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Effect of Storage Containers and Storage Periods on the Moisture Content, Germination and Biotic Status of Durum Wheat (*Triticum turgidum* L.) Seed

Mohammad Sohidul ISLAM[1*], A.S.M. Golam HAFEEZ[2], Md. Kaium CHOWDHURY[3]
Moaz Hosen PRAMANIK[4], A.K.M. Abdul BARI[5], Khandakar AURIB[6], Fatih ÇIĞ[7], Sipan SOYSAL[7]

[1] Hajee Mohammad Danesh Science and Technology University, Department of Agronomy, Dinajpur, Bangladesh
[2] Bangladesh Agricultural University, Department of Agricultural Finance, Mymensingh, Bangladesh
[3] Agricultural Training Institute, Department of Agricultural Extension, Gaibanda, Bangladesh
[4] Hajee Mohammad Danesh Science and Technology University, Department of Agricultural Chemistry, Dinajpur, Bangladesh
[5] University of Rajshahi, Department of Crop Science and Technology, Rajshahi, Bangladesh
[6] University of Dhaka, Department of Disaster Science and Climate Resilience, Dhaka, Bangladesh
[7] Siirt University, Department of Field Crops, Faculty of Agriculture, Siirt, Türkiye
[*]Corresponding author: islam.agn@hstu.ac.bd

Abstract

To observe the moisture content and germination capacity of durum wheat seed stored in different storage containers for certain storage periods, a Lab. experiment was carried out at the Agronomy laboratory, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh during March-May 2016. The experiment was designed completely randomized design (CRD) with three replications under three storage periods (30, 45, and 60 days after storage) and three seed containers (sealed plastic container, polythene bag and gunny bag). Initial seed moisture content (MC) and germination percentage (GP) was measured before storage of seeds. Seeds stored in containers gradually absorb moisture from air with the advancement of storage periods, and air leaked storage container i.e., gunny bag quickly absorb moisture than other two containers. The maximum values of GP were recorded of durum wheat seed with 30 days after storage (DAS) and the GP reduced significantly with increasing storage periods from 30 to 45 DAS. The highest GP (78.00 %) was found at 30 DAS in sealed plastic container while the lowest (57.67 %) at 60 DAS in gunny bag. The rate of reduction was found to increase with the advancement of storage periods. Durum wheat seed kept in sealed plastic container and ply bag maintained the minimum MC and eventually showed highest GP. An outstanding performance of GP was observed in sealed plastic container seed while the gunny bag provided the inferior GP among all of the three containers. Several fungi was observed such as *Alternaria, Aspergillus, Colletotrichum, Fusarium, Penicillium* and *Rhizopus* during germination study, although no insect was found to any storage container during the storage periods. Higher number of fungus was observed in seeds of gunny bag than sealed plastic container and poly bag**.** In conclusion, durum wheat seeds should be stored in air tight container for certain periods.

Research Article

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1. Introduction

Durum wheat [*Triticum turgidum* L. var. *durum* (Desf.)] is an important cereal crop. Approximately 90 % of the wheat grown in the global is the common wheat (*Triticum aestivum*). The remaining 9 % acreage is made up of durum, and club wheat (*Triticum dicoccum*) and the rest minors are grown as livestock feed (Delorit et al., 1974). Durum wheat is adapted widely to semiarid climates than bread wheat. In spite of its low acreage, it is an economically important crop because of its unique characteristics. Durum kernels are usually large, golden amber, and translucent. These characteristics, along with its protein content and gluten strength, make it suitable for manufacturing diverse food products like *suji*, *semya*, *sphagetti*, *egg noodles*, *ouscous*, and *macaroni*. Pasta is the most common durum end product consumed in Europe, North America, and Russia (Delorit et al., 1974). Durum wheat is grown primarily because it withstands drought better and is more resistant to most diseases than the common wheat. Despite of its versatile use and adoptability to the agro-environment, the crop is still neglected both in the research and farmers level. Maximum yield potential of the crop can be exploited through genetic and agronomic manipulation, among these, use of quality seed play a key role to get higher yield. Use of quality seed is the most important factor for better yield, as quality seeds ensure better germination (Ahmad, 2001; Islam et al., 2017, 2018). Using of good quality seed can contribute to increase yield as high as 30% keeping the other factors of production as constant (BARI, 1993). Good seed alone can give an increased production (10-15%) compare to the seed of a poor seed stock (Alim, 1977). A very significant yield reduction of 17% in case of wheat and 10% in case of rice due to effect of different quality components of seed (Huda, 2001). Durum wheat is grown the winter season (November to March) and seeds from harvested crops are stored for at least 8-9 months before sowing in the next season. Major part of seed quality deteriorates at the time of storage. Although seed quality is governed by genetic make-up, but commonly the quality of seeds is deteriorated during storage period. Seeds tend to lose their viability due to the effect of biotic and abiotic factors viz. pathogens, high and low temperature, moisture etc. during this period. The proper storage of seed is a very important factor for the better production of crop and to ensure food security for future generation.

Several studies have indicated the effect of packaging materials on the quality of seeds in terms of germination and viability over a period of time (Sinha and Sharma, 2004; Malaker et al., 2008; Chattha et al., 2012; Sawant et al., 2012; Azam et al., 2018). For instance, blackgram seeds stored in a gunny bag resulted in low germination percentage compared to seeds stored tin and plastic containers (Islam et al., 2018). However, it has been reported that the intensity of quality decreasing of stored seed under different storage techniques differ among plant species and within plant species (Al-Yahya, 2001; Guberac et al., 2003). Using a sweet corn experiment, Camargo and Carvalho (2008) confirmed the advantages of employing hermetically sealed material to maintain quality of seed, under ambient environments. Moreover, Adebisi et al. (2008) included bottles as one of the best materials to store okra seeds. Seeds which are supposed to be planted in the subsequent season need to be dried and stored in moisture barrier materials to control loss of viability and vigour (Justice and Bass, 1979). Thus, the choice of material used in storing seed is crucial in ensuring that the quality of seed is maintained during storage. Moreover, the deterioration rate depends on storage condition that is temperature, relative humidity, seed moisture contents, storage container types, etc. Types of container also regulate temperature, relative humidity, and seed moisture contents. High temperature, relative humidity, and moisture in the storage environment appear to be principle factors involved in deterioration of seed quality (Fakir et al., 1989). The deterioration of seed during storage is greatly influenced by storage period (Islam et al., 2017; Hasan et al., 2017a). It is against this background that this study was conducted to determine the effects of

packaging materials and storage periods on seed quality and to predict the longevity of durum wheat seeds.

2. Materials and Methods

2.1. Location and weather conditions

The investigation was conducted at the Agronomy laboratory of the Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from March to May 2016.

2.2. Weather conditions

The experimental site is located under tropical climate characterized by high relative humidity and temperature during the months of April to July. Information regarding monthly maximum and minimum temperature and relative humidity recorded during the period of experiment are included in Figure 1.

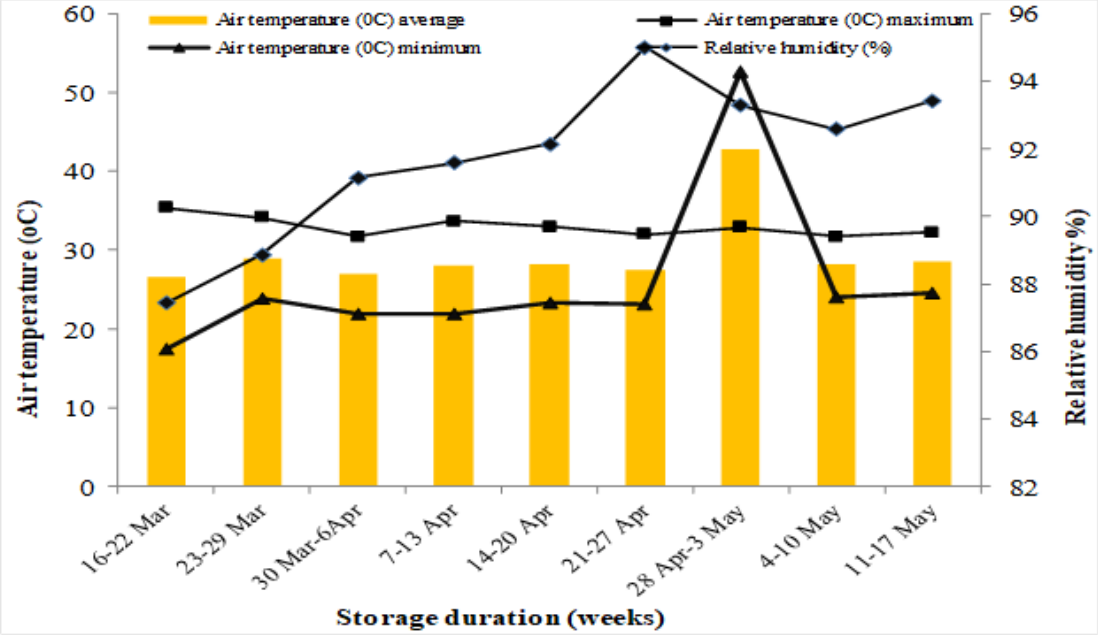

Figure 1. Relative humidity and air temperature at storage during the period of seed storage

2.3. Seed source, experimental treatments and design

Durum wheat seed, used material in the study was collected from Wheat Research Centre (Bangladesh Agricultural Research Institute), Nashipur, Dinajpur, Bangladesh. The experiment consisted two factors naming factor A: three storage containers, viz. i) Sealed container (plastic bottle) (C_1), ii) Poly bag (C_2), and iii) Gunny bag (C_3), and factor B: three storage periods viz., i) 30 (SP_1), ii) 45 (SP_2), and iii) 60 (SP_3) DAS (days after storage). There were altogether nine treatment combinations as follows: i) C_1SP_1, ii) C_1SP_2, iii) C_1SP_3, iv) C_2SP_1, v) C_2SP_2, vi) C_3SP_3, vii) C_3SP_1, viii) C_3SP_2, and ix) C_3SP_3. The experiment was laid out in completely randomized design (CRD) with three replications. Total numbers of experimental units were 27 (3 storage containers x 3 storage duration x 3 replications).

2.4. Experimentation

Collected seeds were sundried and initial seed moisture content was measured (wet basis) before storing the seeds and the value was (10.5%). Seeds were preserved in the containers of sealed (plastic bottle) container, poly bag and gunny bag and stored in room temperature and relative humidity (RH) up to 60 days. The sealed container was covered tightly, and the polythene bag and gunny bag were tight with rope. During the storage period seed samples were taken at 30, 45, and 60 DAS from the containers for determination of change of moisture content (wet basis),

germination percentage, presence of insect and diseases.

2.5. Data collection

Sampling was carried out after 30 days of preservation at 15 day intervals up to 60 days i.e. 3 times. At each sampling, samples were taken randomly from each storage container.

2.5.1. Moisture content test

Moisture content was determined at every 15 days during experimental period from 30 DAS. Moisture content was determined by using high constant temperature oven method (125-130^{0}C, 2 hr) following International Rules for Seed Testing (ISTA, 1999).

2.5.2. Germination test

Four hundred seeds were tested for germination from each container for every storage period in the plastic pots as per the rules of ISTA (1999). Germination test was conducted using sand as substratum in plastic tray. The sand was sieved to discard particles bigger than 0.8 mm and smaller than 0.05 mm in diameter. For every test new sand was used. Seed was placed on a uniform layer of moist sand and then covered to a depth of 10 mm with sand, which was left loose. The pot was irrigated at every odd day. After 5 days and 8 days, germination percentage was determined. Data on normal and abnormal seedlings were recorded from pot experiment. The normal seedlings and abnormal seedlings were classified according to the prescribed rules given by ISTA (2019). Germination percentage was calculated using the following formula ISTA (1999).

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Number of seeds tested}} \times 100$$

2.5.3. Insects and diseases

In every ten days presence and number of insects and diseased seeds were also observed in the stored Durum wheat seed. The pathogens identified from the seed were recorded.

2.6. Statistical analysis

The recorded and calculated data were statistically analyzed using a MSTAT-C Statistical Computer Package Program in accordance with the principles of Completely Randomized Design (Gomez and Gomez, 1984). Duncan's Multiple Range test (DMRT) was performed to compare variations among treatments.

3. Results and Discussion

3.1. Effect of storage containers and storage periods on the moisture content of seed

Moisture absorption by the seeds increased with the increasing storage period from 30 to 60 DAS. Sealed plastic container and poly bag were of the statistically identical moisture content in all sampling dates but the seeds in gunny bag absorbed a lot of moisture over time. At 60 DAS, the highest moisture content (17.88%) was observed in C_3 which was statistically higher than C_1 (13.00%) and C_2 (13.17%). Such result is in agreement with the findings of Ansari et al. (1996), Khalequzzaman et al. (2012), and Hasan et al. (2016) where they concluded that storage containers have significant effect on the absorption of moisture from the surrounding environment. Moisture content was greatly influenced by the storage containers specially in gunny bag possibly due to the fact that gunny bag absorbed moisture from air if it is stored in natural environment where relative humidity is higher than the seed moisture content. For this reason, seeds absorbed moisture from the ambient air and tended to equilibrium with relative. Higher moisture level in seed during storage is one of the main reasons for loses of viability and vigor sooner. The MC of durum wheat seed gradually increased with increasing relative humidity. The correlation between moisture content and relative humidity was observed by Huda (2001) in wheat seed showed that there existed a positive relationship. Equilibrium moisture percentages of different crops are shown in Table 4 (Copeland, 1988).

Table 1. Effect of storage containers and storage periods on the moisture content of durum wheat seed

Storage containers	Moisture (%)			
	Before storage	Storage periods (Days after storage)		
	0 DAS	30 DAS	45 DAS	60 DAS
C1	11.50	12.47b	12.87b	13.00b
C2	11.50	12.58b	13.02b	13.17b
C3	11.50	14.57a	16.33a	17.88a
LSD	-	0.373	0.328	0.457

In a column, figures having similar letter(s) do not differ significantly whereas figure s bearing dissimilar letter (s) differ significantly (as per DMRT); C_1= Sealed plastic container, C_2= Poly bag, and C_3= Gunny bag; DAS= Days After Storage

3.2. Effect of storage containers and storage periods on the GP of durum wheat seed

Germination is the most important function of a seed as an indicator of its viability and worth as seed. Seed germination test provides to the ability of seeds to germinate and produce a seedling that will emerge and develop onto a healthy vigorous plant. The germination percentage (GP) was significantly influenced by the storage containers during the periods of 30, 45 and 60 DAS. The GP of seeds increased with the increasing storage period from 30 to 60 DAS. Among the three containers, germination percentage of the seeds of sealed plastic container was the highest (78.23%) followed by poly bag (77.17%) without any significant variation. The lowest GP (75.83%) was observed in the seeds stored in gunny bag at 30 DAS this is due the fact that the seeds in gunny bag absorbed a lot of moisture from the ambient air over time (Table 2). At the end of 2 months the germination percentage of durum wheat seeds kept in sealed plastic container, poly bag, and gunny bag were decrease to 70.83, 68.05, and 57.61%, respectively. The decline rate was higher in seeds of gunny bag than that of sealed container and poly bag (Table 2). The GP of wheat seeds stored in different types of packing materials decreased with the progress of storage period, and air leaked storage containers remarkably reduced the GP than air tight containers as reported by many researchers (Sinha and Sharma, 2004; Chattha et al., 2012; Sawant et al., 2012; Azam et al., 2018; Islam, 2008). Seed deterioration is natural phenomena and life span of seeds decrease with the passing of time. Seed deterioration processes, however, depend on a large number of genetical and environmental factors. As seed is highly hygroscopic living materials and it absorbs moisture from the surrounding atmosphere. This higher moisture in the seed may be the main reason of quick germination deterioration in the seeds of gunny bag. Similar observations were also recorded by Khalequzzaman et al. (2012) in French bean, Hasan et al. (2017b) in lentil, Islam et al. (2017) in mungbean, and Islam et al. (2018) in blackgram. The main reason of declining GP of the seed in gunny or paper bags was due to insect infestation as a result of high MC (Chattha et al., 2012).

Table 2. Effect of containers and storage periods on the germination percentage of durum wheat seed

Storage containers	Germination (%)			
	Before storage	Storage periods (Days after storage)		
	0 DAS	30 DAS	45 DAS	60 DAS
C1	80.23	78.00	75.17a	70.83a
C2	80.23	77.17	73.33a	68.05a
C3	80.23	75.83	64.83b	57.67b
LSD	-	-	2.258	2.372

Legends: C_1= Sealed plastic container, C_2= Poly bag, and C_3= Gunny bag

3.3. Abnormal seedling

The initial abnormal seedling of seeds in sealed plastic container, poly bag and gunny bag were minimum, but it was increased with increasing storage time. At the end of two months the abnormal seedling of durum wheat seed were increased in all treatment combinations (Table 3). The increasing rate was higher in seeds of gunny bag, might be due

to high moisture and fungal activities (Mali et al., 1983). The percentage of normal seedlings decreased (Table 2) whereas production of abnormal seedlings (Table 3) and the number of dead seeds (data not sow) increased indicating substantial loss in seed viability. Similar observation was also reported by Kaur et al. (1990). Storage conditions along with pathogenic presence of inocula are responsible for causing loss in seed germination and causing primary disease to the emerged seedlings and also eventually increased abnormal seedlings.

Table 3. Effect of containers and storage periods on the abnormal seedling of durum wheat seed

Storage containers	Abnormal seedling (%)			
	Before storage	Storage periods (Days after storage)		
	0 DAS	30 DAS	45 DAS	60 DAS
C1	9.77	11.27a	16.40a	21.00a
C2	9.77	12.00a	17.86a	22.60a
C3	9.77	14.67b	24.67b	31.00b
LSD	-	1.12	8.25	4.23

C_1= Sealed plastic container, C_2= Poly bag, and C_3= Gunny bag

Table 4. Equilibrium Moisture Content (EMC) chart for different kinds of seeds at 25°C

SNo	**Relative Humidity (%)**	30	40	50	60	70	80	90
	Name of Seed	**Seed Moisture Content (%)**						
1	Rice (Rough)	7.9	9.4	10.8	11.8	13.4	14.8	17.6
2	Foxtail millet	8.2	9.2	10.9	11.8	13.6	15.3	18.4
2	Wheat	8.5	9.8	11.1	11.8	13.9	15.9	19.7
3	Maize	8.5	9.8	11.0	12.2	13.1	14.2	18.3
4	Peanut	4.2	5.0	6.1	7.2	8.9	10.9	13.0
5	Rye	8.7	9.9	10.9	12.2	13.5	15.7	20.5
6	Sunflower	4.0	5.3	6.7	8.0	9.3	11.7	15.0
7	Pea	8.6	9.6	10.7	11.9	13.5	15.5	18.6

Source: Copeland (1988)

3.4. Biotic factors

No biotic factors like insects and pathogen was observed during the storage period in all the containers, but during investigation like germination analysis, several fungi was observed such as *Alternaria*, *Aspergillus*, *Colletotrichum*, *Fusarium*, *Penicillium* and *Rhizopus.* No insect was found to any storage container. Higher number of fungus was observed in seeds of gunny bag than sealed plastic container and poly bag. Because as seed is highly hygroscopic living materials and it absorbs moisture from the surrounding atmosphere, this higher moisture in the seed may be the main reason for growing of fungus in the seeds of gunny bag (Mali and Joi, 1985).

4. Conclusion

The moisture content (MC) in seeds stored in gunny bag significantly increased with the increment of storage periods but the absorbance of moisture was minimum in sealed plastic container and poly bag without any significant variation between them. On the other hand, the GP of stored seed in gunny bag were significantly lower than the seeds stored in sealed plastic container and poly bag while, with the advancement of storage periods the GP decreased and MC increased. The highest abnormal seedling was found from gunny bag after two months of storage period than sealed plastic container and poly bag. Sealed plastic container is the best storage containers and can be used for general storage purpose, and durum wheat seeds should be kept in container for short period of storage.

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Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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