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Influence of Desiccants on Seed Quality and Longevity in Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Seed deterioration during storage poses serious threats to crop production, yield and finally food security. The present study aimed to assess the impact of desiccants on seed quality and longevity in rice (*Oryza sativa* L.). The experiment was conducted in the Department of Seed Science and Technology, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur, to evaluate the effect of different desiccants on seed quality and longevity. Seeds of the rice variety Jyothi were treated with calcium chloride 8 g/kg, charcoal 10 g/kg, clay 10 g/kg, pot pieces 10 g/kg, sawdust 10 g/kg, silica gel 10 g/kg, soil 10 g/kg and zeolite beads 10 g/kg and packaged in conventional gunny bags and polyethylene-lined gunny bags. Seed quality parameters, such as

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germination per cent, seed moisture content, mean germination time, time taken for 50% germination and vigour index I were assessed before and after one month of storage. The data recorded were analyzed using analysis of variance (ANOVA) with completely randomized design (CRD), and treatment means were distinguished using Duncan's Multiple Range Test (DMRT). Results showed that seeds treated with calcium chloride effectively lowered the seed moisture content and enhanced vigour. Charcoal and soil recorded high germination per cent. Polyethylene-lined gunny bags work better compared to conventional gunny bags, which shows the importance of choosing the right material for storage. This research study was done due to the need to increase the efficiency of low-cost seed storage for small-scale rice farmers in humid regions, since inadequate storage results in seed deterioration and yield loss.

Keywords: Rice; seed quality enhancement; storage; desiccants; seed vigour; germination.

1. INTRODUCTION

Longevity of seeds is an important aspect in agricultural productivity, especially in crops like paddy, which is the staple food for a large segment of the world's population. Retaining seed viability over longer durations is essential for safeguarding the food security of the country. However, seeds are living entities that deteriorate over time as they are affected by multiple environmental factors, such as temperature, humidity, and oxygen (Patel *et al*., 2017). This is one of the main problems in humid tropics, where seeds are prone to moisture, which deteriorates seed quality and reduces shelf life.

A practical method for improving seed longevity is the use of desiccants during storage. Desiccants are hygroscopic materials that absorb moisture from the surrounding environment and create a favourable environment for seed viability (Anokye-Bempah *et al*., 2023). In this study, different desiccants were used in paddy seed storage, such as calcium chloride (Kondō & Okamura, 1931), charcoal (Oyekale *et al*., 2014), clay, pot pieces, sawdust, silica gel (Zhang & Tao, 1988), soil and zeolite beads (Hay *et al*., 2012). These materials differ in terms of moisture absorption capacity. Clay, soil and pot pieces were easily available, while silica gel and zeolite beads give higher moisture absorption. Charcoal and sawdust, which are byproducts from other industries, represent other environment friendly options. Calcium chloride, a chemical desiccant, is known for its ability to absorb moisture more effectively. Two storage methods were compared, i.e. traditional gunny bags and polyethylene-lined gunny bags, each tested with the nine desiccant treatments. Thus, the aim of this study was to assess how these desiccants impact seed quality and seed physiological parameters during storage.

2. MATERIALS AND METHODS

2.1 Study area

The research was conducted at the Department of Seed Science and Technology, College of Agriculture, Vellanikkara, Thrissur. It is located at latitude 10º 54 N and longitude 76º 28 E at an altitude of 40 m above sea level. The area experiences a typical hot and humid climate.

2.2 Experimental Design

Freshly harvested and dried paddy variety Jyothi, collected from Kerala Agricultural University, Thrissur, was used for the study. Seed quality parameters such as germination per cent, seed moisture content, mean germination time, time taken for 50% germination, and vigour index I were measured before storage and one month after storage. Observations were recorded and analyzed using completely randomized design (CRD) with nine treatments, each of which were packed in gunny bags and polyethylene-lined gunny bags, and three replications per treatment. The experimental setups, such as seed packing, storage and observations, were conducted under controlled laboratory conditions.

2.3 Treatment Variables

Jyothi, a popular rice variety of Kerala was used in the study and four kg seeds each were subjected to the treatments. The desiccants used were Calcium chloride 8 g/kg seed, Charcoal 10 g/kg seed, Clay 10 g/kg seed, Pot pieces 10 g/kg seed, Sawdust 10 g/kg seed, Silica gel 10 g/kg seed, Soil 10 g/kg seed and Zeolite beads 10 g/kg, which were weighed and packed in muslin cloth and kept inside each bags. Two sets of seeds were treated. One set stored in conventional gunny bag and other in polyethylene-lined gunny bags.

2.4 Seed Quality Evaluation

Different quality parameters such as germination per cent, seed moisture content, mean germination time, time taken for 50% germination, and vigour index I were measured.

2.4.1 Germination per cent (%)

Germination test was conducted as per ISTA (ISTA, 1985). Four replicates of 100 seeds each were placed in petri-dishes containing moistened germination paper. The observations were recorded on a daily basis for 14 days. The germination per cent was calculated by the formula (AOSA, 1983)

$$Germination\ percent = \frac{Number\ of\ seeds\ germinated}{Total\ number\ of\ seeds} \times 100$$

2.4.2 Seed moisture content (%)

The moisture content of the seeds was measured using the high constant temperature oven method (ISTA, 2010). 5 g seeds from each replication of each treatment were weighed, course grounded and placed in pre-weighed aluminium cups with lids and weighed. This was placed in a hot air oven at 130 ± 2 ºC for two hours. The sample was allowed to cool in a desiccator for 30 min and weighed with the lid. The moisture content was calculated by the formula

$$Moisture\ content\ (\%) = \frac{M2 - M3}{M1 - M2} \times 100$$

Where,
M1 – Weight of empty container with lid
M2 – Weight of container with sample before drying
M3 – Weight of container with sample after drying

2.4.3 Mean germination time (MGT)

The top of paper germination test was conducted. Seeds are germinated in petri-dishes containing moistened germination paper, and the number of seeds germinated on a particular day was noted for 14 days. Seeds that have a radicle protrusion of 2mm length were considered as germinated. The mean germination time was calculated using the formula (Ellis & Roberts, 1981)

$$Mean\ Germination\ Time\ (MGT)\ = \frac{\sum(n \times d)}{N}$$

Where,
n – number of seeds germinated on day d
d – number of days counted from the beginning of germination
N – total number of seeds germinated at the end

2.4.4 Time taken for 50% germination (T_{50})

The time taken for 50% germination was estimated using the formula of Coolbear *et al.* (1984), which was then modified by Farooq *et al*. (2005).

$$T_{50} = t_i + \frac{(\frac{N}{2} - n_i)(t_j - t_i)}{(n_j - n_i)}$$

Where, N – total number of seeds germinated
n_j and n_i – cumulative number of seeds germinated at adjacent time points t_j and t_i, respectively, when $n_i < N/2 < n_j$.

2.4.5 Vigour index I

The vigour index I was estimated using the formula of Abdul-Baki and Anderson (1973).

$$\text{Vigour index I} = \text{Germination (\%)} \times \text{seedling length (cm)}$$

2.5 Statistical Analysis

Statistical analysis was conducted utilising the General R-shiny based Analysis Platform Empowered by Statistics (GRAPES) developed by Kerala Agricultural University (Gopinath *et al*., 2021). The Complete Randomized Design (CRD)-based Analysis of Variance (ANOVA) was used to analyze the data. The ANOVA was used to determine whether the differences in germination, moisture, mean germination time, time taken for 50% germination, and vigour index I among the treatments were statistically significant. The treatments were ranked using Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

3.1 Initial Seed Quality Parameters

Before storing seeds, several seed quality parameters were recorded. At the time of storing, the germination per cent of seed was 92.333% which indicated good seed germination. Seed moisture content was 14% which was within the safe range for storage. The mean germination time was 4.84 days, and the time taken for 50% germination was 4.78 days. The seedling vigour index I recorded was 2295.

3.2 Seed Quality Parameters After One Month Storage

Observations were taken after seeds were treated with desiccants and stored for one month under ambient storage conditions.

Table 1 shows the quality parameters of seeds stored in conventional gunny bags along with desiccants. Germination per cent ranged from 91 per cent (soil) to 83.33 per cent (control). The treatment soil had an increase in germination by 7 per cent over control. This improvement shows the positive effect of desiccants in maintaining seed viability during storage.

Seed moisture content had declined from the initial 14 per cent, with the decline higher in seeds treated with calcium chloride 8 g/Kg of seed (10.54%), which was lower than the control at one month after storage (13.70%). Other materials, such as charcoal, pot pieces, and sawdust, also effectively reduced the seed moisture content.

The mean germination time (MGT) showed a slight variation among the treatments, ranging from 4.05 days (calcium chloride) to 4.24 days (control). A lower MGT denotes faster germination of seeds (Orchard, 1977).

The time taken for 50% germination (T_{50}) decreased from 4.78 days initially to a range of 3.52–4.25 days after storage. The lowest T_{50} was observed in sawdust, pot pieces, and silica gel (3.52 days), indicating a quicker attainment of 50% germination. The control treatment recorded the highest T_{50} (4.25 days), indicating delayed germination under untreated conditions.

Vigour index I ranged from 2311 (clay) to 1799 (control). Seeds treated with clay (2311), soil (2232), and sawdust (2194) recorded higher vigour index I, signifying better seedling growth and vigour compared to the untreated control.

Table 2 shows the quality parameters of seeds stored in polyethylene-lined gunny bags along with desiccants. Germination percent of treatments ranged from 91.33% (charcoal) to 85.33% (control), with charcoal (91.33%), soil (90.00%), and calcium chloride (89.00%) recording higher values than the untreated control. This indicates the effectiveness of these desiccants in maintaining viability during the storage period.

Seed moisture content declined from 14 % from initial moisture to 10.06% in calcium chloride, which is much lower than the untreated control (13.76%). Other desiccants like charcoal (10.37%) and silica gel (10.47%) kept moisture content low, thereby reducing the deterioration rate of seeds.

Variation in mean germination time ranged from 4.02 days (pot pieces) to 4.2 days (control), lower values can be seen in seeds treated with desiccants, which indicates faster germination.

T_{50} values were minimum in pot pieces (3.40 days), followed by charcoal (3.42 days), compared to control (3.71 days). This indicates faster and more uniform germination after storage under desiccant treatment. Faster germination, lower MGT, and T50 (Orchard, 1977; Coolbear *et al*., 1984) is an indication of how desiccants play a major role in achieving faster development.

Table 1. Effect of desiccants on seed quality in storage (conventional gunny bags)

Treatments	Germination per cent (%)	Seed moisture content (%)	Mean germination time (MGT)	Time taken for 50% germination (T_{50})	Vigour index I
Control	83.33^{e}	13.70^{a}	4.24^{a}	4.25^{a}	1799^{d}
Calcium chloride	83.66^{de}	10.54^{e}	4.05^{c}	3.59^{bc}	1812^{d}
Charcoal	87.33^{bc}	12.40^{cd}	4.17^{ab}	3.57^{c}	2038^{c}
Clay	87.66^{bc}	13.34^{a}	4.18^{ab}	3.64^{bc}	2311^{a}
Pot pieces	88.00^{bc}	11.79^{d}	4.08^{c}	3.52^{c}	2135^{bc}
Sawdust	86.33^{bcd}	12.60^{bc}	4.16^{b}	3.52^{c}	2194^{abc}
Silica gel	89.00^{ab}	12.42^{cd}	4.16^{b}	3.68^{bc}	2055^{c}
Soil	91.00^{a}	13.14^{ab}	4.16^{b}	3.75^{b}	2232^{ab}
Zeolite beads	85.66^{cde}	12.32^{cd}	4.16^{b}	3.52^{c}	2054^{c}
C.D (0.05)	2.702	0.676	0.071	0.163	142.53
SE(m)	0.909	0.227	0.024	0.055	47.971

**C.D (0.05) - Critical Difference at 5% level, SE(m) – Standard Error of the Mean*

Table 2. Effect of desiccants on seed quality in storage (polyethylene-lined gunny bags)

Treatments	Germination per cent (%)	Seed moisture content (%)	Mean germination time (MGT)	Time taken for 50% germination (T_{50})	Vigour index I
Control	85.33[d]	13.76[a]	4.2[a]	3.71[a]	2076[e]
Calcium chloride	89.00[bc]	10.06[e]	4.11[b]	3.56[b]	2471[a]
Charcoal	91.33[a]	10.37[e]	4.06[bc]	3.42[d]	2360[b]
Clay	88.33[bc]	12.81[bc]	4.10[b]	3.55[b]	2162[cd]
Pot pieces	86.00[d]	11.89[d]	4.02[c]	3.40[d]	2121[de]
Sawdust	87.33[cd]	13.00[b]	4.03[bc]	3.50[c]	2118[de]
Silica gel	88.33[bc]	10.47[e]	4.11[b]	3.54[bc]	2157[cd]
Soil	90.00[b]	12.50[bcd]	4.12[b]	3.58[b]	2234[c]
Zeolite beads	86.00[d]	12.12[cd]	4.06[bc]	3.54[bc]	2155[cd]
C.D (0.05)	2.11	0.671	0.082	0.044	73.51
SE(m)	0.711	0.226	0.027	0.015	24.741

**C.D (0.05) - Critical Difference at 5% level, SE(m) – Standard Error of the Mean*

Vigour Index I was highest in calcium chloride (2471), which was significantly greater than the control (2076), confirming the positive effect of desiccants in maintaining the seed vigour.

Comparing the ANOVA results of seeds stored in conventional gunny bags and polyethylene-lined gunny bags, it is evident that desiccants had a significant influence on maintaining seed quality under both storage conditions. In conventional gunny bag storage, soil, silica gel, and clay improved germination and vigour, while calcium chloride showed the lowest seed moisture content. However, when stored in polyethylene-lined gunny bags, overall seed quality parameters improved as germination per cent was high in charcoal, followed by soil, while calcium chloride showed the lowest moisture content and highest vigour index. The lower critical difference and standard error values in polyethylene-lined storage indicate that treatment differences were statistically reliable.

Improved seed performance, when the seeds are stored with desiccants, lies in the capacity of desiccants to dry seeds to an optimal moisture content, thereby reducing the metabolic activity and extending their viability. Hay *et al.* (2012) explain that seeds are dried quickly to low moisture levels by combining them with drying beads and placing them in an airtight bag. The final moisture content reached will depend on the initial capacity of the beads for water, the initial moisture content of the seeds, the bead-to-seed ratio and, to some extent, the temperature of drying. Similarly, the use of zeolite beads, also known as 'drying beads' is an economical and viable method for on-farm conservation of seeds. These beads are used inside seed bags or drums to dry seeds safely at ambient temperatures, maintaining seed viability and also protecting against storage insect pests (Sultana *et al*., 2021).

Overall, desiccant-based seed storage with materials like calcium chloride, charcoal and silica gel was useful in sustaining superior seed quality traits by effectively reducing the moisture content and sustaining the germination capacity and vigour during storage period. These findings confirm those of earlier studies on how the storage environment and control of moisture play an important role in enhancing seed longevity (Ellis & Roberts, 1981; Naik & Chetti, 2018). Hilli and Vyakaranahal (2019) also showed similar results, where they showed that seed storage with desiccants showed better seed quality attributes by reducing its moisture content to a desired level and also maintained better seed quality parameters throughout the storage period.

4. CONCLUSION

The study showed that adding desiccants during rice seed storage significantly improved seed quality parameters under both conventional and polyethylene-lined gunny bags. Seeds treated with desiccants showed lower moisture content, higher germination per cents, faster germination, and improved vigour indices than untreated controls. Out of all the treatments, calcium chloride shows the lowest moisture content and high vigour index. While charcoal and soil maintained high germination. Based on the above result, it is evident that the use of proper desiccants and improved packaging can enhance seed quality. Polyethylene-lined gunny bag proved to be superior to conventional gunny bags by reducing moisture loss. Hence use of cost-effective desiccants such as calcium chloride and charcoal, along with proper packaging, is an affordable solution for small-scale rice farmers in humid regions where seed deterioration is a major problem. These practices can improve the viability of seed, enhance crop establishment and food security. Further research should focus on evaluating the economic viability and scalability of desiccant packaging in combination with other storage methods for small-scale farmers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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