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D Bhadru
Seed Research and Technology Center, Prof. Jaya Shankar Telangana State Agricultural University Rajendra Nagar, Hyderabad, Telangana, India

S Naga Lakshmi
Seed Research and Technology Center, Prof. Jaya Shankar Telangana State Agricultural University Rajendra Nagar, Hyderabad, Telangana, India

T Pradeep
Seed Research and Technology Center, Prof. Jaya Shankar Telangana State Agricultural University Rajendra Nagar, Hyderabad, Telangana, India

K Janshi Rani
Seed Research and Technology Center, Prof. Jaya Shankar Telangana State Agricultural University Rajendra Nagar, Hyderabad, Telangana, India

Correspondence
D Bhadru
Seed Research and Technology Center, Prof. Jaya Shankar Telangana State Agricultural University Rajendra Nagar, Hyderabad, Telangana, India

Assessment of quality of maize seed after cold storage

D Bhadru, S Naga Lakshmi, T Pradeep and K Janshi Rani

Abstract
A controlled atmosphere is essential for safe and long term storage of seeds. Two popular maize hybrids viz., DHM 117 and DHM121 were kept in cold storage unit for one year (2015-16) and seeds collected from different lots were evaluated in the following year (2016-17). Seed germination was found to be more than 90% up to 6 months with a reduction of 1.7 to 6.1 percent in seven different lots and there after drastically reduced in both the hybrids. Seedling vigour traits had more than 50 percent reduction under the ambient conditions after the one year of cold storage. The study suggested the seed material stored in cold storage can be revalidated for another six months and supplied for to farmers safely.

Keywords: maize, cold storage, ambient temperature and longevity

Introduction
Safe storage of seeds till the next sowing season is an essential aspect of seed storage to be handled by the seed production firms. A controlled atmosphere is essential for safe and long term storage of seeds, in tropical and subtropical conditions to maintain high viability of seeds for longer periods. Seed quality is determined in terms of genetic and physical purity whereas post-harvest managements are used to increase seed quality through seed processing while required storage condition maintain its quality. These factors influence on the success of seed germination, normal seedling and final seed production. During storage, seed quality can remain at the initial level or decline to a level that may make the seed unacceptable for planting purpose what is related to many determinants. Storage longevity may vary from six months (usually for maize, soybean and sunflower) up to 20 months or longer if the seed stocks are to be carried over. Longevity of seed in storage is influenced by the initial seed quality as well as conditions of storage. Studies indicate that seed ageing reduce germination and emergence (Rice and Dyre, 2001) [6]. Rate of seed germination, emergence and seedling establishment are decreased with increased seed storage accompanied by an increase in mean germination time (Verma and Tomer, 2003; Basra *et al*., 2003) [7, 3]. Mrda *et al*., 2010 [5] reported significant decline in seed germination in after one year storage. However, it varies among genotypes/maize parental lines. The main factors responsible for rapid seed deterioration are environmental/field weathering**,** mechanical damage, pathogens**,** storage pests & diseases and genetic factors. Cold storage therefore can be a better alternative to enhance the shelf life of the seed under controlled conditions however the economic feasibility depends upon importance of the seed. But there is not much data reported on dynamics of maize seed under cold storage over a period of time as well as after the seed is taken out from the cold storage unit, until it is sold, under ambient conditions. Generally farmers purchase the seed from the private/ public institutes and sow the same when adequate moisture is available in the soil particularly under rain fed conditions. Most of the times sowings may be delayed by 45-60 days and the status of the seed stored during this period under ambient conditions is not known unless germination is tested. Therefore it is necessary to determine the status of seed lots stored under ambient conditions (for 45-60 days) before sowing. Very little information is available and / or limited studies are conducted on the impact of storage period on the seed germination and seedling characteristic of released hybrids. It is in this context a systematic study has been undertaken at Seed Research Technology Center, Rajendra Nagar, Hyderabad to evaluate the performance of seed lots of the two maize hybrids stored in cold storage for one year and subsequently sold to the farmers.

Material and Methods
Two popular maize hybrids viz., DHM 117 and DHM121 which were produced during the rabi, 2014-15 at Maize Research Center, Rajendra Nagar, Hyderabad were kept in cold storage unit for one year. Six seed samples of DHM117 and one sample from DHM 121 were

collected from different seed lots in cold storage after one year and were evaluated for their seed quality parameters under ambient conditions in the laboratory at Seed Research and Technology Center, Rajendra Nagar, Hyderabad. The seed samples were drawn at weekly intervals from each lot for evaluation of seed quality parameters. Germination test was conducted as per the ISTA (Anon., 1996). Four replicates of 100 seeds each were germinated in a germinator maintained at 25 ± 2°C and 95±1 per cent relative humidity. The number of normal seedlings were counted at the end of 14th day and expressed in per cent. Ten normal seedlings were selected at random from each replication of germination samples on the final counting and used for measuring the root and shoot length. Germination (%) was recorded at weekly intervals May 3rd to July 15th and from October 20th to December 8th, 2016 representing cut off of dates for maize sowing during kharif and rabi, respectively and after the 12 months (18th may, 2017) for ensuing kharif season. Standard deviation was estimated based on the mean values of germination and seedling vigour parameters recorded for three months during kharif and over two months in rabi season.

Results and Discussion

The study was taken up to assess the seed quality of two maize hybrids under ambient conditions followed by cold storage for one year presuming a situation wherein suitable conditions don't' prevail for taking up sowing immediately after seed is taken out from cold storage. The data on germination (%) of maize seed is presented in Table 1 and results is discussed in terms of standard deviation in different seed lots and storage intervals. All the seed lots recorded more than 95% germination, up to 3 months of ambient storage. The range of germination (%) was 98-100 in lot KR 00350 and 95-100 in lot KR 00349, representing the initial and at 3 months of after sowing. The standard deviation was the higher (5.3) in lot WG 00665 followed by lot KR 00349 (4.5), indicating the highest and lowest reduction in the seed germination at 3 months of storage period compared to initial.

At six months after storage, the germination (%) recorded wide range (82-95) with high standard deviation (11.8) in lot WG-00664 followed by (85.1-97) with 9.7 standard deviation in lot KR 00349 in the hybrid DHM 117 indicating more reduction in germination over the general mean. However, the germination was above the certification standards in the remaining lots. The seed of hybrid DHM 121 recorded germination (96%) at 6 months of storage with a minimum standard deviation of 2.4 indicating better storability following a cold storage period.

The data recorded on germination of maize seed at 3, 6 and 12 months of storage under ambient conditions and reduction per cent are depicted in table 1. At 3 months of storage period all the seed lots recorded 99-100% germination. At 6 months after storage germination in the maize seed lots maintained in a range of 93.1% in DHM117 hybrid lot KR00349 to 97.7% in DHM 121 hybrid lot RJ-5, which were above the minimum prescribed standards. The percentage reduction (6.1) was maximum in DHM-117 lot KR-00349. At 12 months of storage of period the germination in both hybrids fell drastically which were below the minimum standards. The seed DHM 117 hybrid lot KR00349 recorded the lowest germination (17%) after 12 months, whereas DHM-117 lot WG-00663 recorded (78%) registering only 27% reduction over third months value. Thus, it is evident that hybrid maize seed retains its germanibility up to 6 months under storage followed by a cold storage and can be supplied to the farmers for sowing. Verma and Tomer (2003) [7], Basra *et al*., (2003) [3], Mrda *et al*., (2010) [5] and Belay Garoma *et al*., (2017) [4] also reported that seed germination declined significantly after one year storage.

Apart from germination, seedling vigour is also important from the point of view of uniform establishment and early seedling performance. Average root length in all the lot studied was almost similar (4.4 cm, 4.3cm) and lot no WG-00664 (5.0cm), WG-00666 (4.0 cm) of hybrid DHM 117 and RJ-1 (5.2 cm) of DHM 121 recorded more root length after 12 months of cold storage (Table 2). However, the average shoot length registered highest 18.1cm during the 3 months of storage as compared to the 3 months after the cold storage 96.4cm) and the reduction% of was recorded more than 60% in all the lots of both hybrids after the 12 months of storage. Verma and Tomer (2003) [7], Basra *et al*., (2003) [3], and Belay Garoma *et al*., (2017) [4] demonstrated that seed germination, emergence rate and seedling establishment are decreased with increased in seed storage period. The seedling vigour index (I) as measured by multiplying germination and seedling lengths **(**Abdul-Baki and Anderson, 1973) [1] measured at 3rd and 12th months of storage interval is presented in table 3. Almost 50 percent seedling length was reduced all the lots of both hybrids. Seedling vigour index was recorded more than 2000 in all the lots except WG-00664 (1945.8) and WG-00666 (1820.7). This may be due to the lesser the root length during the 3 months after the cold storage. These observation suggested that greater decline of seed vigor was in maize in response to effect of storage longevity. Agarwal (1974) observed a reduction in shoot length and root length along with the reduction in germination per cent in maize seeds under both room temperature and cold storage after a period of 11 months. Similar results also reported by Verma and Tomer (2003) [7], Basra *et al*., (2003) [3], Mrda *et al*., (2010) [5] and Belay Garoma *et al*., (2017) [4]. Seedling length and seedling vigour Index I are the very important character for the establishment of the crop.

The six seed lots of hybrid DHM 117 and single of lot DHM 121 didn't differ significantly for germination percentage at 3 months of storage which record more than 90 percent. The germination (%) reduced drastically at 12 months of storage, with a range of 10% (WG-00663) to 78.4% (KR00349) reduced germination over values at 3 months of storage. The similar trend was observed with respect to seedling length which recorded percent reduction ranging from 41.4% in lot WG0066 to 62.5% in lot KR00350 of DHM 117 hybrid. The reduction in seed vigour index I was the highest (89.5%) in lot KR-00349 (DHM 117) followed by (79.5%) in lot RJ-1 (DHM 121).

From the results of the present study it can be concluded that maize seed retained its germination and vigour up to 6 months after a cold storage period of one year and thereafter there was a drastic reduction in both the parameters. Thus, the seed can be safely used for sowing up to 6 months, in a contingency of delayed sowings.

However, the exact storage period between 6 and 12 months wherein the germination is falling below the minimum standards of 90% prescribed for maize hybrids, has to be worked out to have more precise data on seed germination dynamics of seed under ambient conditions following a cold storage period.

The varietal / genotype differences, ambient storage under different climates are to be studied further, for comprehending the research findings to find out an implementable practice by seed industry.

Table 1: Germination percentage, standard deviation and germination (%) reduction of maize hybrids under ambient conditions after cold storage

Hybrids	DHM117						DHM121
Date of testing/ lot nos	KR-00350	WG-00663	WG-00665	KR-00349	WG-00666	WG-00664	RJ-1
3 months							
3.5.2016	100	100	100	100	99.0	98.1	100
10.5.2016	100	100	100	100	100	98.3	100
17.5.2016	100	100	100	100	100	98.0	100
26.5.2016	100	99.0	100	99.0	100	100	99.0
3.6.2016	100	100	97.0	98.1	100	100	100
18.6.2016	100	99.0	97	98	100	100	97
25.6.2016	100	99	97	98	100	100	97
1.7.2016	100	99	97	97	99	99	96
8.7.2016	99	99	96	97	99	99	96
15.7.2016	98	98	96	95	96	97	96
Mean	100	99	98	98	99	99	98
Range	98-100	98-100	96-100	95-100	96-100	97-100	96-100
SD	2.0	2.0	5.3	4.8	3.7	3.2	5.6
6 Months							
20.10.206	96	97	95	93.1	94	95	98
28.10.206	96	97	98	97	95	91	95.0
10.11.2016	96.2	97.3	99.1	96.3	93.4	94.4	95.1
18.11.2016	98.0	96.0	98.0	97.0	93.3	88.1	97.0
22.11.2016	98.7	93.1	94.0	94.0	91.0	82.0	95.3
28.12.2016	98.0	96.0	95.0	85.7	89.0	84.8	96.0
Mean	97	96	97	94	93	89	96
Range	96-98	93.1-97.3	94-99.1	85.7-97	89-95	82-95	95-98
SD	2.6	3.5	4.6	9.7	5.1	11.8	2.4
12 months							
18.05.2017	73.0	78.0	71.0	17.0	42.0	46.0	38.0
Mean	73.0	78.0	71.0	17.0	42.0	46.0	38.0
Percentage reduction after 6 months	3.9	2.5	3.9	6.1	5.7	3.8	1.7
Percentage reduction after 12 months	27	21.8	28.3	82.9	57.9	53.6	61.8

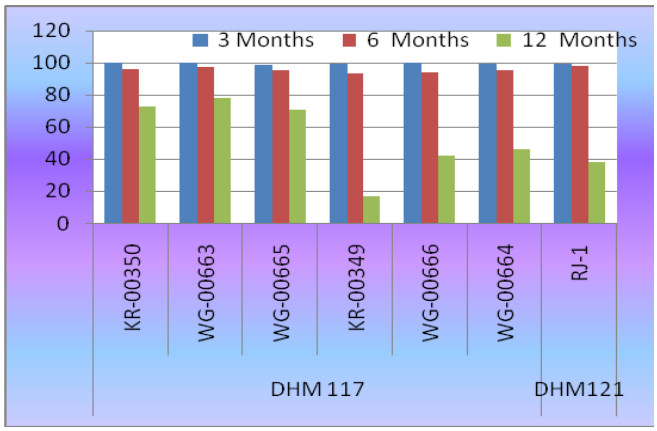

Fig 1: Germination (%) of seed lots of maize hybrids at different storage periods

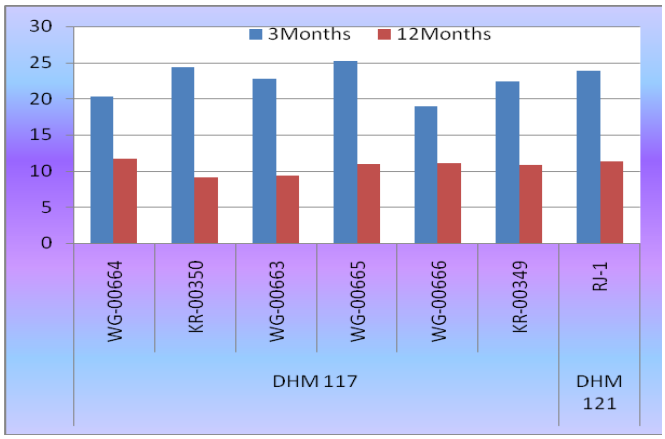

Fig 2: Seedling length of seed lots of maize hybrids at different storage periods

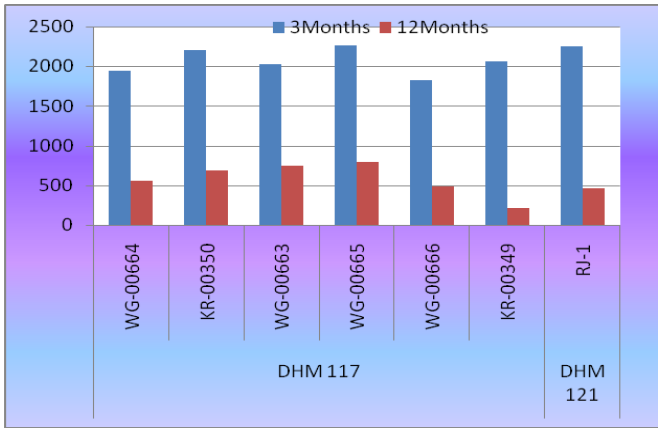

Fig 3: Seedling Vigour Index-I of seed lots of maize hybrids at different storage periods

Table 2: Mean values and reduction (%) of seedling vigour traits after cold storage 3 and 12 months of the maize hybrids.

Name of the entry	Root length (cm)			Shoot length(cm)			Seedling length (cm)			Seed Vigour Index I		
	3M	12M	Reduction%	3M	12M	Reduction%	3M	12M	Reduction%	3M	12M	Reduction%
WG-00664	2.9	5.0	-73.0	17.4	6.9	60.3	20.3	11.7	42.3	1945.8	555.1	71.5
KR-00350	5.2	4.2	18.4	19.1	4.9	74.4	24.3	9.1	62.5	2199.3	686.7	68.8
WG-00663	5.2	3.3	36.6	17.5	6.0	65.7	22.7	9.3	59.1	2029.1	746.3	63.2
WG-00665	6.2	4.4	29.0	19.0	6.7	64.7	25.2	11.0	56.3	2265.6	789.6	65.1
WG-00666	3.6	4.0	-11.2	15.4	7.2	53.1	18.9	11.1	41.4	1820.7	489.3	73.1
KR-00349	4.0	4.1	-3.5	18.4	6.7	63.6	22.4	10.8	51.7	2066.9	216.8	89.5
DHM-121	3.8	5.2	-36.0	20.1	6.1	69.6	23.9	11.3	52.7	2248.0	461.7	79.5
Mean	4.4	4.3	2.4	18.1	6.4		22.5	10.6	52.9	2082.2	563.6	72.9
CD	0.61	0.328		1.64	0.25		2.04	0.407		205.95	56.69	
CV	7.72	4.253		5.032	2.33		5.02	2.13		5.499	5.592	

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