WHEAT SEED QUALITY AS AFFECTED BY STORAGE CONTAINER UNDER AMBIENT CONDITION

BY

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CERTIFICATE

This is to certify that the thesis entitled **'Wheat Seed Quality as Affected by Storage Container Under Ambient Condition'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER of SCIENCE** in **AGRONOMY,** embodies the result of a piece of bonafide research work carried out by **Sabrina Muzain Nabila**, Registration number: **07-02214** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

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DEDICATED
TO
MY BELOVED PARENTS

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The Author

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ABSTRACT

The experiment was conducted at the laboratory condition of Agronomy department of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from April to November 2013. The experiment comprised of two factors viz. Factor A: storage containers (3 containers) like Tin container, Earthen pot and Plastic pot; and Factor B: wheat varieties (3 varieties) of which were BARI Gom 21 (Shatabdi), BARI Gom 25, BARI Gom 26. The experiment was laid out in a Completely Randomized Design (CRD) with four replications. The result revealed that tin container showed the highest germination percentage, shoot length, root length, fresh weight and dry weight of seedlings and lowest 1000 seed weight, moisture percentage, days to germination and electrical conductivity of seeds at 180, 210 and 240 DAS (days after storage). Lowest quality performance was observed from earthen pot. For wheat varieties, BARI Gom 26 showed the highest quality performance in respect of the highest germination percentage, shoot and root length, seedling fresh weight and dry weight. This variety also showed lowest electrical conductivity and days to germination. Due to interaction effect of different storage containers and varieties, the highest germination (97.79%, 96.37% and 94.93%, at 180,210 and 240 DAS respectively) and maximum seedling shoot length, root length, fresh weight and dry weight of seedlings was observed from BARI Gom 26 stored in Tin container and the lowest result was found from earthen pot with BARI Gom-26.

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LIST OF ACRONYMS

Anon.	Anonymous
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BRRI	Bangladesh Rice Research Institute
cm	Centi-meter
CV	Coefficient of variance
DAS	Days After Storage
et al.	And others
g	Gram (s)
ISTA	International Seed Testing Association
NS	Non significant
%	Percentage
SAU	Sher-e-Bangla Agricultural University
WRC	Wheat Research Center
wt.	weight

CHAPTER I

INTRODUCTION

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important food crop and primarily grown across the exceptionally diverse range of environments (WRC, 2009). Importance of wheat crop may be understood from the fact that it covers about 42% of total cropped area in South Asia (Iqbal *et al.,* 2002). Wheat seeds are the forms of basic and crucial input for wheat production. Maintenance of high seed germination and vigour from harvest until planting is of utmost used in a seed production program. Seeds are practically worthless if, upon planting, they fail to give healthy and vigorous plants. Good seed is, therefore, a basic requirement in seed production. The successful production of any crop depends on the quality of seeds sown. A good quality seed may be seriously deteriorated if stored under sub optimal condition. To compensate, farmers use very high seed rate, which is 85-133% higher than the actual requirement (Hossain *et al.*, 2002).

Seed quality means suitability of seed as a planting material for sowing in land in order to get disease free seedling and plant and finally to achieve satisfactory yield. The important parameters for judging seed quality are seed purity, viability, vigour, germination, seed size, seed moisture content and seed health. Presence of contaminants such as weed seeds, insects, varietal mixture, partially filled grains, unfilled grains, other plant parts, inert matters and seeds of other crop species in a seed lot and abnormal seed conditions like as discolored seeds, spotted seeds, deformed seeds, insect damaged seeds, germinated seeds and smutted seeds also indicate poor quality of seeds. Such contaminants and seed conditions can also serve as the sources of inocula of pathogens for transmission and disseminate diseases in the field (Fakir *et al.*, 2002). Good quality seed should possess at least the four major characteristics: seed must have the high yielding potentiality; seed must be viable; seed must be pure i.e. free from varietal mixture and seed must be healthy and able to produce healthy seedlings. Two types of seeds are available in the country for use: certified seed and farmers' saved seed.

Certified seed ensures quality of seed and can ensure availability of genetically pure seed to the farmers. But in our country 10% certified seeds are available to the farmers and farmers have to depend on seeds saved by their own to meet the rest of the need (Fakir *et al.*, 2002). Preservation of seeds in the hot and humid climate of Bangladesh is difficult and the method of preservation is still now poor. For storing seed, farmers are commonly used biscuit tin and kerosene tin, gunny bag, polyethylene bag, earthen jar or motka with or without coalter coating, metal drums, dole cowdung coated dole etc. (Clement *et al.*, 1984). The main purpose of traditional seed storage is to secure the supply of good quality seed for a planting program whenever needed. All these points lead to form opinion that farmers seed may be of poor quality (Fakir *et al.*, 2002). Proper storage condition can bring about considerable improvement in national economy by controlling the losses that are about 10% of the stored food grains (GOP, 2008).

Practical recommendations are provided for favorable combinations of moisture content and temperature for seed storage but such qualitative statements regarding seed longevity have limited use in the design and management of seed storage systems (Ellis and Roberts, 1981). Wheat is hygroscopic in nature and under poor storage condition it has the tendency to become equilibrium to environmental moisture. In a condition with high atmospheric moisture the seed moisture become high and in this conditions seed starts respiration causing heating, which favours storage moulds and stored grain insects to multiply quickly resulting spoilage of the stored seed. But our farmers are not aware of these facts due to lack of knowledge and they are ignorant about the modern storage technique and they store seeds traditionally during wet monsoon period after harvest. Seed stored in such storage conditions are prone to invasion by storage fungi and infestation by stored insects as the seeds gain moisture. Good quality wheat variety produced maximum yield and the varietal demonstration at different districts of Bangladesh revealed that mean yield of Kanchan, Akbar and Sonalika were 3.59, 3.29 and 2.81 t ha^{-1}, respectively (BARI, 1993). Different varieties also respond differently to the prevailing storage environment condition.

Wheat seed has no lemma and palea so it absorbs moisture from the atmosphere easily. Thus it, deteriorates rapidly. So to overcome this problem it is necessary to find out more resistant to adverse condition and to select a standard storage device available to rural people. However, the farmers use all these storage practices traditionally and these have not been standardized. Considerable amount of works have been done on storage of seeds in relation to varied storage conditions in different countries of the world (Purushattam *et al.*, 1996 and Naeem Khalid *et al.*, 2001). But research works on storage of seeds in Bangladesh are limited and preliminary in nature. Though some works have been conducted on the effect of storage conditions viz. storage containers, additives and storage duration of seeds in the country (Mian and Fakir, 1989; Hosan, 2004) but very little critical work has been done on safe storage of wheat seeds (Rahman, 2002 and Fakir *et al.*, 2003). Considering the extent of severity of the problem, detailed investigation is needed to find out a suitable and effective storage practice for storing wheat seed, which should be within the reach of poor farmers.

Considering the above situation the present study was undertaken to investigate the wheat seed quality as affected by container under ambient condition with the following objectives-

- To study the interactive effect of variety and some house hold containers on storability of wheat grains,
- To observe the suitability of different storage containers and select the safe storage container for wheat seed, and
- To study different quality parameters of wheat seed stored in different containers.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Wheat is the most plenteous food crop, based on the area planted and it in fact competes with rice in the amount harvested. Farmers store wheat grains in numerous types of storage receptacles varying in shapes and size. The chemical changes that occur in grains during storage may be due to respiration and germination of seeds. There is an exchange of gases between grain and atmosphere due to respiration, which involves diminution of oxygen and an increase in the carbon dioxide with release of water and energy (heat) due to breakdown of carbohydrate thus leading to loss of weight. The quality of wheat grain is also deteriorated due to loss in weight and other biochemical changes carried out by enzymes such as lipases, proteases and amylases which act on lipids, proteins and starch cause their breakdown. In Bangladesh most of the wheat grain is stored at farm/household level, investigations on storage conditions and their effect are relatively adequate, nevertheless, information on biochemical changes in wheat as a result of improper storage in different containers and their effects on end products are either scanty or outdated. Among the above factors some of the recent past information on wheat grain storage and characteristics related to quality have been reviewed under the following headings:

2.1 Storage of orthodox seeds

Orthodox seeds are generally easy to store if basic processing and storage facilities are available. Most orthodox seeds will maintain a high viability under ambient temperature conditions, at least from harvest to first subsequent sowing season, if the seeds have been thoroughly dried before storage and are stored away from insects. Many orthodox seeds maintain viability for several years under these conditions. Long term storage and storage of more sensitive orthodox seed often necessitates improved storage conditions, where temperature and moisture content are controlled. It should be noted that several species formerly considered short-lived or recalcitrant have been shown to have extended viability and in reality to be orthodox provided their seeds are appropriately processed before storage. A group of species which can be dried to a moisture content low enough to qualify as orthodox, but are sensitive to low temperatures typical for orthodox seeds has recently been termed 'intermediate' (Ellis *et al.*, 1990). Although most non-hard-coated orthodox seeds easily deteriorate under natural conditions, they have a long storage potential and can often maintain viability for many years when stored under optimal conditions (Willan, 1985; Doran *et al.*, 1983).

2.2 Storage of recalcitrant and intermediate seeds

Although the group is very diverse, species with recalcitrant or inter-mediate seed exhibit a number of common traits that justify discussion of their storage as a group. The storage behavior ranges from the extremely recalcitrant and viviparous seeds of some mangrove species to seeds that tolerate at least some desiccation. Desiccation sensitive referred that lowest safe moisture content is 60-70% for some extremely recalcitrant species and 12-14% for some intermediate species. Chilling sensitive revealed that injury depends on species, moisture content and possible duration of chilling. For sensitive species chilling injury may occur below 20^0C. Some species are tolerant of low temperatures (2-5^0C). It seems, at least to some degree, to be restricted to intact seeds: cryopreservation of excised embryos of recalcitrant seeds has shown that several species maintained viability at ultra-low temperatures (Krishnapillay and Engelmann, 1996). Metabolic active means when shed the feature is partly connected to the high moisture content. No dormancy referred germination processes start soon after shedding, and in some cases it is a direct continuation of the maturation process.

The delicate nature of recalcitrant seeds largely limits the manipulation of storage conditions and makes the potential for storage very limited even under the best conditions. Because of the narrow range of environmental conditions in which seeds remain quiescent, i.e. without germination and without rapid deterioration, the demands on storage conditions are often more onerous than those for orthodox seeds. Seed must be stored within a narrow range of moisture and temperature conditions. Although some progress has been made especially for short term storage, and for less recalcitrant and intermediate species, the essential feature of management of recalcitrant seeds is to keep storage period to a minimum. The general desire to reduce storage by a speedy delivery from processing to nursery becomes a must for these seed. However, where storage cannot be avoided, storage conditions must be carefully balanced between reducing metabolism by reducing temperature and moisture contents, without hampering viability by too drastic a decrease in these factors. Storage conditions should basically aim at the following (King and Roberts, 1979): prevent desiccation; control microbial contamination; prevent germination and maintain adequate oxygen supply.

2.3 Packaging materials and containers for seed storage

Considerable research has been published on the effect of storage conditions on the viability of seeds of a range of species including legumes, vegetables and cereals. Although many factors are known to influence the storability of seeds, it is generally accepted that storability may be improved by controlling the storage environment (Lewis *et al.*, 1998). 'Safe' storage conditions were defined as those which maintain seed quality without loss of vigour for three years. Delouche *et al.* (1973) observed that such safe conditions are indeed favourable, but not always economically justified as they do not naturally occur except for small quantities of genetically valuable seed or very costly seed of vegetables, ornamental or forest species (Abba and Lovato, 1999). Canode (1972) found that the length of time that grass seed might be stored without serious reduction in germination depends on the species and storage condition.

On the contrary, Gras and Bason (1990) opined that controlled atmosphere storage might have minor effects on the germination and physico-chemical properties of rice, maize, wheat and barley.

2.4 Packaging materials and seed quality

There is an effect of storage place, packaging material, duration of storage and kind of seed on the viability during storage and the choice of a packaging material in a given climatic condition would depend upon kind of seed and the duration of storage (Garg and Chandra, 2005). Bass and Clark (1975) postulated that materials containing foil provided good moisture and germination protection. In an experiment to study the viability range, Nizersail and BR 1 1 rice seeds grown during the Aman season were dried to 12% moisture and then stored in polyethylene tubes, closed metal ware and gunny bags. In the case of Nizersail seed, germination percentage was equally high in the three containers up to 300 days of storage. But in BR11 seeds, those stored in sealed polyethylene tubes the germination percentage remained high at this stage but seeds stored in metal ware and gunny bags lost seed viability considerably only after 110 days storage and after 240 days they lost seeds viability completely (BRRI, 1985).

Haque and Harron (1983) found that among three rice varieties harvested in Boro season; seed viability range was the highest when seeds were stored in closed container but when stored in gunny bags, seed viability deteriorated very rapidly. The poor germination was probably due to response to storage environment for rapid viability loss. Rahman *et al.* (1985) reported that seed absorbed moisture and reduced germinability when it was stored in indigenous (not air-tight) container. A comparative study was conducted by Miah and Douglass (1992) to investigate the influence of storage structures and storage periods on the viability of high moisture wheat seeds. Laboratory studies showed that moisture content of seed for sealed clay bins remained approximately constant throughout the six week period but in the other structures it decreased. For re-wetted seed grain with 23% moisture content the viability fell rapidly after 2, 4 and 6 weeks storage in the different structures.

Charjan and Tarar (1992) reported that *Helianthus annuus* seed stored in polyethylene bags germinated better and had less fungal contamination than that stored in cloth or jute bags. A direct correlation was found between the total mycoflora of the seed and germination tests after 6, 12 and, 18 months' storage. With the advance of the storage period, field fungi declined and storage fungi increased rapidly. In another experiment, harvested seeds of groundnut were stored in a gunny bag, a plastic silo or a polyethylene-lined gunny bag containing

25 g anhydrous calcium chloride for between 120 and 360 days. Seed viability was significantly higher in both the plastic silo and the polyethylene-lined gunny bag with $CaCl_2$ than in the ordinary gunny bag (Patra *et al.*, 1996).

Groundnut seeds were stored in different containers (gunny bags, tar coated bags, polythene lined gunny bags, high density polyvinyl bags and Kraft paper bags). At about 70% moisture content in ambient conditions, the polyvinyl bags gave the greatest percentage germination and seed vigour after 16 months, but differences at earlier stages were not significant. All containers maintained the minimum certification standard of 70% germination for 12 months, and polyvinyl bags maintained this standard for 14 months (Krishnappan *et al*., 1998).

Seeds of five soybean cultivars were packed in gunny bags or gunny bags lined with polyethylene. Moisture content and germination of the seeds stored in the unlined gunny bags were significantly decreased over the four months. Germination of the seeds stored in the lined bags was only slightly reduced (Sharma *et al*., 1998). Seeds of moth bean (*Vigna aconitfolia*) treated with insecticides and fungicides, alone and in combinations, were stored in cloth bags and 700 gauge polythene bags and stored at ambient condition for 18 months. Irrespective of the treatments, including the control, seeds stored in polythene bags maintained germination above the minimum seed certification standard level, whereas in cloth bags, it was inhibited in accordance to the level of infestation (Jolli and Ekbote, 2005).

There is somewhat of a general conception among people new to saving seed, that plastic materials (for example, zip lock bags) are highly moisture impermeable. The conception is only partially true. Chowdhury *et al*. (1990) reported that the different storage techniques did not produce significant effect on the protein and starch of the lentil grain produced.

Storage in open containers at ambient temperature may be applicable for short term storage of some species, even where moisture content does increase. For example, Omram *et al.* (1989) found that seeds of *Casuarina glauca* and *C. cunninghamiana* could be stored in unsealed bags at room temperature for 8 months without significant loss of viability, albeit their moisture content increased from 5-6% to approx. 8 % during the period. The seeds lost viability in 20 months.

2.5 Storage in bag or in container

Padma and Reddy (2000) found large differences in the retention of viability of onion seed stored in different moisture pervious and moisture impervious containers at 7.15 and 5.30% seed moisture content. They reported that in storage studies with okra seed significant differences were observed in germination potential due to storage containers, moisture levels and their interactions. Seed stored in cloth bag at 10.0 and 7.14% seed moisture recorded germination over certification standard (65%) up to 22 and 26 months while it could safely be stored up to 50 months in polythene bag irrespective of moisture levels studied. Reducing the seed moisture beyond certification standard did not show any beneficial effect on seed longevity (except for cloth bag storage) under subtropical climate of Rajnagar.

From a storage study, Eswarappa *et al.* (1991) found that the germination of rice grains stored in gunny bags under ambient conditions decreased from 85% in August to 48% in March while germination of grains stored in a coal tar drum or plywood bean was 80-90% and 84-95%, respectively throughout the storage period.

Pest infestation and temperature increased in grains stored in the gunny bags compared with grains stored in other containers. Moisture contents were similar in grains stored in the three containers. Seeds stored in perforated containers at 5^0C and 35^0C failed to germinate after 81 days but maintained 9.3 and 10.1% germination, respectively at 25^0C and room temperature even after 172 days. Seed sprayed over the laboratory bench at ambient conditions remained viable up to

263 days with 18.1% germination while those stored at ambient conditions in open container lost complete viability within 2-3 weeks

Ali (1963) showed that seeds stored in gunny bag and in earthen pots lost viability much earlier than seeds stored in closed tin and in glass bottles. Bhattacharyya and Dutta (1972) recommended double plastic bags for seed storage. Transparent plastic bags are versatile containers for seed storage and suitable for many species and storage conditions. Plastic bags or containers should be filled completely so that as little air as possible is stored with the seed (Boland *et al.*, 1990). Vacuum packing or storing in CO_2 in plastic bags practically removes all air and makes the seed samples easy to handle.

Seeds should be stored carefully by placing envelopes inside large glass jars with a bag of silica or powdered milk. These products absorb excess moisture. Alternatively, a tiny package of powdered milk is made by pouring a pile into the centre of a piece of breathable fabric or tissue paper. Corners are pulled together and closed it up with a piece of string or elastic to create a sachet. The best jars for storage are wide mouth mason jars used for canning. They have the proper airtight seal that is essential for long term storage. If the jars are stored in a cool, dark place the seeds should last from a year to a few years, depending on the type. Ali (1963) recommended tin cans for seed storage. While, Anon. (1985) indicated the possibility of involvement of storage fungi in reducing the germination of gram seeds during storage in the containers.

In an experiment conducted on soybean, Agha *et al.* (2004) reported that, field emergence was significantly different for storage containers. Seed emergence was greater in seed stored in containers. Further data demonstrated that storage containers were significantly affected the percentage of healthy seedlings. The seed stored in containers 51.6% healthy seedlings.

Karim and Amiruzzaman (1991) reported that maize seeds stored in polythene lined motka, improved tin, polythene lined jute bag, traditional tin and polythene lined Dole showed lowest insect infestation rate of 0.46, 0.91, 1.14, 3.02 and 3.38 percent, respectively. The containers were opened once after 13 months. The rate of insect infestation trend was more or less similar, that is 0.23, 1.85, 2.10, 2.34 and 2.37 percent infestation were obtained from the seed stored in polythene lined motka, polythene lined jute bag, improved tin, polythene lined dole and traditional tin, respectively. In terms of viability of seeds, polythene lined motka and improved tin gave highest germination rate of 76.67 and 73.33 percent, respectively. The present moisture of the maize seed increased in all treatments from initial 10.47 to 13.44% but this moisture level did not affect the germination of seeds.

2.6 Effect of seed storage

Storage potential is heritable. Species and sometimes genera typically show an inherited storage behavior, which may be either orthodox or recalcitrant. Accordingly, each species is likely to respond identically to a given set of storage conditions (Bonner *et al*., 1994). The storage conditions differ significantly between these two main groups, orthodox and recalcitrant seeds (Roberts, 1973), and the two groups are considered separately.

Raza *et al*. (2010) conducted a study to investigate the changes in wheat grain quality that may occur during storage in different types of containers commonly used in Pakistan i.e. earthen pots, tin containers, cotton bags, jute bags and polypropylene bags. Freshly harvested grains of three different wheat varieties were stored in these containers for 12 months in two consecutive years i.e. 2003-04 and 2004-05, at existing environmental conditions at Food Quality & Nutrition Program of National Agricultural Research Centre, Islamabad. Samples were analyzed before storage and after every 4 months for different quality parameters i.e. moisture content, test weight, flour yield, falling number and fat acidity. Results of both years showed an increase in moisture content during storage that was least in cotton bags and earthen pots resulting in higher test weights and flour yield. Tin containers performed better in retaining low fat acidity values. Storage duration of 12 months generally increased moisture and fat acidity while decreased test weight and flour yield in both years. Falling number also increased in all containers during storage, but remained with in the limits usually required for baking purposes. However, the pattern was not uniform within both the years under study.

2.7 Seed and storage condition effects on seed quality

Viability of many seeds is maintained longer if the seeds are stored at constant rather than fluctuating temperatures (Seeber and Agpaoa, 1976). Khandakar (1980) reported that the factors like moisture, temperature, proportion of infected seeds in storage, presence of foreign materials, activity of insects in seed lot, availability of oxygen to seed and it associated micro flora and fauna were related to the seed viability in storage. Bewley and Black (1994) found that reduction of O_2 pressure, e.g. by replacing oxygen with N_2 or CO_2 had little effect on seed longevity as long as temperature and moisture content were stored low. This is in contrast to earlier belief that reduction of O_2 level had a great influence on seed longevity (Willan, 1985).

McGill *et al.* (2002) reported that, the conditions required to maintain seed viability during storage are not well understood and there are conflicting reports as to whether the seed will retain viability in storage. The decline in seed viability at relatively low seed moisture content is typical of oil storage seeds and consistent with orthodox seed behavior.

Seed longevity can be described as the time until a certain proportion of a seed lot or seed population is dead. For example, the half viability period, P_{50}, is the time taken for 50% of the seeds to die (Roberts, 1972). Attempts to quantify the relationship between seed longevity and the three factors (initial seed quality, seed moisture content and storage temperature) affecting seed deterioration have produced numerous qualitative or quantitative prediction equations (Goodspeed, 1911; Grove,1917; Hutchinson,1944; Roberts, 1972, 1973; Harrington, 1963; Ellis and Roberts,1980, 1981).

2.8 Seed moisture content and seed quality

Seed moisture content is the most important factor that regulates the longevity of seed in storage. Higher moisture content in the seed enhances seed deterioration, which reduces the quality of seed. The moisture content of a sample is the loss in weight when it is dried in accordance with the rules.

The moisture content of seeds during storage is the most influential factor affecting their longevity. It is important to harvest mature, relatively dry seeds or to reduce the moisture content of high moisture seeds soon after harvest (Justice and Bass, 1978). Bass (1953) found that the loss of viability of freshly harvested Kentucky bluegrass seed was correlated with the moisture content of the seed and length of time held at a given temperature. High seed moisture content is known to be detrimental to seed storage of many species (Ellis *et al.*, 1982). Khandakar (1983) found that the higher is the seed moisture content; the lower is the seed longevity. Heydecker (1972) and Harrington (1972) also reported that seed deterioration increased as moisture content increased which resulted in loss of viability and poor germination.

Huda (1992) observed that higher moisture content was negatively correlated with germination percentage and positively with insect infestation. In an experiment, pea seeds with high viability and high moisture content, high viability and low moisture content. Low viability and high moisture content or low viability and low moisture content were soaked in distilled water for 1, 2,4,9 or 12 h or not soaked. Low viability seeds lost viability more rapidly during soaking than high viability seeds at both high moisture and low moisture. High viability low moisture seeds lost viability more rapidly than high moisture seeds (Sivritepe and Dourado, 1995). Fifty seed samples of different rice varieties stored in warehouses for varying periods were tested and significant correlations were found among the numbers of fungi, storage period and germinability. Significant relationships were also found between the fungi and moisture content, normal seedlings, abnormal seedlings, speed of germination and conductance of leachates (Misra *et al.*, 1995). Higher seed moisture content resulted in greater colonization by storage fungi and lower percentage seed germination (Ray, 1998) In an experiment on groundnut, Patra *et al.* (2000) found that with increase in storage period, viability of seeds decreased while pathogen activities, moisture content and sugar content in seeds increased gradually.

Rathi *et al.* (2000) found that increased moisture content caused seeds to respire at faster rate and decreased the germination. In an experiment, Vieira *et al.* (2001) observed that storing of high moisture seeds at 5^0C slightly extended the storage life, however viability loss was observed within one year. Extending the storability of seed by storing under reduced moisture content was reported in onion, tomato and carrot (Padma and Reddy, 2004), but they found that reducing the seed moisture beyond a critical level had not improved the storability of seed. In an investigation by Nakayama *et al.* (2004) dry seeds of nine soyabean cultivars were soaked in water for 48 h and the effects of soaking (flooding stress) on the plant growth were studied in relation to initial seed moisture content. Both seedling emergence and subsequent growth were suppressed by soaking. Sensitivity to flooding stress was greatly influenced by the initial seed moisture content. Soaking of 6.50% moisture content seeds in water resulted in a marked reduction in dry matter accumulation in emerged seedlings from 0.5 to 54% of that in the non-soaked control. However, seeds with high moisture content were less sensitive to flooding. In the seeds containing 14.5% moisture and soaked in water, the dry matter accumulation in the emerged seedlings was 65 to 97% of that in the non-soaked control. The protective effect of increasing the initial seed moisture on flooding stress was observed in all cultivars although the effect varied with the cultivar. Storability of vegetable seeds could be extended by reducing seed moisture content before storage (Padma and Reddy, 2004).

Helmer and Delouche (1964) reported that at seed moisture contents of 8.9, 10.3, and 11.0 percent, tin cans, polyethylene-aluminium inserts, and heat sealed polyethylene bags were superior to sewn polyethylene bags and cloth bags in maintaining rice seed quality during oceanic shipment and storage in Costa Rica. An initial seed moisture contents of 12.2, 13.3, and 14.3 seed deterioration was very rapid in all packaging materials. They recommended that to avoid deterioration, rice seed should be packaged in sealed moisture proof containers at 10.3 percent moisture or less for oceanic shipments and storage in tropical environments.

Henderson and Christensen (1961) observed that most of the stored product insects cease feeding and become inactive between 5^0C and 10^0C. Some species of mites reproduce at 5^0C or even lower, but only if the moisture content of the seed is above 12%. They also stated that the upper limits generally considered safe for long time storage under average condition are 13% for beans, peas and cereal grains including corn 12.5% for soybeans, 10.5% for flax seed and somewhat lower for most vegetables seeds and peanuts. This generalization of moisture limit is probably for temperate regions, it may be lower in case of tropical region.

2.9 Seed quality test

Germination in a seed testing laboratory is defined as the emergence and development from the seed embryo of those essential structures which for the seed in question indicate the seed's ability to produce normal plants under favourable conditions in soil. Laboratory conditions must therefore, not only initiate the seeds growth, but must also favour seedling development in a limited time to a stage in which all essential structures can be fully evaluated. Germination is expressed as a percentage of pure seed number that produces normal seedlings under optimal conditions (ISTA, 2006). Germination test is an integral component of seed quality assessment' A test on the germination capacity of seed lot provides reliable information with respect to the field planting value, as a germination test correlates positively with emergence under field conditions. Under controlled optimum conditions it gives most regular, rapid and complete germination for most samples and increases the reproducibility and uniformity of results (ISTA, 2006). Seed vigor has been described as those seed properties, which determine the potential rapid, uniform emergence and development of normal seedlings under wide range of field conditions (ISTA, 1995).

Dornbos (1994) defined seed viability as the capacity of the seed to germinate and produce a normal seedling. Germination capacity is the most practical indicator of seed viability and vigour. The seeds having low vigour values cannot germinate well under adverse field condition. The vigour of seeds at the time of storage is an important factor that affects their storage life. Vigour and viability cannot always be differentiated in storage environments, especially in seed lots that are rapidly deteriorating. This progressive weakening with age continues until all the seeds became nonviable (Anuja and Aneja, 2004). Zhang *et al.* (2005) opined that seed vigour will decline to low levels prior to planting, even for seed lots with acceptable germination. Low vigour seed may result in poor field stands, especially if planted in less than ideal field conditions. Khandakar and Bradbeer (1983) reported a wide gap between laboratory test and field germination. Decline in vigour and death of seeds can be considered from two aspects: (i) loss of viability or death of a seed lot, i.e. a small or large quantity of seed or (ii) death of an individual seed. The germination percentage of a seed lot is the proportion of individual seed capable of producing normal plants. For this reason the decline in vigour and eventual death of an individual seed should be considered (Justice and Bass, 1978).

For modeling the effects of unfavourable conditions on the field performance of seeds, a number of laboratory seed vigour tests have been developed. Among these, cold test, accelerated ageing test, conductivity test etc. are very effective and are recommended for specific seed species (Abba and Lovato, 1999; ISTA, 2006). Vigour information has been used as a marketing strategy for cereals in the UK and USA (Dornbos, 1995). Heydecker (1972) observed that the seeds having lower vigor values cannot germinate well under tightly condition and do not help in better crop establishment. Low vigor in seed may be due to genetic, physiological, morphological, cytological, mechanical and microbial factors.

Roberts (1972) found that the mechanical damage during harvesting, processing and transportation are the real causes of low vigor in seeds. Delouche *et al.* (1973)

reported that the maximum seed quality attends at physiological maturity after which vigor and viability decline over ageing.

Copeland (1976) reported that threshing, treating, bagging and planting processes may also cause in variations of seed viability. Hampton and Coolbear (1990) and Hampton (2000) gave due emphasis on vigour test information as a seed marketing tool.

The conductivity test provides a measurement of electrolyte leakage from plant tissues and was first recognized for seeds of several crop species by Hibbard and Miller (1928). It has been used for seeds of many species including large seeded legumes, onion, cabbage, cotton, tomato, ryegrass, wheat, maize etc. Conductivity measurement of the soak water in which a bulk sample (25-50 seeds) has been steeped identifies seed lots that have high laboratory germination but poor field emergence potential. Such seed lots have high electrolyte leakage and are classified as low vigour, while those with low leakage are considered high vigour (Justice and Bass, 1978). The integrity of cell membranes determined by deteriorative biochemical changes and/or physical disruption can be considered the fundamental cause of differences in seed vigour which are indirectly determined as electrolyte leakage during the conductivity test (Powell, 1988). Leaching of some compounds, particularly electrolytes, has often been associated with seed quality (Anuja and Aneja, 2004). As a seed rehydrates during early imbibitions, the ability of its cellular membranes to reorganize and repair any damage that may have occurred, will influence the extent of electrolyte leakage from the seed. High vigour seeds are able to reorganize their membranes more rapidly, and repair any damage to a greater extent, than low vigour seeds. Consequently, electrolyte leakage measured from high vigour seed is less than that measured from low vigour seed (ISTA, 2006). Roberts (1972) stated that germination percentage decreases with increase of seed age. Seed deteriorates slowly with the passing of time in a normal storage condition. This deterioration process is dependent on initial moisture content of the seed, temperature and relative humidity of ambient environment. By subjecting the seeds in a closed environment of high temperature and high relative humidity, this deterioration process can be accelerated. The degree of deterioration in naturally aged seed can vary depending on initial moisture content, viability, vigor of seed and storage environment. Ageing involves the process of deterioration of seeds and eventually lost the ability to germinate.

The physiological symptoms of seed ageing include reduced rate of germination and emergence, decreased tolerance to sub-optimal conditions and poorer seedling growth (Powell, 1986). Ageing can also result in loss of dormancy, germination, growth and produced the abnormal seedlings. The conductivity test has the tremendous advantage of simplicity and rapidity, and meets most of the requirements for a good vigour test (Hampton and Coolbear, 1990).

The experiment was conducted by Hussain *et al.* (2013) at the Seed Pathology Center (SPC), Department of Plant Pathology, Bangladesh Agricultural University (BAU), Mymensigh. The aim of the experiment was to determine the seed quality, germination category and rate of germination index of farmers' saved seeds after 45, 90 and 120 days of seed storing in different containers. Three containers viz. kerosene tin, polyethylene bag and gunny were used for seed preservation. Seed samples of rice (var. BR 1) were collected from four upazillas of Bogra districts. In case of seed quality, the highest percentages of discolored and spotted seeds were found in polyethylene bag and it was 2.98-3.72% and 79.51-80.08% respectively. Significantly higher number of normal seedling (77.35%) was recorded when seeds of kerosene tin was tested and higher number of abnormal seedling (4.44%), diseased seedling (12.06%) and dead seed (15.88%)were found in seeds of guuny bag. The rate of germination index in the seeds of kerosene tin, polyethylene bag and gunny bag ranged 95.11-97.68%, 93.74-96.17% and 92.07-94.35% respectively.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The laboratory experiment was conducted during the period from April to November 2013 to study the wheat seed quality as affected by containers under ambient condition. The materials and methods those were used for conducting the experiment have been presented in this chapter. It includes a short description of the experimental site, climate condition, materials used for the experiment, experimental design, data collection and data analysis procedure.

3.1 Experimental site

The experiment was conducted at the laboratory condition of Agronomy Department of Sher-e-Bangla Agricultural University (SAU), Dhaka.

3.2 Climatic condition of the experimental site

Experimental area is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix I.

3.3 Experimental material

The variety BARI Gom 21(Shatabdi), BARI Gom 25, BARI Gom 26 were used as experimental materials. The seeds were collected from the experiment field of Department of Agronomy, SAU, Dhaka, which were grown in the cropping season of 2012-13. After collection of seeds thousand seed weight, moisture percentage, and germination percentage was measured and recorded. After that the seeds were stored in different container at 20 April, 2013 as per treatment of the experiment.

3.4 Treatments of the experiment

Factor A: Storage container (3 containers)

- i Tin container
- ii. Earthen pot
- iii. Plastic pot

Factor B: Wheat variety (3 varieties)

- i. BARI Gom 21 (Shatabdi)
- ii. BARI Gom 25
- iii. BARI Gom 26

There were 9 (3×3) treatment combinations.

Plate 1. Photograph showing different storage containers with wheat seeds

3.5 Experimental design

The experiment was laid out in the ambient condition of the laboratory considering in a Completely Randomized Design (CRD) and the treatments was replicated four times for each.

3.6 Storage of wheat seeds

The healthy and uniform sized seeds were kept in different container as per treatment. Total 2 kg seeds were stored in each container. After that the container made air tied by using masking tape and stored in clean and dry place. The stored containers kept under keen observation for 6 months in air tied condition.

3.7 Sampling and data collection

Three sampling of stored grains was taken at 30 days interval starting from 180 days after storage in different containers for measuring quality of wheat seeds. So data were collected at 180, 210 and 240 days after storage (DAS) of wheat seeds.

3.8 Data collection

The following data were recorded

1. Weight of 1000 seeds
2. Moisture percentage
3. Germination percentage
4. Days to germination
5. Electrical conductivity
6. Seedling shoot length
7. Seedling root length
8. Seedling fresh weight
9. Seedling dry weight

3.9 Procedure of data collection

3.9.1 Weight of 1000 seeds

One thousand seeds were counted from each container at 180, 210 and 240 days after storage and weighed by using a digital electric balance and weight was expressed in gram (g).

3.9.2 Moisture percentage

Seed moisture content was determined following low constant temperature oven method and done as soon as the seed was removed from the container and immediate after taken from the container. An aluminium container was taken with cover and weighed (M_1). Some (about 5 g) wheat seed sample was taken in the container and weighed the seed with cover (M_2). The container was placed on its cover and dried in an oven maintained at a temperature of $103\pm2^{\circ}C$ for 17 ± 1 hours. The drying period begins at the time the oven returns to the required temperature. After 17 hours the door of the oven was opened and the transferring tray with seeds was taken out. The container was closed immediately with its cover and was stored in the desiccators. After cooling (about 30 minutes) the container was weighed with their covers and the weight was recorded as M_3 to three decimals. The moisture content of wheat seeds was determined using the following formula indicated by ISTA (1987). In this process moisture percentage was taken after 180, 210 and 240 days after storage of wheat seeds.

$$\% MC = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M_1 = Weight of container + cover

M_2 = Weight of container + cover + seed before drying

M_3 = Weight of container + cover + seed after drying

3.9.3 Electrical conductivity test

Electrical Conductivity test was done to quantify the leakage of electrolytes from the seed coat with respect to age, storage life and other factors i.e. temperature, humidity, soil and water stress etc. A sample of 50 seeds was taken from each treatment, placed in a 250 ml flask and 200 ml of distilled water was added into it. The flask was stirred to remove air bubbles as well as floating seeds and then covered with aluminum foil to store at 35^0C for 24 hours. After incubating the said time, water of the beaker containing seeds was decanted to separate the seeds. The electrical conductivity of the decanted water containing seed leachate was measured with a conductivity meter (Model-CM-30ET). Four replicates of measurements were made for each sample of seed. Conductivity was expressed on a weight bases in Microsiemens cm^{-1} g^{-1} of seed ($\mu Scm^{-1}g^{-1}$) as describe by Anonymous (2002a).

3.9.4 Germination percentage

Total 100 pure seeds of each treatment combination were placed in plastic box containing filter paper soaked with distilled water. For each test four plastic boxes were used. The boxes were placed in room temperature ($25\text{-}30^0$C) in open condition for germination. Seedling was counted everyday up to the completion of germination. A seed was considered to be germinated as the seed coat ruptured and radicle came out up to 2 mm length as per ISTA (2006) rule. Germination percentage was calculated using the following formula (Krishnashamy and Seshu, 1990).

$$\% \text{ Germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seed tested}} \times 100$$

3.9.5 Days to germination

The germination of wheat seeds was recorded and considered to be germinated as the seed coat ruptured and radicle came out up to 2 mm length as per ISTA (2006) rule and expressed days to germination.

Plate 2. Photograph showing germination test

3.9.6 Seedling shoot length

Seedling shoot length was measured with a meter scale from the shoot tip to the junction of root of 10 selected seedlings from each treatment and their average was taken and expressed in cm.

3.9.7 Seedling root length

Seedling root length was measured with a meter scale from the junction of shoot to the root tip point of 10 selected seedlings from each treatment and their average was taken and expressed in cm.

3.9.8 Seedling fresh weight

The fresh weight of seedling was recorded from the average of ten (10) selected seedlings in grams (gm) with a beam balance including root and shoots.

3.9.9 Seedling dry weight

At first 10 selected seedlings were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken and it was the seedling dry weight.

3.10 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different container and wheat variety. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The findings of the experiment have been presented and discusses with the help of table and possible interpretations were given under the following headings:

4.1 Weight of 1000 seeds

Weight of 1000 seeds of wheat showed statistically significant variation due to different storage containers at 180, 210 and 240 days after storage (DAS) (Appendix II). Data revealed that, the highest weight of 1000 seeds was recorded from Earthen pot (43.53, 44.35 g and 45.11 g, respective to 180, 210 and 240 DAS),followed by plastic pot (42.35, 43.12 and 43.76 g, respectively). The lowest weight was found from Tin container (41.22, 41.78 and 42.63 g, respectively) (Table 1). Patra *et al.* (2000) found that with increase in storage period, increase in moisture content and sugar content of seeds was found from Tin container resulting increases in weight of 1000 seeds.

Different wheat varieties differed significantly in terms of weight of 1000 seeds at 180, 210 and 240 DAS (Appendix II). At 180, 210 and 240 DAS, the highest weight of 1000 seeds was found from BARI Gom 26 (43.12, 44.24 and 45.10 g, respectively) On the other hand, the lowest weight was found from BARI Gom 21 (41.79, 42.31 and 43.13 g, respectively) which was statistically similar with BARI Gom 25 (42.13, 42.69 and 43.27 g, respectively) (Table 1). Different varieties of wheat have different size based on the size of wheat seeds weight of 1000 seeds also differ among varieties.

Interaction effect of different storage containers and varieties showed statistically significant variation in terms of weight of 1000 seeds at 180, 210 and 240 DAS (Appendix II). At 180, 210 and 240 DAS, the highest weight of 1000 seeds was recorded from Earthen pot and BARI Gom 26 (45.43, 46.94 and 47.60 g, respectively) and the lowest weight was recorded from Tin container and BARI Gom 26 treatment combination (40.82, 41.56 and 42.35 g, respectively) (Table 2).

4.2 Moisture percentage

Statistically significant variation was found on moisture percentage of wheat seeds recorded from different storage containers at 180, 210 and 240 days after storage (DAS) (Appendix II). At 180, 210 and 240 DAS, the highest moisture was observed from Earthen pot (10.18%, 11.36% and 12.17%, respectively), which followed by Plastic pot (9.61%, 10.73% and 11.46%, respectively), while the lowest moisture was recorded from Tin container (8.88%, 10.00% and 10.79%, respectively) (Table 1). Seed moisture content is the most important factor that regulates the longevity of seed in storage. Higher moisture content in the seed enhances seed deterioration, which reduces the quality of seed. Bass and Rahman *et al.* (1985) reported that seed absorbed moisture when it was stored in indigenous methods. Miah and Douglass (1992) reported that the influence of storage structures and storage periods on the viability of high moisture wheat seeds.

Moisture percentage at 180, 210 and 240 DAS showed significant differences due to different wheat varieties (Appendix II). At 180, 210 and 240 DAS, the highest moisture was obtained from BARI Gom 25 (9.77%, 10.91% and 11.66%, respectively) which was statistically similar with BARI Gom 21 (9.49%, 10.76% and 11.53%, respectively), again the lowest moisture was found from BARI Gom 26 (9.41%, 10.42% and 11.23%, respectively) (Table 1).

Table 1. Effect of storage container and variety on weight of 1000 seeds and moisture percentage of wheat seed

Treatment	Weight of 1000 seeds (g) at			Moisture percentage (%) at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage containers						
Tin container	41.22 c	41.78 c	42.63 c	8.88 c	10.00 c	10.79 c
Earthen pot	43.53 a	44.35 a	45.11 a	10.18 a	11.36 a	12.17 a
Plastic pot	42.35 b	43.12 b	43.76 b	9.61 b	10.73 b	11.46 b
$LSD_{(0.05)}$	0.975	1.117	1.094	0.278	0.326	0.319
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Wheat variety						
BARI Gom 21	41.79 b	42.31 b	43.13 b	9.49 a	10.76 a	11.53 ab
BARI Gom 25	42.13 b	42.69 b	43.27 b	9.77 a	10.91 a	11.66 a
BARI Gom 26	43.12 a	44.24 a	45.10 a	9.41 b	10.42 b	11.23 b
$LSD_{(0.05)}$	0.975	1.117	1.094	0.278	0.326	0.319
Level of significance	0.05	0.01	0.01	0.05	0.01	0.05
CV(%)	2.75	3.10	2.98	3.47	3.64	3.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 2. Interaction effect of storage container and variety on weight of 1000 seeds and moisture percentage of wheat seed

Treatment	Weight of 1000 seeds (g) at			Moisture percentage (%) at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Tin container × BARI Gom 21	41.21 bc	41.57 c	42.73 c	8.90 de	10.32 c	11.09 c
× BARI Gom 25	41.63 bc	42.21 bc	42.81 c	9.23 cd	10.43 c	11.20 c
× BARI Gom 26	40.82 c	41.56 c	42.35 c	8.52 e	9.25 d	10.07 d
Earthen pot × BARI Gom 21	42.34 bc	42.99 bc	43.88 bc	10.03 a	11.17 ab	12.07 ab
× BARI Gom 25	42.82 b	43.13 bc	43.87 bc	10.17 a	11.43 a	12.21 a
× BARI Gom 26	45.43 a	46.94 a	47.60 a	10.33 a	11.48 a	12.23 a
Plastic pot × BARI Gom 21	41.81 bc	42.39 bc	43.18 bc	9.52 bc	10.78 bc	11.43 c
× BARI Gom 25	42.11 bc	42.74 bc	43.14 bc	9.93 ab	10.87abc	11.56 bc
× BARI Gom 26	43.11 b	44.22 b	44.96 b	9.39 cd	10.55 c	11.38 c
LSD$_{(0.05)}$	1.689	1.935	1.895	0.481	0.564	0.553
Level of significance	0.05	0.05	0.05	0.05	0.01	0.05
CV(%)	2.75	3.10	2.98	3.47	3.64	3.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Due to the interaction effect of storage containers and varieties statistically significant variation was observed in terms of moisture percentage of wheat seeds at 180, 210 and 240 DAS (Appendix II). At 180, 210 and 240 DAS, the highest moisture was attained from Earthen pot and BARI Gom 26 (10.33%, 11.48% and 12.23%, respectively), whereas the lowest moisture was found from Tin container and BARI Gom 26 treatment combination (8.52%, 9.25% and 10.07%, respectively) (Table 2).

4.3 Electrical conductivity

Electrical conductivity of wheat seeds showed statistically significant variation due to different storage containers at 180, 210 and 240 days after storage (DAS) (Appendix III). At 180, 210 and 240 DAS, the highest electrical conductivity was found from Earthen pot (27.25, 38.07 and 52.59, respectively), which was closely followed by Plastic pot (26.62, 34.32 and 43.55, respectively) , while the lowest electrical conductivity found from Tin container (25.61, 31.53 and 38.19, respectively) (Table 3).

Wheat varieties differed significantly in terms of electrical conductivity at 180, 210 and 240 DAS (Appendix III). At 180, 210 and 240 DAS, the highest electrical conductivity was recorded from BARI Gom 21 (28.28, 36.29 and 46.20, respectively) which were followed with BARI Gom 25 (26.50, 34.73 and 44.91, respectively), whereas the lowest electrical conductivity was found from BARI Gom 26 (24.70, 32.90 and 43.22, respectively) (Table 3).

Interaction effect of different storage containers and varieties showed statistically significant variation on electrical conductivity of wheat seeds at 180, 210 and 240 DAS (Appendix III). At 180, 210 and 240 DAS, the highest electrical conductivity was observed from Earthen pot and BARI Gom 21 (28.90, 39.09 and 53.59, respectively) and the lowest electrical conductivity was found from Tin container and BARI Gom 26 treatment combination (23.84, 29.84 and 36.82, respectively) (Table 4).

Table 3. Effect of storage container and variety on electrical conductivity reading of wheat seed

Treatment	Electrical conductivity(μScm^{-1} g^{-1})		
	180 DAS	210 DAS	240 DAS
Storage containers			
Tin container	25.61 b	31.53 c	38.19 c
Earthen pot	27.25 a	38.07 a	*52.59 a*
Plastic pot	26.62 ab	34.32 b	43.55 b
LSD$_{(0.05)}$	1.194	1.152	1.590
Level of significance	0.05	0.01	0.01
Wheat varieties			
BARI Gom 21	28.28 a	36.29 a	46.20 a
BARI Gom 25	26.50 b	34.73 b	44.91 a
BARI Gom 26	24.70 c	32.90 c	43.22 b
LSD$_{(0.05)}$	1.194	1.152	1.590
Level of significance	0.01	0.01	0.01
CV(%)	5.38	3.97	4.24

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 4. Interaction effect of storage container and variety on Electrical conductivity reading of wheat seed

Treatment	Electrical conductivity ($\mu Scm^{-1}g^{-1}$)		
	180 DAS	210 DAS	240 DAS
Tin container × BARI Gom 21	27.23 ab	33.02 cd	39.52 de
× BARI Gom 25	25.76 bc	31.73 de	38.23 e
× BARI Gom 26	23.84 c	29.84 e	36.82 e
Earthen pot × BARI Gom 21	28.90 a	39.09 a	53.59 a
× BARI Gom 25	26.95 ab	38.28 ab	52.85 a
× BARI Gom 26	25.91 bc	36.84 a	51.34 a
Plastic pot × BARI Gom 21	28.70 a	36.75 b	45.50 b
× BARI Gom 25	26.80 ab	34.18 c	43.65 bc
× BARI Gom 26	24.35 c	32.03 d	41.50 cd
$LSD_{(0.05)}$	2.068	1.195	2.754
Level of significance	0.05	0.01	0.01
CV(%)	5.38	3.97	4.24

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.4 Germination percentage

Germination percentage of wheat seeds varied significantly due to different storage containers at 180, 210 and 240 days after storage (DAS) (Appendix IV). At 180, 210 and 240 DAS, the highest germination was found from Tin container (95.47%, 94.15% and 91.56%, respectively), followed by Plastic pot (93.50%, 92.30% and 87.97%, respectively), whereas the lowest germination from Earthen pot (91.17%, 89.42% and 85.88%%, respectively) (Table 5). Hussain *et al.* (2013) reported that the rate of germination index in the seeds of kerosene tin, polyethylene bag and gunny bag ranged 95.11-97.68%, 93.74-96.17% and 92.07-94.35% respectively. Garg and Chandra (2005) reported that there is an effect of storage place, packaging material, duration of storage and kind of seed on the viability during storage and the choice of a packaging material in a given climatic condition would depend upon kind of seed and the duration of storage. Rahman *et al.* (1985) reported that seed reduced germinability when it was stored in indigenous methods.

Germination percentage of wheat varieties was found non-significant at 180, 210 and 240 DAS (Appendix IV). However, at 180, 210 and 240 DAS, the highest germination was recorded from BARI Gom 26 (93.71%, 92.29% and 89.37%, respectively) and the lowest germination was found from BARI Gom 25 (93.04%, 91.61% and 87.61%, respectively) (Table 5). Canode (1972) found that the length of time that grass seed might be stored without serious reduction in germination depends on the species and storage condition. Seedling emergence itself is a genetical character and climatic conditions greatly influence the emergence performance of wheat cultivars (Sharma *et al.*, 2006; Abdullah *et al.*, 2007).

Interaction effect of different storage containers and varieties showed statistically significant variation in terms of germination percentage of wheat seeds at 180, 210 and 240 DAS (Appendix IV). At 180, 210 and 240 DAS, the highest germination was observed from Tin container and BARI Gom 26 (97.79%, 96.37% and 94.93%, respectively) and the lowest germination was attained from Earthen pot and BARI Gom 26 treatment combination (89.74%, 88.04% and 84.23%, respectively) (Table 6).

4.5 Days to germination

Days to germination of wheat seeds showed significant variation at 180, 210 and 240 days after storage (Appendix IV). At 180, 210 and 240 DAS, the highest days to germination was found from Earthen pot (6.12, 5.88 and 5.66 days, respectively), which was closely followed by Plastic pot (5.84, 5.53 and 5.28 days, respectively), while the lowest days to germination of seeds found from Tin Container (5.45, 5.09 and 4.64 days, respectively) (Table 5).

Wheat varieties differed significantly in terms of days to germination (Appendix IV). At 180, 210 and 240 DAS, the highest days to germination was recorded from BARI Gom 25 (6.00, 5.62 and 5.28 days, respectively) which were statistically identical with BARI Gom 21 (5.74, 5.53 and 5.25 days, respectively), whereas the lowest days to germination was found from BARI Gom 26 (5.67, 5.35 and 5.06 days, respectively) (Table 5). Seedling emergence itself is a genetical character, climatic conditions also influences days to germination of wheat cultivars (Abdullah *et al.*, 2007).

Interaction effect of different storage containers and varieties showed statistically significant variation in terms of days to germination percentage of wheat seeds at 180, 210 and 240 DAS (Appendix IV). At 180, 210 and 240 DAS, the highest days to germination was observed from Earthen pot and BARI Gom 26 (6.20, 5.97 and 5.85 days, respectively) and the lowest days to germination was found from Tin container and BARI Gom 26 treatment combination (5.18, 4.60 and 4.10 days, respectively) (Table 6).

Table 5. Effect of storage container and variety on germination percentage and days to germination of wheat seed

Treatment	Germination (%) at			Days to germination at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage containers						
Tin container	95.47 a	94.15 a	91.56 a	5.45 c	5.09 c	4.64 c
Earthen pot	91.17 c	89.42 b	85.88 c	6.12 a	5.88 a	5.66 a
Plastic pot	93.50 b	92.30 a	87.97 b	5.84 b	5.53 b	5.28 b
$LSD_{(0.05)}$	1.645	1.961	1.720	0.265	0.198	0.174
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Wheat varieties						
BARI Gom 21	93.40	91.97	88.43	5.74 ab	5.53 ab	5.25 a
BARI Gom 25	93.04	91.61	87.61	6.00 a	5.62 a	5.28 a
BARI Gom 26	93.71	92.29	89.37	5.67 b	5.35 b	5.06 b
$LSD_{(0.05)}$	--	--	--	0.265	0.198	0.174
Level of significance	NS	NS	NS	0.05	0.05	0.05
CV(%)	2.10	2.55	2.32	5.44	4.29	3.99

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 6. Interaction effect of storage container and variety on germination percentage and days to germination of wheat seed

Treatment	Germination (%) at			Days to germination at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Tin container × BARI Gom 21	94.54 b	93.07 ab	89.95 b	5.55 cd	5.32 d	4.93 de
× BARI Gom 25	94.09 b	93.00 ab	89.80 b	5.63 cd	5.35 cd	4.90 e
× BARI Gom 26	97.79 a	96.37 a	94.93 a	5.18 d	4.60 e	4.10 f
Earthen pot × BARI Gom 21	92.10 bc	90.56 bc	86.78 b-d	6.03 a-c	5.72 a-c	5.50 bc
× BARI Gom 25	91.68 bc	89.67 bc	86.63 b-d	6.17 a	5.93 ab	5.63 ab
× BARI Gom 26	89.74 c	88.04 c	84.23 d	6.20 a	5.97 a	5.85 a
Plastic pot × BARI Gom 21	93.55 b	92.28 b	88.57 bc	5.65 cd	5.53 cd	5.32 bc
× BARI Gom 25	93.36 b	92.17 b	86.40 cd	6.15 ab	5.57 b-d	5.30 bc
× BARI Gom 26	93.59 b	92.46 b	88.94 bc	5.68 b-d	5.47 cd	5.22 cd
LSD$_{(0.05)}$	2.850	3.397	2.978	0.459	0.343	0.301
Level of significance	0.05	0.05	0.05	0.05	0.01	0.01
CV(%)	2.10	2.55	2.32	5.44	4.29	3.99

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.6 Seedling shoot length

Statistically significant variation was recorded on seedling shoot length at 180, 210 and 240 days after storage (DAS) (Appendix V). Data revealed that at 180, 210 and 240 DAS, the maximum seedling shoot length was attained from Tin container (2.56, 2.69 and 2.95 cm, respectively), followed by Plastic pot (2.42, 2.50 and 2.76 cm, respectively), while the minimum seedling shoot length was recorded from Earthen pot (2.27, 2.34 and 2.54 cm, respectively) (Table 7). Agha *et al.* (2004) reported that, field emergence was significantly different for storage containers. Seed emergence was greater in seed stored in containers. Further data demonstrated that storage containers were significantly affected the percentage of healthy seedlings. The seed stored in containers showed 51.6% healthy seedlings.

Seedling shoot length at 180, 210 and 240 DAS showed significant variations in wheat varieties (Appendix V). At 180, 210 and 240 DAS, the maximum seedling shoot length was observed from BARI Gom 26 (2.46, 2.56 and 2.81 cm, respectively) which were statistically similar with BARI Gom 21 (2.41, 2.52 and 2.75 cm, respectively) whereas the minimum seedling shoot length was found from BARI Gom 25 (2.37, 2.45 and 2///...70 cm, respectively) (Table 7). The physiological symptoms of seed ageing include reduced rate of germination and emergence, decreased tolerance to sub-optimal conditions and poorer seedling growth in different variety (Powell, 1986).

Shoot length also showed statistically significant variation due to the interaction effect of different storage containers and varieties (Appendix V). At 180, 210 and 240 DAS, the maximum seedling shoot length was obtained from Tin Container and BARI Gom 26 treatment combination (2.68, 2.86 and 3.15 cm, respectively), again the minimum seedling shoot length was found from Earthen pot and BARI Gom 26 treatment combination (2.25, 2.28 ad 2.46 cm, respectively) (Table 8).

4.7 Seedling root length

Seedling root length showed statistically significant variation at 180, 210 and 240 days after storage (DAS) (Appendix V). At 180, 210 and 240 DAS, the maximum seedling root length was observed from Tin container (2.32, 2.48 and 2.67 cm, respectively), followed by Plastic pot (2.18, 2.36 and 2.45 cm, respectively), whereas the minimum seedling root length from Earthen pot was recorded (2.06, 2.23 and 2.31 cm, respectively) (Table 7).

Wheat varieties differed significantly on seedling root length at 180, 210 and 240 DAS (Appendix V). Data revealed that at 180, 210 and 240 DAS, the maximum seedling root length was recorded from BARI Gom 26(2.22, 2.39 and 2.51 cm, respectively) which were statistically identical with BARI Gom 21 (2.18, 2.36 and 2.49 cm, respectively), while the minimum seedling root length from BARI Gom 25 (2.15, 2.32 and 2.43 cm, respectively) (Table 7).

Interaction effect of different storage containers and varieties showed statistically significant variation on seedling root length (Appendix V). At 180, 210 and 240 DAS, the maximum seedling root length was recorded from Tin Container and BARI Gom 26 combination (2.42, 2.57 and 2.77 cm, respectively) and the minimum seedling root length was obtained from Earthen pot and BARI Gom 26 treatment combination (2.05, 2.21 and 2.25 cm, respectively) (Table 8).

Table 7. Effect of storage container and variety on shoot and root length of wheat

Treatment	Shoot length (cm) at			Root length (cm) at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage containers						
Tin container	2.56 a	2.69 a	2.95 a	2.32 a	2.48 a	2.67 a
Earthen pot	2.27 c	2.34 c	2.54 c	2.06 c	2.23 c	2.31 c
Plastic pot	2.42 b	2.50 b	2.76 b	2.18 b	2.36 b	2.45 b
$LSD_{(0.05)}$	0.053	0.075	0.088	0.037	0.037	0.046
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Wheat varieties						
BARI Gom 21	2.41 ab	2.52 ab	2.75 ab	2.18 b	2.36 ab	2.49 a
BARI Gom 25	2.37 b	2.45 b	2.70 b	2.15 b	2.32 b	2.43 b
BARI Gom 26	2.46 a	2.56 a	2.81 a	2.22 a	2.39 a	2.51 a
$LSD_{(0.05)}$	0.053	0.075	0.088	0.037	0.037	0.046
Level of significance	0.01	0.05	0.05	0.01	0.01	0.01
CV(%)	2.75	3.66	3.74	2.10	1.74	2.39

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 8. Interaction effect of storage container and wheat variety on shoot and root length of wheat

Treatment	Shoot length (cm) at			Root length (cm) at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Tin container × BARI Gom 21	2.51 b	2.66 b	2.88 b	2.28 b	2.47 b	2.65 b
× BARI Gom 25	2.47 bc	2.57 bc	2.84 b	2.26 bc	2.41 bc	2.58 bc
× BARI Gom 26	2.68 a	2.86 a	3.15 a	2.42 a	2.57 a	2.77 a
Earthen pot × BARI Gom 21	2.30 de	2.40 def	2.63 cd	2.09 ef	2.25 e	2.35 f
× BARI Gom 25	2.26 e	2.34 ef	2.54 de	2.06 f	2.22 e	2.32 fg
× BARI Gom 26	2.25 e	2.28 f	2.46 e	2.05 f	2.21 e	2.25 g
Plastic pot × BARI Gom 21	2.42 bc	2.50 cd	2.75 bc	2.18 d	2.35cd	2.45 de
× BARI Gom 25	2.39 cd	2.45 cde	2.72 bc	2.15 de	2.33 d	2.39 ef
× BARI Gom 26	2.44 bc	2.54 bc	2.82 b	2.20 cd	2.38 cd	2.51 cd
LSD$_{(0.05)}$	0.092	0.130	0.152	0.065	0.065	0.079
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	2.75	3.66	3.74	2.10	1.74	2.39

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

4.8 Seedling fresh weight

Storage containers showed significant variation seedling fresh weight (Appendix VI). At 180, 210 and 240 DAS, the maximum seedling fresh weight was found from Tin container (0.17, 0.18 and 0.19 g, respectively), which was followed by Plastic pot (0.15, 0.16 and 0.17 g, respectively). On the other hand, the minimum seedling fresh weigh was observed from Earthen pot (0.13, 0.14 and 0.15 g, respectively) (Table 9). Misra *et al.*, 1995 reported significant relationships between the fungi and moisture content and seedling fresh weight.

Seedling fresh weight at 180, 210 and 240 DAS differed significantly due to varieties (Appendix VI). At 180, 210 and 240 DAS, the maximum seedling fresh weight BARI Gom 26 (0.16, 0.17 and 0.14g, respectively) was found which were statistically similar with BARI Gom 21 (0.15, 0.16 and 0.17 g, respectively), whereas the minimum seedling fresh weight was observed from BARI Gom 25 (0.14, 0.15 and 0.16 g, respectively) (Table 9).

Statistically significant variation was recorded due to the interaction effect of different storage containers and varieties on seedling fresh weight (Appendix VI). At 180, 210 and 240 DAS, the maximum seedling fresh weight was recorded from Tin container and BARI Gom 26 (0.18, 0.19 and 0.20 g, respectively), while the minimum seedling fresh weight was observed from Earthen pot and BARI Gom 26 treatment combination (0.13, 0.14 and 0.14 g, respectively) (Table 10).

4.9 Seedling dry weight

Seedling dry weight of wheat seeds showed statistically significant variation due to storage containers (Appendix VI). Data revealed that at 180, 210 and 240 DAS, the maximum seedling dry weight was recorded from Tin container (0.013, 0.015 and 0.017 g, respectively), which was followed by Plastic pot (0.012, 0.013 and 0.015 g, respectively), whereas the minimum seedling dry weight was observed from Earthen pot (0.010, 0.011 and 0.012 g, respectively) (Table 9).

Wheat varieties differed significantly seedling in seedling dry weight (Appendix VI). At 180, 210 and 240 DAS, the maximum seedling dry weight was recorded from BARI Gom 26 (0.013, 0.014 and 0.015 g, respectively) which was statistically identical with BARI Gom 21 (0.012, 0.013 and 0.015 g, respectively), whereas the minimum seedling dry weight was observed from BARI Gom 25 (0.011, 0.013 and 0.014 g, respectively) (Table 9).

Seedling dry weight also varied significantly variation due to the interaction effect of different storage containers and varieties (Appendix VI). At 180, 210 and 240 DAS, the maximum seedling dry weight was found from Tin container and BARI Gom 26 (0.014, 0.016 and 0.018 g, respectively), while the minimum seedling dry weight was observed from Earthen pot and BARI Gom 26 treatment combination (0.010, 0.011 and 0.012 g, respectively) (Table 10).

Table 9. Effect of storage container and variety on seedling fresh and dry weight of wheat

Treatment	Seedling fresh weight (g) at			Seedling dry weight (g) at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage containers						
Tin container	0.17 a	0.18 a	0.19 a	0.013 a	0.015 a	0.017 a
Earthen pot	0.13 c	0.14 c	0.15 c	0.010 c	0.011 c	0.012 c
Plastic pot	0.15 b	0.16 b	0.17 b	0.012 b	0.013 b	0.015 b
$LSD_{(0.05)}$	0.008	0.008	0.008	0.008	0.008	0.008
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Wheat varieties						
BARI Gom 21	0.15 ab	0.16 a	0.17 a	0.012 ab	0.013 ab	0.015 a
BARI Gom 25	0.14 b	0.15 b	0.16 b	0.011 b	0.013 b	0.013 b
BARI Gom 26	0.16 a	0.17 a	0.14 a	0.013 a	0.014 a	0.015 a
$LSD_{(0.05)}$	0.008	0.008	0.008	0.008	0.008	0.008
Level of significance	0.05	0.05	0.05	0.01	0.01	0.05
CV(%)	4.48	4.72	4.33	5.59	6.17	4.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Table 10. Interaction effect of different storage container and variety on seedling fresh and dry weight of wheat

Treatment	Seedling fresh weight (g) at			Seedling dry weight (g) at		
	180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Tin container × BARI Gom 21	0.16 b	0.18 b	0.19 b	0.013 ab	0.014 b	0.016 b
× BARI Gom 25	0.17 b	0.17 bc	0.19 b	0.012 bc	0.014 b	0.016 b
× BARI Gom 26	0.18 a	0.19 a	0.20 a	0.014 a	0.016 a	0.018 a
Earthen pot × BARI Gom 21	0.14 de	0.15 e	0.16 e	0.011 cd	0.012 cd	0.013 c
× BARI Gom 25	0.13 ef	0.14 f	0.15 f	0.010 d	0.011 cd	0.012 c
× BARI Gom 26	0.13 f	0.14 f	0.14 f	0.010 d	0.011 d	0.012 c
Plastic pot × BARI Gom 21	0.15 c	0.17 bc	0.17 cd	0.012 bc	0.013 bc	0.015b
× BARI Gom 25	0.14 d	0.16 d	0.17 d	0.011 cd	0.013 bc	0.015 b
× BARI Gom 26	0.16 c	0.17 c	0.18 bc	0.012 bc	0.014 b	0.016 b
$LSD_{(0.05)}$	0.015	0.015	0.015	0.015	0.015	0.015
Level of significance	0.01	0.05	0.01	0.01	0.05	0.01
CV(%)	4.48	4.72	4.33	5.59	6.17	4.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

CHAPTER V

SUMMARY AND CONCLUSION

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The experiment was conducted at the laboratory condition of Agronomy department of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from April to November 2013 to study the wheat seed quality as affected by containers under ambient condition.Two factors of the experiment were Factor A: Storage container (3 containers)- Tin container, Earthen pot, Plastic pot; and Factor B: Wheat variety (3 varieties)- BARI Gom 21, BARI Gom 25, BARI Gom 26. The experiment was laid out in a Completely Randomized Design (CRD) with four replications. Data on weight of 1000 seeds, imbibitions rate, germination, shoot & root length, fresh & dry weight of seedling was recorded.

In the case of different storage containers, at 180, 210 and 240 DAS, the highest weight of 1000 seeds was recorded from Earthen pot (43.53, 44.35 g and 45.11 g, respectively), whereas the lowest weight was found from Tin container (41.22, 41.78 and 42.63 g, respectively). At 180, 210 and 240 DAS, the highest moisture was observed from Earthen pot (10.18%, 11.36% and 12.17%, respectively), while the lowest moisture was recorded from Tin container (8.88%, 10.00% and 10.79%, respectively). At 180, 210 and 240 DAS, the highest electrical conductivity was found from Earthen pot (27.25, 38.07 and 52.59 $\mu Scm^{-2}g^{-1}$, respectively), while the lowest electrical conductivity from Tin container (25.61, 31.53 and 38.19 $\mu Scm^{-2}g^{-1}$, respectively). At 180, 210 and 240 DAS, the highest germination (95.47%, 94.15% and 91.56%, respectively) was found from Tin container, whereas the lowest germination was observed from Earthen pot (91.17%, 89.42% and 85.88%%, respectively). At 180, 210 and 240 DAS, the highest days to germination was found from Earthen pot (6.12, 5.88 and 5.66 days, respectively), while the lowest days to germination from Tin container (5.45, 5.09 and 4.64 days, respectively). At 180, 210 and 240 DAS, the maximum seedling shoot length was attained from Tin Container (2.56, 2.69 and 2.95 cm, respectively), while the minimum seedling shoot length was recorded from Earthen pot (2.27, 2.34 and 2.54 cm, respectively). At 180, 210 and 240 DAS, the maximum seedling root length was observed from Tin container (2.32, 2.48 and 2.67 cm, respectively), whereas the minimum seedling root length was recorded from Earthen pot (2.06, 2.23 and 2.31 cm, respectively). At 180, 210 and 240 DAS, the maximum seedling fresh weight was found from Tin container (0.17, 0.18 and 0.19 g, respectively), and the minimum seedling fresh weight was observed from Earthen pot (0.15, 0.16 and 0.17 g, respectively). At 180, 210 and 240 DAS, the maximum seedling dry weight was recorded from Tin container (0.013, 0.015 and 0.017 g, respectively), whereas the minimum seedling dry weight was observed from Earthen pot (0.012, 0.013 and 0.015 g, respectively).

For varieties, at 180, 210 and 240 DAS, the highest weight of 1000 seeds was found from BARI Gom 26 (43.12, 44.24 and 45.10 g, respectively) and the lowest weight was observed from BARI Gom 21 (41.79, 42.31 and 43.13 g, respectively). At 180, 210 and 240 DAS, the highest moisture was obtained from BARI Gom 25 (9.77%, 10.91% and 11.66%, respectively), again the lowest moisture was found from BARI Gom 26 (9.41%, 10.42% and 11.23%, respectively). At 180, 210 and 240 DAS, the highest electrical conductivity was recorded from BARI Gom 21 (28.28, 36.29 and 46.20 $\mu Scm^{-2}g^{-1}$, respectively), whereas the lowest electrical conductivity was found from BARI Gom 26 (24.70, 32.90 and 43.22 $\mu Scm^{-2}g^{-1}$, respectively). At 180, 210 and 240 DAS, the highest germination was recorded from BARI Gom 26 (93.71%, 92.29% and 89.37%, respectively) and the lowest germination was found from BARI Gom 25 (93.04%, 91.61% and 87.61%, respectively). At 180, 210 and 240 DAS, the highest days to germination was recorded from BARI Gom 25 (6.00, 5.62 and 5.28 days, respectively) , whereas the lowest days to germination was found from BARI Gom 26 (5.67, 5.35 and 5.06 days, respectively). At 180, 210 and 240 DAS, the maximum seedling shoot length was observed from BARI Gom 26 (2.46, 2.56 and 2.81 cm, respectively), whereas the minimum seedling shoot length was found from BARI Gom 25 (2.37, 2.45 and 2.70 cm, respectively). At 180, 210 and

240 DAS, the maximum seedling root length was recorded from BARI Gom 26 (2.22, 2.39 and 2.51 cm, respectively), while the minimum seedling root length was found from BARI Gom 25 (2.15, 2.32 and 2.43 cm, respectively). At 180, 210 and 240 DAS, the maximum seedling fresh weight was found from BARI Gom 26 (0.16, 0.17 and 0.17 g, respectively), whereas the minimum seedling fresh weight was observed from BARI Gom 25 (0.15, 0.16 and 0.17 g, respectively). At 180, 210 and 240 DAS, the maximum seedling dry weight was recorded from BARI Gom 26 (0.013, 0.014 and 0.015 g, respectively), whereas the minimum seedling dry weight was observed from BARI Gom 25 (0.012, 0.013 and 0.015 g, respectively).

Due to interaction effect of containers and varieties, at 180, 210 and 240 DAS, the highest weight of 1000 seeds was recorded from Earthen pot and BARI Gom 26 (45.43, 46.94 and 47.60 g, respectively) and the lowest weight was observed from Tin Container and (40.82, 41.56 and 42.35 g, respectively) BARI Gom 26. At 180, 210 and 240 DAS, the highest moisture was attained from Earthen pot and BARI Gom 26 (10.33%, 11.48% and 12.23%, respectively), whereas the lowest moisture was found from Tin container and BARI Gom 26 treatment combination (8.53%, 9.25% and 10.07%, respectively). At 180, 210 and 240 DAS, the highest electrical conductivity was observed from Earthen pot and BARI Gom 21 (28.90, 39.09 and 53.59 $\mu Scm^{-2}g^{-1}$, respectively) and the lowest electrical conductivity was found from Tin container and BARI Gom 26 treatment combination (23.84, 29.84 and 36.82 $\mu Scm^{-2}g^{-1}$, respectively). At 180, 210 and 240 DAS, the highest germination was observed from Tin container and BARI Gom 26 (97.79%, 96.37% and 94.93%, respectively) and the lowest germination was attained from Earthen pot and BARI Gom 26 treatment combination (89.74%, 88.04% and 84.23%, respectively). At 180, 210 and 240 DAS, the highest days to germination was observed from Earthen pot and BARI Gom 26 (6.20, 5.97 and 5.85 days, respectively) and the lowest days to germination was found from Tin container and BARI Gom26 treatment combination (5.18, 4.60 and 4.10 days, respectively) At 180, 210 and 240 DAS, the maximum seedling shoot length was obtained from

Tin container and BARI Gom 26 (2.68, 2.86 and 3.15 cm, respectively), again the minimum seedling shoot length was found from Earthen pot and BARI Gom 26 treatment combination (2.25, 2.28 ad 2.46 cm, respectively). At 180, 210 and 240 DAS, the maximum seedling root length was recorded from Tin container and BARI Gom 26(2.42, 2.57 and 2.77 cm, respectively) and the minimum seedling root length was obtained from Earthen pot and BARI Gom 26 treatment combination (2.05, 2.21 and 2.25 cm, respectively). At 180, 210 and 240 DAS, the maximum seedling fresh weight was recorded from Tin container and BARI Gom26 (0.18, 0.19 and 0.20 g, respectively) , while the minimum seedling fresh weight was observed from Earthen pot and BARI Gom 26 treatment combination(0.13, 0.14 and 0.14 g, respectively). At 180, 210 and 240 DAS, the maximum seedling dry weight was found from Tin container and BARI Gom 26 (0.014, 0.016 and 0.018 g, respectively), while the minimum seedling dry weight from Earthen pot and BARI Gom 26 treatment combination (0.010, 0.011 and 0.012 g, respectively).

Conclusion

Based on the above discussion it was found that Tin storage container was superior in relation to different seed quality parameters under the study. BARI Gom 26 was superior out of the varieties used in this experiment. Tin container and BARI Gom 26 combination seems to be promising for wheat seed storage.

Considering the above results of this experiment, further studies in the following areas may be suggested:

1. Other types of containers and preservation condition may be included in future study.
2. More experiments may be carried out with other varieties for specification variety wise storage containers.

REFERENCES

REFERENCES

Abdullah, M., Rehman, A., Ahmad N. and Rasul, I. (2007). Planting time effect on grain and quality characteristics of wheat. *Pakistan. J. Agri. Sci.* **44**: 200-202.

Abba, E.J. and Lovato, A. (1999). Effect of seed storage temperature and relative humidity on maize (*Zea mays* L.) seed viability and vigour. *Seed Sci. Technol.* **27**: 101-114.

Agha, S.K., Malik, Z.H., Hatam, M. and Jamro, G.H. (2004). Emergence of healthy seedlings of soyabean as influenced by seed storage containers. *Pakistan J. Biol. Sci.* **7**(1): 42-44.

Ali, M.K. (1963). Effect of storage containers on the moisture content, viability and other qualities of jute seed. *Pakistan J. Sci. Res.* **15**(3): 33-38.

Anonymous (1985). Effect of storage containers on the prevalence of fungi and seed viability of gram. M.Sc.Ag. Thesis, BAU. In Anon. (1996). Review of Literature on Seed Technology of Pulses. Seed Technology Section. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701.

Anonymous (2002a). International Seed Testing Association (ISTA). International rules for seed testing. *Seed Sci. Technol.*, **27** (suppl.): 27-32.

Anuja, G. and Aneja, K.R. (2004). Seed deterioration in soybean varieties during storage - physiological attributes. *Seed Res.* **32**: 26-32.

BARI. (1993). Annual Report (1991-92). Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. p. 19-33.

Bass, L.N. (1953). Relationships of temperature, time and moisture content to the viability of seeds of kentucky bluegrass. *Lowa Acad. Sci. Proc.* **60**: 86-88.

Bass, L.N. and Clark, C.F. (1975). Effects of storage conditions, packaging materials and moisfure content on longevity of crimson clover seeds. *Crop Sci.* **15**: 577-580.

Bewely, J.D. and M. Black. (1994). Seeds: Physiology of developments and germination. Second edn. Plenum press. New York.

Bhattacharyya, J.P., and Dutta, A.K. (1972). Storage of Jute seeds., Jute bulletin, 35, 129 -130.

Boland, D.J., Brooker, M.I.H. and Turnbull, J.W. (1990). Eucalyptus seed. CSIRO, Australia.

Bonner, F.T., Vozzo, J.A., Elam, W.W. and Land, S.B.Jr. (1994). Tree seed technology, training course. Instructors manual. Southern Forest Exp. Station, U.S. Dept. Agric. General Technical Report SO-106.

BRRI. (1985). Annual Report for 1983. Bangladesh Rice Research Institgte, Gazipur. p. 56.

Canode, C.L. (1972). Germination of grass seeds as influenced by storage conditions. *Crop Sci.* **12**: 79-80.

Charjan, S.K.U. and Tarar, J.L. (1992). Influence of storage container on germinability and mycoflora of sunflower seed (*Helianthus annuus* L.). *Seeds and Farms*. **18**(4-6): 3-5.

Chowdhury, M.A.H.; Hossain, S.M.A. and Talukder, N.M. (1990). Seed quality of lentil as affected by various storage techniques. *Progress. Agric.* **1**(1): 31-37.

Clement, D.J, Ahmad, A., Khan, T.A and Haque, M.M. (1984). On-Farm Wheat Seed Storage in Bangladesh. Results of twelve districts survey. Survey conducted by: Agriculture Sector Team.

Copeland, L.O. (1976). Principles of Seed Science and Technology. Burgess Publishing Company, Minniapolis, Minnesota, USA. P. 149-342.

Delouche, J.C, Matthes, R.K., Dougherty, G.M. and Boyd, A.H. (1973). Storage of seeds in tropical and subtropical regions. *Seed Sci. Technol.* **1**: 671-700.

Doran, J., Turnbull, J.W., Boland, D.J. and Gunn, B.V. (1983). Handbook on seeds of dry-zone acacias. A guide for collecting, extracting, cleaning, and storing the seed and for treatment to promote germination of dry-zone acacias. FAO, Rome.

Dornbos, D.L. (1994). Seed vigour. In: Seed Quality, Basic Mechanisms and Agril. Implication. (ed. A. S. Basra). pp. 45-80. Food Products press, New york.

Dornbos, D.L. (1995). Production environment and seed quality. In: Seed Quality. Basic mechanisms and Agril. Implication.(ed. A. S. Basra). p. 119-152. Food Products Press. New York.

Ellis, R.H. and Roberts, E.H. (1981). The quantification of aging and survival in orthodox seeds. *Seed Sci. Technol.* **9**: 373-409.

Ellis, R.H., Osei-Bonsu, K. and Roberts, E.H. (1982). The influence of genotype, temperature and moisture content on seed longevity in chick pea, cowpea and soybean. *Ann. Bot.* **50**: 69-82.

Ellis, R.H.; Hong, T.D. and Roberts, E.H. (1990). An intermediate category of seed storage behavior. *J. Expt. Bot.* **41**: 1167-1174.

Eswarappo, H., Ananthanarayana, R. and Krishnamurthy, K. C. (1991). Evaluation of different storage structures for paddy. *Current Res.* **20**: 8-9.

Fakir G.A., Hossain, I. and Ahmad, M.U. (2002). A report on quality of farmer's Boro and T.Aman rice seeds collected before sowing from Bogra, Rajshahi and Rangpur Districts of Bangladesh. Bangladesh Agricultural University (BAU), Mymensingh. 1-4 p.

Fakir, G.A., I. Hossain, M.U. Ahmad, M.K. Anam, M.N. Alam and M. Rahman. (2003). Effect of ash, chalk powder and neem leaf on quality of Boro rice seed stored in gunny bag, motka, plastic drum and tin. A report presented in the Review and Planning meeting of the Rice Seed Health Improvement Sub-project held at BRRI,Gazipur, Bangladesh during 21-22 April 2003. 37pp.

Garg, M.K. and Chandra, P. (2005). Effect of packaging material and storage place on storability of seeds- a simulation study. *Seed Res*. **33**: 57-60.

Gomez, K.A. and A.A. Gomez. (1984). Statistical procedure for Agricultural Research. Second edn. John Wiley and Sons. Inc. New York. p. 304-307.

Goodspeed, T.H. (1911). The temperature coefficient of the duration of life of barley grains. *Bot. Gazette*. **51**: 220-224.

GoP. (2008). Econ. Survey. Finance Div. Econ. Adviser's Wing, Govt. of Pakistan, Islamabad. 22p.

Gras, P.W. and Bason, M.L. (1990). Biochemical effects of storage atmosphere on grain and grains quality. Proceedings of the International Conference on Fumigation and Controlled Atmosphere Storage of Grains. Singapore. l4-I8 Feb. 1989. pp. 83-91.

Grove, J.F. (1917). Temperature and life duration of seeds. *Bot. Gazette*. **63**: 169-189.

Hampton, J.G. (2000). Producing quality seed: the problem of seed vigour. In: Current Research on Seeds in New Zealand, (ed. M. T. McManus, H. A. Outred and K. M. pollock). **12**: 53-62.

Hampton, J.G. and Coolbear, P. (1990). Potential versus actual seed performance-can vigour testing provide an answer? *Seed Sci. Technol.* **18**: 215-228.

Haque, M.Z. and Harron, M. (1983). Loss of different rice varieties as affected by storage environment. A research paper presented at BRRI seminar on 21.1.1983.

Harrington, J.F. (1963). Practical instructions and advice on seed storage. *Proc. Intl. Seed Test Assoc.* **28**: 989-994.

Harrington, J.F. (1972). Seed storage and longevity, Seed Biology, (ed.T.T.Kozlosky) pp, 145-245, New York.

Helmer, J.D. and Delouche, J.C. (1964). Rice seed storage in Costa Rica as influenced by seed moisture content and packaging container. Mississippi Agricultural Experiment Station, Seed Technology Laboratory, State College, Mississippi.

Helmer, J.D. and Delouche, J.C. (1964). Rice seed storage in Costa Rica as influenced by seed moisture content and packaging container. Mississippi Agricultural Experiment Station, Seed Technology Laboratory, State College, Mississippi.

Henderson, L.S. and C.M. Christensen. (1961). Post-harvest control of insect and fungi, Seeds. The yearbook of Agriculture. The United States Department of Agriculture, Washington D.C., USA. pp. 348-353.

Heydecker, W. (1972). The vigour of seeds - a review. Proc.Intl.*Seed Testing Assoc.* **34**: 201-208.

Hibbard, R.P. and Miller, E.V. (1928). Biochemical studies on seed viability. Measurements of conductance and reduction. *Plant Physiol.* **3**: 335-352.

Hosan, M.S. (2004). Effect of ash, chalk powder and neem leaves on quality of T-aman rice seed stored under different storage containers. M.S. Thesis, Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh. 94 p.

Hossain, M., Janaiah, A., Husain, M. and Nahar, F. (2002). Dialogue on Rice seed delivery system and seed policy. The role of seed delivery system in Bangladesh: Institutional and policy issues. Paper presented at the Policy Dialogue under the CPD-PETRRA-DOISys collaborative project held at CPD, Dhaka on January 8, 2002.

Hussain, M.M., Rahman, M.M., Howlader, M.M. and Khatun, M.R. (2013). Effect of farmers' storing process on seed quality, germination category and rate of germination index of rice (var. BR1). *Eco-friendly Agril. J.* **6**(2): 17-20.

Huda, M.N. (1992). Effects of quality of certified seed and farmer's seed on the productivity of rice and wheat.Ph. D. thesis, Deparlment of Agronomy, BAU, Mymensingh.

Hutchinson, J.B. (1944). The drying of wheat. III. The effect of temperature on germination capacity. *J. Soc. Chem. Industry London.* **63**: 104-107.

Iqbal M., Khan, M.A., Anwar, M.Z. (2002). Zero-tillage technology and farm profits: a case study of wheat growers in the rice zone of Punjab. *Pakistan Dev. Rev.* **41**: 665-682.

ISTA. (1987). ISTA handbook for cleaning of agricultural and horticultural seed on small scale machines. Part 1. International Seed Testing Association (ISTA), Bassersdorf, Switzerland.

ISTA. (1995). Handbook of Vigour Test Methods . 3rd Edition. (ed. J.G. Hampton and D.M. Tekrony. The International Seed Testing Association. Zurich, Switzerland. p. 67.

ISTA. (2006). International rules for seed testing. International Seed Testing Association (ISTA), Bassersdorf, Switzerland. p. 43.

Jolli, R.B. and Ekbote, S.D. (2005). Effect of seed treatment and packaging material on bruchid control and viability of moth bean seeds. *Karnataka J. Agril. Sci.* **18**: 174-176.

Justice, O.L. and Bass, L.N. (1978). Principles and practices of seed storage. *Agril. Tech.* **32**: 56-61.

Karim, M.A. and Amiruzzaman, M. (1991). Effect of some traditional and improved containers on insect damage and viability of maize seeds. *Bangladesh J. Zoology.* **19**(1): 69-76.

Khandakar, A.L. (1980). Factors determining seed quality. *Bangladesh J. Jute Fib. Res.* **5**: 95-102.

Khandaker, A.L. (1983). Physico-chemical examination of Jute seed (C. capsularis and c. oritorious) for quality. *Bangladesh J. Jute Fib. Res.* **7**: 1-4.

Khandaker, A.L. and Bradbeer, J.W. (1983). Jute Seed Technology. Bangladesh Agricultural Research Council, Dhaka. p. 21.

King, M.W. and Roberts, E.H. (1979). The storage of recalcitrant seeds - achievements and possible approaches. IBPGR Secretariat, Rome.

Krishnapillay, D.B. and Engelmann, F. (1996). Alternative methods for storage of recalcitrant and intermediate seeds: Slow growth and cryopreservation. In Intermediate/recalcitrant tropical forest tree seeds (Ouédraogo, A.S.; Poulsen, K. and Stubsgaard, F. eds.). Proceedings of a workshop on improved methods for handling and storage of intermediate/recalcitrant tropical forest tree seeds, 1995. pp. 34-39.

Krishnappan, N.; Narayanaswamy, S. and Sreerama, R. (1998). Effect of packaging material on seed quality of groundnut cultivars. *Current Res.* **27**(1-2):205-209.

Krishnasamy, V. and Seshu, D.V. (1990). Germination after accelerated ageing and associated characters in rice varieties. *Seed Sci. Technol.* **18**: 147-157.

Lewis, D.N., Marshail, A.H. and Hides, D.H. (1998). Influence of storage conditions on seed germination and vigour of temperate forage species. *Seed Sci. Technol.* **26**: 643-656.

McGill, C.R., McIntosh, J.C., Outred, H.A. and Fountain, D.W. (2002). Seed storage and seed storage reserves in Chatham Island forget-me-not (Myosotidium hortensia, Boraginaceae). *New Zealand J. Bot.* **40**: 337-346.

Miah, M.A.K. and Douglass, M.P. (1992). Storage structures for grains with special reference to Bangladesh. Agricultural mechanization in Asia. *Africa and Latin America*. **23**(3): 55-58.

Mian, I.H. and G.A. Fakir. (1989). Fungi, moisture content and germinability of rough rice grains during storage. *Seed Res.* **17**: 169-173.

Misra, J.K., Gergon, E.B. and Mew, T.W. (1995). Storage fungi and seed health of rice: a study in the Philippines. *Mycopathol.* **l3l**: 13-24.

Naeem Khalid; S.A. Anwar; M.I. Hoque; A. Riaz and M.S.A. Khan. (2001). Seed-borne fungi and bacteria of rice and their impact on seed germination. *Pakistan J. Phytopath.* **13**(1): 75-81.

Nakayama, N., Hashimoto, S., Shimada, S., Takahashi, M., Kim Yeong Hoo, Oya, Napier, I.A. and Robbins, A.M.J. (2004). Seed storage in the nursery. *Banko Janakari*. **1**: 13-20.

Omram, T.A., El-Lakani, M.H. and Shehata, M.S. (1989). Effect of storage on seed germination on grain quality characteristics of wheat. *Pakistan. J. Agric. Res.* **8**(1):17-23.

Padma, V. and Reddy, B.M. (2000). Evaluation of rice genotypes for dormancy duration and seed storability under natural and accelerated ageing. *Seed Res.* **28**: 158-165.

Padma, V. and Reddy, B.M. (2004). Storage of okra seed under ambient conditions. *Seed Res.* **32**: 39-41.

Patra, A.K., Tripathy, S.K. and Samui, R.C. (2000). Effect of drying and storage methods on seed viability of Groundnut. *Seed Res.* **28**: 32-35.

Patra, A.K., Tripathy, S.K., Samui, R.C. and Nanda, M.K. (1996). Effect of potassium nutrition and type of storage container on seed quality of stored groundnut pods. *Intl. Arachis Newsl.* **l6**: 56-58.

Powell, A.A. (1986). Cell membranes and seed leachate conductivity in relation to the quality of seed for sowing. *J. Seed Tech.* **10**(2): 81-100.

Powell, A.A. (1988). Seed vigour and field establishment. *Adv. Res. Tech. Seeds.* **11**: 29-80.

Purushattam, S.P., Patkar, K.L., Prakash, H.S. and Shetty, H.S. (1996). Storage fungi and their influence on rice seed quality. *Indian Phytopath.* **49**(2): 152-156.

Rahman, M. S', Hossain, I. and Mansur, M. A. (1985). Effect of storage condition on the quality of wheat seed. *Bangladesh J. Agril. Sci.* **12**: l29-134.

Rahman, M.M. (2002). Effect of storage containers under farmer's condition on seed microflora and quality of Boro rice seed. M.S. Thesis. Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh. p. 25-40.

Rathi,S. S., Shah, N. G., Zambre, S. S., Kalbande, V. H. and venkatesh, K. V. (2000). Respiration, sorption and germination of seeds stored in controlled atmosphere. *Seed Sci. Technol.* **28**: 341-348.

Ray, P. (1998). Effect of storage temperature, period and moisture content on seed health of rice. *Oryza*. **35**: 53-56.

Raza, S., Khalil, S., Naseem, K., Gilani, M.A., Amjad, M., Masud, T. and Naqvi, S.M.S. (2010). Effect of household storage receptacles on physico chemical characteristics of wheat. *Sarhad J. Agric.* **26**(2): 275-287.

Roberts E. H. (1972). Storage environments and the control of viability. In: Viability of Seeds (ed. Roberts, E. H.). Chapman and Hall Ltd. p. 448.

Roberts, E.H. (1973). Predicting the storage life of seeds. *Seed Sci. Technol.* **1**: 499-514.

Seeber, G. and Agpaoa, A. (1976). Forest tree seed - storage of seed. In Weidelt, H.J. (compl.). *Seed for sowing. J. Seed Technol.* **10**(2): 81-100.

Sharma, D.L., Antuono, M., Amjad, M., Shackley, B.J., Zaicou-Kunesch, C.M. and Anderson, W.K. (2006). Differences among wheat cultivars in their optimum sowing times in Western Australian environments. Proceedings of 13th Agronomy Conference 10-14 September 2006, Perth, Western Australia.

Sharma, S.N., Goyal, K.C., Gupta, I.J., Gupta, H.C., Kakralya, B.L., Sharma, S.K., Mehta, S.M. and Rathore, A.K.S. (1998). Packaging material and soybean seed quality during storage. *Seed Res.* **26**: 89-91.

Sivritepe, H.O. and Dourado, A.M. (1995). The effect of seed moisture content and storage conditions on seed germination, seedling growth and genetic stability in chinese leymus. *Seed Sci. Technol.* **33**: 431-440.

Vieira, R.D., Tekrony, D.M., Egli, D.B. and Rucker, M. (2001). Electrical conductivity of soybean seeds after storage in several environments. *Seed Sci. Technol.* **29**: 599-608.

Willan, R.L. (1985). A guide to forest seed handling. FAO Forestry Paper No. 20/2. FAO, Rome.

WRC (Wheat Research Center). (2009). Annual Report, 2008–09. Wheat Research Center, Nashipur, Dinajpur, Bangladesh, p. 181.

Zhang, W.D., Dong, G,J., Shu, E.Y., Li, H.J. and Liu, G.S. (2005). Effect of storage conditions on seed germination, seedling growth and genetic stability in Chinese leymus (Lel,tttus chinensis). *Seed Sci. Technol.* **33**: 431-440.

APPENDIX

APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from April to November, 2013

Month (2013)	*Air temperature (^{0}C)		*Relative humidity (%)	* Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
April	34.2	23.4	61	112	8.1
May	34.7	25.9	70	185	7.8
June	35.4	22.5	80	577	4.2
July	36.0	24.6	83	563	3.1
August	36.0	23.6	81	319	4.0
September	34.8	24.4	81	279	4.4
October	26.5	19.4	81	22	6.9
November	25.8	16.0	78	00	6.8

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix II. Analysis of variance of the data on weight of 1000 seeds and moisture percentage of wheat seed as influenced by storage container and variety

Source of variation	Degrees of freedom	Mean square					
		Weight of 1000 seeds (g) at			Moisture percentage (%) at		
		180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage container (A)	2	16.070**	19.824**	18.614**	5.059**	5.532**	5.750**
Wheat variety (B)	2	5.636**	12.517**	14.378**	0.436*	0.745**	0.591*
Interaction (A×B)	4	3.971*	5.974*	4.355*	0.226*	0.601**	0.505*
Error	27	1.356	1.778	1.706	0.110	0.151	0.145

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix III. Analysis of variance of the data on electrical conductivity of wheat seed as influenced by storage container and variety

Source of variation	Degrees of freedom	Mean square		
		Electrical conductivity (μScm^{-2}g^{-1})		
		180 DAS	210 DAS	240 DAS
Storage container (A)	2	8.239*	129.236**	635.935**
Wheat variety (B)	2	38.379**	34.41**	26.858**
Interaction (A×B)	4	4.710*	3.675**	9.863**
Error	27	2.032	1.891	3.603

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on germination percentage and days to germination of wheat seed as influenced by storage container and variety

Source of variation	Degrees of freedom	Mean square					
		Germination (%) at			Days to germination at		
		180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage container (A)	2	55.661**	67.975**	99.094**	1.347**	1.848**	3.172**
Wheat variety (B)	2	1.338	1.375	9.254	0.367*	0.220*	0.169*
Interaction (A×B)	4	10.692*	10.027*	20.271*	0.139*	0.293**	0.424**
Error	27	3.858	5.481	4.214	0.100	0.056	0.043

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on shoot and root length of wheat as influenced by storage container and variety

Source of variation	Degrees of freedom	Mean square					
		Shoot length (cm) at			Root length (cm) at		
		180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage container (A)	2	0.252**	0.388**	0.510**	0.202**	0.194**	0.392**
Wheat variety (B)	2	0.023**	0.036*	0.036*	0.016**	0.014**	0.021**
Interaction (A×B)	4	0.016**	0.038**	0.058**	0.011**	0.008**	0.022**
Error	27	0.004	0.008	0.011	0.002	0.002	0.003

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on seedling fresh and dry weight of wheat as influenced by storage container and variety

Source of variation	Degrees of freedom	Mean square					
		Seedling fresh weight (g) at			Seedling dry weight (g) at		
		180 DAS	210 DAS	240 DAS	180 DAS	210 DAS	240 DAS
Storage container (A)	2	0.017**	0.015**	0.020**	0.002**	0.003**	0.006**
Wheat variety (B)	2	0.001*	0.001*	0.001*	0.0001**	0.0001**	0.0001*
Interaction (A×B)	4	0.001**	0.001*	0.001**	0.0001**	0.0001*	0.0001**
Error	27	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability