Agronomy Journal of Nepal. ***6****(1):36-44*
ISSN: 2091-0649 (Print)
DOI: https://doi.org/10.3126/ajn.v6i1.47926

Effect of Storage Materials and Duration on Quality of Rice Seed

Mamata Bista[1], Prakash Ghimire[1*], Dipak Khanal[1], Narayan Khatri[2] and Sima Marasini[3]

[1]Institute of Agriculture and Animal Science, Paklihawa Campus, Rupandehi, Nepal
[2]National Wheat Research Program, Bhairahawa, Rupandehi, Nepal
[3]Agriculture and Forestry University, Rampur, Chitwan, Nepal
*Corresponding author's email: prakashkoid@gmail.com

Received: May 12, 2022
Revised: June 10, 2022
Published: July 8, 2022

- The authors declare that there is no conflict of interest.

ABSTRACT

Storage loss of rice seed in terms of quality parameters is higher in Nepal due to lack of information about the effect of storage materials. Laboratory experiment was conducted to evaluate the effect of storage materials and storage period on quality parameters of rice seed (*Oryza sativa* L. cv., Bahuguni dhan-1). Rice seed was stored in seven storage materials (metal bin, plastic bin, super grain bag, PICS bag, plastic bag with jute sack, jute sack and earthen pot) in Completely Randomized Design with three replications at the Seed Laboratory of National Wheat Research Program, Bhairahawa, Rupandehi, Nepal from March to July, 2021. Seed moisture content and germination percentage were recorded before storage and after one, three and five months of storage. The population of two insect pests rice weevil and maize weevil was recorded after five months of storage. The result revealed that all the seed quality parameters under study were significantly influenced by storage materials. PICS bag followed by super grain bag was found to be superior in terms of seed moisture content, germination percentage and seed health throughout the storage period. Seed in the indigenous storage materials (earthen pot and jute sack) lost their quality significantly throughout the storage period. Future research strategies should focus on seed quality study under several indigenous storage materials found in Rupandehi district of Nepal.

Keywords: Earthen pot, insect pest population, PICS bag, seed germination, seed moisture.

How to cite this article:
Bista M, P Ghimire, D Khanal, N Khatri and S Marasini. 2022. Effect of storage materials and duration on quality of rice seed. Agronomy Journal of Nepal. **6**(1):36-44. DOI: https://doi.org/10.3126/ajn.v6i1.47926

INTRODUCTION

Rice is the number one staple food crop in Nepal and contributes significantly to livelihood of majority of people and to the national economy. About 73% of rice is produced in the Terai plain, 24% in the hills, and 4% in the high hills (Tripathi et al 2019). Rice is critical to food and nutrition security (67% of total cereal consumption and 23% of protein intake), employment, and income for farmers in addition to its contribution to the economy; e.g. 20% to Agricultural Gross Domestic Product (AGDP) and 7% to GDP (MoAD 2020; CBS 2016). Time-series data show that rice production grew at the rate of 1.8% per annum from 1961-63 to 2010-12 which was below the population growth rate of 2.3% per annum (Tripathi et al 2019).

Seed is one of the essential inputs of agriculture determining crop productivity and quality seed may increase rice yield by 15-20% as well as improve grain quality and market acceptability (Fakir 2004). Crop productivity and the quality of production primarily depend upon the quality of seed. Maintenance of high seed germination and vigor from harvest until planting is of utmost used in a seed production program. Grain production of a country depends on good quality seeds. Quality seeds play a very important role for the production of healthy crop. Healthy seed plays an important role not only for successful cultivation but also for increasing yield of crop (Rajput et al 2005). A good quality seed may be seriously deteriorated if stored under sub-optimal conditions. To compensate, farmers use very high seed rate, which is 85-133% higher than the actual requirement (Hossain et al 2002). In tropical climates, high temperatures and humid conditions combine to cause rapid deterioration of seeds in open storage, resulting in lost value; poor stand establishment, lowered productivity and a disincentive to invest in improved seeds.

Studies report that in developing countries such as India, about 50-60% of the grains are stored in the traditional structures (eg Kanaja, Kothi, Sanduka, earthen pots, Gummi, Kacheri, etc) at the household and farm level for self-consumption and seed (Grover and Singh 2013). The indigenous storage structures are made of locally available materials (grass, wood, mud, rice hull, bamboo etc) without any scientific design, and cannot guarantee to protect crops against pests for a long time. It was found that the estimated losses in maize grains after storing them for 90 days were as high as 59.48% in the traditional storage structures (Costa 2014).

Farmers use several approaches to address storage losses, including traditional methods and synthetic pesticides (Sharma et al 2013). Traditional storage methods and their variants include botanicals (plant parts or extracts), indigenous practice (eg maize stored with sheath intact on *“Thangros”*, which are vertical or horizontal poles), and indigenous structures (e.g., bamboo granaries, bhakari, deri, etc) (Manandhar et al 2001; Subedi et al 2009). Challenges for traditional granaries include their inability to protect grain from insect and disease attacks during storage (Shivakoti et al 2001). Insecticides have been shown to be effective at mitigating insect-caused storage losses. When available, insecticides are used by farmers to prevent storage losses because they tend to be affordable (Obeng-Ofori et al 2015). However, misuse and overuse may have adverse human health consequences, even death (Sharma et al 2013) Incidences of pesticide poisoning have been reported in Nepal, particularly in Dhading district where 20 people were hospitalized and a family of six died after consuming food treated with pesticides (Rathore 2021). An experiment conducted in quality protein maize seed reported that PICS bag and super grain bag showed best germination in maize seed followed by metal bin, while perforated fertilizer bag and earthen pot showed poorer and poorest germination respectively (Bhandari et al 2018).

Storage loss in our country is relatively high due to improper storage structure, lack of knowledge about storage to the farmers and traders and improper management during the storage period. The net availability of rice is considerably less than its gross production due to all these factors. KC (1992) mentioned that grain storage losses in Nepal range from 15-30% annually. It is interesting that, out of the total post-harvest losses of around 14%, the average loss in storage alone is 4.5%. In fact, poor storage practices are one of the main causes of losses in the various stages of the post harvest system (Cleverly 1994). In general, the pre and post-harvest losses due to pests have been estimated to be 15-20% (Neupane 1995). 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). As storage is one of the most critical post-harvest operations, it deserves special attention to estimating the economic magnitude of negative impact of storage materials and methods.

MATERIALS AND METHODS

Experimental site

This experiment was carried out at the Seed laboratory of Agronomy unit, National Wheat Research Program (NWRP), Bhairahawa from March 2021 to July 2021.Geographically, the station is located at 27^0 32’ north latitude and 83^0 25’ east longitudes with an elevation of 104 meter above sea level. The research site is located at Terai physio-graphical region of Nepal.

Design of the experiment

The experiment was carried out in a completely randomized design (CRD) consisting of seven different types of storage materials as treatments (metal bin, plastic bin, super grain bag, PICS bag, plastic bag with jute sack, jute sack and earthen pot) with three replications.

Weather parameters at seed laboratory during experimental period

The meteorological data such as temperature and relative humidity during the entire experimental period (March to July 2021) was recorded at seed laboratory. The mean maximum and minimum temperatures were 33.9 °C in June and 21.3 °C in February. The relative humidity ranged from 39.7% in April to 82.4 % in July.

Storage materials

Metal bin

The metal bin is of the cylindrical shape of metal. The materials are light in relation to their strength and their homogeneous nature. Metal bin, after having been filled with rice seed, the top opening is kept closed by a lid. Its capacity ranges from 20-200 kg.

Plastic bin

Plastic bin is cylinder with a narrow opening at the top. It is usually placed inside the room. After having filled with rice seed, the top opening is air tight by a lid. Its capacity ranges from 20-40 kg.

Super grain bag

The super bag is currently designed to store up to around 50 kg of grain or seed. Super bags reduce the flow of both oxygen and water between the inside storage and the outside atmosphere. When properly sealed, the respiration of grain and insects inside the bag reduces oxygen levels from 21-5%. This reduction inside storage oxygen level reduces insects to less than 1 insect/kg of grain or seed without using insecticides, often within 10 days of sealing.

PICS bag

Purdue University and partner organizations have led efforts to commercialize the Purdue Improved Crop Storage (PICS) technology, focusing on low-resource farmers in different regions of the world. Since 2007, PICS bags have been commercialized in more than 34 countries in Africa, Asia, and more recently in Central America and the Caribbean. The PICS bag is a low-cost, simple, and effective technology for low-resource farmers to help them preserve their dry crops after harvest with minimal losses due to storage insects. PICS technology involves storing grain in triple layer plastic bags. Its capacity varies from 25 and 50 kg.

Jute sack

Jute sack is the most popular hydrocarbon-free and environment-friendly packaging solution for agricultural industries. They are made from jute fiber and are bio-degradable. Jute sack is also popularly known as gunny bag.

Plastic bag with jute sack

A plastic bag or polyethylene bag or pouch is a type of container made of thin, flexible, plastic film, non-woven fabric, or plastic textile. Several design options for plastic bags and features are available. In this practice, rice seed is kept in general marketable plastic bag and covered with a jute sack bag.

Earthen pot

Earthen pots of varying sizes and made of clay and burnt in kilns. It is made by potter and sold in the local markets and is used by the farmers for storing rice seed and grains. Its capacity varies from 10-100 kg.

Experimental procedure

The laboratory, storage materials and seed were cleaned before the setup of the experiment. Five kilograms of clean rice seed of Bahuguni Dhan-1 variety was stored in seven different storage materials for a period of five months. Before storage, laboratory tests were carried out for recording the initial seed quality parameters like moisture content and germination percentage. Seed moisture content (%) was determined directly with the grain moisture meter. The germination test was carried out by the rolling towel method. In this method, 400 rice seeds i.e. 100 seeds per replication were put on moistened germination paper and incubated at 28 °C for two weeks. Normal seedlings were counted from each replication and average germination percent was worked out by the following formulae (Krishnasamy and Seshu 1990).

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

Rice sample of 200 g was collected from the top, middle and bottom layer of each treatment by a sampler and kept in trays for the identification and counting of the pest population. The total number of insects was counted for each sample. Different prevailing insects were identified based on their respective identifying characteristics. The initial seed moisture content and germination percentage were 12.5% and 87% respectively.

Statistical Analysis

Collected data were analyzed by the analysis of variance (ANOVA) using Genstat software. Treatment means were compared by Least Significant Difference (LSD) at 5% level.

RESULTS AND DISCUSSION

Seed moisture content

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 (Kamruzzaman et al 2015). The initial seed moisture content was 12.5%. Significant ($p \leq 0.01$) variation was found on moisture percentage of rice seeds recorded from different storage materials at different storage period (Table 1). Results of the present study revealed that moisture content of rice seed was found decreased with the increase of storage time in all the storage materials and throughout the storage duration (Table 1). The increase in moisture content of rice seed after five month of storage was ranked as: earthen pot>jute sack>plastic bag with jute sack>plastic bin>metal bin>super grain bag>PICS bag. Improved seed storage materials viz., PICS bag, super grain bag, metal bin, and plastic bins recorded lower mean moisture content throughout the storage period compare to traditional storage materials (jute sack and earthen pot). The seeds of earthen pots and jute sacks came to the contact with air and their moisture contents were increased more than the other storage materials (Khatri et al 2019). As PICS bag and super grain bag were more air tight; and metal bin and plastic bins were more or less air tight, the seeds of these storage materials could not come to the contact with the ambient room air resulting lower change in their moisture contents. Irrespective of storage materials, moisture content of seeds increased gradually with increase of storage time. Similar results were also reported by found by Miah et al (1992); Uddin (2005) and Quais et al (2013).

Table 1. Effect of storage materials and duration on seed moisture content of rice

	Seed moisture content (%)		
Treatments	**After 1 month**	**After 3 month**	**After 5 month**
Metal bin	13.3^{b}	13.6^{b}	14.2^{b}
Plastic bin	13.4^{b}	13.7^{b}	14.3^{b}
Super grain bag	12.8^{bc}	13.4^{bc}	13.9^{bc}
PICs Bag	12.6^{c}	13.2^{c}	13.7^{c}
Plastic bag with jute sack	15.1^{a}	15.6^{a}	16.2^{a}
Jute sack	15.1^{a}	16.2^{a}	16.7^{a}
Earthen pot	15.4^{a}	16.6^{a}	17.2^{a}
F test	**	**	**
LSD (<0.05)	0.6	0.4	0.5
CV (%)	2.6	1.4	1.8
Grand Mean	**14.0**	**14.6**	**15.2**

*Means followed by the common letter (s) within a column are non-significantly different based on DMRT.

Seed germination percentage

Germination is the most important function of a seed as an indicator of its viability and worth as a seed (Akter et al 2014). The germination capacity of rice was recorded at 87% before storage. Results of the present study revealed that the germination percentage of rice seed was found to decrease with the increase of storage time in all the storage materials and throughout the storage duration (Table 2). The decrease in germination percentage of storage materials after five months of storage was ranked as earthen pot>jute sack>plastic bag with jute sack>plastic bin>metal bin>super grain bag>PICS bag. A similar decrease in germination percentage with the progress of the storage period was reported in wheat grains by Chattha et al (2012). The equation of linear regression analysis (Figure 1) (y=-2.675x + 119.8) reveals that 81.6% variation in seed germination was attributed to seed moisture content. Due to the high moisture contents of seeds of earthen pots and jute sacks, the germination percentage decreased rapidly as compared to other storage materials. The increase in value of the moisture content increased the breakdown of carbohydrates, lipids and proteins, because of accelerated metabolism, and finally decreased the wheat quality (Ruska and Timar 2010). Microbial activities also grow with increasing the values of moisture content and increase the losses of quality (Ruska and Timar 2010). These results were consistent with the findings of Akter et al (2015). Seeds stored in PICS bag and super grain bag retained the highest seed germination for a longer time (Khatri et al 2019) than other tested seed storage materials.

Table 2. Effect of different storage materials on seed germination of rice

Treatments	**Seed germination (%)**		
	After 1 month	**After 3 months**	**After 5 months**
Metal bin	83.9[ab]	81.4[c]	80.7[c]
Plastic bin	84.6[ab]	82.3[bc]	81.0[bc]
Super grain bag	86.3[ab]	83.8[ab]	83.0[ab]
PICs Bag	86.9[a]	84.8[a]	84.0[a]
Plastic bag with jute sack	82.9[c]	80.5[c]	79.3[c]
Jute sack	77.3[d]	75.0[e]	73.7[d]
Earthen pot	75.7[d]	73.1[d]	73.3[d]
F test	**	**	**
LSD (<0.05)	3.2	1.8	2.02
CV (%)	2.2	1.3	1.5
Grand Mean	**82.6**	**80.13**	**78.29**

*Means followed by the common letter (s) within a column are non-significantly different based on DMRT.

Insect-pest population

The results of the present study indicate that rice was attacked by two major insect pests (rice weevil and maize weevil) during the period from March to July 2021. The population of rice weevil was significantly different among the storage materials ($p \leq 0.05$), while the population of maize weevil was statistically at par after five months of storage. Considering all the storage materials, the trend in the protection of rice grain from rice weevil showed the following order: PICS bag= super grain bag > metal bin > plastic bag > plastic bag with jute sack > earthen pot > jute sack and from maize weevil as: PICS bag > super grain bag > metal bin = plastic bag > plastic bag with jute sack > earthen pot > jute sack. The highest number of insect pests in jute bags indicated its lower efficacy for protecting the grain against insect infestation. Baloch et al (1994) observed similar results and concluded that jute bags increased the risk of insect infestation. Similarly, a high level of infestation in gunny bags was also observed by Singh (2001) in stored wheat. The equation of linear regression analysis (Figure 2) (y= 14.27x - 186.1) reveals that 54.5% variation in insect pest population was attributed by to seed moisture content. Prakash (1983) also reported that high moisture content facilitated insect infestation in storage.

Table 3. Effect of different storage materials on insect pest population

Treatment	Storage insect pest population after five month of storage	
	Rice weevil	**Maize weevil**
Metal bin	15[c]	4
Plastic bin	19[bc]	4
Super grain bag	6[c]	2
PICs Bag	5[c]	2
Plastic bag with jute sack	30[abc]	5
Jute sack	51[a]	12
Earthen pot	48[ab]	8
F test	*	ns
LSD (<0.05)	28.8	
CV (%)	66.1	85.8
Grand Mean	25	5

*Means followed by the common letter (s) within a column are non-significantly different based on DMRT.

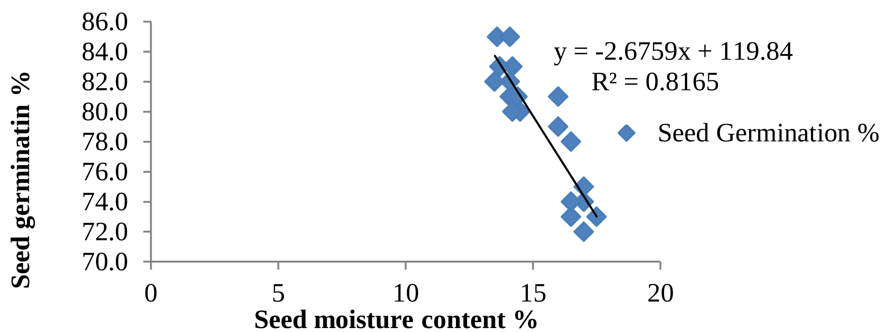

Figure 1. Relationship between seed moisture content (%) and seed germination (%) after five months of storage

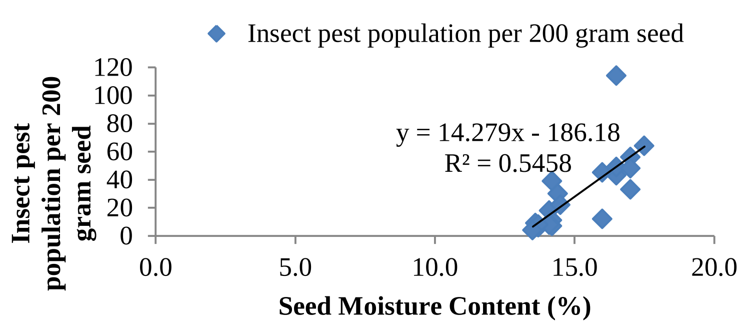

Figure 2. Relationship between seed moisture content (%) and insect pest population after five months of storage

CONCLUSIONS

The study concluded that PICS bag followed by super grain bag was found to be superior than other tested seed storage materials (metal bin, plastic bin, jute sack, plastic bag with jute sack and earthen pot) in relation to different seed quality parameters (seed moisture content, germination percentage and insect pest infestation). Seed in the indigenous storage materials (earthen pot and jute sack) lost their quality significantly throughout the storage period. Future research strategies should focus on seed quality study under several indigenous storage materials found in Rupandehi district of Nepal.

ACKNOWLEDGEMENTS

The authors like to acknowledge National Wheat Research Program for providing the laboratory facilities for conducting the trial.

AUTHORS' CONTRIBUTION

M. Bista formulated the project, carried out the experiment, prepared ANOVA and the manuscript. D. Khanal and P Ghimire supervised the experiment. N. Khatri analyzed the data and S. Marasini contributed to refine the manuscript.

CONFLICTS OF INTEREST

The authors have no any conflict of interest to disclose.

REFERENCES

Akter MA and I Hossain. 2015. Quality of some hybrid seeds of rice and control of seed-borne fungi in Bangladesh. J. Bangladesh Agric. Univ. **13**(2):161-168.

Akter N, MM Haque, MR Islam and KM Alam. 2014. Seed quality of stored soybean (Glycine max L.) as influenced by storage containers and storage periods. The Agriculturists. **12**(1):85-95.

Baloch UK, M Irshad and M Ahmed. 1994. Loss assessment and loss prevention in wheat storage-technology development and transfer in Pakistan. Stored Product Protection.

Bhandari G, TB Ghimire, S Kaduwal, J Shrestha and R Acharya. 2018. Effects of storage structures and moisture contents on seed quality attributes of quality protein maize. Journal of Maize Research and Development. **3**(1):77–85.

Calverley DJB. (1994). Programme for the prevention of food losses: A study of eleven projects in Asia concerned with rice. Final report, FAO.

CBS. 2016. National Economic Census 2018: A New Initiative in the National Statistical System of Nepal. Central Bureau of Statistics, National Planning Commission, Kathmandu.

Chattha SH, LA Jamali, KA Ibupoto and HR Mangio. 2012. Effect of different packing materials and storage conditions on the viability of wheat seed (TD-1 variety). Science Technology and Development.

Costa SJ. 2014. Reducing Food Losses in Sub-Saharan Africa. An 'Action Research'Evaluation Trial from Uganda and Burkina Faso.

Fakir GA. 2004. A monograph on seed health and quality of farmer-saved rice seed in Bangladesh. Rice seed health improvement subproject, PETRRA, IRRI, Banani, Dhaka.

GOP. 2008. Population, Labour Force and Employment, Economic Survey of Pakistan, Finance Div. Econ. Adviser's Wing, Government of Pakistan.

Grover DK and JM Singh. 2013. Post-harvest Losses in Wheat Crop in Punjab: Past and Present. Agric. Econ. Res. Rev. **26**(2):293-297.

Hossain M, A Janaiah, AMM Husain and F Naher. 2002. Rice seed delivery system and seed policy. CPD-IRRI, Dhaka, Bangladesh.

Kamruzzaman M, S Khatun, A Rakib, MI Hoque and MH Rani. 2015. Temporal variation in seed quality of Indian spinach preserved in different containers. Int. J. Agril. Res. Innov. Tech. **5**(2): 51-57.

KC G. 1992. On farm level pre-harvest and post-harvest food loss preventive system in Nepal. In Proceeding of National Seminar on Issues and Constraints Related to Post Harvest Food Loss Management.

Khatri N, D Pokhrel, BP Pandey, KR Pant and M Bista. 2019. Effect of different storage materials on the seed temperature, seed moisture content and germination of wheat under farmer's field condition of Kailali district, Nepal. Sci. Technol. **11**:352-355.

Krishnasamy V and DV Seshu. 1990. Germination after accelerated ageing and associated characters in rice varieties. Seed Sci. Technol. **18**(1):147-156.

Manandhar, DN and BP Mainali. 2001. Review of research on post-harvest insect control in Nepal. Developing and disseminating technology to reduce post-harvest losses in maize. Developing and disseminating technology to reduce post-harvest losses in maize.

Miah MAK, A Ahmed, MA Baqui and MHS Rahman. 1992. Storage of paddy in rural Bangladesh. Bangladesh Rice J. **3**:113-118.

MoAD. 2020. Agribusiness Promotion and Statistics Division, Kathmandu, Nepal.

Neupane FP. 1995. Review of agricultural entomology country profile-Agricultural Entomology in Nepal. CAB. International, UK.

Obeng-Ofori D, C Adarkwa and C Ulrichs. 2015. Chemical, physical and organic hermetic storage technology for stored-product protection in African countries. Proceedings of the IOBC-WPRS Bulletin, Working Group "Integrated Protection of Stored Products.

Prakash A.1983. Factors affecting losses due to insects and their management in rice storage ecosystem. Insect ecology and resource management.

Quais MK, S Jahan, MM Haque and MR Khan. 2013. Variation in seed quality of radish preserved in different storage containers. Bangladesh j. agric. res. **38**(3):545-552.

Rajput MA, MA Pathan, AM Lodhi, GS Shah and KA Khanzada. 2005. Studies on seed-borne fungi of wheat in Sindh Province and their effect on seed germination. Pak. J. Bot. **37**(1):181-185.

Rathore HS. 2021. Pesticide-Laced Flour Kills Six. Available online: https://kathmandupost.com/miscellaneous/2015/03/10/ pesticide laced flour kills six (accessed on 25 January 2021).

Ruska L and A Timar. 2010. Storage of wheat at high moisture. Acta Agraria Debreceniensis. **1:** 111-114.

Sharma DR, RB Thapa, HK Manandhar, SM Shrestha and SB Pradhan. 2012. Use of pesticides in Nepal and impacts on human health and environment. Journal of Agriculture and environment. **13**:6774.

Shivakoti GP and DN Manandhar. 2001. An overview of post-harvest losses in maize in Nepal. Developing and disseminating technology to reduce post-harvest losses in maize.

Subedi S, Y GC, RB Thapa and JP Rijal. 2009. Rice weevil (*Sitophilus oryzae* L.) host preference of selected stored grains in Chitwan Nepal. J. Inst. Agric. Anim. Sci. **30**:151-158.

Tripathi BP, HN Bhandari and JK Ladha. 2019. Rice strategy for Nepal. Acta Scientific Agriculture. **3**(2):171-180.

Uddin MJ. 2005. Effect of storage environment on seed longevity. Hand note, Certificate course of seed technology, Sher-e-Bangla Agril. Uni., Dhaka, Bangladesh.