EFFECT OF PRE-STORAGE SEED TREATMENT ON STORABILITY OF TRANSPLANTED AMAN RICE SEED

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF PRE-STORAGE SEED TREATMENT ON STORABILITY OF TRANSPLANTED AMAN RICE SEED"** submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by MD. MARUF RAIHAN, Registration No. 19-10192 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 been duly acknowledged.

(Prof. Dr. Md. Shahidul Islam)
Supervisor

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Dhaka, Bangladesh

Dedicated to

My

Beloved Parents

ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV %	=	Percentage Coefficient of Variation
DAS	=	Days After Storage
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Mililitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celcius
%	=	Percentage
mg	=	Miligram
L	=	Litre
µg	=	Microgram
WHO	=	World Health Organization

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The Author

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EFFECT OF PRE-STORAGE SEED TREATMENT ON STORABILITY OF TRANSPLANTED AMAN RICE SEED

ABSTRACT

The experiment was conducted at the Central Laboratory of Sher-e-Bangla Agricultural University, Dhaka to find out the effect of pre-storage seed treatment on storability of transplanted aman rice seed during the period from January to October, 2020. Two T. aman rice varieties *viz*. BRRI dhan87 (V_1) and BR11 (V_2) and five seed treatments *viz*. control treatment; no seed treatment (T_0), ascorbic acid @ 0.5 g/kg seeds (T_1), aspirin @ 0.1 g/kg seeds (T_2), bleaching powder @ 2 g/kg seeds (T_3) and red chili powder @ 2 g/kg seeds (T_4) were used in this experiment. The experiment was carried out following Randomized Complete Block design with four replications. Data were collected after treatment and at storage (initial, 236 days after storage and 271 days after storage) on germination percentage, germination speed index, seedling vigour index, germination rate, mean daily germination, mean germination time, peak value, germination value, shoot length, root length, total length, moisture content percentage and viability percentage. The result revealed that BRRI dhan87 (V_1) finally (at 271 days after storage) showed the highest germination percentage (81.20%), germination speed index (8.26), seedling vigour index (17.95), germination rate (10.74), mean daily germination (5.35), mean germination time (27.31), peak value (16.93), germination value (93.94), shoot length (13.59 cm) and viability percentage (84.15%) compared to the variety BR11 (V_2). The maximum storage duration (at 271 days after storage), seeds treated with Bleaching powder @ 2 g/kg seeds (T_3) performed better in maintaining significantly higher germination (71.75%), germination speed index (7.66), peak value (15.60), germination value (83.60) and viability percentage (76.00%) followed by aspirin @ 0.1 g/kg seeds (T_2). These treatments also showed better performance at 236 days after storage whereas control treatment T_0 showed least performance. At 271 days after storage, interaction effect of BRRI dhan87 and bleaching powder @ 2 g/kg seeds (V_1T_3) gave the highest germination percentage (86.50%), germination speed index (8.85), mean germination time (29.89), peak value (18.45), germination value (115.85) and viability percentage (89.00%). V_1T_3 also gave better performance at 236 days after storage compared to other treatment combinations whereas V_2T_0 showed lower performance on recorded storage parameters. It is concluded that seeds of BRRI dhan87 treated with bleaching powder @ 2 g/kg seeds (T_3) at storage and the interaction of V_1T_3 followed by BRRI dhan87 × seed treated with aspirin @ 0.1 g/kg seeds (V_1T_2) performed better in maintaining the T. aman rice seed quality during storage for 9 months at room temperature.

CHAPTER I

INTRODUCTION

Bangladesh is an excellent habitat for rice (*Oryza sativa L.*) a semi–aquatic annual grass plant belongs to Poaceae family. It contains 22 species, of which 20 are wild species and two, *Oryza sativa* and *Oryza glaberrima*, are cultivated. *Oryza sativa* is the most widely grown of the two cultivated species (Vaughan *et al.,* 2003). Rice is the staple food for half of the world population and the second most important crop in the world after wheat, with more than 98% currently grown in Asia (USDA, 2012). Agriculture in Bangladesh is characterized by intensive crop production mainly rice. Rice plays absolutely dominant role in Bangladesh agriculture as it covers 68.35% of the total cropped area. Among the rice groups grown in the country transplanted Aman rice is the most important. Rice is an important contributor to the food security of Bangladesh. It is estimated that 840 million people in the world currently suffer from hunger and more than 50 percent live in areas where rice is vital for food, income and employment (Nguyen and Ferrero, 2006). It is also the most important food crop and a major food grain for more than one third of the world population and 50% of the global population (Zhao *et al.*, 2011).

The importance of seed storage has been recognized since human began to domesticate plants. The duration of successful storage depends upon both the objectives and the species concerned. Since biginning of agriculture, the farmers have had to maintain viable seeds from one growing season to the next (i.e. short term seed storage, generally 3 to 9 months). Influences of provenance on potential longevity result from the cumulative effect of environment during seed formation, maturation, harvesting, drying and the pre-storage environment, and the time of seed harvest, duration of drying and the subsequent period before seed is placed in store. Seeds are stored for a considerable period of time in order to catch the next growing season. Storage of rice seeds need to have a good storage quality to ensure that it maintains conditions until it is used for sowing. Seeds must be properly stored in order to maintain an acceptable level of germination and vigor until the time of planting. Low seed moisture content is a pre-requisite for long-term storage, and is the most important factor affecting longevity. During storage, quality can remain at the initial level or it may decline to a degree that will cause seed to be unacceptable for planting (Pratt *et al.,* 2009). Seed deterioration occurs during storage, leading to reduction of vigor, germination percent, and decreasing seedling growth rate. Temperature and moisture content are the important factors, which influence the viability of seeds during storage (Nematadly *et al*., 2011). In most cases farmer's stored seeds are badly infested with stored grain pests and moulds with very poor germination (Miah *et al*., 2000). Poorly stored seeds will result in poor seed quality leading to poor stand establishment, low seedling vigour and low grain yield (*Bam et al.,* 2007). Seeds lose viability and vigor during processing and storage mainly because of high seed moisture content (McCormack, 2004). High moisture content will encourage the growth of pathogens and deterioration in short time leading to low vigour of seeds consequently affecting the quality of rice seed. Rice seed should be well dried as rice seed contains a lot of moisture, there is active respiration causing a deterioration of the rice seed. Seed deterioration starts immediately after harvest and therefore, post-harvest handling of rice seed plays a key role in the maintenance of seed quality (Vange *et al*., 2016). Moisture enhances harmful insects and micro-organisms activities, causing rice seeds to deteriorate.

Seed germination is one of the most important phases in the life cycle of plant, which is highly responsive to its existing environment. Seed germination is observed to be affected by many factors such as substrate type used, and environmental factors like oxygen, temperature and light. Germination of the rice seed is initiated when the temperature is adequate (10°C-40°C) and moisture is present and any existing seed dormancy removed. The germination rate of rice is lowered due to toxins that are produced by the growth of mould. Therefore, it is important to reduce moisture in rice seeds to prevent deterioration (Wimberly, 1983). If seeds may not be dried to the appropriate moisture content on the field before storage leading to rapid seed deterioration in storage (Bam *et al*., 2007). It is important to preserve the genetic integrity of seeds during storage to retain high seed quality (Pradhan and Badola, 2012). The optimum moisture content for storing rice seed is between 12-14% (Whitehouse *et al*., 2015). However, reduction in storage temperature and seed moisture content has been shown to increase seed storage time (Mbofung *et al*., 2013). Loss of germination, reduction in vigour, and accumulation of pests, disease and volatile toxin compounds may occur due to poor storage conditions (Vange *et al*., 2016).

During the last few decades, various synthetic pesticides have been applied to protect stored grains and other agricultural products from insect infestation, but their massive use has imposed so many detrimental effects on the environment and cause intoxication of non-targeting organisms. However, these chemicals are declared ecologically unsafe because of their persistance for longer period in the environment and enter into the food chain. It has been reported that certain insect pests have acquired resistance against most of the insecticides. To overcome the bad effects of synthetic pesticides, the best alternative is to going back for adopting indigenous traditional knowledge for protecting the food grains and seeds from insect pest attack. Hence, the indigenous traditional knowledge should be documented at each and every instance, which can be used by the present and next generation. However, these factors can be controlled to reduce their effects on the rate of the seed deterioration in storage by treating seeds with different chemicals, pharmaceuticals and crude plant products. Organic acids like ascorbic acid, salicylic acid are known for years for their antibacterial and antifungal properties which have been widely used food stuff industry and agriculture (De Muynck *et al*., 2004). Salicylic acid was the best priming agent to increase germination and subsequent seedling growth of rice. It also induces protective mechanism enhancing resistance to biotic and abiotic stresses (Zahra *et al*., 2010) through regulation of antioxidant enzymes with the greatest role in stress condition in comparison to other hormones (Khan *et al*., 2003). Among several methods for maintenance and enhance quality of seeds, seed invigoration is promising one. Various dry powder exposures have been reported to check seed quality deterioration in various crop seeds (Bhattacharya *et al*., 2015). Works by various researchers around the world have already proved the positive influence of seed invigoration with various materials like chemicals, crude plant product, pharmaceutical product etc. on seed and seedling quality parameters of various crops (Basra *et al*., 2003). Another important factor responsible for seed quality is storage duration.

Keeping all these facts in mind, the present experiment was planned to observe seed and seedling quality parameters of rice at various storage period under seed invigoration. Therefore, the present investigations were made to explore the probable dry-dressing compounds that are affordable to the local farmers which could slow down the loss of vigor and viability of seeds under airtight storage conditions with the following objectives:

1. To find out the varietal variations on storage quality of rice seeds
2. To explore the effect of seed treatments before storage on seed quality during storage.
3. To investigate the combined effect of variety and pretreatments of seeds on quality of rice seeds during storage

CHAPTER II

REVIEW OF LITERATURE

Quality seed, being the basic input in agriculture, plays an important role in realizing optimum yield and productivity of any crop. Seed with high quality and vigour will not only help in achieving optimum plant population in the field but also result in vigorous seedling, which can overcome the initial abiotic and biotic stresses to significant extent. Deterioration of seed during storage is inevitable and leads to different changes at various levels *viz*., impairment or shift in metabolic activity, compositional changes, decline or change in enzyme activities, phenotypic, cytological changes apart from quantitative losses. Rice (*Oryza sativa L.*) is an important cereal crop. Everyone agrees that the real value of a seed is the genetic material that it hides inside. But there is a reason these days to look at what is on the outside of a seed as well. Seed deterioration is an irreversible, inexorable and inevitable process. But the rate of seed deterioration could be slowed down either by storing the seeds under controlled conditions or by imposing seed treatment with seed treatment chemicals (Duan and Burris, 1997). Proper attention should be given on the storage duration as well as on storage conditions of rice seeds with proper techniques of storage which are usually stored for certain period. Experimental evidences on these aspects are so rare both here and abroad. However, the available literature related to the pre-storage treatments and storage durations of rice seeds have been presented below.

2.1 Effect of seed treatment on seed quality during storage

Seed treatment before storage can be done with fungicides, microbial treatments and insecticides. It is one of the most economical approaches for improving seed performance. As the controlled conditions involve huge cost, seed treatment remains the best alternative approach to maintain the seed quality. Recently, various quality enhancement treatments are given to seed before storage and sowing. Among these, seed treatment is one of the techniques wherein external materials, *viz*., polymers, fungicides and insecticide are applied directly on the seed to enhance the quality and production potential of seed without significantly increasing the size or weight of the seed and obscuring the seed shape (Kumar, 2007). The application of different treatments to seed serves as an extra exterior shell in order to give the desired seed characteristics *viz*., quick or delayed water uptake and enhanced germination that would be beneficial for better emergence and establishment in the given condition (Taylor *et al*., 1988). Seed treatments with different chemicals or botanicals provide protection from the stress imposed by accelerated ageing, which include fungal invasion. It improves plant stand and emergence of seeds, and this technique is recommended for high value agricultural crops (Sherin *et al.,* 2005).

Padhi *et al*. (2017) studied the effect of seed treating materials on storability of paddy seeds on seed quality and observed that seeds treated with polymer @ 4ml + vitavax 200 2g/kg of seed recorded significant superiority over untreated control for all seed quality parameters *viz*., germination percentage (first and final count), speed of germination, root length (cm), shoot length (cm), root dry weight (g), shoot dry weight (g), vigour index - I and vigour index - II after 7 months of storage of seeds.

Patel *et al*. (2017) recorded that soybean seeds treated with Mancozeb @ 2g/kg of seeds resulted in significantly higher germination as compared to control during 2 years storage period.

Sharma and Dhiman (2017) studied the effect of seed treatment with synthetic polymer and additives on paddy seed quality parameters viz., germination percentage (first and final count), seedling length (cm), seedling dry weight (g), seedling vigour index - I, seedling vigour index - II and observed that Polymer @ 3 ml/kg + vitavax 200 @ 2 g/kg of seed recorded significantly higher germination percentage (first and final count), seedling length (cm), seedling dry weight (g), seedling vigour index - I, seedling vigour index - II, followed by polymer + vitavax @ 2 g/kg of seed over untreated control after 12 months of storage of seeds.

Sharma *et al*. (2017) studied the effect of seed treatments on seed quality in HQPM 1 hybrid maize during storage and observed that seeds treated with polymer @ 3 ml/kg + vitavax 200 @ 2 g/kg of seed recorded significant superiority over untreated control for all seed quality parameters viz., germination (%) - first count (%), final count (%), seedling length (cm), seedling dry weight (g), seedling vigour index - I, seedling vigour index - II after 12 months of storage of seeds.

Goswami *et al*. (2017) conducted an experiment on the effect of seed treatment materials (polykote, flowable thiram and vitavax) and storage containers (cloth bags and polythene bags) on root length (cm), shoot length (cm), seedling fresh weight (g) and seedling dry weight (g). They observed significantly higher seedling root length, shoot length, seedling fresh weight and seedling dry weight by polymer + vitavax 200 @ 2g/kg seed treatment followed by flowable thiram @ 2.4 ml/kg in comparison to untreated control.

Manoharapaladagu *et al*. (2017) studied the effect of seed treatments on chilli during storage and observed that seeds treated with polymer @ 7 ml/kg + thiram @ 2 g/kg of seed recorded significant superiority over untreated control for all seed quality parameters viz., germination (%) first count (%), final count (%), seedling length (cm), seedling dry weight (g), seedling vigour index - I, seedling vigour index - II after 6 months of storage of seeds.

Thakur and Dhiman (2016) conducted an experiment on the effect of seed treatment with synthetic polymer and additives on soybean seed quality parameters viz., germination percentage (first and final count), seedling length (cm), seedling dry weight (g), seedling vigour index - I, seedling vigour index - II and observed that polymer + Flowable Thiram @ 2.4 ml/kg of seed recorded significantly higher germination percentage (first and final count), seedling length (cm), seedling dry weight (g), seedling vigour index - I, seedling vigour index - II, followed by polymer + Vitavax @ 2 g/kg of seed over untreated control after 12 months of storage of seeds.

Veraja and Rai (2015) conducted an experiment on the effect of polymer coating, chemicals and biocontrol agent on storability of black gram (*Vigna mungo* L.). Seeds after treating with six treatments viz., [T_1: Polymer coat, T_2: Polymer + Thiram, T_3: Polymer + Imidacloprid, T_4: Polymer + Thiram + Imidacloprid, T_5: Polymer + Thiram + Imidacloprid + *Trichoderma viride* and T_6: Control] were packed in cloth bag (C_1) and polythene bag of 700 gauge thickness (C_2), and stored at ambient conditions. The recorded results showed that germination percentage, root length, shoot length, seedling length, seedling dry weight, seedling vigour indices and protein content were high in T_5C_2 as compared to all other treatments, while total fungal colonies and moisture content were less in T_5C_2.

Rathinavel (2015) studied the storability of cotton (*Gossypium hirsutum* L.) seeds through polymer treatment under ambient storage condition and revealed that seeds coated with polymer @ 3 ml/kg + Thiram @ 2.5 g/kg + Super red @ 5 ml/kg + Cruiser @ 5 g/kg of seeds was found superior in preserving seed quality parameters viz., germination (%), seedling vigour, field emergence and lesser seed infection over untreated seeds, when stored at ambient conditions for 26 months after packing in polythene bag (700 gauge).

Manikandan and Srimathi (2015) conducted an experiment on the effect of seed treatments and containers on storability of grain amaranthus (*Amaranthus hypochondriacus* L.) cv. Suvarna and revealed that seeds treated with Carbendazim and Imidacloprid @ 2 g/kg of seed and 0.1 g/kg of seed, respectively, maintained maximum germination of 97 percent after six months of seed storage in poly-laminated aluminum foil pouch.

Desai *et al*. (2015) studied the effect of seed treatment on storability of soybean (*Glycine max* L. Merill) and revealed that the seed treated with polymer and

Vitavax maintained storability above minimum seed certification standards (MSCS) for 270 days and also exhibited higher vigour index, lower electrical conductivity and less seed mycoflora.

Ananthi *et al*. (2015) studied the effect of seed treatment on seed and seedling quality characters in red gram and reported that seed hardening with 100 ppm $ZnSo_4$ and treatment with polymer @ 3 ml/kg of seed, Bavistin @ 2 g/kg of seed and Imidacloprid @ 1 ml/kg of seed along with *Pseudomonas fluorescencs* @ 10 g/kg of seed and *Rhizobium* recorded highest germination percentage than the control.

Wani *et al*. (2014) worked on the effect of seed treatments and packing materials on seed quality parameters of maize during storage and observed that seeds treated with Captan recorded higher germination (80%) and vigour index (2161).

Udabal *et al*. (2014) observed the effect of six seed treatments, [T1: Sweet flag rhizome powder (5 g/kg), T2: Neem leaf powder (10 g/kg), T3: Custard apple seed powder (10 g/kg), T4: Deltamethrine (40 mg/kg), T5: Vitavax (3 g/kg) and T6: Control (without any seed treatments).] on storability of sunflower (*Helianthus annuus* L.) seeds and reported that seeds treated with Vitavax (3 g/kg) recorded significantly higher seed germination (84.37%), 100-seed weight (4.36 g), root and shoot length (17.66 cm and 16.25 cm, respectively), vigour index (2865), lower electrical conductivity (232 dSm^{-1}) and seed moisture content (9.14%) at the end of eleven months of seed storage as compared to other treatments.

Shakuntala *et al*. (2014) worked the influence of polymer treatment on storage quality of sunflower seeds and found that storability of sunflower (RSFH-130) was improved by treating the seeds with polymer seed coating @ 5 g/kg of seeds + Vitavax (Carboxin 37.5% + Thiram 37.5%) @ 2 g/kg of seeds + Imidachloprid @ 5 g/kg of seeds after fourteen months of seeds storage in polythene bag.

Patil *et al*. (2014) evaluated the impact of seed treatment chemicals on seed storability in pigeonpea (*Cajanus cajan*(L.) millsp.) and concluded that Thiram @ 3 g/kg of seed + spinosad @ 0.04 ml/kg treated seeds, when stored in super bag, recorded significantly higher germination (83.50%), seedling length (30.43 cm), seedling dry weight (28.90 mg), seedling vigour index-I (2555) and II (24.27) and lowest seed moisture 8.45 (%) at the end of sixth months of storage period compared to control.

Joshi *et al*. (2014) observed the effect of seed treatments, fungicides and botanicals, and packing materials on seed quality parameters of soybean *(Glycine max)* and reported that the seeds treated with Captan recorded significantly higher germination (80.41%) and lower moisture content (8.84%) and cloth bags recorded maximum germination (78.55%), vigour index (2600) and moisture content (10.06%) at the end of sixth months of storage period.

Harish *et al*. (2014) studied the effect of seed treatments on seed quality parameters of tomato seeds and concluded that seeds treated with Vitavax @ 2 g + polymer coating @ 20 ml/kg of seeds recorded significantly higher seed germination (76.38%), vigor index (1414), lesser EC (0.578 dSm^{-1}) and moisture content (7.03%) at the end of storage period.

Badiger *et al*. (2014) studied the impact of synthetic polymer coating and chemicals seed treatment on seed longevity of cotton seed (*Gossypium hirsutum* L.) and found that cotton seed coated with polykote @ 3 ml/kg + Vitavax 200 @ 2 ml/kg of seeds maintain germination and other seed quality parameters for ten months of storage, when stored in the polythene bag (400 gauge).

Sushma (2013) studied the effect of polymer coating and chemicals seed treatment on seed storability of chickpea, and revealed that the treatment combination of polymer coated seed @ 10 ml/kg along with Deltamethrin 2.8 EC @ 0.4 ml/kg of seed + Vitavax power @ 2 g/kg of seed recorded significantly higher seed germination (98.88%), shoot and root length (8.39 cm and 15.63 cm), seedling vigour index (2093), seedling dry weight (263.32 g), test weight (177.12 g) and lower EC value (0.831 dSm^{-1}) as compared to T_1 (untreated seeds) at the end of storage period.

Pathare (2013) studied the efficacy of insecticide seed treatment on cotton seed germination and vigour index during storage, and recorded higher germination percentage, field emergence, root length, shoot length, seedling vigour index, dry matter, lower electrical conductivity in the seeds treated with Thiram @ 1.50 g/kg of seed and Imidacloprid @ 7.50 g/kg of seed, followed by seed coating with polymer @ 5.00 g/kg of seeds and Thiram @ 1.50 g/kg of seeds.

Narayanareddy and Biradarpatil (2012) studied the effect of sowing invigoration seed treatments on seed quality in sunflower hybrid KBSH-1. The different pre-sowing invigorations seed treatments showed differential response for all the seed quality parameters. Among the treatments, seeds treated with 2% $CaCl_2$ for 12 hours and drying back to original moisture content at room temperature recorded significantly higher germination percentage (86.60%), seedling vigour index (2243) and field emergence (81.50%) followed by GA3 treatment and water hydration.

Rettinassababady *et al*. (2012) studied the role of polymer treatment on seed quality status of hybrid rice (*Oryza sativa* L.) during storage under coastal ecosystem by coating with synthetic polymer alone and in combination with flowable thiram and vitavax. Results indicated that among the treatments, seeds coated with vitavax recorded maximum germination, followed by seeds coated with flowable thiram.

Khatun and Bhuiyan (2011) studied the effect of different botanicals on chickpea seed quality parameters viz., moisture content (%), germination (%), seedling dry weight and vigour index during storage and observed highest values for all the parameters in comparison to the control, when seeds preserved with neem leaf powder.

Raikar *et al*. (2011) conducted a storage experiment on rice seed coated with inorganic (fungicides and insecticides) and organic (botanicals) and observed that treated seeds retained germination more than MSCS and seedling vigour after 20 months of storage period under ambient conditions.

Vimal *et al*. (2011) evaluated seed treatment effect with synthetic polymer and additives on seed quality in hybrid rice and observed that treatment with Polykote, followed by dry treatment of Thiram and finally the Imidacloprid treatment followed with drying for 24 h at room temperature was the best treatment for enhancement of seed quality parameters viz., germination and field emergence with decrease in total fungal count.

Avelar *et al*. (2011) worked on the storability and quality of soybean seed, treated with fungicide, insecticide, and with liquid and powered polymer. They observed that all the coating material protected the seeds during storage, except powder polymer which reduced seed germination.

Mrda *et al*. (2010) studied effect of storage period and chemical treatment with fungicides and insecticides on seed germination of three commercial hybrids of sunflower. The results indicated that all three hybrids treated with fungicides and the control had a significantly higher germination than hybrids treated with insecticides.

Thobunluepop *et al*. (2009) evaluated on physiological and biochemical basis of rice seed storability using seeds treated with fungicide (Captan), biological fungicide polymers (chitosan-lignosulphonate polymer and eugenol incorporated into chitosan - lignosulphonate polymer) and un-coated seeds as control. After 12 months storage, seed moisture content and seed water activity increased that affected the germination rate, seedling vigor, seedling dry weight, shoot and root length and seedling growth rate.

Jeyabal *et al*. (2008) evaluated the effect of seed treatment with organic, inorganic nutrients and biofertilizers on seed yield and yield attributes of soybean and observed that seed treatment with bio-digested slurry 50%, superphosphate 2%, bradyrhizobium 2%, and phosphobacteria 2% increased the number of filled pods and seed yield by 29.60% and 37.20%, respectively over the uncoated seeds. They further revealed that there was significant increase in the test weight of seeds due to seed treatment with phosphobacteria.

Giang and Gowda (2007) studied the effect of seed treatment with synthetic polymer and chemicals such as Captan, Thiram, Gaucho and Super red on seed quality and storability of hybrid rice (*Oryza sativa* L.). They observed that coated seeds stored in polythene bag recorded the highest germination in comparison to the seeds stored in cloth bag.

Kumar *et al*. (2007) reported that chemical coated cotton seeds recorded significantly higher germination up to nine months of storage as compared to control. Among the different treatment combinations, higher germination was recorded for seed coating with polymer @ 5 g/kg and Thiram @ 1.5 g/kg of seeds (77%) as compared to control (52%).

Sud *et al*. (2005) studied the effect of pre-storage fungicidal treatments on seed health and viability of kidney bean, *Phaseolus vulgaris* L., treated with Bavistin + TMTD, Baylaton, Captan and Thiram. They observed that all fungicidal treatments for the first four months of storage either enhanced or maintained the seed germination and vigour at same level as was recorded at initial stages, but a decline was recorded thereafter.

CHAPTER III

MATERIALS AND METHODS

Details of different materials used and methodologies followed in the experiment are presented in this chapter.

3.1 Experimental period

The laboratory experiment was conducted during the period from January to October 2020.

3.2 Experimental site and climate

A laboratory experiment was conducted at the Department of Agronomy in Sher-e-Bangla Agricultural University to find out the appropriate pre-storage treatment technique for rice in order to increase rice productivity through maintaining seed quality during seed storage and reducing storage cost. The experimental area was situated at 23°46´ N latitude and 90°23´ E longitude at an altitude of 8.45 meter above the sea level. The experimental site is under subtropical humid climatic conditions.

3.3 Collection of seed samples

The healthy and uniform sized seeds were collected from the experimental field of the Department of Agronomy Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, which were grown in the aman rice cropping season in 2019.

3.4 Experimental material and design

a) **Material**: Storage material; Rice seed of two varieties (BRRI dhan87 and BR 11)

b) **Design of experiment**: The two factors experiment was arranged in Randomized Complete Block Design (RCBD) with four replications each.

3.5 Description of the factors and the treatments

Two factors in the experiment were as:

3.5.1 Factor A: The two rice varieties like-

1. BRRI dhan87 (V_1)
2. BR11 (V_2)

3.5.2 Factor B: The five seed treating materials like-

1. Control = T_0
2. Ascorbic Acid @ 0.5 g/kg seeds = T_1
3. Aspirin @ 0.1 g/kg seeds = T_2
4. Bleaching powder @ 2 g/kg seeds = T_3
5. Red chili @ 2 g/kg seeds = T_4

3.5.3 Total treatments combinations of the experiment were as follows:

1. V_1 T_0 = BRRI dhan87 × Control
2. V_1 T_1 = BRRI dhan87 × Ascorbic Acid @ 0.5 g/kg seeds
3. V_1 T_2 = BRRI dhan87 × Aspirin @ 0.1 g/kg seeds
4. V_1 T_3 = BRRI dhan87 × Bleaching powder @ 2 g/kg seeds
5. V_1 T_4 = BRRI dhan87 × Red chili @ 2 g/kg seeds
6. V_2 T_0 = BR11 × Control
7. V_2 T_1 = BR11 × Ascorbic Acid @ 0.5 g/kg seeds
8. V_2 T_2 = BR11 × Aspirin @ 0.1 g/kg seeds
9. V_2 T_3 = BR11 × Bleaching powder @ 2 g/kg seeds
10. V_2 T_4 = BR11 × Red chili @ 2 g/kg seeds

3.6 Dry-dressing treatment

High quality pure seeds of rice were dry dressed with ascorbic acid @ 0.5 g/kg seeds(T_1), aspirin @ 0.1 g/kg seeds(T_2), bleaching powder @ 2 g/kg seeds(T_3), red chili @ 2 g/kg seeds(T_4) and control(T_0) following the method of Basu and coworkers, (Mandal and Basu, 1986) with some modification. In this experiment 200 g, of rice seeds from each variety were taken for each treatment. Dry dressing treatments were given in the plastic pot (300 ml capacity) and kept at room temperature to prevent the escape of volatiles from different treatments. After treatment, each pots were shaken every day up to 7 days, for thoroughly mixing the chemicals, pharmaceutical products and crude plant materials with the seeds.

3.7 Preservation of seeds

A total 40 plastic containers were used and 200 g healthy and uniform sized seeds were kept in each container as per treatment. After that the container was stored in clean and dry place in the Agronomy Lab. in SAU campus. The stored containers were kept under keen observation for 9 months in air tied condition at room temperature.

3.8 Parameters study as quality tests

The following parameters were studied as quality of rice seeds

1. Moisture percentage
2. Viability percentage
3. Percentage of seed germination
4. Shoot length of seedling
5. Root length of seedling
6. Total length of seedling
7. Seedling vigor index (SVI)
8. Germination speed index (GSI)
9. Germination rate (GR)

10. Mean daily germination (MDG)
11. Mean germination time (MGT)
12. Peak value (PV)
13. Germination value (GV)

3.9 Methods of studying characteristics

After 7 days, treated seeds thoroughly mixed with the chemicals, pharmaceutical products and crude plant materials with the seeds were used for initial data recording according to parameters.

3.9.1 Moisture percentage: For the moisture content the seeds were dried in an electric oven at 70 °C for 72 hours and dry weight for all four replications were taken and calculated based on wet – basis moisture content method. Moisture content of seeds was determined by the following formula given by (Evans, 1972).

$$\text{Moisture content percentage} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.9.2 Viability percentage

Fifty (50) seeds from each variety were soaked with 1% tetrazolium (TZ) solution at room temperature for 48 hours. After staining, the seeds were observed and evaluated the seeds on the basis of staining pattern and colour intensity. Among stained seeds, seeds with bright red/pink staining are completely viable while partially stained seeds may produce either normal or abnormal seedlings. Completely unstained seeds are non-viable.

$$\text{Viability Percentage} = (\text{No. of viable seeds}/\text{No. of total seeds}) \times 100$$

3.9.3 Germination Percentage: Standard germination test was done in plastic pot and river bed sand was used as a growing media. The seeds were checked on daily basis up to 14 days and the number of germinated seeds were recorded.

Germination associated parameters were calculated by using following formulas:

The germination percentage was calculated using the formula by Shakirova *et al*. (2003) -

$$GP = (N_1/N_2) \times 100$$

In this equation, N_1 is number of normal seedling and N_2 is number of total seeds sown.

3.9.4 Seedling Vigor Index: This was used to calculate the seedling vigor index (SVI) using the formula below (Aliloo and Darabinejad, 2013).

$$SVI = (\text{Germination } \% \times \text{Seedling Length})/100$$

3.9.5 Germination Speed Index (GSI): It was also computed as shown below (Ali *et al*., 2011).

$$GSI = (\text{Number of Germinated Seeds/Days of } 1^{st} \text{ Count}) + \ldots\ldots + (\text{Number of Germinated Seeds/Days of Final Count})$$

3.9.6 Germination rate: GR = (Final GP/t); where, GP = germination percentage and t = germination time.

3.9.7 Mean Daily Germination (MDG): Mean daily germination can be calculated by the following formula given by Czabator (1962).

$$MDG = \text{Total number of germinated seeds/Total number of days}$$

3.9.8 Mean Germination Time (MGT): Mean germination time was calculated by the formula given by (Ellis and Roberts, 1981).

MGT = n1 × d1 + n2 × d2 + n3 × d3 + --------/Total number of days

Where, n = number of germinated seed; and d = number of days

3.9.9 Peak Value (PV): PV = Final GP/No. of days required to reach the peak value of germination (Czabator, 1962).

3.9.10 Germination Value (GV): GV = Peak value × Mean daily germination (Czabator, 1962).

3.9.11 Seedling root and shoot length

Randomly selected 5 seedlings were taken from each replication to measure root and shoot length. It was measured with a measuring scale and expressed in centimeters. Root and shoot length of the seedlings were measured after 14 days of seed setting (ISTA, 1995).

Seedling length (cm) = Root length + Shoot length

3.10 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant differences among the treatments by using the Statistix 10.0 computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference (LSD) at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out the effect of pre-storage seed treatment on storability of transplanted aman rice seed. The results have been presented and discusses with the help of Table and Graphs and possible interpretations given under the following headings:

4.1 Germination percentage

Effect of variety

Varietal performance of rice seed during storage showed significant variation on germination percentage at 271 days after storage (DAS) (Figure 1 and Appendix III). Initially seeds of the variety V_1 (BRRI dhan87) and V_2 (BR 11) showed non-significant difference between them on germination percentage but initially the seed germination percentage of the variety V_2 (BR 11) was higher than V_1 (BRRI dhan87) (94.18 and 95.00%, respectively). Again, at 236 DAS, non-significant variation was found between V_1 (BRRI dhan87) and V_2 (BR 11) on germination percentage but V_1 (BRRI dhan87) showed higher germination percentage (89.20%) than V_2 (BR 11) (88.40%). At 271 DAS, significant variation on germination percentage was recorded and the V_1 (BRRI dhan87) showed the maximum percent germination (81.20%) whereas the minimum germination percentage (55.10%) was recorded from the variety V_2 (BR 11).

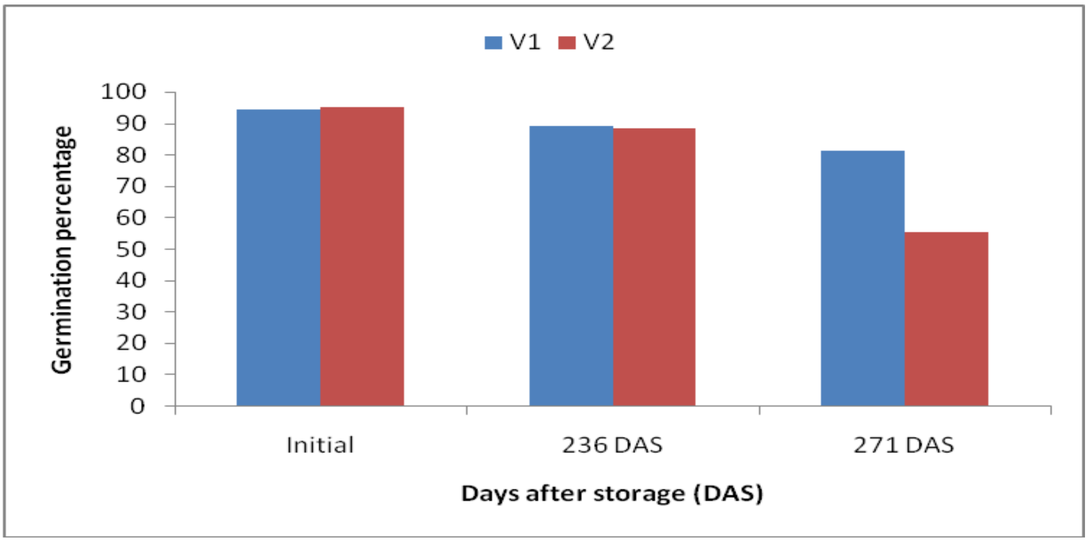
Effect of seed treatment

Significant variation was recorded for germination percentage of rice seeds at 236 and 271 DAS by different seed treatments, but initial storage condition (after 7 days, treated seeds thoroughly mixed with the chemicals, pharmaceutical products and crude plant materials with the seeds were used for initial data record according to parameters), it was not differed significantly (Figure 2 and Appendix III). It was observed that germination percentage was gradually decreased with the increasing of storage duration. At 236 DAS, the maximum germination percentage (91.75%) was found from the seed treatment of T_3 (Bleaching powder @ 2 g/kg seeds) while initial storage condition it was 94.63%. Seed treatments of T_1 (Ascorbic acid @ 0.5 g/kg seeds), T_2 (Aspirin @ 0.1 g/kg seeds) and T_4 (Red chili powder @ 2 g/kg seeds) at 236 DAS showed significantly similar to T_3 (Bleaching powder @ 2 g/kg seeds). The minimum germination percentage (86.25%) was recorded from the control treatment T_0 (no seed treatment) while initially it was 94.44%. At 271 DAS, the maximum germination percentage (71.75%) was also recorded from the seed treatment of T_3 (Bleaching powder @ 2 g/kg seeds) that was significantly similar to the treatment of T_1 (Ascorbic acid @ 0.5 g/kg seeds), T_2 (Aspirin @ 0.1 g/kg seeds) and whereas the minimum germination percentage (64.50%) was recorded from the control treatment T_0 (no seed treatment). The result obtained from the present study was similar with the findings of Padhi *et al*. (2017), Rettinassababady *et al*. (2012), Raikar *et al*. (2011), Vimal *et al*. (2011) and Thobunluepop *et al*. (2009); they observed that germination percentage of rice seeds during storage was higher with seed treatments compared to control.

Combined effect of variety and seed treatment

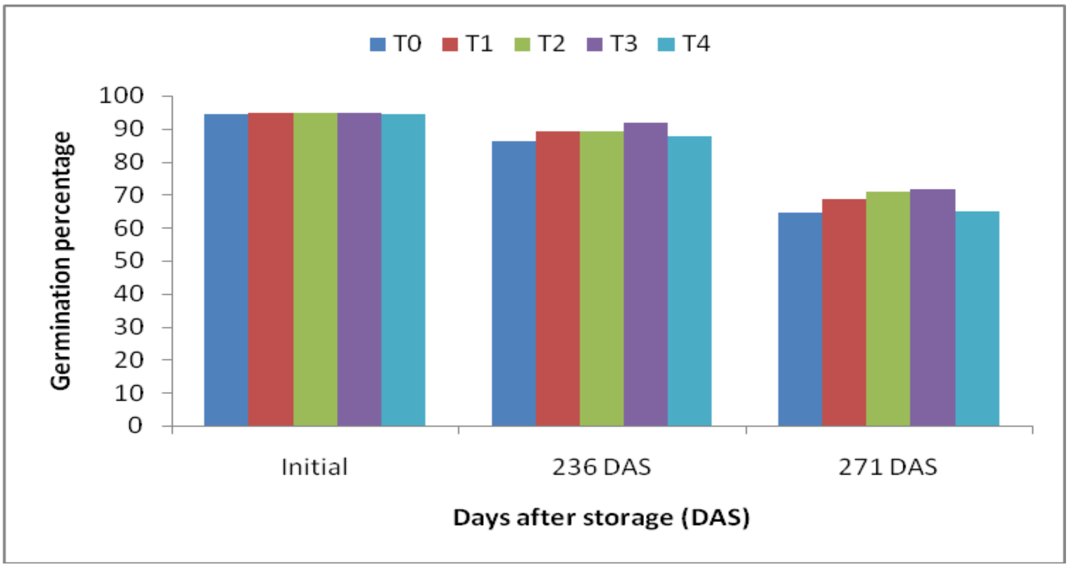
Different seed treatments at storage combined with different rice varieties showed significant variation on germination percentage at different days of storage while at initial level non-significant variation was found among the treatment combinations (Table 1 and Appendix III). At 236 DAS, result exhibited that the treatment combination of V_1T_3 gave the maximum germination percentage (93.00%) (initially it was 94.38%), which was significantly similar to the treatment combinations of V_1T_0, V_1T_1, V_1T_2, V_1T_4, V_2T_1, V_2T_2, V_2T_3 and V_2T_4 whereas the V_2T_0 gave the minimum seed germination percentage (85.00%) while initially it was 95.13%. At 271 DAS, V_1T_3 also gave the maximum germination percentage (86.50%) (initially it was 94.38%), which was significantly similar to the treatment combinations of V_1T_0 and V_1T_2 whereas the V_2T_0 gave the minimum seed germination percentage

(47.50%) (initially it was 95.13%), which was significantly different from other treatment combinations.



V_1 = BRRI dhan87, V_2 = BR 11

Figure 1. Effect of variety on germination percentage of Taman rice seed ($LSD_{0.05}$= 0.31, 3.20, 3.35 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 2. Effect of seed treatment on germination percentage of Taman rice seed ($LSD_{0.05}$ = 0.49, 5.07, 5.29 at initial, 236 DAS and 271 DAS, respectively).

Table 1. Combined effect of variety and seed treatment on germination percentage of T. aman rice seed

Treatments	Germination (%)		
	Initial	**236 DAS**	**271 DAS**
V_1T_0	93.75	87.50 ab	81.50 abc
V_1T_1	94.38	88.50 ab	79.00 bc
V_1T_2	94.25	89.50 ab	84.00 ab
V_1T_3	94.38	93.00 a	86.50 a
V_1T_4	94.13	87.50 ab	75.00 c
V_2T_0	95.13	85.00 b	47.50 e
V_2T_1	95.13	90.00 ab	58.50 d
V_2T_2	95.13	88.50 ab	57.50 d
V_2T_3	94.88	90.50 ab	57.00 d
V_2T_4	94.75	88.00 ab	55.00 d
$LSD_{(0.05)}$	**NS**	**7.1754**	**7.4938**
CV(%)	**0.51**	**5.57**	**7.58**

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

V_1 = BRRI dhan87, V_2 = BR 11

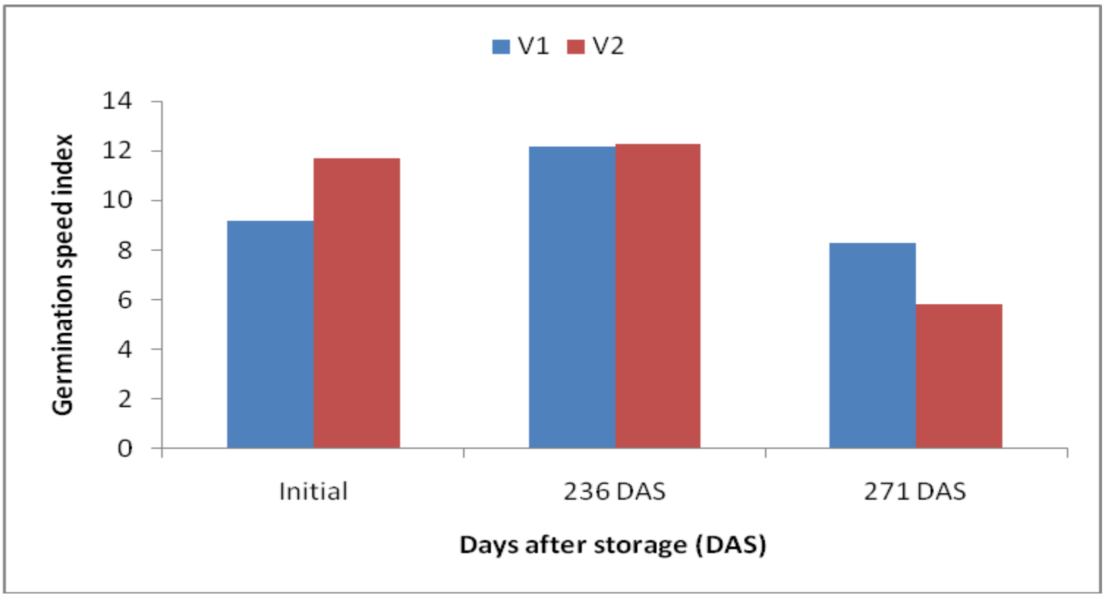
T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

DAS = Days after storage

4.2 Germination speed index

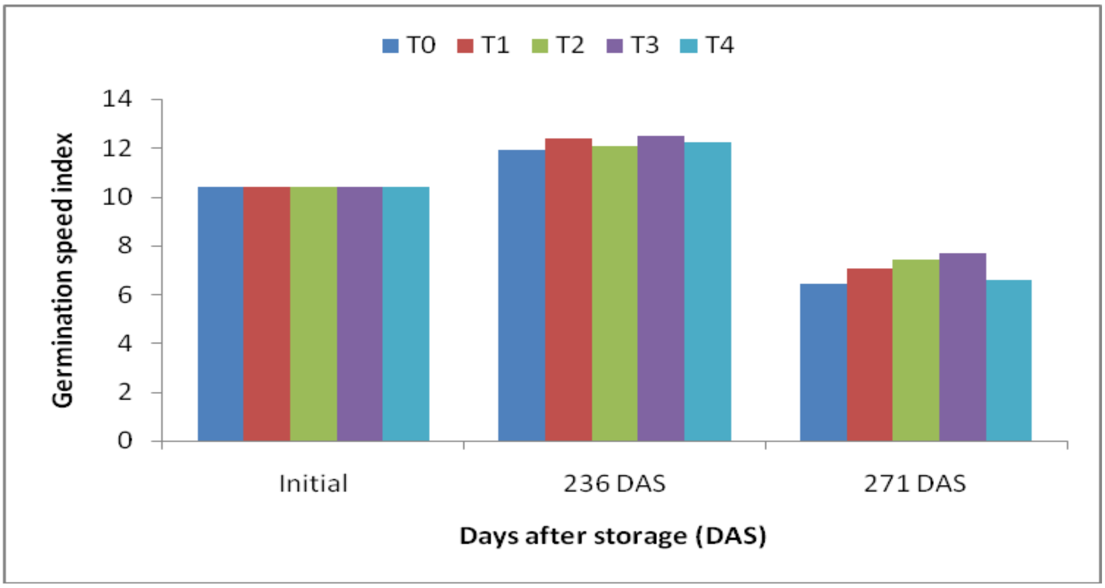
Effect of variety

Germination speed index of rice seeds at initial storage condition and at 271 DAS varied significantly between two varieties while at 236 DAS non-significant variation was recorded due to varietal difference (Figure 3 and Appendix IV). Initially the maximum germination speed index of rice seeds (11.66) was recorded from the variety V_2 (BR 11) whereas the minimum (9.14) was found from V_1 (BRRI dhan87) but at 271 DAS, variety V_1 showed the maximum germination speed index (8.26) whereas V_2 showed the minimum germination speed index (5.78). At 236 DAS, non-significant variation was found, however, the maximum germination speed index (12.27) was recorded from V_2 whereas V_1 showed the minimum germination speed index (12.15).



V_1 = BRRI dhan87, V_2 = BR 11

Figure 3. **Effect of variety on germination speed index of T. aman rice seed ($LSD_{0.05}$= 0.11, 0.46, 0.54 at initial, 236 DAS and 271 DAS, respectively).**



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 4. **Effect of seed treatment on germination speed index of T. aman rice seed ($LSD_{0.05}$= NS, 0.72, 0.85 at initial, 236 DAS and 271 DAS, respectively).**

Effect of seed treatment

Significant variation was recorded for germination speed index of rice seeds at initial storage stage and at 271 DAS by different seed treatments but at 236 DAS it was not differed significantly (Figure 4 and Appendix IV). It was observed that at 271 DAS, the maximum germination speed index (7.66) was found from the seed treatment of T_3 (Bleaching powder @ 2 g/kg seeds) (initially it was 10.40) which was statistically similar to the seed treatments of T_1 (Ascorbic acid @ 0.5 g/kg seeds) and T_2 (Aspirin @ 0.1 g/kg seeds). The minimum germination speed index (6.42) at 271 DAS was recorded from the control treatment T_0 (no seed treatment) (initially it was 10.40) that was significantly similar to T_4 (Red chili powder @ 2 g/kg seeds).

Table 2. Combined effect of variety and seed treatment on germination speed index of T. aman rice seed

Treatments	**Germination speed index**		
	Initial	**236 DAS**	**271 DAS**
V_1T_0	9.14 b	11.95	8.23 ab
V_1T_1	9.14 b	12.09	7.89 ab
V_1T_2	9.15 b	11.99	8.83 a
V_1T_3	9.14 b	12.51	8.85 a
V_1T_4	9.14 b	12.21	7.48 bc
V_2T_0	11.66 a	11.90	4.60 e
V_2T_1	11.67 a	12.68	6.19 d
V_2T_2	11.67 a	12.14	6.00 d
V_2T_3	11.66 a	12.43	6.47 cd
V_2T_4	11.66 a	12.22	5.67 de
$LSD_{(0.05)}$	**0.255**	**NS**	**1.211**
CV(%)	**1.67**	**5.81**	**11.89**

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

V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

DAS = Days after storage

At 236 DAS, non-significant variation was found, however, the maximum germination speed index (12.47) was also recorded from the seed treatment of

T_3 (Bleaching powder @ 2 g/kg seeds) whereas the minimum germination speed index (11.92) was recorded from the control treatment T_0 (no seed treatment). Padhi *et al*. (2017) also supported the results of the present study and found that treated seeds before storage showed higher speed of germination compared to control.

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on germination speed index at 271 days of storage while at initial storage stage and at 236 DAS non-significant influence was recorded (Table 2 and Appendix IV). At 271 DAS, the treatment combination of V_1T_3 gave the maximum germination speed index (8.85) (initially it was 9.14) which, was significantly similar to the treatment combinations of V_1T_0, V_1T_1 and V_1T_2 whereas V_2T_0 gave the minimum seed germination speed index (4.60) (initially it was 11.66) which was statistically similar to V_2T_4. At 236 DAS, non-significant variation was found among the treatment combination on germination speed index, however, the maximum germination speed index (12.68) (initially it was 11.67) found from V_2T_1 whereas the V_2T_0 gave the minimum seed germination speed index (11.90) (initially it was 11.66).

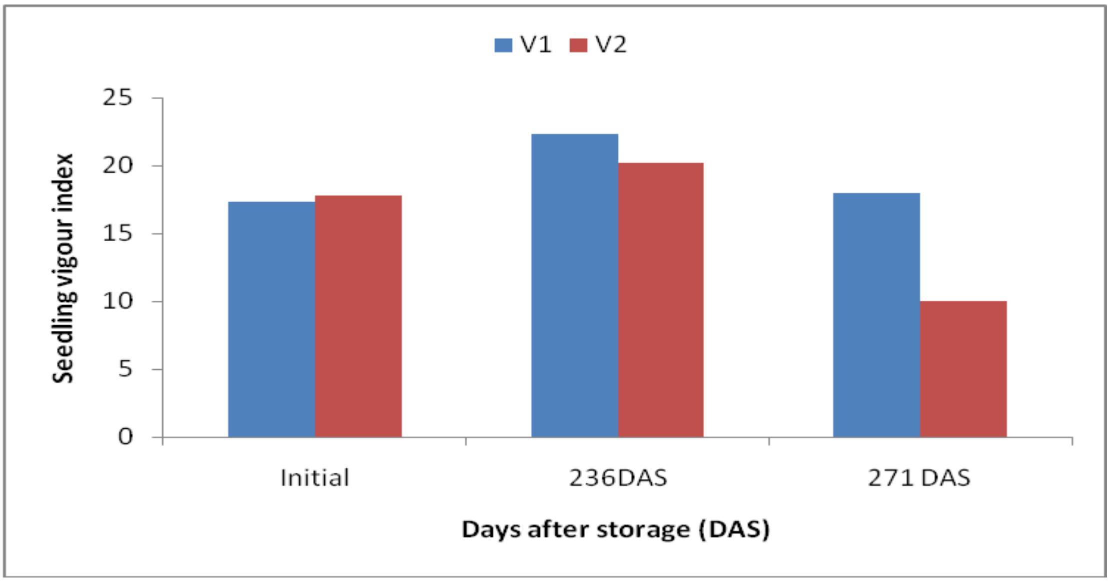
4.3 Seedling vigour index

Effect of variety

Varietal performance of rice seed during storage showed significant variation on seedling vigour index at all storage stage initial, 236 and 271 days after storage (DAS) (Figure 5 and Appendix V). Initially seeds of the variety V_1 (BRRI dhan 87) and V_2 (BR 11) showed significant difference between them on seedling vigour index and initially the seedling vigour index of the variety V_2 showed maximum seedling vigour index (17.78) whereas the minimum seedling vigour index (17.36) was recorded from the variety V_1 . Again, at 236 and 271 DAS, significant variation was found between V_1 and V_2 on seedling vigour index and V_1 showed maximum seedling vigour index (22.34 and 17.95, respectively) whereas the minimum seedling vigour index (20.17 and 9.99, respectively) was recorded from the variety V_2 .

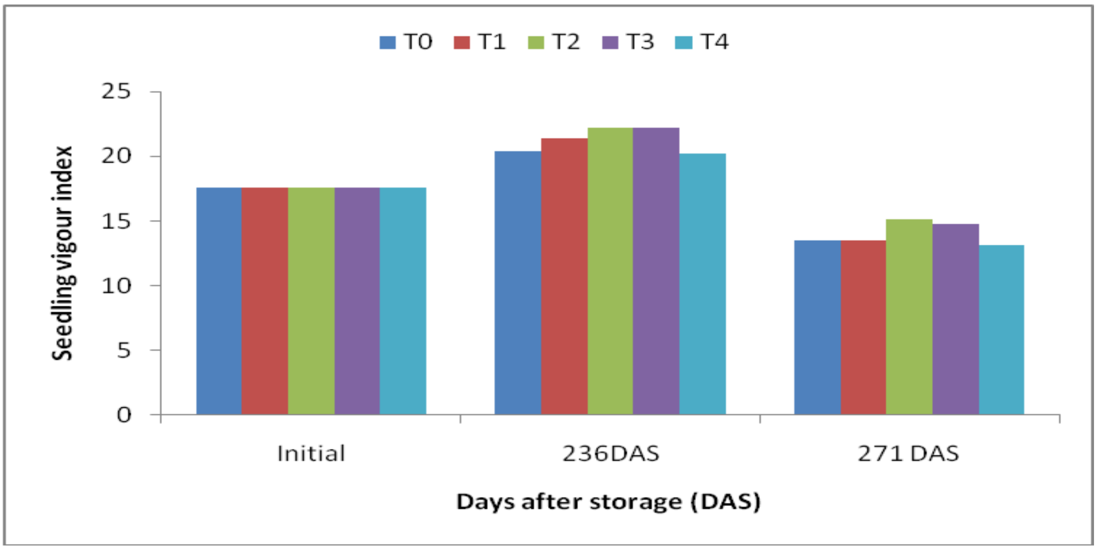
Effect of seed treatment

Significant variation was recorded for seedling vigour index of rice seeds at 236 and 271 DAS by different seed treatments while initially it was not differed significantly (Figure 6 and Appendix V). At 236 DAS, the maximum seedling vigour index (22.20) was found from the seed treatment of T_2 (Aspirin @ 100 mg/kg seeds) (initially it was 17.57) which was statistically similar to T_1 (Ascorbic acid @ 0.5 g/kg seeds) and T_3 (Bleaching powder @ 2 g/kg seeds) whereas the minimum seedling vigour index (20.17) was recorded from T_4 (Red chili powder @ 2 g/kg seeds) (initially it was 17.57). At 271 DAS, the maximum seedling vigour index (15.07) was also recorded from the seed treatment of T_2 (Aspirin @ 0.1 g/kg seeds) that was significantly same to the treatment of T_3 (Bleaching powder @ 2 g/kg seeds) whereas the minimum seedling vigour index (13.08) was recorded from T_4 (Red chili powder @ 2 g/kg seeds) treatment. The result obtained from the present study was similar with the findings of Padhi *et al*. (2017) and, Sharma and Dhiman (2017) who observed that the treated seeds showed higher vigour index in rice seed during storage compared to non-treated seeds. Similarly, Harish *et al*. (2014) found similar result in tomato and Sharma *et al*. (2017) found similar result in maize seeds.



V_1 = BRRI dhan87, V_2 = BR 11

Figure 5. Effect of variety on seedling vigour index of T. aman rice seed ($LSD_{0.05}$= 0.31, 0.97, 0.70 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 6. Effect of seed treatment on seedling vigour index of T. aman rice seed ($LSD_{0.05}$= NS, 1.54, 1.10 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different treatment combinations of variety and seed treatments at storage condition showed significant variation on seedling vigour index at different days of storage while at initial level significant variation was found among the treatment combinations (Table 3 and Appendix V). At 236 DAS, the treatment combination of V_1T_2 gave the maximum seedling vigour index (23.55) (initially it was 17.36) which was significantly similar to the treatment combinations of V_1T_3 and V_1T_4 whereas the V_2T_4 gave the minimum seedling vigour index (18.13) (initially it was 17.78). At 271 DAS, V_1T_2 also showed the maximum seedling vigour index (20.07) (initially it was 17.36) which was significantly same to the treatment combinations of V_1T_0 and V_1T_3 whereas the minimum seed seedling vigour index (8.29) (initially it was 17.78) was given by V_2T_0 which was statistically similar to the treatment combination V_2T_4.

Table 3. Combined effect of variety and seed treatment on seedling vigour index of T. aman rice seed

Treatments	Seedling vigour index		
	Initial	**236DAS**	**271 DAS**
V_1T_0	17.36 b	21.33 bcd	18.72 a
V_1T_1	17.37 b	21.46 abcd	15.04 c
V_1T_2	17.36 b	23.55 a	20.07 a
V_1T_3	17.37 b	23.14 ab	19.11 a
V_1T_4	17.36 b	22.21 abc	16.84 b
V_2T_0	17.78 a	19.44 de	8.29 f
V_2T_1	17.78 a	21.20 bcd	11.92 d
V_2T_2	17.78 a	20.86 cd	10.07 e
V_2T_3	17.78 a	21.20 bcd	10.34 e
V_2T_4	17.78 a	18.13 e	9.32 ef
$LSD_{(0.05)}$	**0.014**	**2.188**	**1.568**
CV(%)	**0.06**	**7.10**	**7.74**

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

V_1 = BRRI dhan87, V_2 = BR 11
T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

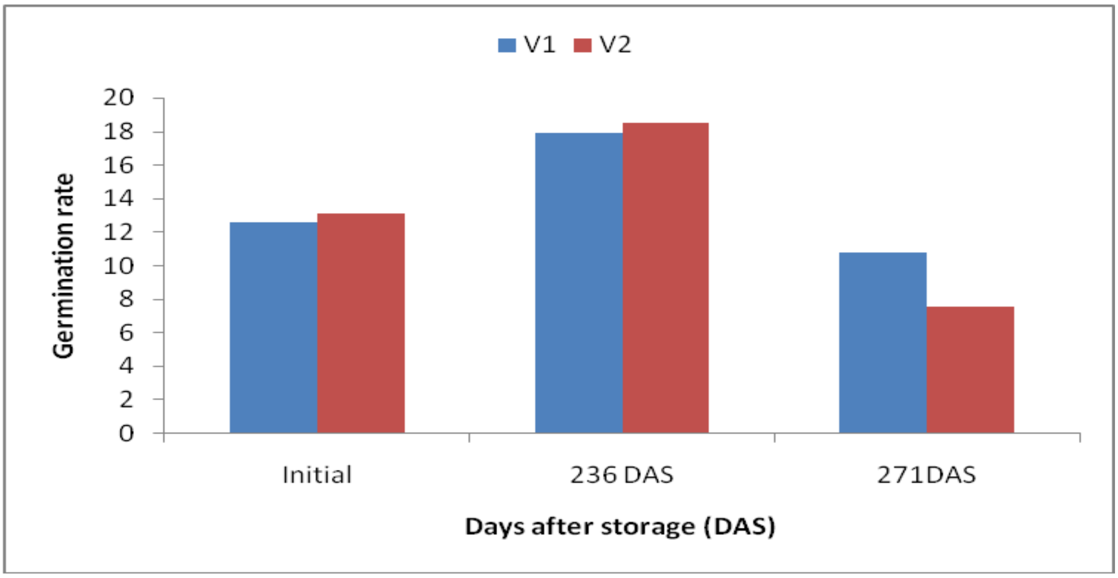
4.4 Germination rate

Effect of variety

Germination rate of rice seeds at initial condition and at 271 DAS varied significantly between two varieties but at 236 DAS non-significant variation was recorded due to varietal difference (Figure 7 and Appendix VI). Initially the maximum germination rate of rice seeds (13.10) was recorded from the variety V_2 (BR 11) whereas the minimum (12.57) was found from V_1 (BRRI dhan87) but at 271 DAS, variety V_1 (BRRI dhan87) showed the maximum germination rate (10.74) whereas V_2 (BR 11) showed the minimum germination rate (7.49). At 236 DAS, non-significant variation was found, however, the maximum germination rate (18.47) was recorded from V_2 (BR 11) whereas V_1 (BRRI dhan87) showed the minimum germination rate (17.87).

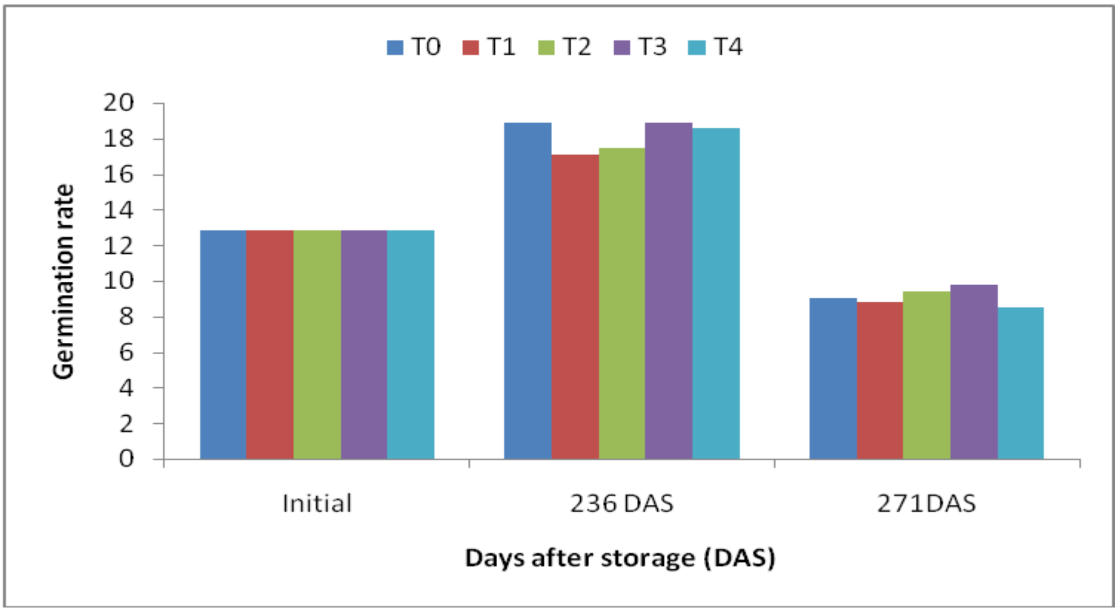
Effect of seed treatment

Non-significant variation was recorded for germination rate of rice seeds at initial stage and at 236 and 271 DAS, non-significant variation was found as influenced by different seed treatments (Figure 8 and Appendix VI). At initial stage, the maximum germination rate (12.84) was recorded from T_3 and T_4 treatment whereas the minimum germination rate (12.83) was recorded from T_0, T_1 and T_2. At 236 and 271 DAS, non-significant variation was found among the treatments, however, at 236 and 271 DAS, the maximum germination rate (18.89 and 9.78, respectively) was found from the seed treatment of T_3 (Bleaching powder @ 2 g/kg seeds) (initially it was 12.82) whereas the minimum germination rate at 236 DAS (17.12) was found from T_1 (Ascorbic acid @ 0.5 g/kg seeds) but at 271 DAS, the minimum germination rate (8.52) was found from T_4 (Red chili powder @ 2 g/kg seeds) treatment. Thobunluepop *et al*. (2009) also found similar result of the present study in rice seeds during storage where treated seeds showed higher germination rate compared to control.



V_1 = BRRI dhan87, V_2 = BR 11

Figure 7. Effect of variety on germination rate of T. aman rice seed ($LSD_{0.05}$= 0.11, 1.66, 1.04 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 8. Effect of seed treatment on germination rate of T. aman rice seed ($LSD_{0.05}$= NS, 2.63, 1.65 at initial, 236 DAS and 271 DAS, respectively).

Table 4. Combined effect of variety and seed treatment on germination rate of T. aman rice seed

Treatments	Germination rate		
	Initial	**236 DAS**	**271DAS**
V_1T_0	12.56 b	18.65	11.84 a
V_1T_1	12.57 b	16.23	9.58 abc
V_1T_2	12.57 b	17.18	11.21 ab
V_1T_3	12.57 b	19.80	11.69 ab
V_1T_4	12.57 b	17.50	9.38 bc
V_2T_0	13.10 a	19.05	6.21 d
V_2T_1	13.10 a	18.00	8.09 cd
V_2T_2	13.10 a	17.70	7.67 cd
V_2T_3	13.12 a	17.99	7.87 cd
V_2T_4	13.11 a	19.63	7.64 cd
$LSD_{(0.05)}$	**0.264**	**NS**	**2.336**
CV(%)	**1.42**	**14.11**	**17.66**

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

V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

DAS = Days after storage

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on germination rate at 271 days of storage while at 236 DAS non-significant variation was found (Table 4 and Appendix VI). Initial seed samples also showed significant variation on germination rate. At 271 DAS, the treatment combination of V_1T_0 gave the maximum germination rate (11.84) (initially it was 12.56), which was significantly similar to that of treatment combinations of V_1T_1, V_1T_2 and V_1T_3 whereas V_2T_0 gave the minimum seed germination rate (6.21) (initially it was 13.10), which was statistically similar to V_2T_1, V_2T_2, V_2T_3 and V_2T_4. Initially, the maximum germination rate (13.12) was recorded from V_2T_3 whereas V_1T_0 showed the minimum seed germination rate (12.56). At 236 DAS, non-significant variation was found among the treatment combination on germination rate, however, the maximum germination rate (19.80) (initially it was 12.57) found from V_1T_3 whereas V_1T_1 gave the minimum seed germination rate (16.23) (initially it was 12.57).

4.5 Mean daily germination

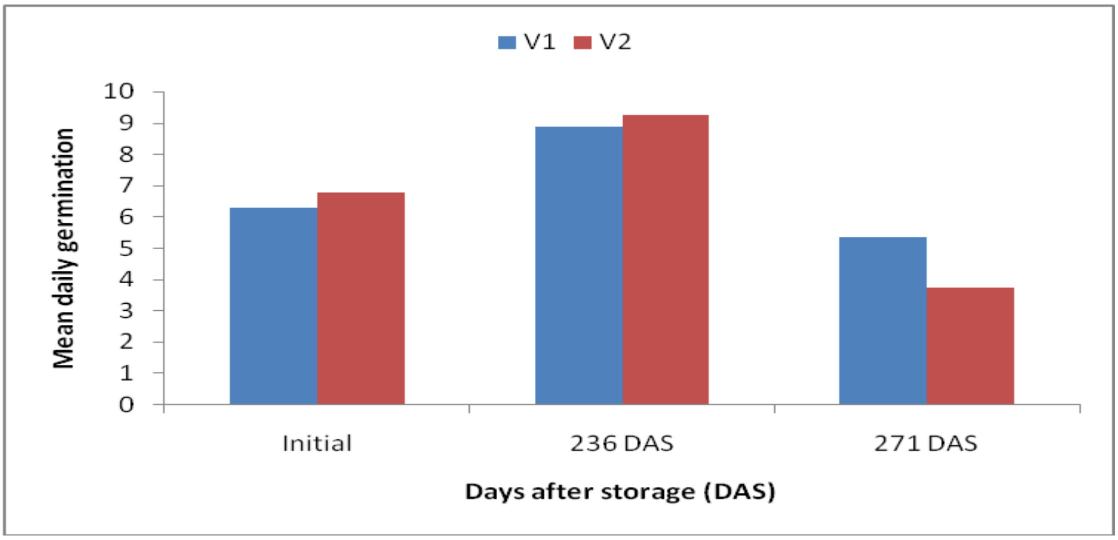
Effect of variety

At initial storage stage and at 271 DAS, mean daily germination of rice seeds varied significantly between two varieties but at 236 DAS, non-significant variation was recorded due to varietal difference (Figure 9 and Appendix VII). Initially, the maximum mean daily germination of rice seeds (6.78) was recorded from the variety V_2 (BR 11) whereas the minimum (6.27) was found from V_1 (BRRI dhan87) but at 271 DAS, variety V_1 showed the maximum mean daily germination (5.35) whereas V_2 showed the minimum mean daily germination (3.73). At 236 DAS, non-significant variation was found, however, the maximum mean daily germination (9.25) was recorded from V_2 whereas V_1 showed the minimum mean daily germination (8.86).

Effect of seed treatment

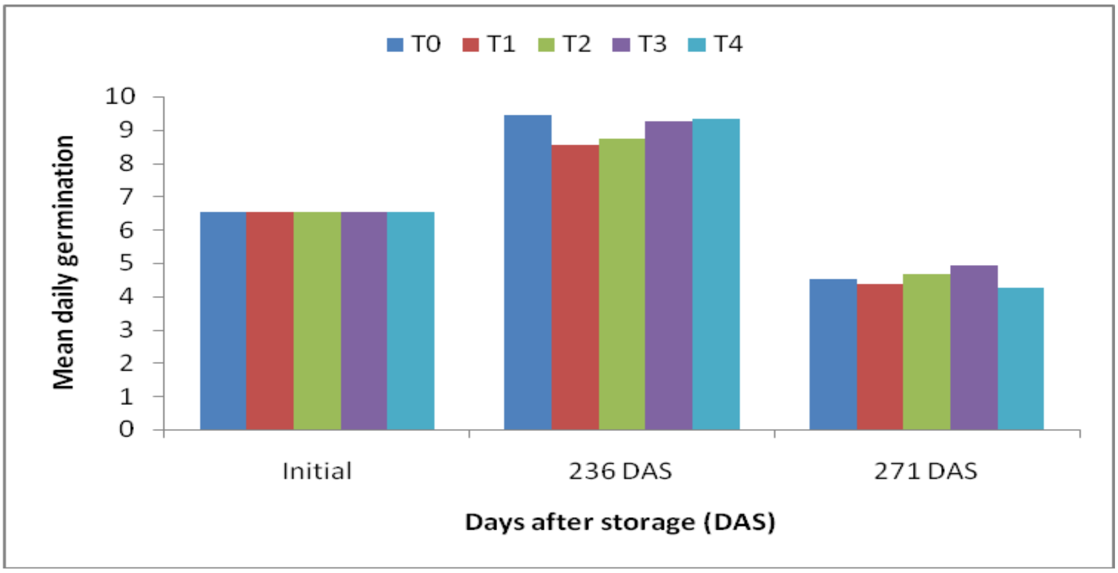
Non-significant variation was recorded for mean daily germination of rice seeds at initial stage and at 236 and 271 DAS as influenced by different seed treatments (Figure 10 and Appendix VII). At initial stage, the maximum mean daily germination (6.53) was recorded from T_3 (Bleaching powder @ 2 g/kg seeds) treatment whereas the minimum mean daily germination (6.52) was recorded from T_1 (Ascorbic acid @ 0.5 g/kg seeds). At 236 and 271 DAS, non-significant variation was found among the treatments, however, at 236 DAS, the maximum mean daily germination (9.43) was found from the control treatment T_0 (no seed treatment) (initially it was 6.52) but at 271 DAS, the maximum mean daily germination (4.91) was found from T_3 (Bleaching powder @ 2 g/kg seeds) treatment whereas the minimum mean daily germination at 236 DAS (8.56) was found from T_1 (Ascorbic acid @ 0.5 g/kg seeds) but at 271

DAS, the minimum mean daily germination (4.25) was found from T_4 (Red chili powder @ 2 g/kg seeds) treatment.



V_1 = BRRI dhan87, V_2 = BR 11

Figure 9. Effect of variety on mean daily germination of T. aman rice seed ($LSD_{0.05}$= 0.03, 0.87, 0.51 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 10. Effect of seed treatment on mean daily germination of T. aman rice seed ($LSD_{0.05}$= NS, 1.37, 0.81 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on mean daily germination at 271 days of storage while at 236 DAS non-significant variation was found (Table 5 and Appendix VII). Initial seed samples also showed significant variation on mean daily germination. At 271 DAS, the treatment combination of V_1T_0 gave the maximum mean daily germination (5.92) (initially it was 6.26) which was statisticall same to the treatment combinations of V_1T_3 whereas V_2T_0 gave the minimum seed mean daily germination (3.11) (initially it was 6.77) which was statistically similar to V_2T_1, V_2T_2, V_2T_3 and V_2T_4. At 236 DAS, non-significant variation was found among the treatment combination on mean daily germination, however, the maximum (9.89) (initially it was 6.78) found from V_1T_4 whereas V_1T_1 gave the minimum mean daily germination (8.12) (initially it was 6.27).

Table 5. Combined effect of variety and seed treatment on mean daily germination of T. aman rice seed

Treatments	Mean daily germination		
	Initial	236 DAS	271 DAS
V_1T_0	6.26 b	9.33	5.92 a
V_1T_1	6.27 b	8.12	4.79 abc
V_1T_2	6.27 b	8.59	5.48 ab
V_1T_3	6.28 b	9.50	5.88 a
V_1T_4	6.26 b	8.75	4.69 bc
V_2T_0	6.77 a	9.53	3.11 d
V_2T_1	6.78 a	9.00	3.98 cd
V_2T_2	6.78 a	8.85	3.82 cd
V_2T_3	6.78 a	8.99	3.93 cd
V_2T_4	6.78 a	9.89	3.82 cd
$LSD_{(0.05)}$	**0.076**	**NS**	**1.157**
CV(%)	**0.80**	**14.82**	**17.57**

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

V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

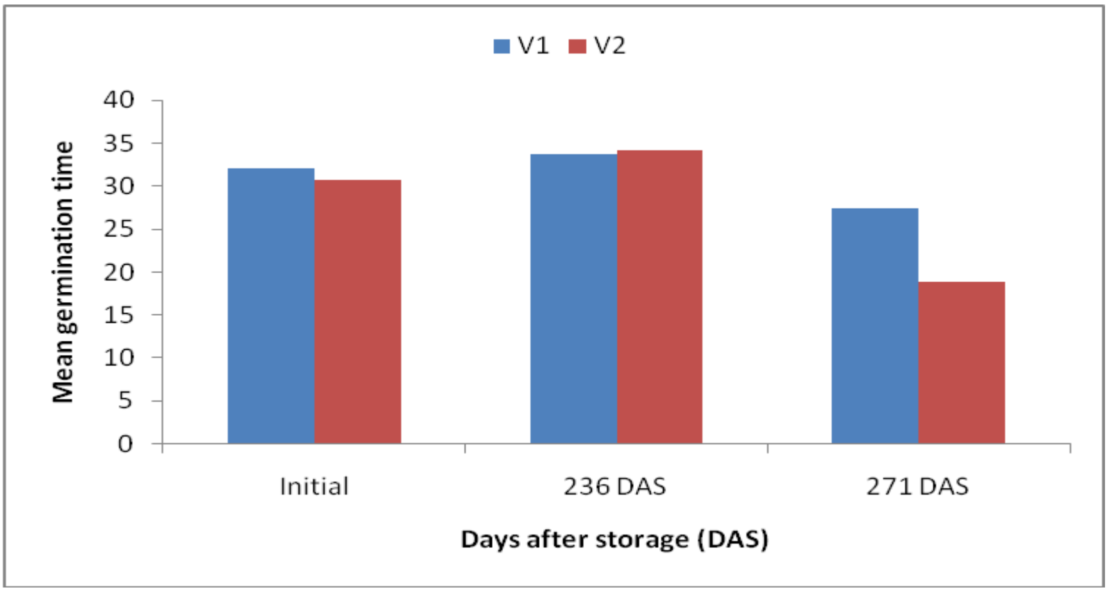
4.6 Mean germination time

Effect of variety

Initial seed samples of V_1 (BRRI dhan87) and V_2 (BR 11) showed non-significant variation on mean germination time and also these varieties showed non-significant variation at 236 DAS on mean germination time but at 271 DAS, it was varied significantly due to varietal difference (Figure 11 and Appendix VIII). However, at initial seed samples V_1 (BRRI dhan87) showed maximum mean germination time (31.96) whereas V_1 (BRRI dhan87) showed minimum mean germination time (30.69). At 236 DAS, the maximum mean germination time of rice seeds (34.12) was recorded from the variety V_2 whereas the minimum (33.73) was found from V_1 . Again, at 271 DAS, variety V_1 showed the maximum mean germination time (27.31) whereas V_2 showed the minimum mean germination time (18.82).

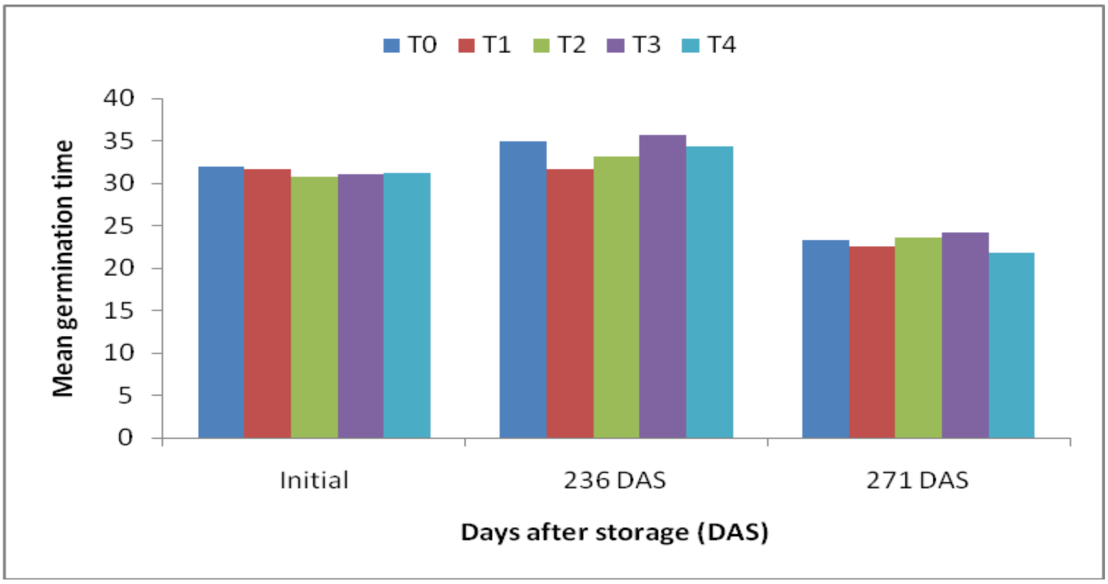
Effect of seed treatment

Non-significant variation was recorded for mean germination time of rice seeds at initial stage and also at 236 and 271 DAS as influenced by different seed treatments (Figure 12 and Appendix VIII). However, at 236 DAS, the minimum mean germination time (31.68) was recorded from T_2 (Aspirin @ 0.1 g/kg seeds) treatment (initially it was 31.59) whereas the maximum mean germination time (35.69) was recorded from T_3 (Bleaching powder @ 2 g/kg seeds) treatment (initially it was 31.11). Similarly, at 271 DAS, the minimum mean germination time (21.80) was recorded from T_4 (Red chili powder @ 2 g/kg seeds) treatment (initially it was 31.24) whereas the maximum mean germination time (24.13) was recorded from T_3 (Bleaching powder @ 2 g/kg seeds) treatment (initially it was 31.11).



V_1 = BRRI dhan87, V_2 = BR 11

Figure 11. Effect of variety on mean germination time of T. aman rice seed ($LSD_{0.05}$= 1.28, 2.93, 2.22 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 12. Effect of seed treatment on mean germination time of T. aman rice seed ($LSD_{0.05}$= 2.02, 4.64, 3.51 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on mean germination time at 236 and 271 days after storage (DAS) while initially non-significant variation was found (Table 6 and Appendix VIII). At 236 DAS, the treatment combination of V_1T_1 gave the minimum mean germination time (30.62) (initially it was 32.98) whereas the maximum mean germination time (37.88) was recorded from V_1T_3 which was significantly similar to the treatment combinations of V_1T_0, V_1T_2, V_1T_4, V_2T_0, V_2T_1, V_2T_2, V_2T_3 and V_2T_4. Similarly, at 271 DAS, the minimum mean germination time (16.70) was found from V_2T_0 (initially it was 32.12) which was significantly similar to the treatment combinations of V_2T_3, V_2T_4, V_2T_1 and V_2T_2 whereas the maximum mean germination time (29.89) was found from V_1T_3 which was significantly similar to the treatment combinations of V_1T_0 and V_1T_2.

Table 6. Combined effect of variety and seed treatment on mean germination time of T. aman rice seed

Treatments	Mean germination time		
	Initial	**236 DAS**	**271 DAS**
V_1T_0	31.73	35.00 ab	29.85 a
V_1T_1	32.98	30.62 b	24.58 bc
V_1T_2	31.77	33.06 ab	27.83 ab
V_1T_3	31.87	37.81 a	29.89 a
V_1T_4	31.43	32.15 ab	24.41 bcd
V_2T_0	32.12	34.81 ab	16.70 e
V_2T_1	30.21	32.75 ab	20.43 cde
V_2T_2	29.70	33.10 ab	19.43 de
V_2T_3	30.35	33.57 ab	18.36 e
V_2T_4	31.06	36.38 ab	19.20 e
$LSD_{(0.05)}$	**NS**	**6.572**	**4.977**
CV(%)	**6.31**	**13.35**	**14.87**

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

V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

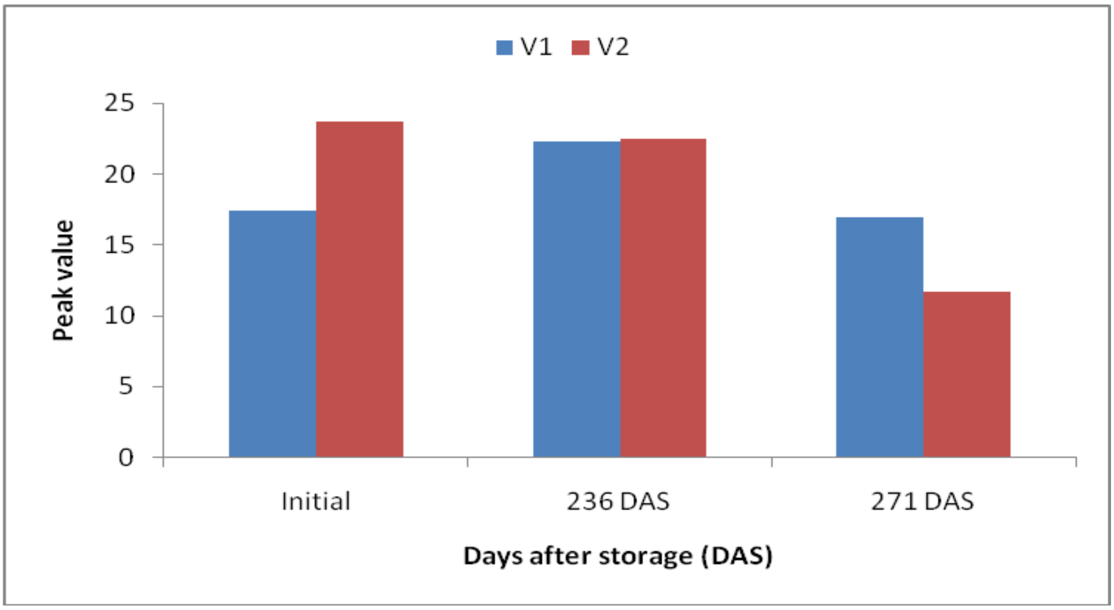
4.7 Peak value

Effect of variety

Different variety of rice seed showed non-significant variation on peak value at 236 DAS but significant variation on peak value was found at 271 DAS while initial seed sample also varied significantly due to varietal difference (Figure 13 and Appendix IX). At 236 DAS, however, the maximum peak value (22.48) was recorded from V_2 (BR 11) (initially it was 23.7) whereas V_1 (BRRI dhan87) gave the minimum peak value (22.28) (initially it was 17.43). At 271 DAS, variety V_1 (BRRI dhan87) showed the maximum peak value (16.93) whereas V_2 (BR 11) showed the minimum peak value (11.69).

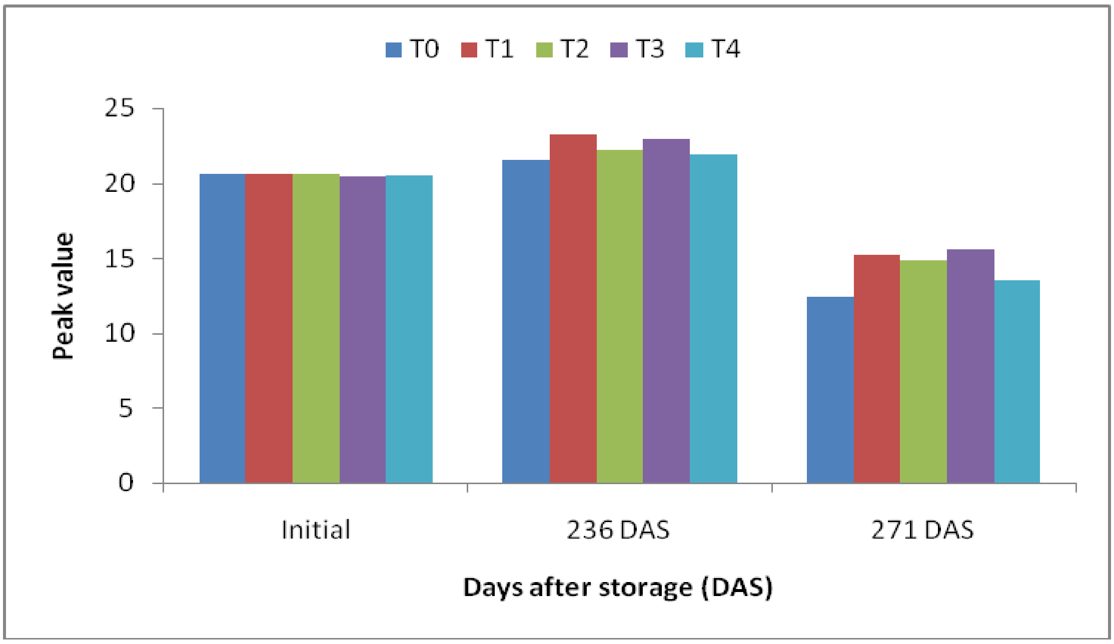
Effect of seed treatment

Different pre-storage seed treatments of rice showed significant variation on peak value at 271 DAS but at 236 DAS, non-significant variation was observed while initially it varied significantly among the treatments (Figure 14 and Appendix IX). At initial stage, the maximum peak value of rice seeds (20.66) was recorded from control treatment T_0 (no seed treatment) that was statistically similar to T_1 (Ascorbic acid @ 0.5 g/kg seeds), T_2 (Aspirin @0.1 g/kg seeds) and T_4 (Red chili powder @ 2 g/kg seeds) whereas the minimum peak value (20.42) was recorded from T_3 (Bleaching powder @ 2 g/kg seeds). At 236 DAS, non-significant variation was found among the treatments, however, the maximum peak value (23.26) was found from T_1 (Ascorbic acid @ 0.5 g/kg seeds) treatment (initially it was 20.61) whereas the minimum peak value (21.56) was found from control treatment T_0 (no seed treatment). At 271 DAS, significant variation was found among the treatments and the maximum peak value (15.60) was found from T_3 (Bleaching powder @ 2 g/kg seeds) (initially it was 20.42) that was statistically similar to T_1 (Ascorbic acid @ 0.5 g/kg seeds) and T_2 (Aspirin @ 0.1 g/kg seeds) whereas the minimum peak value (12.40) was recorded from control treatment T_0 (no seed treatment) (initially it was 20.66) that was statistically similar to T_4 (Red chili powder @ 2 g/kg seeds).



V_1 = BRRI dhan87, V_2 = BR 11

Figure 13. Effect of variety on peak value of T. aman rice seed ($LSD_{0.05}$= 0.10, 1.22, 1.14 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 14. Effect of seed treatment on peak value of T. aman rice seed ($LSD_{0.05}$= 0.17, 1.94, 1.81 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on peak value at 236 and 271 days of storage including initial seed samples (Table 7 and Appendix IX). Initially, the maximum peak value (23.81) was recorded from V_2T_0 and V_2T_1 whereas V_1T_3 showed the minimum peak value (17.35). At 236 DAS, the treatment combination of V_2T_1 gave the maximum peak value (24.40) (initially it was 23.81) which was statistically similar to the treatment combinations of V_1T_0, V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_2T_2, V_2T_3 and V_2T_4 whereas V_2T_0 gave the minimum seed peak value (21.25) (initially it was 23.81). At 271 DAS, the maximum peak value (18.45) was recorded from V_1T_3 (initially it was 17.35) which was statistically similar to the treatment combinations of V_1T_1 and V_1T_2 whereas V_2T_0 gave the minimum peak value (9.24) (initially it was 23.81) that was statistically similar to the treatment combinations of V_2T_4.

Table 7. Combined effect of variety and seed treatment on peak value of T. aman rice seed

Treatments	Peak value		
	Initial	**236 DAS**	**271 DAS**
V_1T_0	17.51 c	21.88 ab	15.57 bc
V_1T_1	17.41 c	22.13 ab	17.18 ab
V_1T_2	17.45 c	22.25 ab	17.90 ab
V_1T_3	17.35 c	23.25 ab	18.45 a
V_1T_4	17.45 c	21.88 ab	15.58 bc
V_2T_0	23.81 a	21.25 b	9.24 e
V_2T_1	23.81 a	24.40 a	13.20 cd
V_2T_2	23.70 ab	22.13 ab	11.83 d
V_2T_3	23.50 b	22.63 ab	12.75 d
V_2T_4	23.67 ab	22.00 ab	11.43 de
$LSD_{(0.05)}$	**0.236**	**2.749**	**2.569**
CV(%)	**0.79**	**8.47**	**12.37**

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

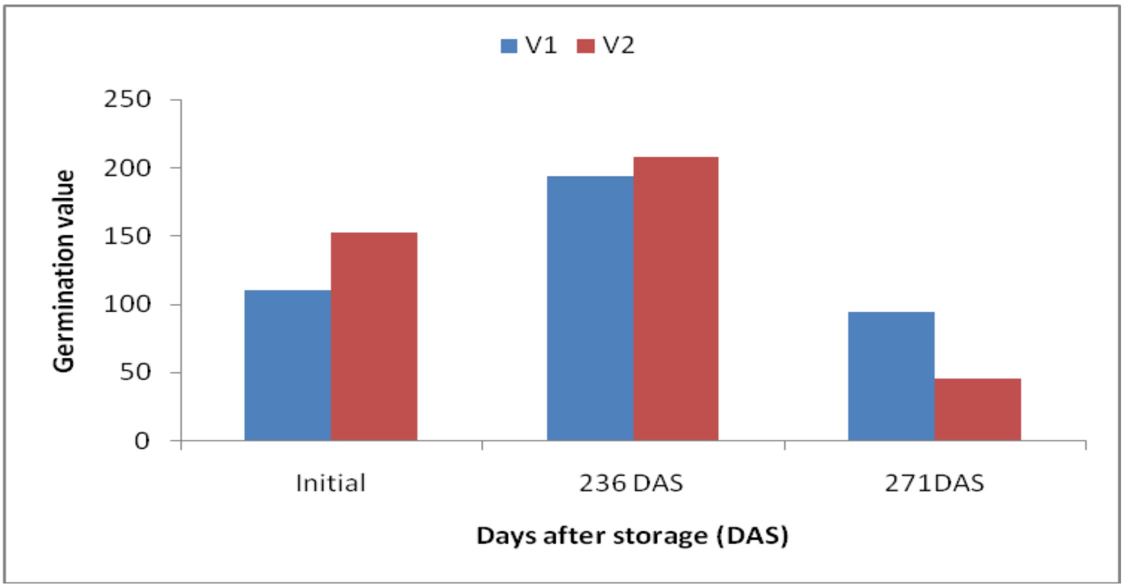
V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

4.8 Germination value

Effect of variety

Statistically significant variation on germination value of rice seeds of different varieties at 236 and 271 DAS including initial level (Figure 15 and Appendix X). At 236 DAS, the maximum germination value (207.50) was recorded from V_2 (BR 11) (initially it was 152.60) whereas V_1 (BRRI dhan87) gave the minimum germination value (193.38) (initially it was 110.36). Similarly, at 271 DAS, variety V_1 (BRRI dhan87) showed the maximum germination value (93.94) whereas V_2 (BR 11) showed the minimum germination value (44.81).

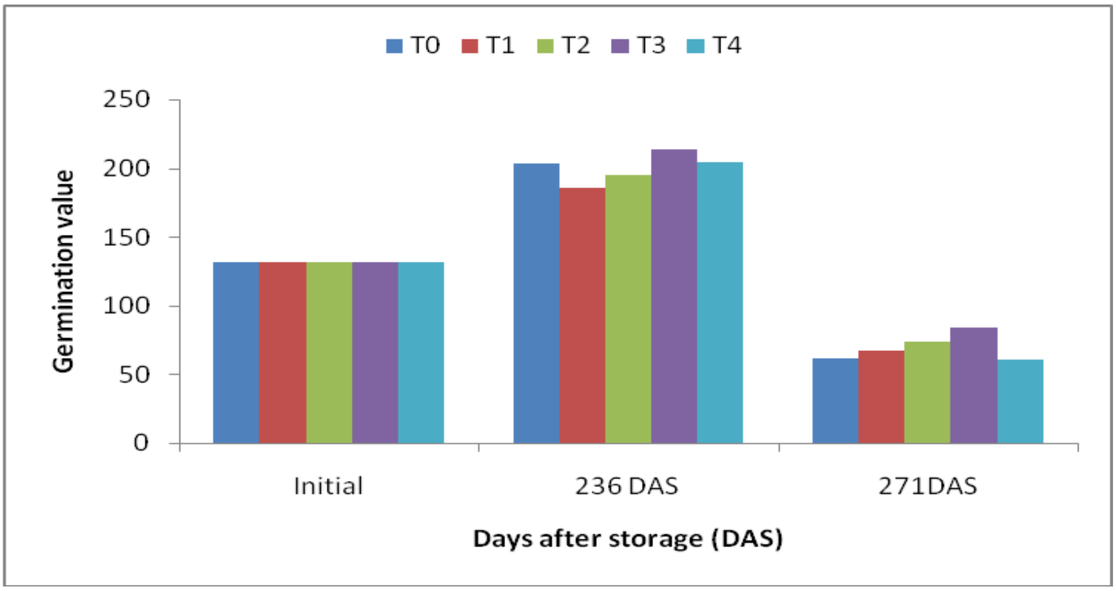


V_1 = BRRI dhan87, V_2 = BR 11

Figure 15. Effect of variety on germination value of T. aman rice seed ($LSD_{0.05}$= 0.13, 2.01, 0.19 at initial, 236 DAS and 271 DAS, respectively).

Effect of seed treatment

Different pre-storage seed treatments of rice showed significant variation on germination value at all storage duration mentioned at 236 and 271 DAS but at initial levels non-significant variation was found (Figure 16 and Appendix X). At 236 DAS, the maximum germination value (213.29) was found from T_3 (Bleaching powder @ 2 g/kg seeds) treatment (initially it was 131.43) followed by control treatment T_0 (no seed treatment) and T_4 (Red chili powder @ 2 g/kg seeds) whereas the minimum germination value (185.93) was found from T_1 (Ascorbic acid @ 0.5 g/kg seeds). At 271 DAS, the maximum germination value (83.60) was found from T_3 (Bleaching powder @ 2 g/kg seeds) (initially it was 131.43) followed by T_2 (Aspirin @ 0.1 g/kg seeds) whereas the minimum germination value (60.36) was recorded from T_4 (Red chili powder @ 2 g/kg seeds) (initially it was 131.41) that was significantly different from other treatments.



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 16. Effect of seed treatment on germination value of T. aman rice seed ($LSD_{0.05}$= 0.21, 3.18, 0.30 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on germination value at 236 and 271 days of storage including initial level (Table 8 and Appendix X). Initially, the maximum germination value (152.80) was recorded from V_2T_1 whereas V_1T_3 showed the minimum germination value (110.28). At 236 DAS, the treatment combination of V_1T_3 gave the maximum germination value (222.06) (initially it was 110.28) which was significantly different to other treatment combinations followed by V_2T_1 and V_2T_4 whereas V_1T_1 gave the minimum seed germination value (155.99) (initially it was 110.52). At 271 DAS, the maximum germination value (115.85) was recorded from V_1T_3 (initially it was 110.28) followed by V_1T_2 whereas V_2T_0 gave the minimum germination value (28.95) (initially it was 152.48) that was significantly different to the treatment combinations.

Table 8. Combined effect of variety and seed treatment on germination value of T. aman rice seed

Treatments	**Germination value**		
	Initial	**236 DAS**	**271DAS**
V_1T_0	110.39 c	204.55 c	94.21 c
V_1T_1	110.52 c	155.99 f	81.82 d
V_1T_2	110.30 c	192.82 de	102.62 b
V_1T_3	110.28 c	222.06 a	115.85 a
V_1T_4	110.32 c	191.46 e	75.19 e
V_2T_0	152.48 b	202.61 c	28.95 i
V_2T_1	152.80 a	215.87 b	52.84 f
V_2T_2	152.63 ab	197.16 d	45.37 h
V_2T_3	152.58 ab	204.52 c	51.35 g
V_2T_4	152.50 ab	217.33 b	45.53 h
$LSD_{(0.05)}$	**0.310**	**4.507**	**0.433**
CV(%)	**0.16**	**1.55**	**0.43**

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

V_1 = BRRI dhan87, V_2 = BR 11

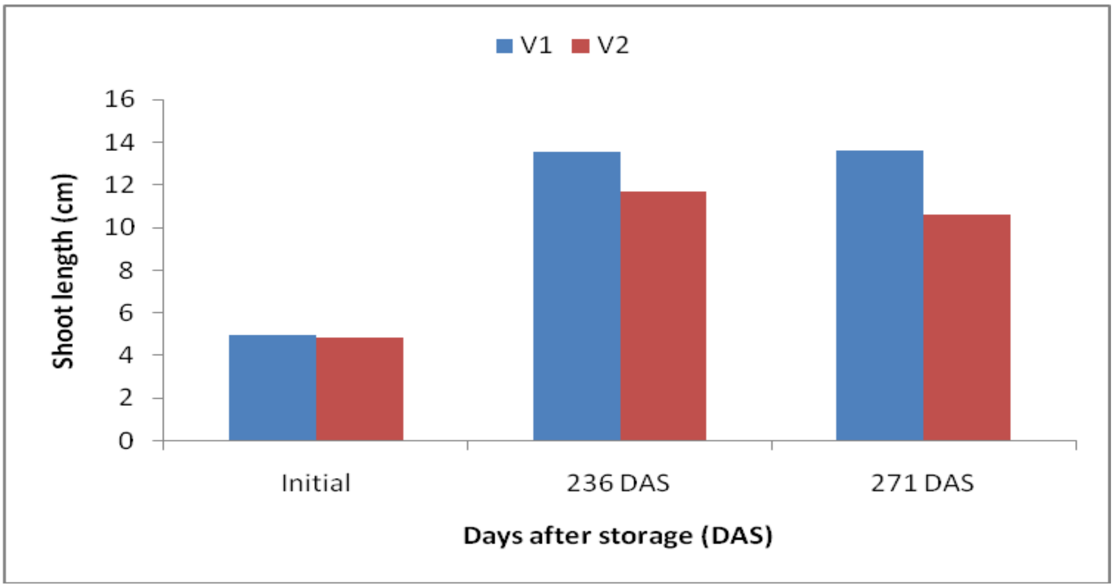
T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

4.9 Shoot length

Effect of variety

Different variety of shoot length produced from stored seed varied significantly at 236 and 271 days after storage (DAS) but initially it showed non-significant variation (Figure 17 and Appendix XI). Results showed that the variety V_1

(BRRI dhan87) gave the highest shoot length (13.55 and 13.59 cm at 236 and 271 DAS, respectively) (initially it was 4.93 cm) whereas the variety V_2 (BR 11) showed the lowest shoot length (11.67 and 10.58 cm at 236 and 271 DAS, respectively) (initially it was 4.80 cm).



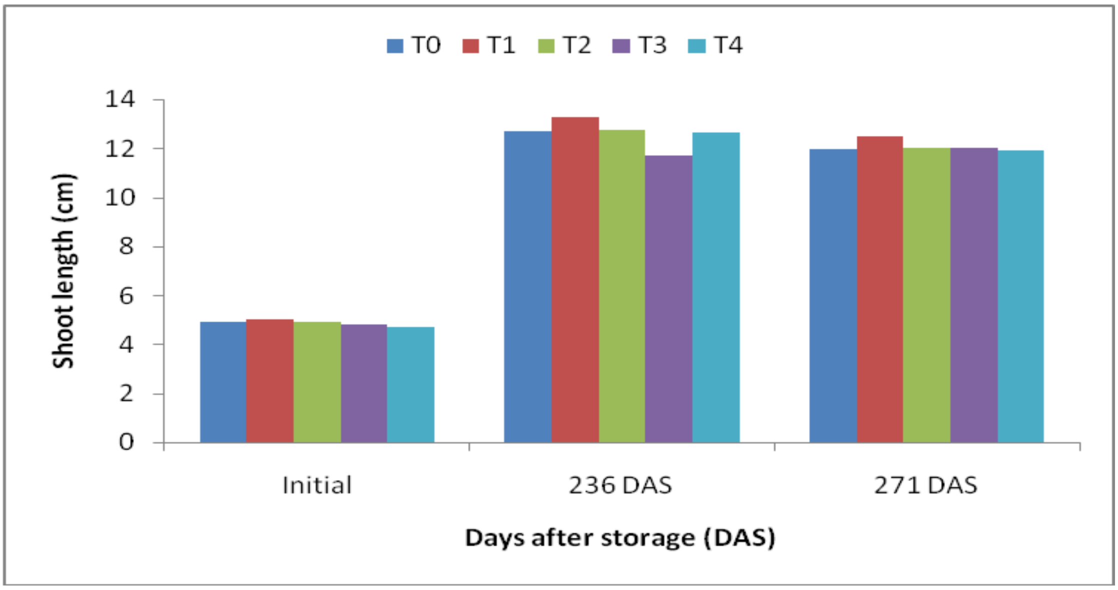
V_1 = BRRI dhan87, V_2 = BR 11

Figure 17. Effect of variety on shoot length of T. aman rice seed ($LSD_{0.05}$= 0.27, 1.11, 1.09 at initial, 236 DAS and 271 DAS, respectively).

Effect of seed treatment

Different pre-storage seed treatments of rice showed non-significant variation among the treatments on shoot length of initial seeds storage stage, seeds of 236 DAS and 271 DAS (Figure 18 and Appendix XI). However, at 236 and 271 DAS, the highest shoot length (13.29 and 12.51 cm) was found from T_1 (Ascorbic acid @ 0.5 g/kg seeds) treatment (initially it was 5.01 cm) whereas the lowest shoot length at 236 DAS (11.71 cm) (initially it was 4.82 cm) was found from T_3 (Bleaching powder @ 2 g/kg seeds) but the lowest shoot length at 271 DAS (11.91 cm) was found from T_4 (Red chili powder @ 2 g/kg seeds) treatment (initially it was 4.70 cm). Similar result was observed by Padhi *et al*.

(2017) and Thobunluepop *et al*. (2009) who found higher shoot length from treated stored seeds compared to non-treated stored seeds of rice. Similar result was also observed by Goswami *et al*. (2017) in soybean, Veraja and Rai (2015) in black gram, Udabal *et al*. (2014) in Custard apple and Sushma (2013) in chickpea.



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 18. Effect of seed treatment on shoot length of T. aman rice seed ($LSD_{0.05}$= 0.43, 1.75, 1.73 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on shoot length of stored seed at 236 and 271 storage but shoot length of initial seeds showed non-significant variation among the treatment combinations (Table 9 and Appendix XI). At 236 DAS, the treatment combination of V_1T_1 gave the highest shoot length (14.32 cm) (initially it was 5.21 cm) that was statistically similar to the treatment combinations of V_1T_0, V_1T_2, V_1T_4 and V_2T_1 whereas V_2T_2 gave the minimum shoot length (11.42 cm) (initially it was 4.67 cm). At 271 DAS, the highest shoot length (14.00 cm) was recorded from V_1T_2 (initially it was 5.14 cm) that was statistically similar to the treatment combinations of V_1T_0, V_1T_1, V_1T_3, V_1T_4 and V_2T_1 whereas V_2T_2 gave the lowest shoot length (10.03 cm) (initially it was 4.67 cm) that was statistically similar to the treatment combinations of V_2T_3 and V_2T_4.

Table 9. Combined effect of variety and seed treatment on shoot length of T. aman rice seed

Treatments	Shoot length (cm)		
	Initial	236 DAS	271 DAS
V_1T_0	4.81	13.62 abc	13.68 a
V_1T_1	5.21	14.32 a	13.40 a
V_1T_2	5.14	14.12 ab	14.00 a
V_1T_3	4.88	11.59 c	13.30 a
V_1T_4	4.62	14.10 ab	13.58 a
V_2T_0	4.99	11.74 bc	10.28 b
V_2T_1	4.80	12.25 abc	11.63 ab
V_2T_2	4.67	11.42 c	10.03 b
V_2T_3	4.76	11.82 bc	10.73 b
V_2T_4	4.79	11.16 c	10.25 b
$LSD_{(0.05)}$	**NS**	**2.485**	**2.454**
CV(%)	**8.68**	**13.58**	**14.00**

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

V_1 = BRRI dhan87, V_2 = BR 11

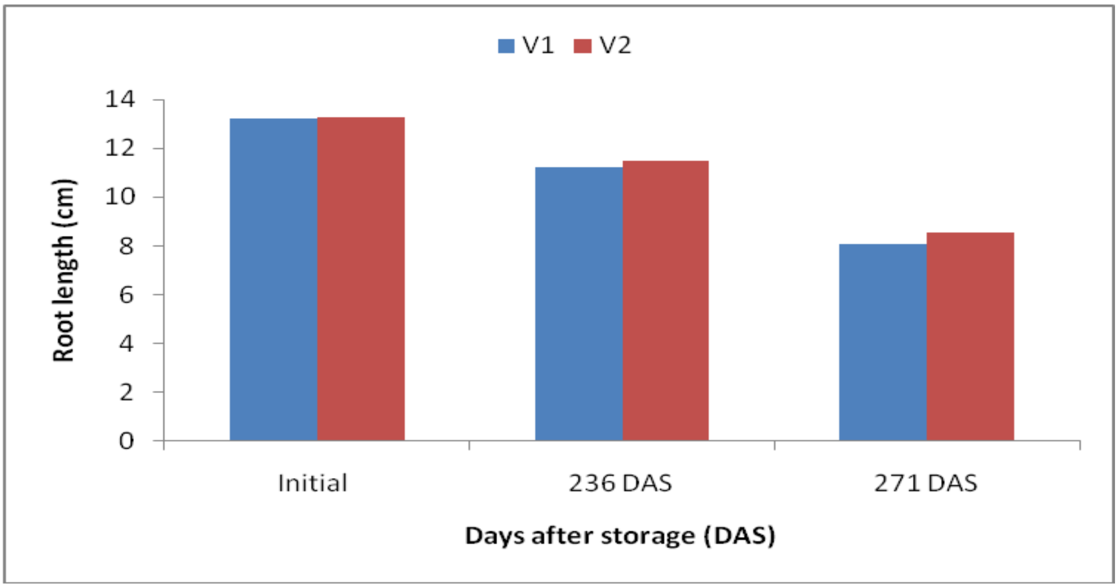
T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

DAS = Days after storage

4.10 Root length

Effect of variety

Different variety of root length produced from stored seed showed non-significant variation at 236 and 271 days after storage (DAS) including initial stage (Figure 19 and Appendix XII). However, results showed that the variety V_2 (BR 11) gave the highest root length (11.47 and 8.53 cm at 236 and 271 DAS, respectively) (initially it was 13.27 cm) whereas the variety V_1 (BRRI dhan87) showed the lowest root length (11.21 and 8.06 cm at 236 and 271 DAS, respectively) (initially it was 4.80 cm).

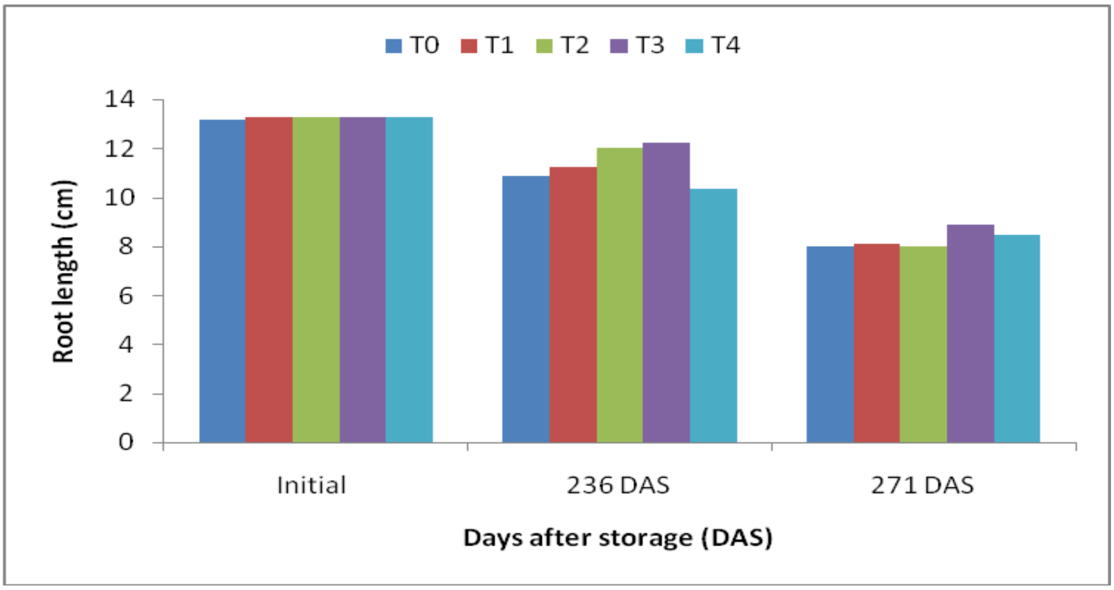


V_1 = BRRI dhan87, V_2 = BR 11

Figure 19. Effect of variety on root length of T. aman rice seed ($LSD_{0.05}$= 0.10, 1.03, 0.72 at initial, 236 DAS and 271 DAS, respectively).

Effect of seed treatment

Different pre-storage seed treatments of rice showed non-significant variation among the treatments on root length of initial stage and seeds of 271 DAS but at 236 DAS, significant variation was found (Figure 20 and Appendix XII). At 236 DAS, the highest root length (12.25 cm) was found from T_3 (Bleaching powder @ 2 g/kg seeds) treatment (initially it was 13.26 cm) and it was statistically similar to T_1 (Ascorbic acid @ 0.5 g/kg seeds), T_2 (Aspirin @ 0.1 g/kg seeds) and control treatment T_0 (no seed treatment) whereas the lowest root length (10.33 cm) was found from T_4 (Red chili powder @ 2 g/kg seeds) treatment (initially it was 13.27 cm). At 271 DAS, non-significant variation was found among the treatments, however, the highest root length (8.90 cm) was found from T_3 (Bleaching powder @ 2 g/kg seeds) treatment (initially it was 13.26 cm) whereas the lowest root length (7.99 cm) was found from T_2 (Aspirin @ 0.1 g/kg seeds) treatment (initially it was 13.25 cm). Supported result was observed by Padhi *et al*. (2017) and Thobunluepop *et al*. (2009) in rice who found higher root length from treated stored seeds compared to non-treated stored seeds. Similar result was also observed by Goswami *et al*. (2017) in soybean, Veraja and Rai (2015) in black gram, Sushma (2013) in chickpea and Pathare (2013) in cotton seed.



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 20. Effect of seed treatment on root length of T. aman rice seed ($LSD_{0.05}$= 0.15, 1.63, 1.15 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on root length of stored seed at 236 DAS, but root length of initial seeds and seeds of 271 DAS showed non-significant variation among the treatment combinations (Table 10 and Appendix XII). At 236 DAS, the treatment combination of V_2T_3 gave the highest root length (13.12 cm) (initially it was 13.29 cm) that was statistically similar to the treatment combinations of V_1T_2 and V_2T_2 whereas V_2T_4 gave the lowest root length (9.47 cm) (initially it was 13.27 cm). At 271 DAS, non-significant variation was found on root length among the treatment combinations, however, the highest root length (9.08 cm) was recorded from V_2T_3 (initially it was 13.29 cm) whereas V_1T_1 gave the lowest root length (7.65 cm) (initially it was 13.27 cm).

Table 10. Combined effect of variety and seed treatment on root length of T. aman rice seed

Treatments	Root length (cm)		
	Initial	236 DAS	271 DAS
V_1T_0	13.19	10.50 bc	7.78
V_1T_1	13.27	11.18 abc	7.65
V_1T_2	13.18	12.25 ab	8.23
V_1T_3	13.23	10.94 abc	8.73
V_1T_4	13.27	11.19 abc	7.93
V_2T_0	13.16	11.22 abc	8.25
V_2T_1	13.30	11.30 abc	8.55
V_2T_2	13.32	12.25 ab	7.75
V_2T_3	13.29	13.12 a	9.08
V_2T_4	13.27	9.47 c	9.00
$LSD_{(0.05)}$	**NS**	**2.313**	**NS**
CV(%)	**1.17**	**14.06**	**13.54**

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

V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

4.11 Total length

Effect of variety

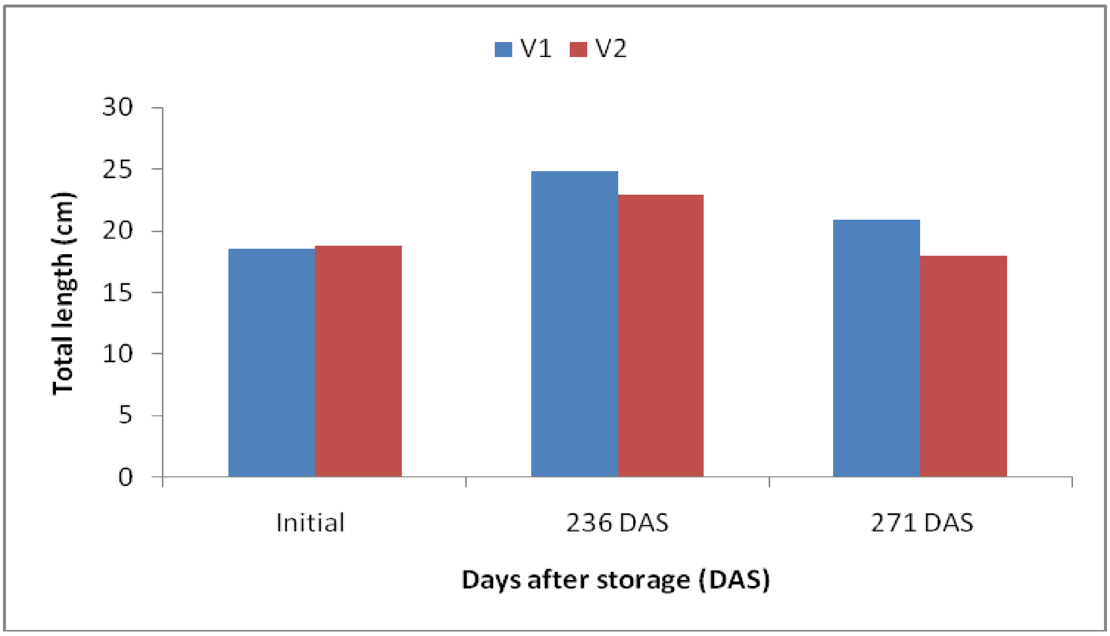
Total length of seedling of different rice varieties, produced from stored seed showed significant variation at 236 and 271 days after storage (DAS) but initially it was not varied significantly (Figure 21 and Appendix XIII). Results showed that the variety V_1 (BRRI dhan87) gave the highest total length (24.82 and 20.89 cm at 236 and 271 DAS, respectively) (initially it was 18.51 cm) whereas the variety V_2 (BR 11) showed the lowest total length (22.88 and 17.90 cm at 236 and 271 DAS, respectively) (initially it was 18.74 cm).

Effect of seed treatment

Different pre-storage seed treatments of rice showed non-significant variation among the treatments on total length of initial seeds storage stage and seeds of 271 DAS but at 236 DAS, significant variation was found (Figure 22 and Appendix XIII). At 236 DAS, the highest total length (25.01 cm) was found from T_2 (Aspirin @ 0.1 g/kg seeds) treatment (initially it was 18.55 cm) and it was statistically similar to T_1 (Ascorbic acid @ 0.5 g/kg seeds), T_3 (Bleaching powder @ 2 g/kg seeds) and control treatment T_0 (no seed treatment) whereas the lowest total length (22.55 cm) was found from T_4 (Red chili powder @ 2 g/kg seeds) treatment (initially it was 18.60 cm). At 271 DAS, non-significant variation was found among the treatments, however the highest total length (20.24 cm) was found from T_1 (Ascorbic acid @ 0.5 g/kg seeds) (initially it was 18.69 cm) whereas the lowest total length (18.46 cm) was found from T_4 (Red chili powder @ 2 g/kg seeds) treatment (initially it was 18.60 cm). This result was conformity with the findings of Padhi *et al*. (2017) and Thobunluepop *et al*. (2009) who found higher shoot and root length in rice from treated stored seeds compared to non-treated stored seeds.

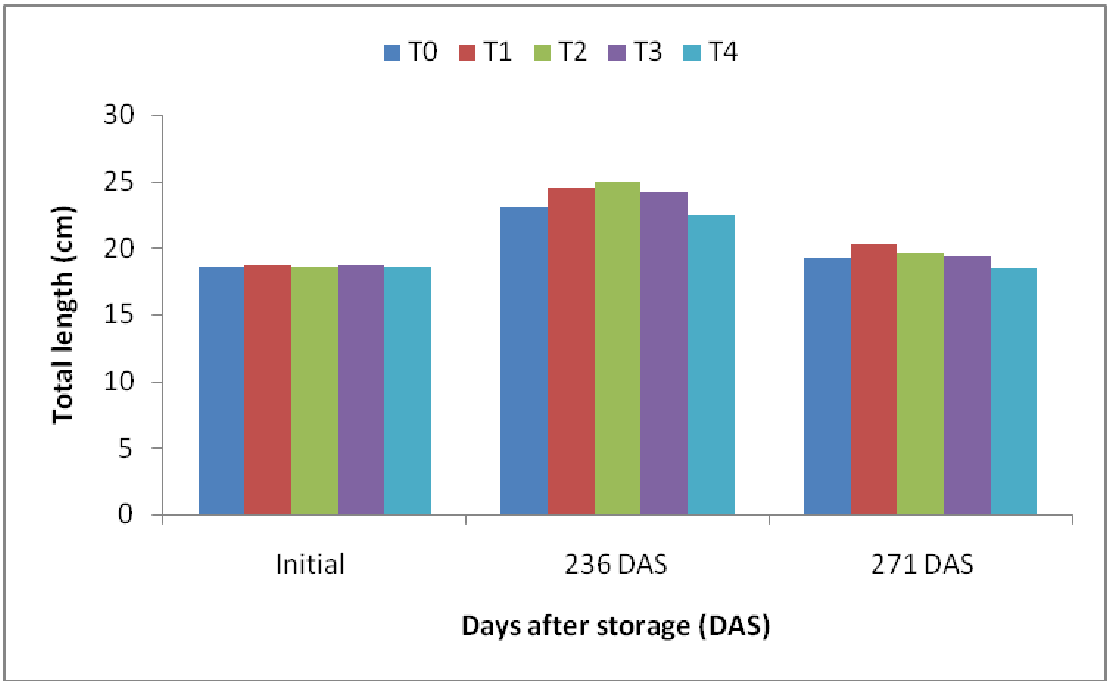
Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on total length of stored seeds of 236 DAS and 271 DAS (Table 11 and Appendix XIII). At 236 DAS, the treatment combination of V_1T_2 gave the highest total length (26.37 cm) (initially it was 18.55 cm) that was statistically similar to the treatment combinations of V_1T_1, V_1T_3, V_1T_4 and V_2T_2 whereas V_2T_4 gave the lowest total length (20.80 cm) (initially it was 18.80 cm). At 271 DAS, the highest total length (22.23 cm) was recorded from V_1T_1 (initially it was 18.78 cm) which was statistically similar to V_1T_0, V_1T_2, V_1T_3, V_1T_4 and V_2T_0 whereas V_2T_2 gave the lowest total length (17.00 cm) (initially it was 18.55 cm) which was statistically similar to V_2T_3 and V_2T_4.



V_1 = BRRI dhan87, V_2 = BR 11

Figure 21. Effect of variety on total length of T. aman rice seed ($LSD_{0.05}$= 0.23, 1.25, 1.77 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 22. Effect of seed treatment on total length of T. aman rice seed ($LSD_{0.05}$= 0.37, 1.98, 2.80 at initial, 236 DAS and 271 DAS, respectively).

Table 11. Combined effect of variety and seed treatment on total length of T. aman rice seed

Treatments	Total length (cm)		
	Initial	**236 DAS**	**271 DAS**
V_1T_0	18.24	23.18 bc	20.30 abc
V_1T_1	18.78	25.50 ab	22.23 a
V_1T_2	18.55	26.37 a	22.10 ab
V_1T_3	18.57	24.87 ab	20.88 abc
V_1T_4	18.39	24.31 ab	18.93 abc
V_2T_0	18.98	22.95 bc	18.30 abc
V_2T_1	18.59	23.55 bc	18.25 bc
V_2T_2	18.55	23.66 ab	17.00 c
V_2T_3	18.78	23.43 bc	17.95 c
V_2T_4	18.80	20.80 c	18.00 c
$LSD_{(0.05)}$	**NS**	**2.807**	**3.967**
CV(%)	**1.98**	**8.11**	**14.10**

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

V_1 = BRRI dhan87, V_2 = BR 11

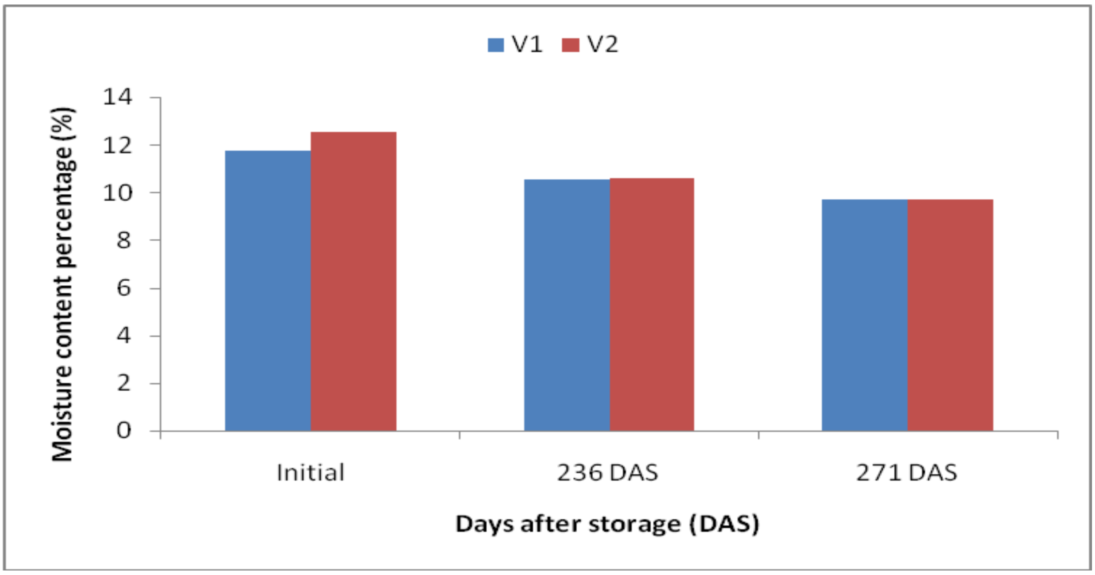
T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

DAS = Days after storage

4.12 Moisture percentage

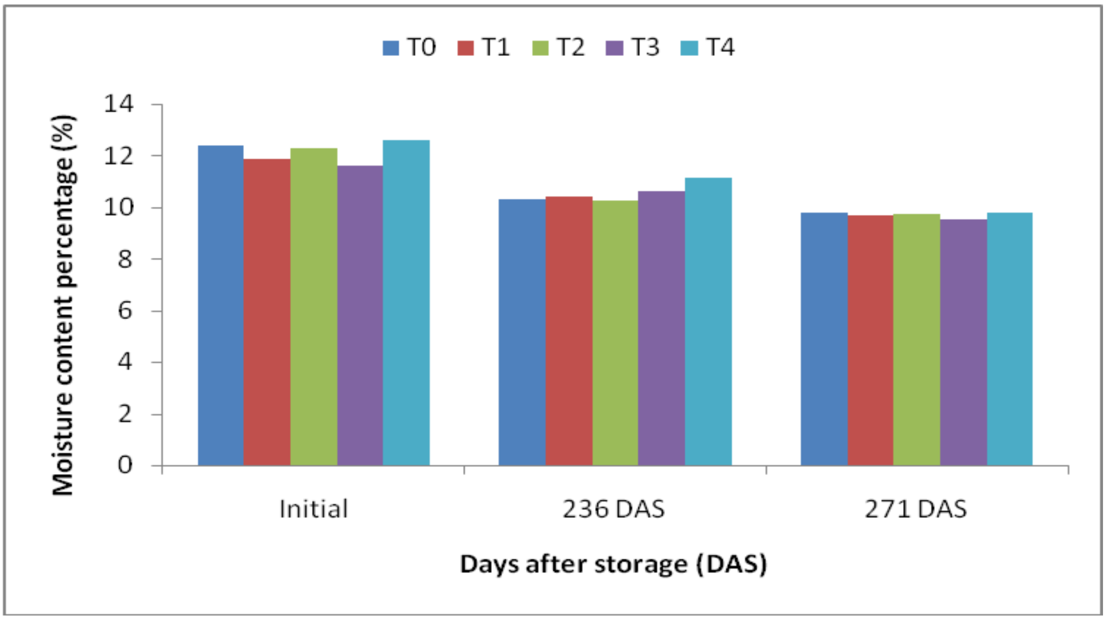
Effect of variety

Moisture content of different stored seeds of rice varieties showed non-significant variation at 236 and 271 days after storage (DAS) but initially it was varied significantly (Figure 23 and Appendix XIV). Initially, the variety V_2 (BR 11) showed the maximum moisture percentage (12.54%) whereas the V_1 (BRRI dhan87) showed the minimum moisture percentage (11.76%). Again, at 236 and 271 DAS, non-significant variation was found, however, the maximum moisture percentage (10.58 and 9.72%, respectively) was recorded from the variety V_2 (BR 11) (initially it was 12.54%) whereas the minimum moisture percentage (10.52 and 9.68%, respectively) was recorded from the variety V_1 (BRRI dhan87) (initially it was 11.76%).



V_1 = BRRI dhan87, V_2 = BR 11

Figure 23. Effect of variety on moisture content of T aman rice seed ($LSD_{0.05}$= 0.34, 0.22, 0.16 at initial, 236 DAS and 271 DAS, respectively).



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 24. Effect of seed treatment on moisture content of T aman rice seed ($LSD_{0.05}$= 0.55, 0.35, 0.26 at initial, 236 DAS and 271 DAS, respectively).

Effect of seed treatment

Different pre-storage seed treatments of rice showed significant variation among the treatments on moisture content percentage of initial seeds and seeds of 236 DAS but at 271 DAS, non-significant variation was found (Figure 24 and Appendix XIV). Initially, the maximum moisture percentage (12.58%) was found from T_4 (Red chili powder @ 2 g/kg seeds) treatment that was statistically similar to T_2 (Aspirin @ 0.1 g/kg seeds) and control treatment T_0 (no seed treatment) whereas the minimum moisture percentage (11.61%) was found from T_3 (Bleaching powder @ 2 g/kg seeds) treatment. At 236 DAS, the maximum moisture percentage (11.13%) was found from T_2 (Aspirin @ 0.1 g/kg seeds) treatment (initially it was 12.58%), which was followed by T_3 (Bleaching powder 2 g/kg seeds) whereas the minimum moisture percentage (10.23%) was recorded from T_2 (Aspirin @ 0.1 g/kg seeds) treatment (initially it was 12.29%). At 271 DAS, non-significant variation was found among the treatments, however the maximum moisture percentage (9.80%) was found from control treatment T_0 (no seed treatment) (initially it was 12.39%) whereas the minimum moisture percentage (9.54%) was found from T_3 (Bleaching powder @ 2 g/kg seeds) treatment (initially it was 11.61%). It is evident that High seed moisture 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. Heydeeker (1972) and Harrington (1972) also reported that seed deterioration increased as moisture content increased, which resulted in loss of viability and poor germination. Under the present study, it was found that the treated seeds including control those had higher moisture content during storage that showed lower germination percentage. In an experiment, Vietra *et al*. (2001) observed higher viability and germination with lower moisture content during storage in onion, tomato and carrot (Padma and Reddy, 2004).

Combined effect of variety and seed treatment

Different treatment combination of variety and seed treatments showed significant variation on moisture content percentage of initial samples and stored seeds of 236 DAS and 271 DAS (Table 12 and Appendix XIV). At initial stage the maximum moisture percentage (12.91%) was recorded from V_2T_4 was statistically similar to the treatment combinations of V_2T_0 and V_2T_2 whereas V_1T_3 gave the lowest moisture percentage (10.17%). Again, at 236 DAS, the treatment combination of V_1T_4 gave the maximum moisture percentage (11.19%) (initially it was 12.25%) that was statistically similar with V_2T_3 and V_2T_4 whereas V_2T_2 gave the minimum moisture percentage (10.09%) (initially it was 12.69%). At 271 DAS, the maximum moisture content percentage (10.09%) was recorded from V_2T_0 (initially it was 12.67%), which was statistically similar to V_1T_4 whereas V_1T_3 gave the minimum moisture percentage (9.45%) (initially it was 10.71%) which was statistically similar to V_2T_1.

Table 12. Combined effect of variety and seed treatment on moisture content of T. aman rice seed

Treatments	Moisture (%)		
	Initial	**236 DAS**	**271 DAS**
V_1T_0	12.11 bc	10.21 c	9.51 cd
V_1T_1	11.82 c	10.45 bc	9.85 abc
V_1T_2	11.89 c	10.38 c	9.71 bcd
V_1T_3	10.71 d	10.39 c	9.45 d
V_1T_4	12.25 abc	11.19 a	9.91 ab
V_2T_0	12.67 ab	10.44 bc	10.09 a
V_2T_1	11.95 bc	10.39 c	9.50 cd
V_2T_2	12.69 ab	10.09 c	9.76 abcd
V_2T_3	12.51 abc	10.90 ab	9.64 bcd
V_2T_4	12.91 a	11.07 a	9.63 bcd
$LSD_{(0.05)}$	**0.780**	**0.507**	**0.377**
CV(%)	**4.42**	**3.31**	**2.68**

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

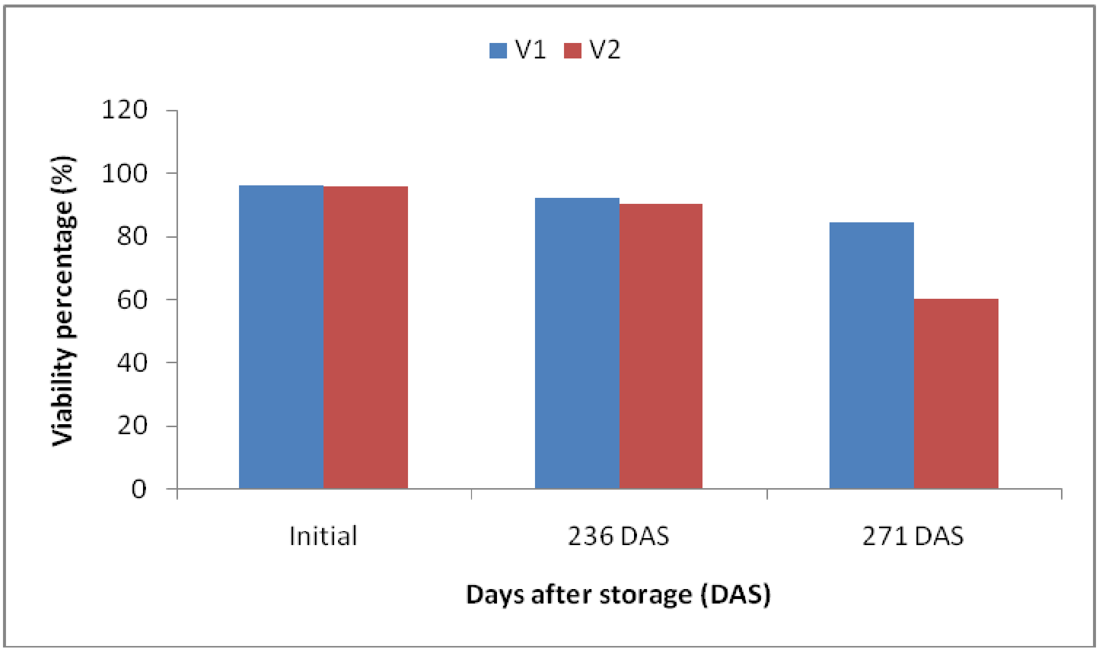
V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

4.13 Viability percentage

Effect of variety

Varietal performance of rice seed during storage showed significant variation on viability percentage at 271 days after storage (DAS) but seeds at initial condition and seed of 236 DAS showed non-significant variation (Figure 25 and Appendix XV). Initially the seed viability percentage of the variety V_1 (BRRI dhan87) was higher than V_2 (BR 11) (95.93 and 95.78%, respectively). Again, at 236 DAS, non-significant variation was found on viability percentage between V_1 (BRRI dhan87) and V_2 (BR 11), however, V_1 (BRRI dhan87) showed higher viability percentage (91.95%) than V_2 (BR 11) (90.30%). At 271 DAS, significant variation on viability percentage was recorded and the variety V_1 (BRRI dhan87) showed the maximum viability germination (84.15%) whereas the minimum viability percentage (60.10%) was recorded from the variety V_2 (BR 11).

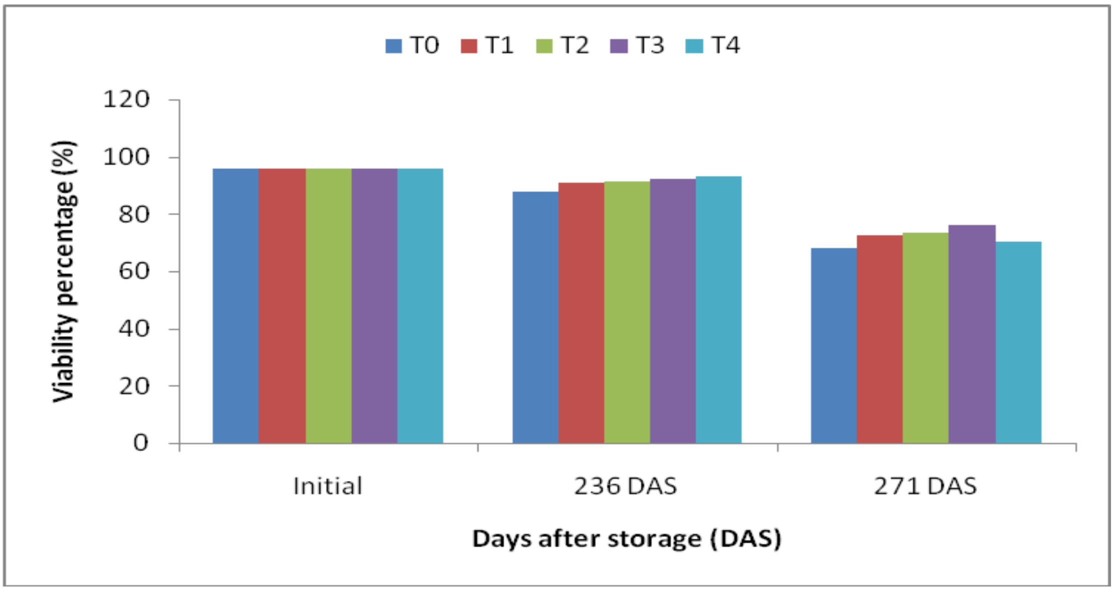


V_1 = BRRI dhan87, V_2 = BR 11

Figure 25. Effect of variety on viability percentage of T. aman rice seed ($LSD_{0.05}$= 0.24, 2.21, 3.03 at initial, 236 DAS and 271 DAS, respectively).

Effect of seed treatment

Significant variation was recorded for viability percentage of rice seeds at 236 and 271 DAS by different seed treatments before storage but initially it was not differed significantly (Figure 26 and Appendix XV). It was observed that viability percentage was gradually decreased with the increasing of storage duration. At 236 DAS, the maximum viability percentage (93.13%) was found from the seed treatment of T_4 (Red chili powder @ 2 g/kg seeds) (initially it was 95.88%) that was statistically similar to T_1 (Ascorbic acid @ 0.5 g/kg seeds), T_2 (Aspirin @ 0.1 g/kg seeds) and T_3 (Bleaching powder @ 2 g/kg seeds) whereas control treatment T_0 (no seed treatment) showed the minimum seed viability percentage (87.75%) (initially it was 96.00%). At 271 DAS, the maximum viability percentage (76.00%) was recorded from the seed treatment of T_3 (Bleaching powder @ 2 g/kg seeds) (initially it was 95.75%) that was significantly similar to the treatment of T_1 (Ascorbic acid @ 0.5 g/kg seeds) and T_2 (Aspirin @ 0.1 g/kg seeds) whereas the minimum viability percentage (68.00%) was recorded from the control treatment T_0 (no seed treatment) (initially it was 96.00%). Dornbos (1994) defined seed viability as the capacity of the seed to germinate and produce a normal seedling which depends on pathogen activities, moisture content and sugar content in seeds. 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. Heydeeker (1972) and Harrington (1972) also reported that seed deterioration increased as moisture content increased which resulted in loss of viability and poor germination. Germination capacity is the most practical indicator of seed viability and vigour (Anuja and Aneja, 2004). Sud *et al*. (2005) found that pre-storage treated seeds showed higher viability in kidney bean compared to non-treated seeds.



T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

Figure 26. Effect of seed treatment on viability percentage of T. aman rice seed ($LSD_{0.05}$= 0.38, 3.50, 4.79 at initial, 236 DAS and 271 DAS, respectively).

Combined effect of variety and seed treatment

Different rice varieties combined with different seed treatments showed significant variation on viability percentage of rice seeds at initial level and also at different days after storage (DAS) (Table 13 and Appendix XV). Initially, the treatment combination of V_1T_4 exhibited the maximum seed viability percentage (96.25%), which was statistically similar to the treatment combinations of V_1T_0, V_1T_1, V_1T_3, V_2T_0, V_2T_1 and V_2T_2 whereas the minimum seed viability percentage (95.50%) was given by V_2T_4 that was significantly similar to V_1T_2. Again, at 236 DAS, result exhibited that the treatment combination of V_1T_4 gave the maximum seed viability percentage (94.25%) (initially it was 94.25%), which was statistically similar to the treatment combinations of V_1T_0, V_1T_1, V_1T_2, V_1T_3, V_2T_1, V_2T_2, V_2T_3 and V_2T_4 whereas the treatment combinations of V_2T_0 gave the minimum seed viability percentage (85.50%) while initially, it was 96.00%. At 271 DAS, V_1T_3 gave the maximum viability percentage (89.00%) (initially it was 95.88%), which was significantly similar to the treatment combinations of V_1T_0 and V_1T_2 whereas the V_2T_0 gave the minimum seed viability percentage (51.50%) (initially it was 96.00%), which was significantly different from other treatment combinations.

Table 13. Combined effect of variety and seed treatment on viability percentage of T. aman rice seed

Treatments	Viability (%)		
	Initial	**236 DAS**	**271 DAS**
V_1T_0	96.00 ab	90.00 ab	84.50 ab
V_1T_1	95.88 ab	91.00 a	81.75 b
V_1T_2	95.63 b	90.50 a	85.5 ab
V_1T_3	95.88 ab	94.00 a	89.00 a
V_1T_4	96.25 a	94.25 a	80.00 b
V_2T_0	96.00 ab	85.50 b	51.50 d
V_2T_1	95.88 ab	91.00 a	63.50 c
V_2T_2	95.88 ab	92.50 a	61.50 c
V_2T_3	95.63 b	90.50 a	63.00 c
V_2T_4	95.50 b	92.00 a	61.00 c
$LSD_{(0.05)}$	**0.539**	**4.952**	**6.7838**
CV(%)	**0.39**	**3.75**	**6.84**

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

V_1 = BRRI dhan87, V_2 = BR 11

T_0 = Control, T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds, T_4 = Red chili powder @ 2 g/kg seeds

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at Department of Agronomy in Sher-e-Bangla Agricultural University, Dhaka to find out the effect of pre-storage seed treatment on storability of transplanted aman rice seed. Two T. Aman rice varieties *viz.* V_1 = BRRI dhan87 and V_2 = BR11 and five seed treatments including control *viz.* T_0 = Control treatment (no seed treatment), T_1 = Ascorbic acid @ 0.5 g/kg seeds, T_2 = Aspirin @ 0.1 g/kg seeds, T_3 = Bleaching powder @ 2 g/kg seeds and T_4 = Red chili powder @ 2 g/kg seeds were used in this experiment. The experiment was carried out following Randomized Complete Block design (Two Factorial) with four replications.

During the study, data were recorded on germination percentage, germination speed index, seedling vigour index, germination rate, mean daily germination, mean germination time, peak value, germination value, shoot length, root length, total length, moisture content percentage and viability percentage.

Considering varietal performance, at 236 days after storage, non-significant variation was found for all the recorded parameters except seedling vigour index, germination value, shoot length and total seedling length. At 236 days after storage, the variety V_1 (BRRI dhan87) showed the maximum seedling vigour index (22.34), shoot length (13.55 cm) and total seedling length (24.82 cm) whereas V_2 (BR11) showed least performance but V_2 (BR11) gave the maximum germination value (193.38) compared to V_1 variety. Again, at 271 days after storage, all the recorded parameters were varied significantly due to varietal difference except root length and moisture percentage. At 271 days after storage, variety V_1 gave the maximum germination percentage (81.20%), germination speed index (8.26), seedling vigour index (17.95), germination rate (10.74), mean daily germination (5.35), mean germination time (27.31), peak value (16.93), germination value (93.94), shoot length (13.59 cm), total length (20.89) and viability percentage (84.15) than the varietyV_2 .

Regarding seed treatment effect, at 236 days after storage, germination percentage, seedling vigour index, germination value, root length, total length, moisture content percentage and viability percentage were varied significantly by different seed treatments at initial storage stage, among them the maximum germination percentage (91.75%), germination value (213.29) and root length (12.25 cm) was from T_3 (Bleaching powder @ 2 g/kg seeds); showed maximum seedling vigour index (22.20) and total length of seedling (25.01) was from T_2 (Aspirin @ 0.1 g/kg seeds) and the maximum moisture percentage (11.13%) and viability percentage (93.13%) was from T_4 (Red chili powder @ 2 g/kg seeds) whereas the minimum germination percentage (86.25%), seedling vigour index (20.17), root length (10.33 cm) and total length of seedling (22.55 cm) was from T_4 (Red chili powder @ 2 g/kg seeds); minimum germination value (185.93) was from T_1 (Ascorbic acid @ 0.5 g/kg seeds); minimum moisture percentage (11.13%) was from T_2 (Aspirin @ 0.1 g/kg seeds) and minimum viability percentage (87.75%) was from control treatment T_0 (no seed treatment).

At 271 days after storage, different seed treatments showed significant variation on germination percentage, germination speed index, seedling vigour index, peak value, germination value and viability percentage among them, the maximum germination percentage (71.75%), germination speed index (7.66), peak value (15.60), germination value (83.60) and viability percentage (76.00) was from T_3 (Bleaching powder @ 2 g/kg seeds) and the maximum seedling vigour index (15.07) was from T_2 (Aspirin @ 0.1 g/kg seeds) whereas the minimum germination percentage (64.50%), germination speed index (6.42), peak value (12.40), and viability percentage (68.00) was from control treatment T_0 (no seed treatment) but the minimum seedling vigour index (13.08) and germination value (60.36) was from T_4 (Red chili powder @ 2 g/kg seeds) treatment.

In terms of the treatment combination of variety and seed treatment for storage of rice seeds, all the recorded parameters showed significant variation at 236 days after storage except germination speed index, germination rate and mean daily germination.

At 236 days after storage, the maximum germination percentage (93.00%), mean germination time (37.81) and germination value (222.06) was found from the treatment combination of V_1T_3; while the maximum seedling vigour index (23.55) and total seedling length (26.37 cm) was from V_1T_2; peak value (24.40) was from V_2T_1; shoot length (14.32 cm) was from V_1T_1; root length (13.12 cm) was from V_2T_3 and the maximum moisture percentage (11.19%) and viability percentage (94.25%) was from V_1T_4 whereas the minimum germination percentage (85.00%), peak value (21.25) and viability percentage (85.50%) was achieved from the treatment combination of V_2T_0 while the minimum seedling vigour index (18.13), root length (9.47 cm) and total length (20.80 cm) was from V_2T_4; mean germination time (30.62) and germination value (155.99) was from V_1T_1 and shoot length (11.42 cm) and moisture content percentage (10.09%) was recorded from V_2T_2. At 271 DAS, V_1T_3 showed the maximum germination percentage (86.50), germination speed index (8.85), mean germination time (29.89), peak value (18.45), germination value (115.85) and viability percentage (89.00%) whereas V_1T_2 gave the maximum seedling vigour index (20.07) and shoot length (14.00 cm) and V_1T_0 gave the maximum germination rate (11.84) and mean daily germination (5.92) but the maximum total length of seedling (22.23 cm) and moisture content percentage (10.09%) was recorded from V_1T_1 and V_2T_0, respectively. Similarly, at 271 days after storage, V_2T_0 showed the minimum germination percentage (47.50%), germination speed index (4.60), seedling vigour index (8.29), germination rate (6.21), mean daily germination (3.11), peak value (9.24), germination value

(28.95) and viability percentage (51.50%) whereas V_2T_2 gave the minimum shoot length (10.03 cm) and total length of seedling (17.00 cm) but the minimum mean germination time (18.36) and moisture percentage (9.45%) was performed by V_2T_3 and V_1T_3, respectively.

From the above results, it can be concluded that the variety V_1 (BRRI dhan87) showed better performance compared to V_2 (BR11) for the maximum storage parameters of stored rice seeds recorded at 236 and 271 days after storage (DAS) compared to initial recorded data. Again, considering seed treatments at initial storage stage the treatment T_3 (Bleaching powder @ 2 g/kg seeds) performed better for the maximum storage parameters of stored rice seeds recorded at 236 and 271 days after storage (DAS) and next to the treatment T_2 (Aspirin @ 0.1 g/kg seeds) whereas control treatment T_0 (no seed treatment) showed least performance considering initial recorded data. Regarding treatment combinations of variety and seed treatments at initial storage stage, V_1T_3 showed the better performance both at 236 and 271 days after storage on the most of the recorded different storage parameters which can be considering as the best treatment combination whereas V_2T_0 gave least performance compared to other treatment combinations.

RECOMMENDATION

This was a single year and single location experiment. So, for wide acceptability of the result, this experiment may be conducted in different year and in different region of the country taking more variety and using other seed treating agents available at farmers level including treatments used in the present study.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

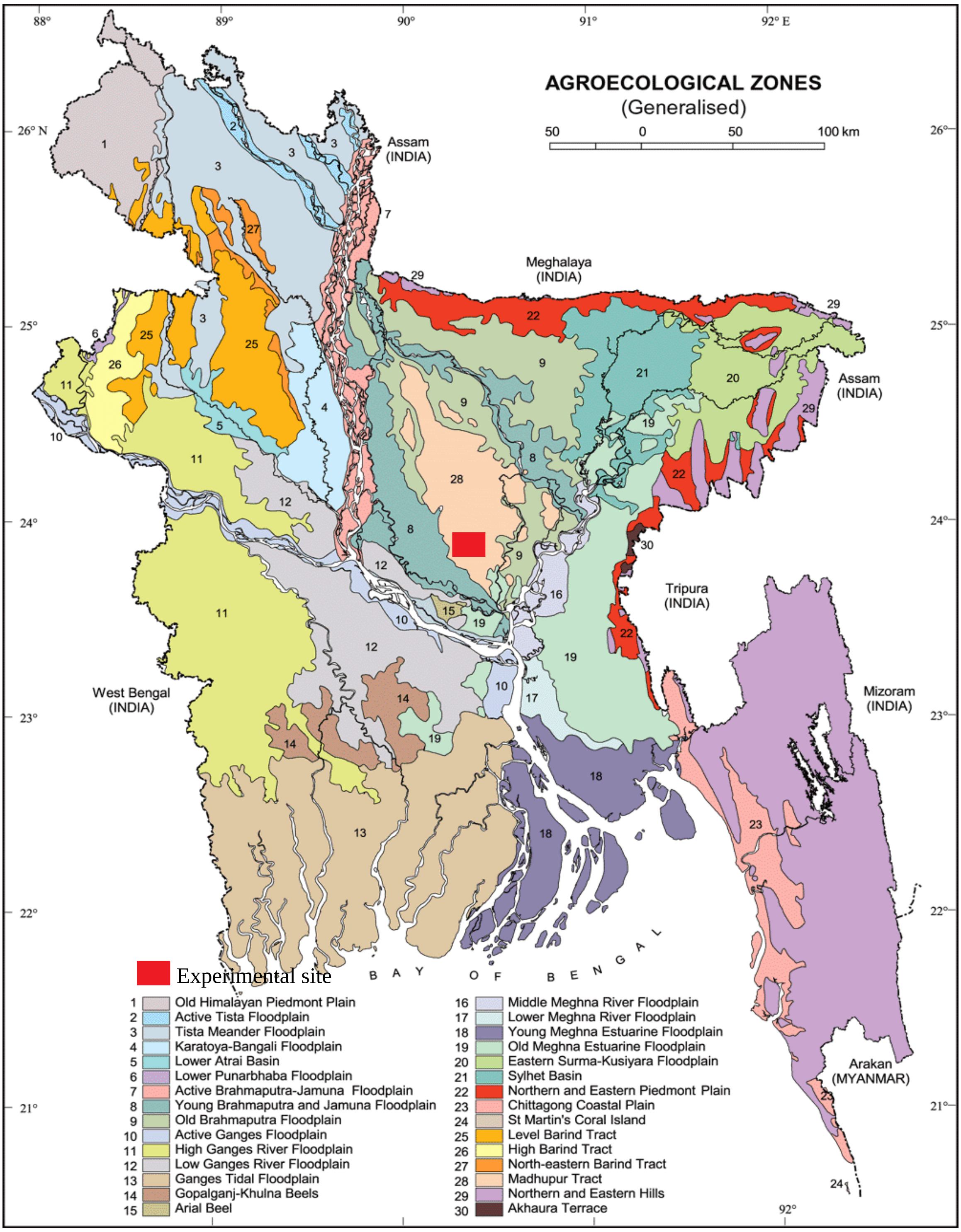

Fig. 27. Experimental site

Appendix II. Monthly records of air temperature and relative humidity during the period from January to October 2020

Year	Month	Air temperature (°C)			Relative humidity (%)
		Max	***Min***	***Mean***	
2020	January	23.80	11.70	17.75	46.20
2020	February	22.75	14.26	18.51	37.90
2020	March	35.20	21.00	28.10	52.44
2020	April	34.70	24.60	29.65	65.40
2020	May	32.64	23.85	28.25	68.30
2020	June	27.40	23.44	25.42	71.28
2020	July	30.52	24.80	27.66	78.00
2020	August	31.00	25.60	28.30	80.00
2020	September	30.8	21.80	26.30	71.50
2020	October	30.42	16.24	23.33	68.48

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Germination percentage of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Germination percentage		
		Initial	**236 DAS**	**271 DAS**
Replication	3	0.05625	33.8667	207.57
Factor A	1	6.80625^{NS}	6.4000^{NS}	6812.10^{NS}
Factor B	4	0.16562^{NS}	33.1000**	86.65*
AB	4	0.22812^{NS}	6.4000**	71.35*
Error	27	0.23681	24.4593	26.68

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IV. Germination speed index of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Germination speed index		
		Initial	**236 DAS**	**271 DAS**
Replication	3	0.0279	0.45676	8.3970
Factor A	1	63.5292*	0.14762^{NS}	60.984*
Factor B	4	8.375E-05^{NS}	0.40196^{NS}	2.2600**
AB	4	2.2355**	0.14873^{NS}	1.2584**
Error	27	0.0309	0.50307	0.6971

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Seedling vigour index of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Seedling vigour index		
		Initial	236DAS	271 DAS
Replication	3	0.38005	8.2470	6.2070
Factor A	1	1.73472 ^{NS}	1324.6*	1073.5*
Factor B	4	0.00015^{NS}	402.11*	394.11*
AB	4	0.71712**	117.36*	104.56*
Error	27	0.23208	6.523	4.873

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Germination rate of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Germination rate		
		Initial	236 DAS	271DAS
Replication	3	0.05467	7.8300	5.3000
Factor A	1	2.78256**	1014.3 ^{NS}	2269.3*
Factor B	4	0.00017^{NS}	359.24 ^{NS}	581.04 ^{NS}
AB	4	2.72837**	104.11 ^{NS}	637.40*
Error	27	0.03322	6.1721	8.7144

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Mean daily germination of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Mean daily germination		
		Initial	236 DAS	271 DAS
Replication	3	0.00113	0.18086	1.5402
Factor A	1	2.60610**	1.56025 ^{NS}	26.1954*
Factor B	4	0.00023^{NS}	1.20552 ^{NS}	0.5128 ^{NS}
AB	4	0.73386**	0.83108 ^{NS}	1.3735**
Error	27	0.00272	1.80088	0.6364

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Mean germination time of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Mean germination time		
		Initial	236 DAS	271 DAS
Replication	3	6.5013	7.9036	9.162
Factor A	1	16.179 ^{NS}	1.5484 ^{NS}	720.54*
Factor B	4	1.6777 ^{NS}	19.865 ^{NS}	6.7880 ^{NS}
AB	4	3.2719 ^{NS}	19.856*	30.298**
Error	27	3.9028	20.519	11.767

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Peak value of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Peak value		
		Initial	236 DAS	271 DAS
Replication	3	0.039	0.8969	62.60
Factor A	1	392.5*	0.4202 NS	274.9*
Factor B	4	0.062**	3.9815 NS	14.07**
AB	4	0.016**	2.8890**	2.431**
Error	27	0.027	3.5895	3.136

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix X. Germination value of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Germination value		
		Initial	236 DAS	271DAS
Replication	3	0.37911	10.67	0.3
Factor A	1	1783.0*	1994.5*	24138.6*
Factor B	4	0.0841 NS	861.82*	739.900*
AB	4	0.0196**	1793.7*	673.400*
Error	27	0.04552	9.6500	0.10000

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XI. Shoot length of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Shoot length		
		Initial	236 DAS	271 DAS
Replication	3	0.20003	1.7784	0.6190
Factor A	1	0.16900 NS	35.156*	90.601*
Factor B	4	0.10078 NS	2.6175 NS	0.4702 NS
AB	4	0.18652 NS	3.1356**	1.4485**
Error	27	0.17825	2.9337	2.8614

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XII. Root length of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Root length		
		Initial	236 DAS	271 DAS
Replication	3	0.01064	1.91648	0.95492
Factor A	1	0.01722 NS	0.66564 NS	2.16225 NS
Factor B	4	0.01462 NS	5.13364*	1.21288 NS
AB	4	0.00798 NS	3.95181**	0.72912 NS
Error	27	0.02393	2.54245	1.26047

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XIII. Total length of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Total seedling length		
		Initial	236 DAS	271 DAS
Replication	3	0.61142	1.1274	6.6829
Factor A	1	0.52212 NS	38.631*	89.102*
Factor B	4	0.02410 NS	8.3907*	3.2254 NS
AB	4	0.26146 NS	3.1255**	5.3354**
Error	27	0.13644	3.7440	7.4768

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XIV. Moisture percentage of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Moisture percentage		
		Initial	236 DAS	271 DAS
Replication	3	1.45059	0.29663	0.51460
Factor A	1	6.20944*	0.03136 NS	0.01444 NS
Factor B	4	1.25006**	1.01671**	0.08274 NS
AB	4	0.76115**	0.19742**	0.28023**
Error	27	0.28897	0.12210	0.06741

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XV. Viability percentage of T. aman rice seed

Sources of variation	Degrees of freedom	Mean square of Viability percentage		
		Initial	236 DAS	271 DAS
Replication	3	0.21667	8.7583	128.49
Factor A	1	0.22500 NS	27.2250 NS	5784.0*
Factor B	4	0.08750 NS	33.6250*	73.620*
AB	4	0.28750**	13.9750*	71.530*
Error	27	0.13796	11.6472	21.860

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level