.164	79.38	1.33
LINE 1346-2148. GIZA 135/LINE 950	65.5 (8.1)	2.9	72.3	20.3	32.3	8.00	15.9	0.091	128.79	0.74
PUGLN	66.1 (8.1)	3.4	78.7	16.3	35.8	5.00	16.0	0.168	129.60	1.36
1953/LEE B52-91 PI 13242	80.3 (9.0)	2.9	51.6	7.0	13.6	0.00	16.1	0.236	144.90	2.12
THATCHER/RESCUE	81.3 (9.0)	3.2	68.8	16.0	27.8	0.33	12.6	0.112	113.40	1.01
GIZA139/MIDA/CADET	66.4 (8.1)	2.9	73.9	14.3	17.7	3.00	14.4	0.159	116.64	1.29
LLCAFEN	75.9 (8.7)	3.1	84.2	17.3	25.8	4.00	15.3	0.194	133.11	1.69
LERMA//YAQUI/ KENTANA'S'.II-988-26-4B	60.5 (7.8)	3.0	73.2	28.7	20.3	0.00	14.9	0.135	116.22	1.05
FROCOR/KT.II-2463- 2B-2B-IT	65.7 (8.1)	3.2	64.5	10.0	16.8	0.00	2.5	0.182	20.25	1.47
SPRING WHEAT/ GABO//LERMA	67.5 (8.2)	3.1	55.2	10.6	20.8	0.00	15.2	0.240	124.64	1.97
KENTANA//THACHER/ MENTANA	72.7 (8.5)	3.3	61.1	15.2	27.5	5.33	13.6	0.216	115.60	1.84
MAGNIF.F/TIMSTEIN	65.9 (8.1)	3.4	70.9	23.8	36.0	2.00	19.5	0.169	157.95	1.37
NA482/3/HOPE/ 3*GIZA139	70.2 (8.4)	3.1	78.8	17.8	25.3	1.67	18.1	0.282	152.04	2.37
NA485/3/MIDA/CADET C.I.1244//2*GIZA 39	74.0 (8.6)	2.5	84.3	17.1	31.0	4.33	24.3	0.189	208.98	1.63
1990/1756//P/3/KT48	71.6 (8.5)	3.7	76.0	25.5	33.0	4.00	11.4	0.136	96.90	1.16
RELIANCE	70.5 (8.4)	2.4	57.7	15.5	28.5	3.00	13.3	0.102	111.72	0.86
DGV.II/RODESIA 17A-54	75.3 (8.7)	4.1	78.0	28.4	40.0	1.00	2.2	0.237	19.14	2.06
MARIAESCOBAR// MCMURACHY/MINN.2698/3/64	60.7 (7.8)	2.9	77.6	18.1	21.0	1.00	15.3	0.123	119.34	0.96
GABO//AQUILERA- KENYA/PILOT-MARROQUI	78.1 (8.8)	3.8	60.7	13.7	29.5	5.67	11.9	0.087	104.72	0.77
MARIAESCOBAR//H44/ MARQUIS 74A-81	70.6 (8.4)	3.4	57.5	16.6	29.5	5.33	15.7	0.099	131.88	0.83
RIONEGRO/2* MENTANA/KENYA	64.1 (8.0)	3.2	71.1	23.0	26.8	0.00	16.1	0.166	128.80	1.33

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MENTANA	68.0 (8.2)	3.8	79.1	19.4	31.9	1.00	21.8	0.174	178.76	1.43
MARIAESCOBAR2*/ NEWTH.//GABO	73.3 (8.6)	2.7	76.7	25.3	37.5	2.33	13.5	0.129	116.10	1.11
PI 195727	63.2 (7.9)	3.2	62.7	9.6	17.5	0.00	12.9	0.147	101.91	1.16
DURAZIOMOLAR	72.8 (8.5)	2.6	74.1	13.1	29.0	1.00	18.7	0.137	158.95	1.16
356.A.2.A	75.2 (8.7)	3.4	61.4	10.8	20.5	0.00	13.6	0.181	118.32	1.57
YUMA	64.7 (8.0)	3.1	72.6	20.0	16.0	0.33	13.0	0.258	104.00	2.06
GRIFONI 235	70.5 (8.4)	3.3	31.5	7.1	13.2	0.00	23.2	0.312	194.88	2.62
MELANOPUS	63.3 (8.0)	2.9	73.0	22.2	32.5	1.00	13.6	0.148	108.80	1.18
PI 94623	71.3 (8.4)	2.7	79.8	19.9	26.5	0.00	4.2	0.274	35.28	2.30
PI 94650	67.1 (8.2)	3.6	56.2	15.1	31.7	8.00	14.2	0.209	116.44	1.71
PI 94675	68.8 (8.3)	2.9	84.0	23.6	15.5	5.33	26.1	0.146	216.63	1.21
LEE/FRONTANA// EGYPT/TIMSTEIN	65.4 (8.1)	2.7	68.4	17.4	30.1	0.00	16.8	0.170	136.08	1.38
PALESTINE	75.2 (8.7)	3.6	62.8	14.2	24.5	6.67	21.0	0.091	182.70	0.79
1610//TH./ STACATALINA	64.3 (8.0)	3.4	63.1	24.3	12.5	0.00	23.4	0.222	187.20	1.78
DOCTEM MAZET	68.6 (8.3)	2.7	75.6	19.2	43.8	8.67	13.6	0.221	112.88	1.83
MELANOPUS 2B	70.5 (8.4)	2.4	20.0	4.8	11.7	0.00	14.4	0.066	120.96	0.55
KHAPLI	70.8 (8.4)	3.4	60.2	17.0	22.0	3.33	13.7	0.110	115.08	0.92
YAQUI 54	55.1 (7.4)	3.1	69.5	20.1	32.3	1.33	23.9	0.149	176.86	1.10
LEE//NOR10/B29	73.6 (8.6)	3.2	70.3	15.5	29.5	3.00	8.8	0.084	75.68	0.72
WT//NOR10/B26	73.5 (8.6)	4.1	60.5	15.7	31.0	0.00	15.7	0.156	135.02	1.34
KT/FN//MY48.P947-4B	73.4 (8.6)	3.4	74.0	20.4	27.5	1.33	23.7	0.119	203.82	1.02
THACHER/KENYA FARMER	74.4 (8.6)	3.0	73.2	23.9	26.5	1.00	18.9	0.153	162.54	1.32
WHEAT 4	63.6 (8.0)	3.3	80.5	6.2	12.3	0.00	14.3	0.114	114.40	0.91
CELEBRATION	64.9 (8.1)	3.5	72.7	26.0	13.0	0.00	4.6	0.082	37.26	0.66
II-50-17/RMR	65.2 (8.1)	2.9	83.2	24.0	34.0	6.00	13.3	0.200	107.73	1.62
FR/KAD-MGF/FR/3/FR	70.8 (8.4)	2.8	69.6	14.2	17.6	2.67	19.8	0.135	166.32	1.13
SAIDAMA KOMUGI	64.6 (8.0)	3.1	83.3	18.9	40.0	3.00	18.0	0.139	144.00	1.11

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LIN CALEL M.A.	81.9 (9.0)	3.4	77.9	14.1	25.5	0.00	4.7	0.152	42.30	1.37
ME/E-7//CLY./3/ ND81/4/CLY 64-12-43	71.9 (8.5)	3.1	52.5	13.1	20.1	0.00	11.1	0.309	94.35	2.63
CONLEY/ND 137-2	67.9 (8.2)	3.5	84.2	21.0	37.5	4.00	12.3	0.191	100.86	1.57
II-62-7	66.6 (8.2)	3.0	68.0	18.1	36.5	5.00	15.5	0.175	127.10	1.44
II-62-19	58.4 (7.6)	2.5	77.2	18.4	36.3	0.00	15.3	0.145	116.28	1.10
BAJIO 66	74.1 (8.6)	3.4	50.3	13.8	13.6	0.00	12.0	0.098	103.20	0.84
TIBA 63	56.5 (7.5)	3.1	64.9	24.7	24.0	1.67	9.3	0.199	69.75	1.49
KENYA/GULAR/EUREKA	66.3 (8.1)	2.8	74.5	20.0	25.5	0.00	12.5	0.127	101.25	1.03
38013. PI 249820	63.4 (8.0)	3.3	73.1	16.4	25.5	1.33	13.8	0.185	110.40	1.48
THATCHER/2265/ 2*REDMAN R.L.2563	76.0 (8.7)	3.0	72.4	20.9	30.6	2.00	9.0	0.151	78.30	1.31
NAINAR 160	68.5 (8.3)	3.1	74.1	14.3	32.5	0.00	9.9	0.127	82.17	1.05
N.10-B17/YAQUI 53// YAQUI 50/3/KENTANA 54/4/II-50-17/RUSHMORE II-61-12	67.1 (8.2)	3.3	91.9	24.8	34.6	0.00	6.3	0.149	51.66	1.22
CIVITELLA	73.0 (8.5)	3.1	76.0	14.9	15.3	0.00	15.0	0.117	127.50	0.99
YAQUI 48//KENYA 58/ NEWTATCH	64.3 (8.0)	3.5	78.8	15.0	25.3	1.00	5.8	0.182	46.40	1.46
LUSITANO	58.6 (7.7)	3.3	66.6	22.6	21.5	1.00	11.2	0.104	86.24	0.80
<b>CD @ 0.05</b>	<b>0.301</b>	<b>0.599</b>	<b>4.812</b>	<b>0.885</b>	<b>0.906</b>	<b>0.765</b>	<b>3.093</b>	<b>0.070</b>	<b>4.331</b>	<b>0.357</b>

Values in parentheses are square root transformation

Table 2. Correlation matrix between different seed characters

Character	Germination (%)	Dormancy (%)	Seedling length (cm)	Seedling dry wt (g)	Vigour index-I	Vigour index-II
Germination (%)	-					
Dormancy (%)	0.054	-				
Seedling length (cm)	-0.031	0.173**	-			
Seedling dry weight (g)	-0.020	-0.089	0.019	-		
Vigour index-I	0.122	-0.025	0.974**	0.017	-	
Vigour index-II	0.233*	0.234*	-0.006	0.973**	0.037	-

\*,\*\*Significant at P=0.05 and P=0.01, respectively

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