Utilizing Modern Technology and Sustainable Methods for Storing Rice

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Abstract: Since the dawn of civilization, grain storage has been necessary to ensure food security. Grain storage has a more extended history than one might think and is connected to farming history. India is the next-largest producer of wheat, followed by China. In terms of food security, storage is primarily intended to keep grains for a longer time. It guards against degradation, exposure to the outside environment, and potential microbe and insect attacks. Silo, CAP storage, and Godown storage were used to test the wheat’s temperature and moisture content. To obtain the reading, a temperature sensor and a RH sensor were installed within the silo. Grain storage in underground pits was employed in the past and is still used in some regions today. The holes were excavated and measured at 1 m in diameter and 1 m in depth, with a mixture of 3:3:1 cow dung, straw, and sorghum, amounting to around two quintals each. A total of 10–20 wheat samples kept in the silo were examined for fungus and fungal development. The samples were placed inside a glass bottle filled with sterile water and closely watched to ensure that no fungal source entered the container used for collection. Each colony was isolated and purified separately once it emerged to obtain an isolated single fungus. The pure fungus was positioned and examined using imaging and organized on figurative plates under a microscope. The germination percentage in various storage arrangements was tested for seed viability using wet paper towels. For the following three months of storage, the temperature within the silo increased rapidly from 28°C to 35°C. The grain retained its quality during the first three months, and there was little to no infestation. The lower ambient temperature and measured relative humidity of 95–97% are to blame for this. Before drying, the moisture content in the silo increased from 11 to 17%.
2006 to November 2006, the moisture content in Godown bag storage increased at the same pace as in the silo. Wheat moisture content rises in direct proportion to its storage time. This is thought to be the result of an increase in insect population brought on by the respiration of insects and wheat, which helped raise moisture content. All of the isolated fungi in the silo were discovered to produce a significant number of spores and conidia on their surfaces. Aspergillus is a harmful toxin-producing fungus well-known for damaging various seeds, grains, and nuts. It is also famous for its destructive properties.

Keywords: Germination, Moisture content, relative humidity, seeds, storage, temperature

1 Introduction

Grain storage is essential for food security; it has been practiced since the beginning of human civilization. Storage of grain is older than it could be imagined it is interlinked to farming history. It is believed that first farmers are nomads from Egypt, they basically live a more settled lifestyle which enables the production of non-transportable storage equipment such as pottery and also grain processing equipment such as the pestle and mortar.

Grain production is influenced by the geographical region and to a specific location, whereas its consumption rate is yearly and not to a certain location. One of the biggest problems faced in the 21st Century is food security in the community and societies. It is one of the major challenges in relation to sustainability of human society development. Out of the sum of grain production in India, wheat production is about a quarter of the total sum after paddy.

India is the second largest country to China in terms of global wheat production scale; it produces about 12.5% of the global wheat production. However, unlike China, India keeps its wheat domestically for food security.

India produces a total yield of 1.8 billion tons of wheat between 2000-2020. Wheat is one of the most cultivated crops globally that exceed a production rate of above two hundred and twenty million ha planted every year, under different climatic conditions in diverse geographical regions compared to agricultural favorable conditions. Approximately six hundred and seventy million tons are produced yearly.

Cultivation of Wheat in India holds 30.23 million hectares of area corresponding with the production of 93.5 million tons and productivity of 30.93 q per ha.

Wheat storage is an important factor in Maharashtra state specifically in a coastal of Konkan. Most of the Indian farming population are involved in the remote parts of the country which most of the farmers have marginal to small land in possession. Climate change has a greater impact on the agricultural sector specifically in rainfed areas heavily dependent on the monsoon. A prediction has been made based on past experiences that increase in temperature by 2.5°C to 4.9°C results in the decrease of rice and wheat production by 32-40% and 41-52% respectively. Maharashtra is the third largest state in India and is at higher risk to climatic change that faces natural constraints such as floods, cyclones, droughts, changing rainfall patterns, and temperature change.

Konkan is located at the narrow coastal belt along the western margin of the state. It has variation in rainfall, temperature, and geographical challenges. Therefore, it is not suitable to grow wheat in Konkan because of those constraints. Due to very high relative humidity, it is impossible to store and preserve wheat quality using traditional structures for storage during the year for consumption.
Storage primarily aims to preserve grains for a longer period in terms of food security. It prevents the deterioration, possible attack from microorganisms, insects, and exposure to the external environment.

Traditionally, farmers store surplus in traditional storage structures such as ground pits, clay pots, bamboo houses, dolbe, etc. Modern storage structures, such as metal silos, bag silos, etc., are designed to store grains in large quantities while maintaining quality at the same time.

Cover and plinth were the common storage practices for storing food grains in relation to Godown storage when there was excessive surplus. Traditional structures used to store grains in Konkan are Kananj, mudi, Kangee, etc. However,sects can still enter these structures, as well as the growth of fungi and rodents and is not safe for fumigation.

Moisture content is one of the major constraints in storage structures that result in the growth of molds that destroy the stored grains in the structures. Increase or decrease in moisture content is determined by variations in climatic conditions, as a result, it can lead to the deterioration of grains stored in bulk.

The aim of this article is to compare and highlight the variations in temperatures, moisture content, and other environmental factors that have an influence on grains, especially wheat. The article will also point out the negative impact of temperature and moisture content on wheat seeds deterioration.

2 Literature Review

Variations in temperature, humidity in storage structures have a greater influence on seed germination of wheat. Seed has a very important and vital impact on production output and the product quality. High-quality seeds result in higher production output. Poorly handled seeds during storage result in low performance in the field, resulting in lower production output that affects food security. Unfavorable storage conditions and duration of storage have an impact, which lowers the germination potential of seeds at some point.

Most research has confirmed that a decrease in germination percentage from 5.0-10.0% if wheat was sowed right after harvest and 5-17% decrease from seed stored grain approximately for 5 months. Fluctuation in storage temperature and dampness and its duration results in significant loss of nutrients.

Preparation and storage of grain is labor intensive and time consuming. Sowing of high-quality seeds has proven to increase production in terms of quantity and quality. Low-quality seeds will result in low production yields, even though the land is fertile and the environment is favorable.

However, in storage, the main challenge is the increase in moisture content of the grain that affects the biochemical process in grains. With high moisture content and sufficient oxygen, aerobic respiration within the grain cells.

A study on maize seed was done in conventional seed containers, fertilizer sack, and earthen pot and the improved ones include metal bins, super grain bags, and Purdue Improved Crop Storage bag from February 2015 to January 2016. At each treatment after 4 months were recorded in terms of germination. PIC bags and super grain bags result in the best germination followed by metal whereas in conventional seed containers, shows poor germination after one year.

All treatments with lower moisture content display favorable results compared to those with higher moisture content.

Germination experiment on the seed of maize on different storage structures was conducted in the laboratory between December 2017 and May 2018 (5 months) in Ethiopia, West Shawa, and Bako. Two treatments combined with two factors, combination with the storage material types, Gombisa, sack, and Hermatic bag with the storage period from 0-6 months. It was recorded that from 98% germination reduced subsequently to 72%, 76%, and 88.6% from Gombisa, Sack, and Hermatic bag, respectively.

Experiment in Bangladesh was conducted in two treatments combined with two factors, combination with these storage material types, Gombisa, sack, and Hermatic bag with the storage period from 0-6 months. It was recorded that from 98% germination reduced subsequently to 72%, 76%, and 88.6%.
factors by three storage container namely sealed tin container, plastic container and Gummy bag in four different storage periods, 15, 30, 45 and 65 days. Germination percentage of seeds stored in gummy bags rapidly decreased from 66.1% to 32.8% due to high moisture content, decreased slowly in sealed tin container from 80.4% to 69.2% with less moisture content. The escalation of seed is interrelated to temperature and relative humidity from the surroundings [14].

A study was carried out in India on effect of seed moisture content on germination percentage and seed infection in rice varieties. The results reveal that seeds produce in arid environment show minimum seed infections (15.26, 10.01, and 18.51%), humid environment shows maximum percentage seed infection (19.49, 14.01 and 22.14%) moisture content of seed (11.98, 11.70 and 12.31%) and low germination percentage (61.97, 64.84 and 44.92%) as recorded in IR 36, IR 64 and Annada varieties stored for nine months in gummy bag at room temperature [15].

There were number of traditional storage methods practiced for grain storage in the past this includes floor storage, bags, granaries, jar, baskets and pots. However, those structures do not protect the grains from insects, pests, rodents and moulds [16]. In modern storage system, large grain quantities can be stored in Galvanized metal silo and Godown for preservation and food security which reduces storage loss in terms of production and consumption, However, the most challenging factor in large scale-grain storage is deterioration and mildew caused by fluctuation in temperature, insect damage, relative humidity, fungal growths etc. [17]. Increase in temperature during storage is certainly caused by respiration in grain cells and solar radiation. Insect activity during storage can also damage the grain structure, fumigation can control the insect’s population. Many studies have proven that high humidity caused rapid deterioration of wheat seed during storage [18]. Apart from Silo, there are other methods of storage such as jute bulk storage in rooms and open-air storage. Wheat quality loss due to improper storage in jute bags exceed 6.6% under outdoor condition while this loss can be reduced to 2% when stored in metal silo [19].

The advantage of silo bag storage it prevents grain loss during transportation, the atmospheric storage system as a result from respiration in grain and microorganisms increase Carbon dioxide and decrease oxygen concentration less than 10%. This creates an unfavorable environment for insect to repopulate and reduce the mould growth [20]. The metal silo does not completely provide protection from insect damage and mould during storage, they suffer fluctuation in temperature, lumping of grains as a result of moisture condition in the internal wall and high energy consumption results in mechanical aeration [21-23].

During storage, deterioration is mainly result from interaction between the different variables (physical, chemical and biological). Growth rate of microorganisms that causes damage to the stored grains largely depends on temperature and moisture content of the grain. Respiration in the storage structure is likely to cause deterioration in grains [24, 25].

3 Procedure and Materials

3.1 Measuring of Grain Temperature in Corrugated Silo
Fig. 1. Corrugated metal grain silo used for storing wheat.

The experimentation on the seed of wheat was mainly to assess and evaluate its performance during storage. For this study, Lok 1 variety of wheat was used. For each storage Godown and CAP storage, 50 kg of gummy bags capacity was used. There were total of 30 bags used in this experimental study measured size was 75 x 30 x 25 cm. Inside the storage, Temperature sensor and RH sensors were used for the measurement of the internal temperature and relative humidity located at the middle top and center of the silo as shown in figure 1 (a and b respectively).

Moisture content was determined using a hot air oven (Make: quality instruments, Kudal). The sample were kept for two hours while the Temperature for moisture content measurement was maintained at 130 ± 1°C (AOAC Method). Determination of moisture content was done by drawing samples from top, middle and bottom of the silo. The moisture content was measured in a weekly time interval using the dry oven method from calculation. Following is the equation used to calculate moisture content percentage on wet basis, expressed as:

$$\text{moisture content (w.b.)} = \left(\frac{W_1 - W_4}{W_1}\right) \times 100$$

Where:

- $W_1$ = weight of the sample taken (g)
- $W_2$ = weight of the empty moisture dish (g)
- $W_3$ = weight of moisture dish with sample after drying (g).
- $W_4$ = weight of sample after drying (g).

3.2 Underground Storage Pit

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Grain samples of 1000 gm were placed in each of the ten pits with 2x sleeve sampler for one-month interval for the total of 3 months. In this experiment, several factors were measured including moisture content of grain, weight loss, molds, and germination test for each pit. Germination test in those pits was done with a sample of 100 sorghum seeds that was dipped into 4 ml of 0.75% of hydroxide in a 200ml flask. Which the seeds then placed at a room temperature for 2 days (48 hrs). After 48 hours the flask was drained and the seeds were counted and expressed in percentage. The grain weight change was determined and calculated that was affected by different environmental factors which was calculated as initial weight minus the final weight. For fungal growth examination of those seeds with the presence of fungi was counted (Aspergillus spp.) after moved to the fungal nutrient media and incubated. It was calculated as follows Girma & Ali, 2019.

3.2.1 Fungal Growth of Wheat in Silo

Between 10-20 grains of wheat samples which were stored in the silo in Sakaka were tested to detect the fungal growth and its presence. The samples were placed in a glass bottle containing distilled water and placed right beside where the sampling area was, under a careful watch to make sure a fungus source reach the container used for collection. After collection it was taken to the laboratory the fungus was isolated using 5.0 ml of water with the spore’s mixture from the grains surface in a 9.0 cm Petri dish. Then 15.0 ml of rose Bengal Potato Dextrose Agar (PDA) was added and were placed in an isolated condition in a germfree condition. The dishes were completely covered and a parafilm was used to sealed tightly to make sure it is completely sealed and were placed upside down in a previously radiation sterilized plastic bags and incubated at 28°C and were closely monitored until there was sign of fungal colonies. After the emergence of fungal colonies each colony were separately isolated and purified separately, to procure an isolated single fungus. The pure fungus was then placed and viewed under microscope with imaging and arranged figurative plates. This result is similar to the results obtained from... which shows that increase in moisture content results in increase of fungal growth (mildew).

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\text{infected seeds (\%)} = \frac{\text{(no. of infected seeds)}}{\text{total no. of seeds incubated}} \times 100
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3.2.2 Germination Percentage

The germination test of seeds was undertaken using paper method with 10 seeds were placed in a paper towel and a plastic bag. The paper towel was sprayed with water before wrapping the seeds in it but not too wet. The seeds were spread evenly across the paper towel and folded in half to balance the moisture in both sides of the seeds. The paper towel was rolled into tube like shape and placed into the plastic bag labelled the bag. The seeds were monitored and rewet from time to time if needed until 6-8 days. The germination rate in percentage was calculated as follows. This method is reliable and can be used widely for any seed viability test. This shows similar results from...

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\text{germination (\%)} = \frac{\text{No of seeds sprouted}}{\text{total No of seeds tested}} \times 100
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4. Results and Discussions

4.1. Grain temperature in Galvanized iron silo
The final stage of storage period was 28°C. It was noticed that during the first three months of storage, temperature inside the silo was lower than the ambient temperature observed in Thanjavur at 36.37°C. During the first three months, the grain maintained its quality which was observed as there was no or less infestation. For the next three months of storage, the temperature inside the silo was exponentially reduced from 35°C to 28.23°C. This is due to the lower ambient temperature and the observed relative humidity was 95-97%. The result observed within only six months period is similar to the result observed by Sawant et al (2012). In comparison, both researches have shown that increase in temperature directly proportional to the time. The longer it takes the grain to be stored, the more susceptible it becomes to deterioration as shown in Figure 2.

4.2. Moisture Contents

The type of materials and methods used to store grains can influence the amount of moisture content within a particular storage structure as well as the internal environment of the storage structure and external environment, where it is stored and the storage period (Azam et al 2019). Figure 3 displays the difference in moisture content of different storage materials namely tin pot, plastic container, and gunny bag with the storage period. An initial moisture content of 11.20% - wet basis was the initial moisture content of wheat before storage. Moisture content of the wheat increased in relation to the storage period as shown in Figure 3. This is suspected to be the increase in insect's population resulting during the respiration of insects and wheat which both contributed to the increase in moisture content. The comparison of those different materials has proven that plastic leaning storage pit gives a desired outcome which prevents the moisture from entering the pit.
4.3 Germination Percentage

Wheat germination percentage was found to be decreased from initially to advanced storage period as shown in Figure 4. The study has shown that decrease in germination percentage is due to the increase in moisture content during storage from different structures and materials. Initially, wheat germination percentage was 86% which shows that there was an increase in germination percentage in the first months. The percentage were then decreased to 92% at the end of the storage period. The result has shown that at the end of the storage period all three storage structures displayed very low germination percentage. The Germination of seeds stored in silo was 80% after 5 months period that was good, in comparison, germination in silo was higher compared to CAP storage and Godown storage. Figure 4. Shows the differences in the germination percentage in GIC silo, Godown and CAP storage Sawant et al (2012).

4.4 Insect and Fungal Growth

Usually nutrients are stored in endosperm of the wheat seeds including starch granules and also protein as shown in Figure 5 (a). Starch can affect the edibility of wheat, and its properties according to other studies. In advanced storage period of wheat has shown in Figure 5 (b) where more holes appeared in the granules and Figure 5 (c) display the results, showing the longer it took for the wheat in the storage structure it causes serious destruction to the seeds endosperm. All fungus from the wheat grains isolated from the surface inside the silo were found to be very successful in production of large number of spores as well as conidia. Fungus Aspergillus produces a toxin known as aflatoxin, it is well known of its destructive characteristics of causing damage to many seed including nuts and grains. Production of conidia by A. flavus is huge on the biseriate sterigmata. While production of conidia from A. niger is in large quantity but are carried on two row stregmata that appears to be like a long chain and black in color. Circinella Umbellate a fungus that has a large number of spores in many sporangia.
Microscopic structure of three different stages of fungal growth in wheat seeds from (a) 0 day, (b) 12th day, and (c) 24th day. Source (Wang et al. 2020).

From the six lining materials used as shown in Figure 6, the fungi are tested initially at 7% level of infection and were used in all six storage types. According to the results obtained, the infection level rate of plastic and cement was consistent from month 0 to the 3rd month of storage compared to the other four. Room was the worst for storage with an infected level of approximately 95%.

5 Conclusion

Different materials used for the construction of storage structures can also influence the accumulation of moisture content in the structure. In comparison to different storage structures for grains, Silo gives astonishing results in terms of temperature balance, moisture content, and germination percentage. The longer it takes to store the seeds, the lesser the germination percentage of the seeds. Germination percentage determines the quality of the seeds. Increase in temperature results in an increase in relative humidity that also has an impact on the wheat grain moisture content during storage that can affect the germination percentage. Increased moisture content has a greater impact on fungal growth as well as an increase in insect population in storage structures in relation to changes in temperature.

The geographical location in which the wheat is stored and the environmental factors also determine the deterioration of wheat. Higher moisture content can result from the respiration of microorganisms that live and respire. Therefore, in order to prevent deterioration of wheat during storage, moisture content, relative humidity, ambient temperature, and internal temperature of the storage structure must be kept at an optimum level.
References

1. Agriculture, Food and Beverage. (4 August, 2022). These are the top 10 countries that produce most wheat. World Economic Forum. Retrieved from https://www.weforum.org/agenda/2022/08/top-10-countries-produce-most-wheat.


emmer wheat (Triticum dicoccum L) in Ethiopia.}

15. The history of grain storage. Milling and Grain. Dynamic


