KUVEMPU UNIVERSITY

"Evaluation of Traditional Storing Practices for Paddy in Malnad Region of Karnataka for Seed Traits"

A Thesis submitted to Kuvempu University for the award of degree of

Doctor of Philosophy

in

Botany

Submitted by,

Mr. Sunil Kumar T V

Guide
Prof. Rajeshwari N
Professor
Department of Studies and Research in Botany,
Sahyadri Science College,
Kuvempu University,
Shivamogga-577 203,
Karnataka, INDIA.

Co. Guide
Prof. M Krishnappa
Professor
Department of P.G. Studies and Research in Applied Botany,
Kuvempu University,
Jnanasahyadri, Shankarghatta- 577 451,
Shivamogga Dist, Karnataka, INDIA.

Submitted To,

P.G. Department of Studies and Research in Applied Botany,
Jnanasahyadri, Kuvempu University,
Shankaraghatta-577451, Shivamogga Dist., Karnataka, INDIA.

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2023

Mr. SUNIL KUMAR T V
Research Scholar,
Department of Studies and Research in Botany,
Sahyadri Science College,
Kuvempu University, Shivamogga-577 203,
Karnataka, INDIA.

DECLARATION

I hereby declare that thesis entitled **"Evaluation of Traditional Storing Practices for Paddy in Malnad Region of Karnataka for Seed Traits",** embodies the results of bona fide research work done by me under the guidance of **Prof. Rajeshwari N**, Professor, Department of Studies and Research in Botany, Sahyadri Science College, Kuvempu University, Shivamogga-577203. And under the Co. guidance of **Prof. M Krishnappa.** Professor, Department of P.G Studies and Research in Applied Botany, Jnanasahyadri, Kuvempu University, Shankaraghatta. Karnataka, India. I further declare that the results of this work have not been previously submitted for any other diploma or degree either in this or any other university.

Date: 31/03/2023
Place: Shivamogga

(Sunil Kumar T V)

KUVEMPU UNIVERSITY

Sahyadri Science College

(Constituent College of Kuvempu University)

Prof. Rajeshwari N
Professor and Research Guide
Department of Studies and Research in Botany,
Sahyadri Science College,
Kuvempu University,
Shivamogga-577 203,
Karnataka, INDIA.

Mobile: +91 9480329762
E-mail: rejeshwaribabu02@gmail.com

CERTIFICATE

This is to certify that thesis entitled **"Evaluation of Traditional Storing Practices for Paddy in Malnad Region of Karnataka for Seed Traits",** submitted by **Mr. Sunil Kumar T V,** to Kuvempu University, Jnanasahyadri, Shankaraghatta- 577 451 for the award of degree of **Doctor of Philosophy in Botany**, is a record of original work carried out by him under my guidance. I further declare that the results of this work have not been previously submitted for any other diploma or degree either in this or any other university.

Date: 31/03/2023
Place: Shivamogga

(Prof. Rajeshwari N)

KUVEMPU UNIVERSITY

Prof. M Krishnappa
Professor
Department of P.G Studies and
Research in Applied Botany,
Jnanasahyadri, Kuvempu University,
Shankaraghatta 577 203,
Shivamogga, Karnataka, INDIA.

Mobile: +91 9448943864
E-mail: krishnappam1007@gmail.com

CERTIFICATE

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Date: 31/03/2023
Place: Shankaraghatta

(Prof. M Krishnappa)

KUVEMPU UNIVERSITY

Dr. Y L Krishnamurthy
Professor and Chairman
Department of P.G Studies and Research in Applied Botany,
Jnanasahyadri
Kuvempu University,
Shankaraghatta, Shivamogga-577 451,
Karnataka, INDIA.

Mobile: +91 9845646821
E-mail: murthy_ylk@yahoo.co.in

CERTIFICATE

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Date: 31/03/2023
Place: Shankaraghatta

(Dr. Y L Krishnamurthy)

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1 "Evaluation of Traditional Storing Practices for Paddy in Malnad Region of Karnataka for Seed Traits" Paddy production worldwide Paddy (Oryza sativa. L), a monocot plant is one of the staple food worldwide. Twenty percent of the world's population consumes rice in their daily routine (Kim et al.,2012); recently, it is increased to half of the world population (Kaur K and Gill B S 2020), and consumption happens more in Asia (Cho et al., 2016). In addition, 35 % of the Rice grain production in the world was contributed by China (Xiong et al., 2015). More than 90% of the world's rice was grown and produced in Asia, according to Food and Agriculture Organization (FAO), in 2014. The majorly cultivated variety in Asia is Oryza sativa L , and in Western Africa, its Oryza glaberrima (Kalita et al., 2017). Global paddy production in the year 2017 was 759.6 million tonnes (503.9 million tonnes on a milling basis) which were a little more than 2016 production of 751.9 million tonnes (499.2 million tonnes on a milling basis). From various Asian countries, the total production in 2017 was 686.7 million tonnes (455.6 million tonnes on a milling basis). India stands second in this list. From African countries, it was 32.1 million tonnes (20.9 million tonnes on a milling basis), and Paddy production in some Asian countries is as follows.

2 Source: According to FAO-Rice Market Monitor.2017-2018 Significance of paddy It has a good amount of nutrition, vitamins, carbohydrates and starch is one of the major components many varieties of food can be prepared, so consumption percentage is high worldwide (Kalita et al., 2017). Rice can be further separated Country Production (in Million tonnes) China 208.6 (142.9 on milled basis) India 166.5 (111.0 on milled basis) Indonesia 73.9 (46.3 on milled basis) Vietnam 42.8 (27.8 on milled basis) Bangladesh 37.3 (25.2 on milled basis) Thailand 33.7 (22.3 on milled basis) Phillipines 19.3 (12.6 on milled basis) Cambodia 10.4 (6.4 on milled basis) Pakistan 11.1 (7.4 on milled basis) Korea 5.3 (3.97 on milled basis)

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Shankaraghatta-577 451

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-Sunil Kumar T V

Dedicated to

My Beloved parents

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LIST OF NOTATIONS AND ABBREVIATIONS

%	Percentage
^{o}C	Degree centigrade
Kilo.cal	Kilo Calare
Kg	Kilogram
Cm	Centimetre
Km	Kilometre(s)
mm	Milli meter(s)
Ft	Feet
Fig	Figure
et al.,	And others (co-authors)
Mha	Million hectares
Avg.	Average
PW	Panatha made of wood
PC	Panatha made of cement & Brick
KB	Kanaja made of Bamboo
KM	Kanaja made of Metal
JB	Jute bag
PB	Polythene bag
SMG	Shivamogga
CKM	Chikkmagaluru
UK	Uttara Kannada
HAS	Hassan
KOD	Kodagu
SA	Sagara

TH	Thirthahalli
HO	Hosanagara
SS	Sirsi & Siddapura
HKB	Honnavara, Kumta & Bhatkal
AKY	Ankola, Karwara & Yellapura
SR	Sringeri
MU	Mudigere
SAK	Sakaleshpura
SO	Somvarpet
MA	Madikeri
VI	virajpet

CONTENTS

1. INTRODUCTION

1.1 Paddy Production Worldwide

Paddy (*Oryza sativa.* L), a monocot plant is one of the staple food worldwide (Vithyashini & Wickramasinghe, 2016). Twenty percent of the world's population consumes rice in their daily routine (Kim *et al.*,2012) recently, it is increased to half of the world population (Kaur & Singh 2000) and consumption happens more in Asia (Cho *et al.*, 2016). In addition, 35% of the Rice grain production in the world was contributed by China (Xiong *et al*., 2015).

More than 90% of the world's rice was grown and produced in Asia, according to Food and Agriculture Organization (FAO), in 2014. Majorly cultivated variety in Asia is *Oryza sativa* L, and in Western Africa, its *Oryza glaberrima* (Kalita *et al*., 2017). Global paddy production in the year 2017 was 759.6 million tons (503.9 million tons on a milling basis) which were a little more than 2016 production of 751.9 million tons (499.2 million tons on a milling basis). From various Asian countries, the total production in 2017 was 686.7 million tons (455.6 million tons on a milling basis).

India stands second in this list, from African countries, it was 32.1 million tons (20.9 million tons on a milling basis), and Paddy production in some Asian countries is listed in Table 1.1.

Table 1.1 Annual Paddy Production in some Asian countries

Country	Production (in Million tonnes)
China	208.6 (142.9 on milled basis)
India	166.5 (111.0 on milled basis)
Indonesia	73.9 (46.3 on milled basis)
Vietnam	42.8 (27.8 on milled basis)
Bangladesh	37.3 (25.2 on milled basis)
Thailand	33.7 (22.3 on milled basis)
Philippines	19.3 (12.6 on milled basis)
Cambodia	10.4 (6.4 on milled basis)
Pakistan	11.1 (7.4 on milled basis)
Korea	5.3 (3.97 on milled basis)

Source: According to FAO-Rice Market Monitor, 2017-2018.

1.2. Significance of Paddy

It has a good amount of nutrition, vitamins, carbohydrates and starch is one of the major components many varieties of food can be prepared, so consumption percentage is high worldwide (Kalita *et al.*, 2017). Rice can be further separated into starchy endosperm (about 92%), embryo (about 2%) and bran (about 6%) (Cho & Lim, 2016). The Antioxidants present are valuable in controlling diabetes (Type 2), cardiovascular problems and cancer (Kaur and Gill 2020). in germinated rice, bioactive alfa-aminobutyric acid (GABA) get produced to act as a stress decreasing also effective in the control of cancer cell growth (Chungcharoen *et al*., 2015). By consuming brown rice, the vitamin B1 (Thiamine) deficiency disease ‘‘beriberi” which is a representative illness related to the nutritional imbalance, can be overcome (Cho & Lim, 2016).

We can see in the last few years, much more interest in the study on quality nutrients present in germinated brown rice, and it does helps in the large-scale preparation of rice-based foodstuffs (Xu *et al*., 2011). Table 1.2 shows the difference in nutritional content of rice with other regularly using cereals. The Flour of germinated seeds are replacing wheat flour in preparation of bakery items. This healthy shift will be good from a food industrial point of view and also benefits paddy producers (Veluppillai *et al*., 2009).

Verities like *Gudna* and *Jonga-Sirhatti* are used to manage lactation problems in children, *Dhanwar* considered for safer pregnancy in cow, *Karanga* rice for a dysenteric patients with boiled banana and *Karhani* veritie to people who had irritation while urine release and to weak people *Karia Gora, Saraiphool, Dani Gora* and *Pakheru* (Rahman *et al*., 2006).

Table1.2: Nutritional value of rice compared with other cereals

Nutrition	**Cereals**				
	Rice (raw)	**Rice bran**	**Ragi**	**Wheat**	**Jowar**
Protein (gm)	6.8	13.5	7.3	11.8	10.4
Fat (gm)	0.5	16.2	1.3	1.6	1.9
Minerals (gm)	0.6	6.6	2.7	1.5	1.6
Calcium (gm)	10	67	344	41	25
Fiber (gm)	0.2	4.3	2.6	1.2	1.6
Energy (Kilo.cal)	345	393	328	346	349

(Value for 100 grams)

If we analyse the significance of paddy in cultivation, it had capacity to grow in different flexible environment factors like soil conditions, humidity and temperatures (Cho & Lim, 2016). Some plant species own tolerance towards the effluent concentrations shows reasonably good growth (Samuel & Muthukkaruppan, 2011).

In the field, it needs more water to grow so as to sustain in submerged conditions, as post germination process was near to complete, 'gibberellins' and 'ethylene' get activated to elongate internode length of a shoot, which helps in rapid growth and to come out, from water level (Lee *et al*., 2009) this made it one of the global cultivar.

So, we can articulate the expression "Rice is life," which frames the importance of rice. From 'Biryani' in India to 'Risotto' in Italy to 'Nasi goreng' in Indonesia to 'Jollof' rice in Ghana to 'Paella' in Spain and with many other dishes, rice feeding billions of people around the world. Paddy straw was used to feed cattle's, thatching roofs, in the cottage industry, soap industry, rice bran as wax, a byproduct of rice bran oil, is used in industries, preparation of hats, mats, ropes, sound absorbing, strawboard, lightweight material, paper making and as a fuel source. Considering its significance, the United Nations designated the year 2004 as the "International Year of rice.

1.3. Cultural Practices

If we think about rice cultivation culture in South Asia, it will take us back to documentation found in Vedas 5000 years ago. In Rigveda (IV.24.7) (one of the five Vedas (c. 3700–2000 BC), the word 'Dhana' was coined according to the Sanskrit dictionary it means 'rice'. In the literatures on Puranas, Samhitas, Buddhist, Jain and Kautilya's Arthasastra, there was mention of rice. If we study the Indus-Saraswati

civilization, there was evidence of the cultivation and consumption of rice of the variety *Oryza sativa*, with these other two verities, *Oryza nivara* and *Oryza rufipogon (*wild annual and wild perennial, respectively) were in use. Sayanacharya (1400 AD) from the Vijaynagar dynasty also commented on 'Dhana' and he called it as 'Tandula' means rice (Nene, 2005)

In India, rice occupies the first place in cultivation, about 42.24 million hectares, producing about 82 million tonnes (Krishnamurthy *et al*. 2005). Chhattisgarh was called the 'Rice Bowl' of the nation, in Assam, there are four seasons named Sali, Ahu, Boro and Bao, to grow paddy. Jharkhand and Bihar are known to cultivate some more nutritive indigenous verities they are Ramdi, Muru, Danigora, Karhani Bhama, Hindmauri, Kalamdani and Punaigora (Rahman *et al*., 2006). It is cultivated as a purely rain-fed crop where the monsoon is precarious and grown as both Kharif (July to October) and Rabi (October to March) crops. Paddy needs a substantial quantity of water for its cultivation (Wv *et al*., 2001). It requires 25 to 35^0C as the optimal temperature to produce good seedlings in field conditions (Jiang *et al*., 2006), it was cultivated in 11% of the total cropped area in Karnataka (about 1.42 Mha). The overall production of paddy by considering five districts of malnadu region is 14,00,000 tons in about 1,75,000 h of agricultural land.

1.4. Rice Cultivation

Cultivation of paddy in field conditions involves the following steps.

A. Seed Preparation

The paddy seeds are soaked for 24 hours in clean water. And it was incubated for 30-36 hours in a sack filled to half of its capacity. For better enzymatic activities and uniform germination, this setup was kept in a warm place.

B. Seedbed Preparation

Seedbed was prepared one day before the sowing, plots size of one meter wide and any convenient length were considered, and about 100-150 m^2 were required to sow 15 kg of seeds. The soil around the seedbed area was collected and raised to about five centimetres above the original ground level, and the seedbed surface was smoothened. Like this required number of seedbeds was prepared. A 40 to 50cm of space between the seedbed was maintained. About 100 gm of seeds / m^2 were sown evenly in the smoothened soil, as soon as the seeds sprouted about 3-4 cm high, it was irrigated, and the shallow water level was kept maintained as the seedlings grow taller, water depth also increased gradually. After 16 days of sowing, seedlings are ready to transplant, these should be transplanted before 25 days.

C. Land Preparation and Transplanting

A well-prepared and Irrigated field, the required number of hills were digger to the depth of 3-4cm in a straight row or random manner with a distance of 25cm. Selected 3-4 seedlings were placed on each hill. Transplanting can also be done with standing water in the field.

1.5. Habitat and Inflorescence:

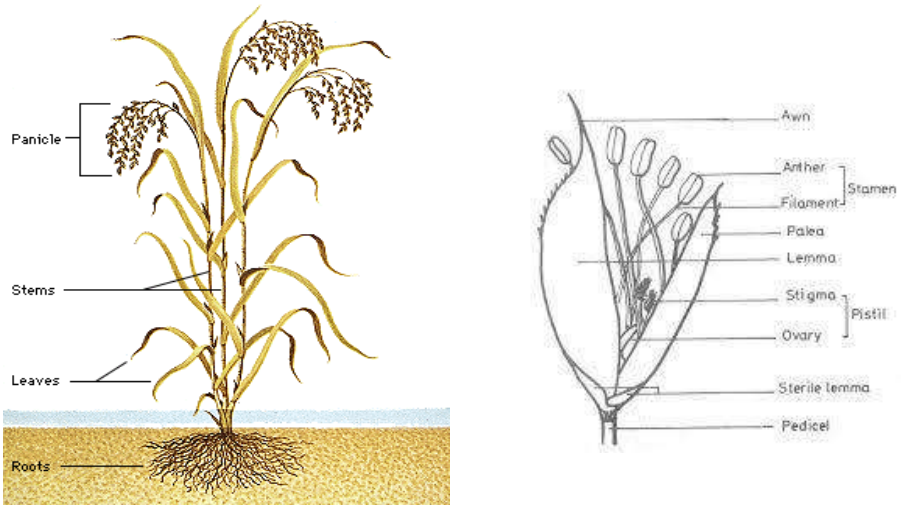


Fig.1. Habitat and Inflorescence

Botanical Description:

The paddy plant is a Poaceae (earlier-Gramineae) family member. The commonly cultivated paddy is an annual plant that usually grows to a height of a half meter to two meters with respect to verities. Some varieties grow to 6-9 meters. The plant body can be divided into two parts, A. Underground part called root system to billow the ground level, B. Areal part called the shoot system above the ground level.

Root System: well, germinates grain in submerged low land condition give rise to primary, embryonic roots (radicle) which come out through the coleorhizae, radical producing secondary roots. These two or more secondary roots develop as lateral and secondary adventitious roots gets grown from the underground nodes of the stem

Shoot System: Plant parts above the ground level is mainly composed of stem, leaves and inflorescence.

A. **Stem:** The stem consists of a series of nodes and internodes. Usually, stem is hollow except at the nodal regions. Each node bears a leaf and a bud. Buds near ground level give rise to tillers under favourable conditions, and these primary tillers give rise to secondary and tertiary tillers.

B. **Leaves:** The leaves are sessile in nature they are borne at an angle, on the stem in two ranks along the stem, one at each node. The leaf blade is attached to the node by the leaf sheath, and a prominent ligule is present with length more than one centimetre. The leaf number is more on a primary tiller with to the secondary and tertiary tillers.

C. **Inflorescence:** The inflorescence is known as panicle it contains group of spikelets bear on the uppermost node of the stem. The primary panicle branch bears the spikelet on secondary or sometimes on its tertiary branches.

D. **Spikelet:** The individual spikelet consists of two outer glumes, all the parts above the outer glumes are collectively called as floret. Spikelet consist two hard covering 'lemma' and 'palea' (the glumes) the complete flower present in between this cover. The flower has six functioning stamens (male organ) and a pistil (female organ) and at the base two transparent structures called 'lodicules' are present. Paddy is a self-pollinated crop, when flower is ready to bloom, the lodicules become turgid and push the lemma and palea apart, it allows the stamens to emerge outside, anthers then rupture to release pollen grains. After the pollen grains are shed on stigma surface the lemma and palea close.

E. **Grain (Caryopsis):** after pollination and fertilization are completed, Rice grain develops. The grain is tightly enclosed by the lemma and palea (together called "hull"), The de-hulled grain is known as brown rice as it covered by a brownish pericarp it's the outermost layer, which envelopes the caryopsis. The embryo lies

at the ventral side of the spikelet next to the lemma adjacent to the embryo a dot-like structure called ‘hilum’ is present. The embryo contains plumule and radicle in a primitive form and is enclosed by a sheath known as ‘coleoptile’ and ‘coleorhizae,’ respectively.

1.6. Common Storage Methods Worldwide

17% of the year food production must be stored considered the security of the nation according to FAO (Food and Agriculture Organization) (Xiaoli *et al*., 2008). A safe storage place must be provided for the grain produced until it is needed for consumption or multiplication. Since grain production is seasonal and consumption is continuous around the world, having safe storage is a must to maintain grain quality and quantity. This means that grains must be protected from weather, moisture, temperatures, contamination, insects, rodents, birds, mould, microorganisms, objectionable odors and improper & unauthorized distribution.

Seed is the living component, and storage may be defined as the preservation of viable seeds from the time of collection after the harvest from the field until they are required for sowing and consumption. By following adequate storage methods, we can maintain its quality and longevity (Holmes & Buszewicz, 1958). Cereals, pulses, oilseeds etc., are very important products for storage. So, to protect agricultural produce, several methods were used, both traditional and modern.

In Latin America and Africa, some of the traditional or hermetic storages were recorded by Bruin *et al.*, (2012), such as Argentine Silo Bag, CDC II (Collapsible Dryer Case II), SilBag, GKC (Grain Keep Center), GrainSafe, Semi-hermetic storages, and PICS (Purdue Improved Cowpea Storage). In Sri Lanka, normal warehouse is very

common and plastic baskets in house conditions for pulses and cereals (Wasala *et al*., 2016 & Abeysundara *et al*., 2017) and as a modified one airtight - ferro-cement bin system was also in regular use (Adhikarinayake *et al*., 2006).

In Japan, modified storage bottle containing the humidity sensor and absorbing moisture by silicone grease were sagest by Genkawa *et al.,* 2008 for small scale use. To increase the life of seeds they are stored in low temperature ($4^{O}C$) area with the help of cool refrigerator air (Longstaff, 1994 and Genkawa *et al*., 2008). In North-East China, Srzednicki *et.al*., (2006) gave about the use of Computer simulation as high technology instrument to check temperature variations in the storage system. Like this 'CoolBot' is an another modern system which maintain room temperature in storage system and acts as an air conditioner (Kumar *et al*., 2015). In Japan, for some suggested storage chambers, Air-tight desiccators were installed to adjust the room temperature and relative humidity (Aibara *et al*., 2017). In Thailand 'R22 thermosyphon' was used in a large steal cylindrical bin which is self-heat rejecting unit and controls the heat liberated from seed respiration (Dussadee & Kiatsiriroat, 2004).

In West Africa, commonly used indigenous storage systems for maize are bamboo granaries, cemented floor in a house and mud silo (Fandohan *et al*., 2006). In Ethiopia, traditionally followed grain storage methods are pits in underground, baskets, sacks/bags, earthenware pots ,bark, basket silos, maize cribs, earthen silos, roof storage, Gombisa made by bamboo poles or other tree sticks (Befikadu, 2014), community-level large-scale storage in Thailand are 'Rice Bank' and 'Seed Bank', while at the household level, stored in heaps, wooden racks, sheds, in bags or hung on ropes under a shade was common. Seeds of wheat, Paddy and pulses were stored in bulk within close structures (Chomchalow, 2003).

Several traditional storage methods have been practiced since time immemorial in India (Suresh *et al*., 2016). Usually, these traditional storage structures were constructed by mud, bamboo or other plant materials (Karthikeyan *et al*., 2009) we can also observe some modifications. In the country it was estimated that 60-70% of produced food grains were stored at home level in their traditional storages, in northern Karnataka of India, the tribal community kept grains in Thenemane, Maize cobs tied to overhead ropes above the cooking place, Mud pots, Bamboo basket, Gunny bag, Cloth bag, Plastic woven bag, Tins, Metal drums, Steel box, Steel bins, Plastic pot, Plastic boxes (Naveena *et al*., 2017). In Haryana also, hermetic storage open environment and traditional storage silo, systems (Bhardwaj & Sharma, 2015).in Punjab, 'Bukhari' for wheat, Moong (Vigna radiata) Bharola was an egg-shaped earthen pot and Kupp are in use (Dhaliwal & Singh, 2010). In Madya Pradesh, 'Kothila' constructed with paddy straw to store cereals and wheat seeds are placed with wheat straw or onions seeds of (*Triticum aestivum* L.) like this use of common salt for Red gram, Ash for sorghum, leaves of Neem for Ragi, and cow dung for vegetable seeds are common (Kumar *et al*., 2015).

In Tamil Nadu as observed by Karthikeyan *et al*., (2009), red gram (*Cajanus cajan*) grains stored with salt, sorghum (Sorghum bicolor) seeds was coated with ash in a ratio 1:4, leaves of Neem (*Azadirachta indica*) and thumbai which are organic repellant to insects were placed with Ragi (*Eleusine coracana*). Paddy was kept in 'Macchu' within this structure earthen pot filled with regular water of its ¾ was placed which attract and kill the insects. Camphor was used for pulses and cereals in jute gunny bags, and for extra care, sometime leaves of pungam (*Pongamia glabra*) plant were kept between the bags, vegetable seeds protected by covering with cow dung and powder of *Acorus calamus* (sweet flag) is mixed with pulses and cereal seeds because

its odor controls storage pest. Sundaramari *et al*., (2011), recorded some more structures named for grain storage, 'Kulumai', 'Kalangiyam',' Kudhir', 'Modappanai' (Kiruba & Clollege, 2018), recorded some small scale bin storages they are Vattappetti, Thallpai (Paddy Straw bin), Addukkupaanai (Earthen pot-pile), Pathayam (Bin of Wooden), Mankattai (Made by Mud), Kulukkai (Earthen bin) and Thombai (Bamboo bin).

1.7 About Malnad Region and Storage Methods

Malnad is a region of Karnataka state in the South part of India. malnad covers the western and eastern slopes of the Western Ghats, stretched to over 650km in length and 50-76km (roughly 100 km) in width, and the height ranges from 900-1500 meters from sea level. It has an attractive hill covered with dense evergreen forest most of the parts of these terrains come under the heavy rainfall belt. It's a humid region with an annual rainfall of 1000 to 3800 mm. The districts covered in malnad region were Shivamogga, Chikmagalur, Uttara Kannada, Kodagu and Hassan, as by Malnad Area Development Board, created as per Malnad Area Development Act,1991.

Traditional practices usually evolved by trial and error methods from generation to generation (Karthikeyan *et al*., 2009). Traditional storage structures in malnad region are so eco-friendly and very much sustainable for many years, even during adverse environmental conditions. These methods physical structures vary from big to smaller storehouses, as outdoor or indoor, installed permanently or temporarily and individual or for the community. Storage systems followed are Kanaja/Galagi, Sandaka, Kothi, Utrani and Hagevu, Panatha, Bamboo structures, and metal bins each different in size, design, shape and function. Most of the time, these structures were constructed by users for their own only in big scale and for some of the structures, they depend on skilled

persons for construction. These structures provide safe, chemical-free, cost-effective and protect commodities against insect infestation, mould growth, and varying weather conditions, they also ensure exceptional qualities with nutritional value and they can build to store for several quintals at household level, so large number of users are found in these regions.

1.8. Seed Treatment Before Storage

Process of protection of seeds has been following from our ancestors and from Vedic periods Sarangdhara Samhita (13 AD), the plant based products like husk, shell, ash and animal products like cow urine, cow dung, milk and red earth and sand are the regular uses for the seed protection (Mehta *et al*., 2012). It is essential in the direction of revitalize, support and documents these methods because the materials used are biodegradable in nature.

Tirawanichakul *et al*., (2004), about 18-26% of water contain in recently harvested paddy seed. So, pre-storage process like drying is needed, improper drying effects on antioxidants (phenolic and anthocyanin) which lead early aging of stored rice by Lindemann *et al*., (2019), these precautions help farmers to store paddy for longer period. This method of drying was also used for cereals and pulses by the people as a Standard process (Srzednicki *et al*., 2006), use of solar dryers were mentioned and recommended by Dansi *et al*., (2008), for the seeds of leafy vegetables. Treatment before storage an important step seeds were dried to safer moisture level would be the preliminary process, some method observed are, for paddy seed was soaked in salt water of ratio 1:10, for Sorghum the powder of cow dung was mixed to seeds or supernatant layer of lime water was applied. For Pigeonpea seeds neem leaves, plant dust, red soil, Pongamia leaf or drumstick seeds extract, powder of Guntur chili or bitter

gourd are very common uses. Chickpea seeds were protected by mint leaves or oils of cotton seed, citronella leaf, soybean or castor and powdered root by sweet flag (Baje), Green gram seeds were cover by ash. And sunflower seeds protected within dry fruit of sponge gourd (Mathad *et al*., 2013).

1.9. Problem During Storage and Studies to Overcome

The majority grain loss occurred at the time of storage when it was handled improperly and when storage facilities were not up to the mark minimum of 4 to 6% loss was expected, managing these losses will increase the farmer's and traders income (Wasala *et al*., 2016). The process of storage is to care for seeds for a longer or shorter period. Effective food grains preservation is necessary otherwise seeds may get spoil by pests, rodents, moths, weevils, beetles and changing weather (Negi & Solanki, 2015). also, by Angoumois grain moth, lesser grain borer, rust-red flour beetle, *Sitotroga cerealella* Olivier, grain beetles Cryptolestes spp, *Rhyzopertha dominica* F., rice weevil and *Sitophilus oryzae* L in both the cases of outdoor and indoor storage condition. Insects in storage container can live in temperature between 8-41^{0}C (Jayas, 2003). So proper check need to be done with interval of time and also its very important to clean the seeds before storage (Frischie *et al*., 2020).

Seeds heath also get altered by storage microbes, fungi are stand as primary damaging microorganism for the seeds (Ora *et al*., 2011) cause deterioration which do lead to loss in quality and quantity (Chungcharoen *et al*., 2015). Improper handling during postharvest processes maximizes the fungal activity and mycotoxin percentage during storage.

Mahananda (2004), so percussion taken is mandatory, and the selection of storage systems must be very good and appropriate. By selecting an effective storage system and maintenance, these problems can be overcome to the maximum extent some examples are listed in Table 1.3.

Table 1.3 List of problems during storage and some general methods followed to overcome it

Sl No.	Type of Problem	During Storage time (Months)	Overcome by	Effectiveness	Reference
1	Insect Problems	3rd onwards	Airtight containers	Insects get suffocate as soon as oxygen level decrease	(Gupta & Station, 2010). (Thilakarathna *et al*., 2006),
			Use of Sealed, hermetic storage	Avoids insects	(Rickman & Aquino, 2007). (Jayas & White, 2003). (Kiruba & Clollege, 2018).
			Fumigation by chemicals, Also, by plant extract (Lauraceae, Apiaceae,	Control insects' growth	(Rajendran & Muralidharan, 2001) (Rajendran & Sriranjini, 2008)

			Myrtaceae and Lamiaceae)		
			matchbox	Insect repellent	(Dhaliwal & Singh, 2010)
2	Rodents (Voles, gerbils, squirrels, mice, rats, birch mice and jerboas)	When there is any damage to the structure	Sealed storage, Manual observation	Protects seeds by getting damage and contamination	(Sarangi *et al*., 2009) (Negi & Solanki, 2015)
			Medicinal and spices plants in raw or extracted form	Act as repellents	(Chomchalow, 2003)
3	Increased heat from respiration	5th onwards	Ventilation, Use of Jute bags	Seed kernels turn yellow	(Tirawanichakul, 2004). (Fandohan *et al*., 2006)
4	Stored grain pests	2nd or 3rd onwards	Synthetic pesticides	Controls pests	(Prakash *et al*., 2016)
5	Microbes	2nd or 3rd onwards, In more moisture condition	Drying of seeds before storage to the optimum level	It avoids seed deterioration, Control the fungi growth and producing mycotoxins, Bad odor	(Wolpert, 1966). (Magan & Aldred, 2004) (Chungcharoen *et al*., 2015). (Ora *et al*., 2011)

			Fumigant (bromide & phosphine)	Control the fungi growth	(Rajendran & Sriranjini, 2008). (Page and Lubatti, 1963),
			Artificially synthesized chemical fungicides	Control the producing mycotoxins,	(Mohana & Raveesha, 2007) (Lemon, 1967)
6	Seed moisture	Long-term storage, Improper drying	Drying of seed to the optimum level Heat treatment by the furnace	Prohibit microbial activity, seed longevity prolongs Decrease moisture level	(Ravi & Venkatachalam, 2014). (Mohana & Raveesha, 2007) (Srzednicki *et al*., 2006)
7	Temperature & Humidity	2nd onwards	By Ventilation	Vetiver structure (had good ventilation)	(Hengsadeekul & Nimityongskul, 2004)
			Producing ambient air	Controls humidity	(Tirawanichakul, *et al.*, 2004)
			Use of gunny bags	Good in air exchange	(Dhaliwal & Singh, 2010)

8	Physical Structure	During harvest or storage	Proper handling during loading and unloading	Seed damage & increase microbial activity	(Zhongkai *et al.*, 2003).
9	Chemical Properties of Paddy		Avoid long term preservation	Seeds quality get decrease	(Cooper *et al.*, 2008) (Abeysundara *et al*., 2017)

Evading of chemicals or high-tech storage system and artificial treatment for drying and cooling will decrease the storage cost (Adhikarinayake *et al.*, 2006). Economic storage systems must be found and promoted more considering the poor farmer number among the nation (Mehta *et al*., 2012). There is a requirement to study the physical property of paddy seeds for better designing of specific storage structures (Ravi & Venkatachalam, 2014). To avoid the influence of Hi-tech or chemical-dependent storage methods and also expensive laboratory process like an analysis on storage protein happening in recent years to improve self-life (Aiswariya & Thomas, 2016), switching to traditional structures that build using plant materials, cement and mud is better. By following these structures, farmers will become self-dependent, coast can be minimized and increase farmers earnings even in the off-season (Wasala *et al*., 2016; Hengsadeekul & Nimityongskul, 2004).

To control insect damage using synthetic insecticides could negatively influence the environment and human health (Wijayaratne *et al*., 2009). So in this work, we expect to overcome these problems. (Kumar *et al.*, 2015) Studies suggest to go for traditional systems rather than chemicals that pollute the biochemical, ecology property of nature and are harmful to beneficial microbes.

Traditional methods of storage had good reference with ancient texts like Krishi-Parashara Varahamihira's Brihat Jataka, Kautilya's Arthashastra and Beejotpathi Vidhi also proven by research work with logical and scientific explanations, these methods more to be considered by its beneficial aspect such are ecofriendly, cost-effective, non-chemical and durability as medium scale (Mathad *et al*., 2013; Hengsadeekul & Nimityongskul, 2004) the experimental result explains positivity in using traditional method like silos constructed with Vetiver grass and clay. This structure was considered more sustainable, they are not harmful to people handling them and are more eco-friendly there was a significant reduction in the risk of contamination, resulting in safer products for human and animal consumption. These observations encouraged us to take up this work with the following objectives.

OBJECTIVES

- To understand the traditional method followed for treatment and storage
- To survey the areas where traditional knowledge has been practiced in malnad region
- To identify biological and natural control measures followed by communities to manage seed storage with emphasis on paddy
- To standardize the method for routine use

2. REVIEW OF LITERATURE

Storage world widen

Barry C Langtaff worked on several common storage techniques in Australia to avoid insect growth in the grain storage chamber. Techniques include heat treatment, fumigation, hygiene, magnetic field, refrigerator air and others. He gave work details of these and concluded with its positive and negative impacts (Longstaff, 1994).

Lee *et al.*, (2009), Cipk15 act as integrate between sugar and oxygen deficiency found that Nipponbare rice had hypersensitivity towards anaerobic underwater conditions for germination the cipk 15 regulates enzymes and promotes germination, thirty seeds were used for each test. To improve the oxygen deficiency verities because of the flooding was common in the terrestrial region of Taiwan, this kind of new verities was needed. Some seven verities were selected and made them germinate in controlled condition phenotype of germinated seeds was measured for its length to record tolerant and intolerant verities. Two genes were found by them Sub A and CIPK15 which get activate and improve germination in rice during the anaerobic condition.

Nagamine, (1991), observed three generations of rice seedlings to state their result as the chlorosis percentage in seedlings to evaluate cold verities response in several samples which they collected locally in Japan. Chs1, Chs2 & Chs3 were the genes responsible for rice to withstand in low temperature of $5^{o}C$, this study gave a brief explanation of how the cross-breed cold tolerant varieties react with local high-yielding verities.

Magan and Aldred, (2004) Examination of stored content in regular intervals could let us know the deterioration pattern and role of mycotoxin in damaging seeds

which resulted in a decline in storage time and made seeds unable to consumption. At the field condition fungi belong to genera Aspergillus, Penicillium, and Eurotium are less active but more in storage condition due to of its low oxygen sensitivity. Considering the damage of seeds in their quality and quantity by mycotoxin, we took up this work to analyze the effects with respect to storage time period. Several samples were collected from regular rural storage systems, and samples were classified considering storage time to analyze its damage. Activity of Aspergillus species was more at storage time of six months, and it increased by 30 to 35% when proper attention was absent.

Samuel & Muthukkaruppan, (2011) It known by the study that physico-chemical parameters like electrical conductivity, pH, chloride, hardness, COD, sulphate, calcium, magnesium and TDS were moderately high in sugar factory effluent and relentlessly affects on seed germination. It leads to a gradual decrease in germination percentage. The study concludes sugar industry effluent concentration governs seed germination. And it also varies with the crop because some plant species have their own tolerance towards the effluent concentrations.

Befikadu, (2014) studies showed that 5-26% was the estimated grain loss recorded In Ethiopia during post-harvest and storage process. To care the grains from rodents, insects and deterioration was the main agenda for every grain storage system or structure. Seeds to be protect from interrelated problems, the initial condition of the grain, grain temperature, moisture content, moulds, insects and pest. Other factors that need to be considered are climate, harvesting system, crop variety, processing system, seed handling at the time of harvest, process, bagging, storage and transporting. Traditional structures are the common storage found followed by Ethiopian farmers,

but they had poor construction quality and they not monitor it properly and negligible in maintaining was observed so the loss of grains was the result. Action to educate the poor people in improving their knowledge about grain storage, nature of storage and factor affecting the storage system was also needed and additional interest should be given to build cost effective system.

In the work by Bruin *et al.,* (2012), discussed on the benefits of hermetic storage with respect to the alternative modern hi-tech storage systems. Preferably they got good result and better performance by hermetic storage, when these storage systems are properly sealed to make it airtight. Also, these are found as, cost effective, free from chemical, easy to transportable, user friendly and sustainable. Hermetic storages are can be used without pesticides, fumigants and can avoid refrigeration this will make it a more compatible storage. They also compared this with conventional storages, which had less preference in performance in humid and hot climatic conditions here also, hermetic system stand out. Production of aflatoxins was condemned by preventing mould growth with all these good characters, they say that people in ninety countries of the five continents were using hermetic storage to store seeds of wheat, beans, coffee, cocoa, rice, maize and silage.

To get an alternative solution over refrigerated storage (Genkawa *et al.,* 2008) took work on the advantages of the low-moisture storage technique for brown rice. The freshly harvested brown rice samples was collected at Kyushu University Farm these samples made several units each had 500g rice. Samples were kept stored in plastic bottles at 15^{o}C and 25 ^{o}C for six months, in different rate of moisture content from 16.2, 14.4, 12.8, and 11.0%. To evaluate the low-moisture storage effect on each sample, seeds were tested for their germination, microbes and fat acidity rate every month.

Spores of microorganisms start formed on the seeds of all the samples, but sample placed at 25^{o}C with moisture rate 16.2% showed less spore growth compare to other three samples, also with best germination percentage of 97% and fatty acid was also retained up to 24.3%. With these test results they state that applying low-moisture storage technique have more advantage over the refrigerator storage method.

Traditional Storage

Hengsadeekul & Nimityongskul (2004), with many paddies supplies in the market after harvest, farmers have to sell their produce as soon as possible, farmers are lacking in financial support and their storage structure is very poor. Such a low-cost structure like silos is the most commonly used method, the use of rice straw and clay composite was a possible material required to build this grain storage structure and it named as Vetiver which is the ideal type of storage structure. In this work they compared this with Metal bins because the use of it was minimum because it needs regular maintenance, corrosion, implosion caused by the vacuum and chemical affection. And another one they use to compare was concrete bins it had fireproof, low maintenance, water resistant and had no use of the chemical. They concluded that a suitable structural would-be Vetiver of it they came to this by observing Bearing Flexural, Tensile and Shearing Strength Density and had good ventilation and low infestation.

Kanwar and Sharma, (2006), Currently following traditional methods are the result of trial-and-error methods of some structures practiced over the years. Promila and Netu listed some of these from Himachal Pradesh, vernacular names of these were kothi, khalari, tandup, matka, peri, peti are some others. They visited the study area district wise, kothi and kathla was mud-made structures people refer these two

structures more because seeds got less infected. Kothies was made by loamy soil mixed with chopped wheat straw. Twenty-four different structures were used to store rice, wheat, pulses, seeds etc. Users experience on metal bin, which decreases the germination rate with time and its maintenance challenges were mentioned in conclusion.

Tirawanichakul *et al.,* (2004), was carried work on seed drying technique by means of ambient air temperature and revealed its action on head rice yield, stickiness and whiteness of seeds. They established that calculated temperature, humidity, load quantity and airflow rate helped decrease the yellowing of seeds which later enhanced seed quality. They further recommended, safer drying temperatures should be within 30-40°C with relative humidity under 70% and ambient airflow of more than 0.75 m^3/min m^3. Overall, they say that the temperature raised by constant respiration of stored seeds do condense moisture content. An additional supply of ambient air seeds was brought to its safer moisture level.

Moulick *et al.,* (2016), Were evaluated seedling growth of basmati rice which induced by selenium (Se) during seed priming process. Also, they studied its effect on the growth of seedlings under the stress of AsIII (sodium-m-arsenite) and AsV (sodium arsenate). Got a good result in shoot and root length, surprisingly seedling biomass was improved, which marked the *Se* action as a growth promoter. Different dosages were used to high-yielding verities and observed the effect of Se and as in seedling growth.

Veluppillai *et al.,*(2009), A study was carried out to discover biochemical changes such as germination rate, reducing sugar, free amino acids, soluble protein content and its variation. Activities of Amylolytic, proteolytic, gibberellic acid and surfactants were observed at the time of germination. Result was verified and conclude

as, contradictorily rate of germination get declined by gibberellic acid and surfactants. They further analyzed the flour collected by germinated grains and said this flour could replace wheat flour in the preparation of bakery items with this, the market value of rice also increased.

Xu *et al.*, (2012), The study was on brown rice flour and starch with the objective to understand variations in physic-chemical properties during germination. Because it was known that the total starch content, crude protein, enzyme hydrolysis and amylose content were found reduce in flour. A safer level of starch granules was recorded by Scanning electron micrographs in both brown rice (BR) and germinated brown rice (GBR). The experimental result on GBR was stated as it had higher content of slowly digestible starch (SDS) due to changes in the structure of amylopectin, decreased in the rate of retrogradation with minor gelatinization temperature.

Dhaliwal & Singh, (2010), Done the study about indigenous knowledge on storage practices they sagest to document after these were identify in rural areas of Punjab. This practitioner had good information in taking care of grains by pest, use of matchbox, placing of washing soap, rubbing of neem leaves on inner side of the walls of *bukhari* storage structure. The use of Calotropis (aak) plant leaves was common for wheat. *Bhrola and Kupp* were the other storage structure recorded. Covering seeds with ash can protect from *khapra* beetle this will be scientifically agreeable method. Wheat straw with gunny bag in combination effective in control of *Dhora* (Callosobruchus sp.) and *khapra* (*Trogoderma ganarium)* beetles. With all this study, they focused on finding eco-friendly practices which can be approached scientifically.

Ravi & Venkatachalam, (2014), Analysing of physical properties of paddy like Porosity, Densities, Volume, and Surface area. The mass does help in the calculated

specific and scientific construction of storage structures. We can predict the variation in moisture percentage, and its effect during storage time, as an example, seeds of barnyard millet and soybean were studied. Found density increased by increased moisture content when paddy was stored in bulk.

People make use of medicinal and spices plants in raw or extracted form as a storage protectant to control pests, and these are traditionally followed methods. In the developing country work was on going to know more and more information on these medicinal and spices plants to use as storage protectant. These plant materials are also very effective as antifungal, repellents, antimicrobial and antifeedant. The paper by (Chomchalow, 2003) was a review work of research papers relevant to the application of these plant materials as the traditional method in Thailand. They examined some methods, example neem extracts (containing azadirachtin) were placed it in a cloth bag, for test three sample 1kg seeds was made, named sample 1,2 & 3 which contain 5, 10 and 20ml of neem extract respectively this experimental setup was placed in storage and results was observed in six to seven days. This method was found effective in controlling maize weevil up to four months. They say that *Fusarium semitectum,* fungus infected more to paddy rice, blackgrams and mungbeans. They named five plants as best in action to control insects and fungus they are Thai neem (*Azadirachta siamensis*), holy basil (*Ocimum sanctum*), aloe (*Aloe vera*), bitter bush (*Eupatorium odoratum*) and sugar apple (*Annona squamosa*).

Fandohan *et al.,* (2006) were tested on the Impact of indigenous storage on controlling insects and contamination. Famers in Benin of, West Africa, use four storage structures regularly, they selected all the four for the study, which are store on a platform, bamboo granary, on the cemented floor at the house and store in mud silo.

Commonly get contaminated by Fusarium species, and their production of the aflotoxin becomes unhealthy for consumption. Growth of Fusarium was recorded more in the non-ventilated concrete floor at household level with respect to other systems, but Fusarium recoded less in the structure made by bamboo and also along with this Aspergillus sp. and Penicillium sp. were observed. Their result says maize stored on the cement floor at the house was not a suitable practice compared to others.

One of the factors in rice germination was temperature, 27-37^{o}C is the standard temperature for good germination. Lower temperatures reduce sugar activity and demote the germination process, Saman *et.al.*, (2008) studied it by taking waxed and non-waxed rice samples. They observed rice constituents like glucose, pentose, maltose, and maltotriole, which produced during germination. And they compared the concentration of the same, which produce in rice syrup. They deduced that oligosaccharides production depends on germination and it was recorded more in rice syrup.

Aibara *et al.*, (2017) taken the three paddy varieties which grow more in Japan. In this paper, they try to describe the degradation pattern of the rice bran lipid, which leads to the deterioration of rice flavor. It occurs when the amount of free fatty acid increases by releasing three types of acids by triacylglycerol's lipid, which are present in aleuron cells and embryo of paddy, according to their experimental result. During the storage, rice bran lipid releases free fatty acids like linoleic, Oleic, and Palmitic acid. These increased with the increase of storage time. By storing the seeds in aerobic conditions at room temperature and at 4^{o}C the release of fatty acids by triacylglycerol can be controlled. It been shown by experimental results which mentioned the table. These table showing the pattern of % of free fatty acid in the paddy verities when they

tested after six months and fifteen months relatively. In discussion they said long storage could be achieved by storing at low temperature (4℃) after drying the paddy to a safer moisture level (15%).

Srzednicki *et al.,* (2006) stated that by maintaining internal temperature to 5^{o}C or more to known period for in-store grains it can protect the grains bevues it maintains the moisture level. They were educated us with information about the pros and cons of heat treatment by the furnace and gave details of its maintenance with labour costs.

In Sri Lanka, the most critical three rice varieties were BG-352, BG-300 and AT-362 these are selected by Abeysundara *et al.,* (2017) for the study of amylose and amylopectin percentages which determine the consumption quality of rice. By assay technique, they calculated the presence of amylase content and found good up to thirteen weeks of storage time, but there was some difference in amylase content value in all three varieties. After 40 weeks of storage time, all three paddy varieties showed a decline in their amylase content, and they were not recommended for consumption.

To understand the effective use of ferro-cement bin over the loss in quality and mass loss was the motto for this work. (Adhikarinayake *et al.,* 2006) in Sri Lanka. The paddy is the primary food consumed by most people in this country. So, it most important to them to find good long lasting storage structure to overcome the problem mentioned above. Samples from the ferro-cement bin were taken to check moisture, grain mass for thousand seeds (before and after storage), insects, presence, moulds, head rice yield and germination. They note that the concentration of oxygen dropped to 2.7%, and carbon dioxide was increased to 9.1% in less than 30 days. The presence of insects was the main reason for this as the insect's number increased, this percentage also increased. In six-months sample moss loss was recorded to 0.4%, head rice yield

at 35.8% and 0.85% of moulds. With these results, they state that ferro-cement bin was suitable to use.

A study was conducted on Jasmine 85 a paddy verity by Akowuah & Addo, (2012), to check the ability of methods like seed drying before storage and storage duration on seed quality. Seed drying helps to control temperature gradients and moisture levels in storage conditions and improves the milling quality of paddy. Sample seeds were dried under direct sunlight (as control) and by tunnel dryer (at 45°C, 50°C & 55°C as treatment) after seed dry process was completed, they are stored for three months in sealed plastic bags. Quality of Milled rice, head rice yield and Induced fissures was found affected by varied drying temperature. Head rice yield 76.3% of and 10% of fissure rate were recorded from the control, they sagest 45°C and 50°C of temperatures to dry the seeds before storage.

It became common that brown rice (BR) was consumed less with respect to white rice because people feel inferior to eat for its after-cook texture. (Cho & Lim, 2016), in their paper, they mentioned the befits of BR consumption, BR contains a good amount of fibers, minerals, vitamins and c-oryzanol as bio-functional components. Promoting the consumption of germinated brown rice which contain gamma-aminobutyric acid (GABA) which is a healthy bioactive component it does proliferate the cancer cells. They say some more study has to happen in complete understanding of the uses of germinated brown rice.

Hybrids rice samples LaGrue, XP710, Cypress, XL8, Bengal, and M204 was examined to check their quality after the night-time temperature effect (Cooper *et al.*, 2008). In this work, a large growth chamber was used and, in this rice, samples were placed at controlled temperatures of 18, 22, 26, and 30°C between 1 AM to 5 AM until

the kernel development initiation. Milling quality of these verities was taken into consideration to analyse its quality after the treatment here, they observed a decrease in Milling quality with increased night-time temperature especially for LaGrue and M204 verities. Later tests were conducted for these samples to check its properties like flour viscosity, amylose, amylopectin, protein and total lipid content. It observed that Cypress and Bengal verities have not shown any decrease in head rice yields (HRY) means significantly less variations in the above-mentioned properties but all other verities HRY were decreased. And they also observed the decline in brown rice kernel width by an increase of night-time temperatures. With all the results, they concluded that this night-time temperature effect was good for some hybrid verities.

A study was undertaken by Dussadee & Kiatsiriroat, (2004) to find the best model for the control moisture level during the bulk storage of paddy. Respiration by seeds increases the moisture percentage in the bulk storage, which lead to its deterioration to control this, an earlier cold storage technique was used. In this work, a detailed examination was done on the new instrument called 'Thermosyphon Temperature Gradient Model' to replace the cold storage technique. In this model, copper tubes were used in the steel cylinder, and electricity was used to heat the copper tubes. It vaporizes the moisture and gets absorbed by the condenser. In condenser, the vapor turns to liquid and settles in the bottom by gravity this is how the 'thermosyphon temperature gradient model' has helped to remove moisture very effectively from bulk storage. They expressed the comparison result between thermosyphon and cold storage, finally they highlighted its benefits by analysing the milling quality, head rice yield and moisture contents of seeds before and after the storage.

Search for the alternative control measures even though effective synthetic chemical fungicides are present to protect stored grains/cereals is the work taken by Mohana & Raveesha, (2007). They look for controlling agents which are eco-friendly and without toxicity problems. So, they chose use Phyto-chemicals from some higher plants which had antibacterial properties. Eight plants belong to different families were selected. Leaves are used from seven plants for extraction processes, and the root (young rhizome) by one plant *Decalepishamiltonii* Wight & Arn. Petroleum ether, benzene, chloroform, methanol, ethanol and water are the solvents used for extraction. Selected plants are undertaken for aqueous extraction first, and tested for its antifungal activity later, only those plants that passed test was chosen for other solvent extraction.

Prakash *et.al.,* (2016) As we know, stored grain pests seriously damage food grains during storage. To control that former has been using several synthetic pesticides despite their adverse effects on the environment and chance of entering into the food chain. So, Prakash and team aimed to record and highlight the benefits of indigenous storage methods to formers for routine use. Selected study areas are Srinivaspura taluk, Kolar District and Mylandlahalli, Kuruburu and Kurtahalli villages of Chintamani taluk, Chickballapura District of Karnataka State (Prakash *et, al.*,2016), During their study, several storage methods was recorded out of the 24 methods which that recorded some are mentioned here, use of ash, red soil coating method, plastering of storage bins with clay and cow dung, Storage of pulses with common salt, Turmeric application method, use of garlic cloves, use of salt and chili powder. The benefits of following these methods were explained both by formers and scientific views point.

Roy *et al.,* (1996), Their study suggests us direct seeded rice, shown increased field emergence, and greater seedling vigor which may lead to higher yield. Rice plants

grown in wetland field conditions was selected, and its seed was collected and sorted considering size, which was determined by weighing. Classified each sample was subjected to germination and vigor tests. The study concludes that even with the same germination environment, the percentage of seed germination and seedling vigor are directly connected with the seed size. Bigger seeds had better germination percentage and seedling vigor than smaller seeds.

The process of protection of seeds has been following from our ancestors. From Vedic periods, the plant-based products like husk, shell, ash and animal products like cow urine, cow dung, milk and minerals like red earth and sand are the regular uses for protection (Mehta *et al.,* 2012), mentioned these information's in their work. In further, they collected information about indigenous seed storage methods practiced in some regions of Uttarakhand. Many storage practices were recorded from the former, mainly from women in many villages, these selected study areas are present in 15 districts of Uttarakhand. Seeds are stored more than 80% of in bins made up of timbers from plants like Pine, Deodar, Bamboo and Ningal. These bins are plaster with paste made by mixing cow dung, cow urine, mustard cake, and carbon collected from the back side of used iron tawa. This paste helps in repelling of storage insect's pests. They also listed the best materials used in particular to the crops in the table. Any seeds and grains can be used for storage. They recorded that in tribal regions like Jaunpur and Jaunsar red baked soil is used to control seeds from pests, and it is their traditional knowledge. In conclusion, they gave importance to reveal the difference between use of chemical pesticides and eco-friendly traditional storage methods.

Bhardwaj & Sharma, (2015) were conducted work to find out the infection rate of storage fungi *Aspergillus flavus*. Its percentage was observed minimum on paddy

stored in godown and jute sacks. Germination of paddy stored in jute sacks was analysed and found decreased with the increase of storage time. These changes in paddy resulted in poor milling quality. Cylindrical shaped Silo structure was found to be common in use, but seeds near its wall were damaged more than the seeds in the inner side. Colour, damaged, broken, chalky and kernel milling are the characters considered for analysis of total damage. Detail about ferro-cement bin structure was mentioned and recommended it to paddy as this air-tight storage structure reduces the insect activity, but this will be apposite for tropical regions.

Ravi & Venkatachalam, (2014), Analysing the physical properties of paddy like Porosity, Densities, Volume, Surface area and Mass, helps calculate specific and scientific information essential to construct the storage structures. We can predict the variation in moisture percentage and its effect during storage time. To explain this as an example seeds of barnyard millet and soybean was studied. And found density get increased by increase moisture content when paddy stored in bulk, after study on the fifteen different storage methods, (Mehta *et al.,* 2012) explained the materials required for constructing these, and they also recorded that these materials are cost-effective and more helpful for poor farmers. They highlighted the importance of preserving the traditional knowledge by supporting poor farmers by facilitating them with the materials required to construct their storage structures. The study was conducted in Uttarakhand Himalaya.

In Malwa region of Punjab a detailed inspection was conducted by (Dhaliwal & Singh, 2010) on traditional storage practices and examined for its scientific approach, they interacted with twelve villages with experienced farmers to get information about traditional food storage methods. The gathered data was subject to scientific analysis

by discussing with the biological scientist to standardize some of these methods for regular use. Bharola Kupp Moong and bukhari are some regularly used practices even though these practices are famous in use, they also needed scientific evaluation to standardize them.

Kanwar & Sharma, (2006), were conducted their fieldwork in Kullu, Chamba, Sirmaur, Mandi, Hamirpur, Solan, Shimla, Bilaspur, Kangra, Lahaul and Kinnaur of Himachali to understand the traditional storage methods followed by rural people. Users say these methods had some drawbacks as they needed skilled people to build, they were fixed in one place and had to check regularly, so some people had less interest in applying these methods. The author also mentioned the uses and listed the number of storage methods Lakolu, Chhabra Peti, Peru, Kuthla. They concluded that the modified structure, like metal bins, was durability as pros and a low germination rate as a cons.

Aiswariya & Thomas, (2016), done experimental process to analyse the variability in genetic and its related impact on paddy (five varieties were used) grown in selected areas of Kerala. Genetic diversity among and between the species were analyzed. As genetic marker storage protein is used and analyzed the diversity in its genetics among the selected species. To generate the dendrogram, a UPGMA also SDS PAGE was subjected for protein profiling. The improved shown more band pattern than the traditional verities, and here they conclude that difference in band number due to the improper cultivation of improved verities.

Use of solar dryers were mentioned by Dansi *et al.*, (2008), very regularly used by the people Benin rural areas during the dry seasons as normal seeds were dried under direct sun light. In their work they women at the house hold level are main take carer

of seeds and these methods. Still some more awareness needed in controlling pest and other common problem during dry in field.

Control of moisture and air present around the stored seeds in the storage structure is necessary (De Vitis *et al.,* 2020), it avoid the growth of microorganisms, keep the seed metabolic activity at low and will increase the seeds storage duration for more than normal. They also studied the vigor and viability of the collected seeds and they say seeds has to be collect at the right time to get right value to deduce the moisture effect on seeds. Some of collected seeds were little longer exposed to sun dry and these shown low vigor and viability.

Marahatta, (2021), analyzed the root and shoot length of the maize after the germination. These were collected from storage containers like bin made of metal and bag type storage method (jute, and PICS), pot made by soil. Collected seeds were classified on the basis of storage time from 45, 90, 135, 180 and 240 days. They found similar value of germination seeds stored in pot made by soil, PICS and Jute bag for six months.

Frischie *et al.,* (2020), explained about the importance of seed cleaning at the time of harvest they consider it more importantly before storage. They discussed about the traditional and modern seed cleaning process and gave details of some methods. Gave more stress on to make the seeds fee from un wanted mater (inert matters or un wanted seeds). Deduce some experimental result done in the laboratory with seed cleaning machines. They guided to follow proper seed cleaning methods.

Kusena *et al.,* (2017), *Aspergillus flavus, Aspergillus niger* are commonly grown fungi with this Curvularia sp, Fusarium sp. and Penicillium sp. are other fungi

had their presence in low amount on the stored seeds. They observed these fungi on the seeds collected from government and relatives and these verities are also failed in keeping good moisture rate and germination, this was proven by the tests. So, they suggest to small storage holder must keep these in mind to improve the quality of the seeds during storage and to over-come these problems.

Marahatta, (2021), analyzed the root and shoot length of the maize after the germination. These were collected from storage containers like bin made of metal and bag type storage method (jute, and PICS), pot made by soil. Collected seeds were classified on the basis of storage time from 45, 90, 135, 180 and 240 days. They found similar value of germination seeds stored in pot made by soil, PICS and Jute bag for six months.

Marcos (2015), selected work on to know the relation between aging of seed with its vigor. He stated that higher the vigor the seed can be stored for long duration. And gave a protocol to perform this test. Electrical conductivity test and tetrazolium tests are also conducted to analyse the seed vigor. Author predicts that in the future vigor will be calculated by using computers. And also suggest to use more than one marker for assessment of the seed germination quality in order to get perfection in the result. In addition, said to follow more than one type test for seed quality analysis.

Modi, (2002), explained the major role of farmers traditional treatment like smoke treatment on seed germination explain and understanding it was the main objective. Farmers produce smoke by burning of wood this smoke was passed to seeds the author say these seeds shown more germination than the un treated seeds percentage difference was up to 2.2%. so, author had more interest to study further to mention the unknown seed treatment methods and explain it.

Moreno *et al.,* (2006), were studied the storage methods followed by Mayan farmers. In this region farmers commonly use rustic granaries with first preference and card board made palm thatch were used to cover this. This structure was found placed in in door and out door. Mainly interested to give attention for farmer growing maize and to improve their storage methods and recommending them to follow more and more traditional methods of storage.

Storage practices can be called good when it ensures quality of stored seeds for long term and keeping it health good and it is very much need to select more familiar appropriate techniques. So (Suresh *et al.,* 2016) studied on some better traditional structure were mentioned in traditional texts.. The methods given are used by organic materials these will be good against use of chemicals. they compared the conventional with traditional methods used for storage and also to treat the seeds (*Embelia ribes*). germination test was conducted to know the effect of mention two type storage structures on seed health. With their result they say conventional storage systems is good.

Vithyashini & Wickramasinghe, (2016), were studied in the Sri Lanka gave some basic detail of total land using for production of paddy and annual production (about 3.3 million tonnes). People grow paddy in rain season in most parts of the Sri Lanka but current change in environment condition shown the effect in paddy cultivation. On the basis of seeds storage protein paddy are classified and selected to grow in the name of hybrid verities. Extraction of storage protein was done to verify the growing paddy verities for improvisation of it and to give complete details of use of these verities for farmers.

3. MATERIALS AND METHODS

3.1 Traditional Treatments and Storage methods

3.1.1 Traditional seeds treatment followed before and during storage

Seed treatment is an in-between process done after harvest and before storage, It is a crucial stage for preparing seed conditions (Longstaff, 1994) for better and long-term storage. Some commonly followed traditional storage methods were recorded in the data sheath while interacting with farmers and storage holders during fieldwork. There is much evidence for the use of traditional treatment (Chomchalow, 2003), farmers may use some medicinal plants, parts of some other plants, vegetable oils, spices and inert materials to control storage pests (Kumar *et al*., 2015).

3.1.2 Traditional Storage Methods Observed

Farmers and storage holders are storing paddy only for consumption purposes these days. For storage, they prefer methods they follow for several generations, which can be referred to as traditional storage methods. The structures found were constructed some years ago, and they are still in use, maintained in good condition, same structure used for any verities they have grown. During our visit, it was observed that these are maintained very well with extra care, in the intermediate of time, they observe the entire structure, the wall, base, roof, and inner side of the structure, and repaired it if any damages were found. Panatha are made by two types of materials by wood and another by cement and brick. Kanaja made of bamboo and metal sheath, Jute bags and Polythene bags are regularly used for mass storage in Malnad. Interacted with many farmers and storage holders for details (Karthikeyan *et al*., 2009), regarding these storage structures and the construction process, materials used for construction, their

durability, size of use, maintenance and their opinions all these information was recorded in the data sheath for better understanding and comparison.

PANATHA

Panatha is one of the good old structure that have been following for more than two hundred years earlier. There are two types of Panatha

A. Constructed by using wood.

B. Constructed by using Cement and Brick.

A. Constructed by using wood

Panatha was constructed by using wood as a primary material. Commonly forest trees are used to construct the whole structure some of the plants used are matti, muthuga, halasu and other. Farmers simply call these plants as 'kaadjathi mara'. Panatha was found constructed in various sizes to store required quantities in largely constructed panatha many chambers were made, and chamber numbers may vary from 2-6, in few panatha eight chambers was observed.

For more safety entire Panatha structure is constructed above the ground level of 6-15 inches height, it is achieved with the help of square-shaped rock placed below the structure at its four corners. As the basement of the Pantha on four rocks, the square-shaped wooden beams with thickness of 4-6 inches in diameter of required length were placed horizontally in a square or rectangular shape. If the Panatha size of five feet long, they use four pillars, one at the corner with the height of 8-10 feet, if the pillar size is small, they prefer to install six pillars for more stability. These pillars are also made of wooden, having the size of the beams these pillars were fixed vertically, one on each

corner. While fixing six pillars, the four are placed at respective corners, and the remaining two were fixed as they come center between the two cornered pillars on any two sides of the base beam finally, it forms as box-like structure. Then, plates made of wood with the usual preferred size was of 2.5 inches thickness with length of 3-5 feet (as per requirement). These plates are fixed between pillars on all six faces of the box. Top plate provided with doors (1or 2) to load and unload paddy. The structure may or may not be painted, it had a protective roof over it which was made of wooden beams where mud plates are arranged on it. This whole structure was placed in outdoor or indoor for use.

B. Constructed by using Cement and Brick

Cement and bricks were used to construct Panatha structures as an alternative to wood, as its less available and has more coast. The basic structural principle is the same as wood Panatha-like shape, raised floor and roof. Here floor, wall and roof are constructed by cement and bricks, the walls have 12 inches in thickness and the height is five feet (or as required) the top is also made of cement, but the door is made of wood for the load and unloading of paddy. This structure was constructed a little away from the house or within, with no chambers.

KANAJA

Kanaja is one of the commonest paddy storage methods in many parts of Malnad, with two types of Kanaja were observed A. Made of Bamboo B. made of Metal sheath.

A. Made of Bamboo

Construction of Kanaja using bamboo needs skilled persons, for the construction, they use Bamboo plants. Here they select a bamboo plant which is not too young and older, the stem part is used to make kanaja wall. The bamboo stem is sliced for a few feet as long as they can or to the entire length of the bamboo stem. This strip is 1-3mm thick, 3-4 inches wide, and 5-8 feet long; like this, many strips are prepared. These strips have moisture content in it, before these strips get dried completely, they are used to construct Kanaja wall. These strips are sewed, that is each strip crosses over many other strips which arranged right angles to it repeatedly and when tightened by stretching little bit, in the same way many stripes are weaved together to get required size of kanaja wall. This whole sheath-like structure is folded in such a way to get a cylinder like structure and tie the edges. This entire cylinder is placed directly on the ground or on the floor made of wooden plates. Kanaja wall is smeared by slurry made by the mixing of cow dung, or in some cases, farmers use pure red soil powder in paste form for smearing on both the surface of the wall. This cylinder is now ready to use, before paddy was poured inside firstly, the bottom covered with a plastic sheath (used polythene bag) or paddy husk (hottu) was spread for 2-3 inches, this avoids direct contact of paddy seeds to the floor and prevents from the cold effect.

B. Made of Metals Sheath

Here the Kanaja was constructed using aluminum sheath available in the local market. The sheath of length 5ft wider and 5-7ft longer, and 6-8mm thickness were used as regular size, and sometimes size may vary according to users' requirements. The entire length of the sheath is folded to get a cylinder-like structure; both ends are locked with nut and bolts and gape sealed. Now, this cylinder structure is ready to use,

before storing paddy bottom was filled with paddy husk for about 3- 4 inches in height to form a seed bed.

JUTE BAG

Jute bag is another kind of storage method regularly used because of its easy handling, can be used in different sizes and is very convenient for transportation. The bag size can be varied from a few kg to 100kg as required to store and transport the same bag can be used several times. Coconut jute was used to make Jute bags, the jute is made to long threads, and these threads are sewed in such a way that a set of many number of threads are made, crossing throw another set of threads arranged at right angles to it. This form a sheath-like structure which used to make bags of different sizes. Two sheaths of the required size were placed, one above the other and three sides of its was closed by sewing and one side is kept open to fill and remove the storing material. When the bags are filled the known quantity of seeds then it was closed by sewing again now it's ready to store or transport. The threads in the bag are arranged in such a manner even though they have many tiny openings, no seed loss will happen, these bags are arranged one above the other.

POLYTHENE BAG

Polythene bags are (used since 1957) made by using artificially synthesized polythene threads, these threads are weaved in such a way that to form a plane sheath. The long plane sheath can be used to prepare different sizes of bags according to the size needed. The two set plane sheaths are placed one on one and heat pressed at two sides to form a bag and sewed at one side, other side is kept open as mouth to fill seeds.

After filling the proper quantity of seeds, it is closed by sewing. Like this packed bag kept in the basement for it these bags are also reusable for several times.

3.2. Fieldwork

Personal visit was done to derive the paddy storage structure in Malnad regions of Karnataka state, India. The Malnad region is part of the Western Ghats, has a geographical area of 8465 sq. km and is located at $13^0$27' and $14^0$39'N and $74^0$38' and $76^0$4'E. The Malnad area development board created a list of districts as per Malnad area development Act 1991 at present, and it covers part or entire area of 13 districts of the state. The five districts, namely Shivamogga, Uttara Kannad, Chikkamagaluru, Hassan and Kodagu were selected for our study. A few taluks of Shivamogga, Chikkamagaluru, Hassan and the entire Uttara Kannada and Kodagu marked as Malnad regions. Table 3.1 shows the list taluks comes under Malnad belt with its respective districts and, Longitude and Latitude was mentioned.

Survey

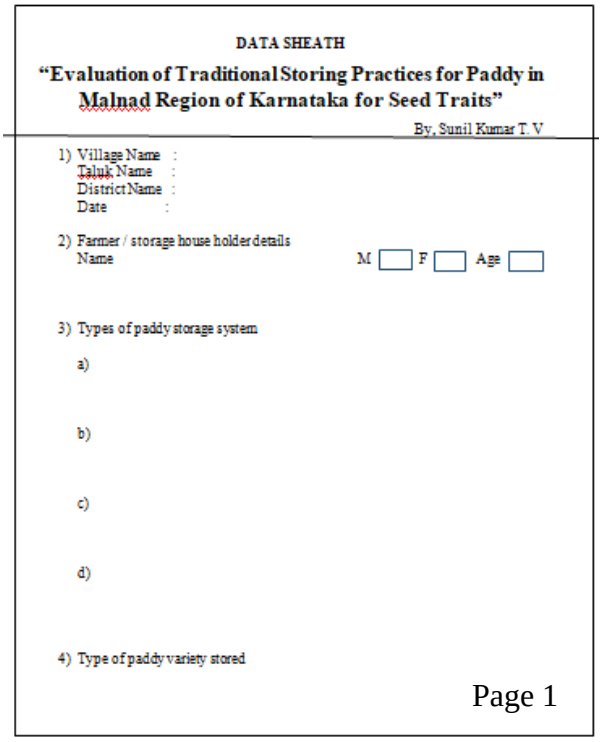
Farmers from villages in these taluks were found using traditional structures in huge numbers. The knowledge and technology of construction, maintenance and seed treatments were passed from generation to generation here and it became the traditional knowledge. The visit was done to meet the storage holders in villages of taluks in the five districts of the Malnad region during the year 2017-2019. Some important regularly practicing structures and treatment methods were recorded, the seeds samples from the different storage structures were collected and photos were taken.

Table 3.1 Shows the Location of Selected Taluks with Districts.

Sl No	District	Location	Longitude	Latitude
1	Shivamogga	SA	14.1667^0N	75.033^0E
		TH	13.690^0N	75.245^0E
		HO	13.92^0N	75.05^0E
2	Chikkamagluru	SR	13.42^0N	75.25^0E
		MU	13.137^0N	75.606^0E
3	Hassan	SAK	12.893^0N	75.725^0E
4	Uttara Kannada	SS	14.6195^0N	74.8354^0E
		HKB	14.28^0N	74.4439^0E
		AKY	14.97^0N	74.72^0E
5	Kodagu	SO	12.6^0N	75.87^0E
		MA	12.4209^0N	75.7397^0E
		VI	12.2^0N	75.8^0E

Data sheath and Sample collection

The information regarding the storage structures and other related required details were noted during the visit; a data sheath (Karthikeyan *et al*., 2009) was prepared for it. The data sheath contains several information like storage holders name, location, date of collection, gender and age than the types of storage structure they follow at present and in past, about its construction details, their opinion about their structure and problems associated with it at the time of construction and during use. Paddy stored in different storage structures for the different periods was collected and labeled.



DATA SHEATH

"Evaluation of Traditional Storing Practices for Paddy in Malnad Region of Karnataka for Seed Traits"

By, Sunil Kumar T. V

1) Village Name :
Taluk Name :
District Name :
Date :

2) Farmer / storage house holder details
Name M ☐ F ☐ Age ☐

3) Types of paddy storage system

a)

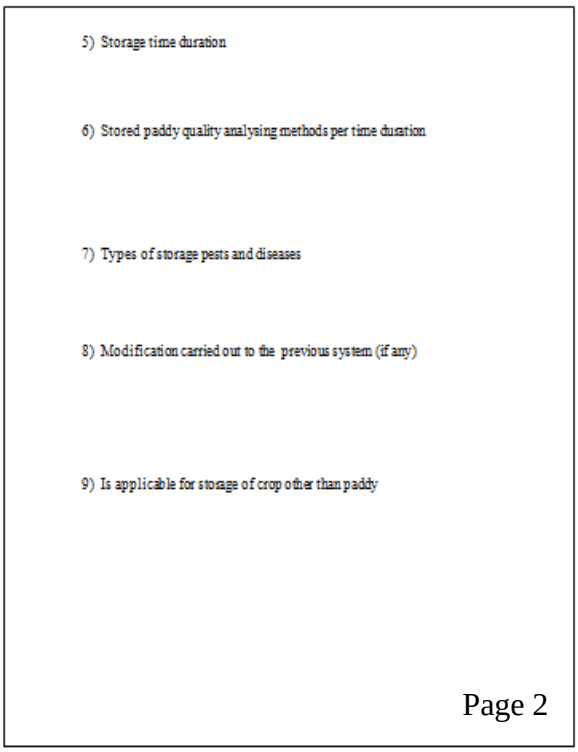
b)

c)

d)

4) Type of paddy variety stored

Page 1



5) Storage time duration

6) Stored paddy quality analysing methods per time duration

7) Types of storage pests and diseases

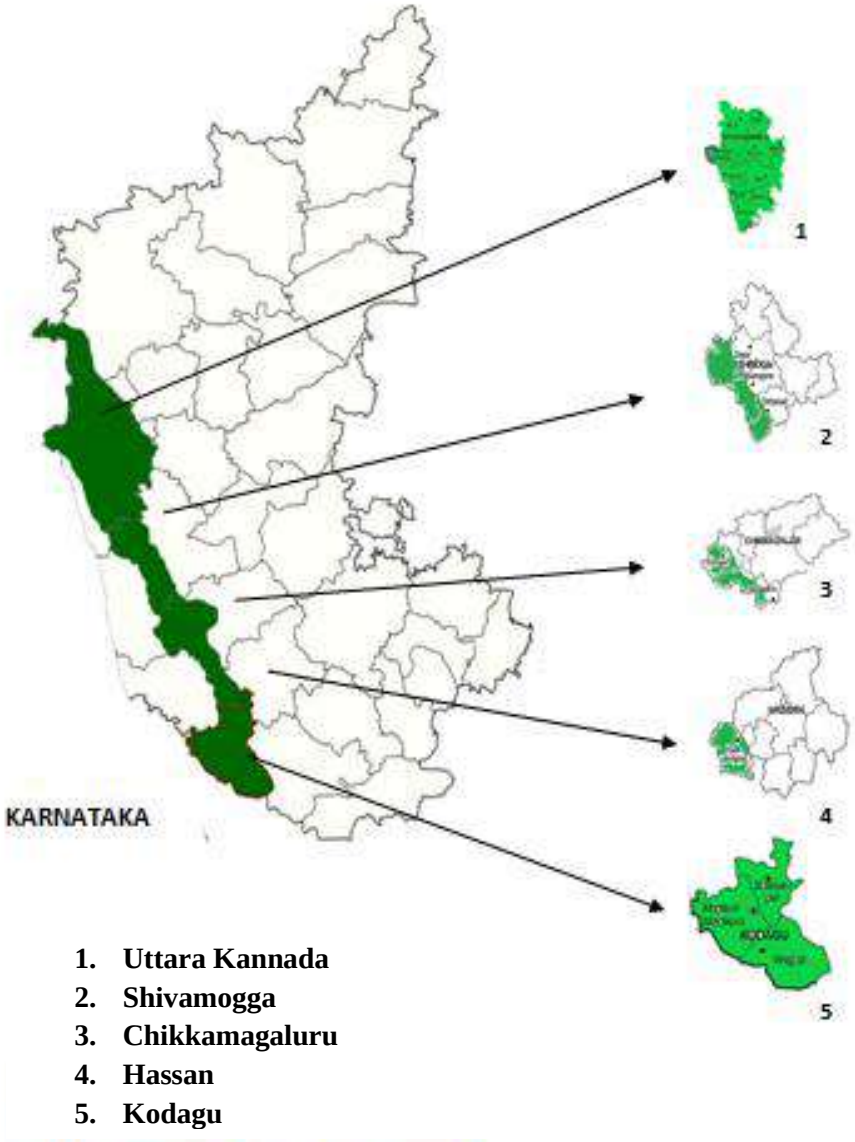
8) Modification carried out to the previous system (if any)

9) Is applicable for storage of crop other than paddy

Page 2

Fig. 2 Data sheath

Map Showing Study Region



1. **Uttara Kannada**
2. **Shivamogga**
3. **Chikkamagaluru**
4. **Hassan**
5. **Kodagu**

Fig. 3: The Map Marked Green Color Shown Malnad Regions in Karnataka and Five Districts.

3.3. Stored Seed Analysis

3.3.1 Biological and natural methods used

The knowledge present among the storage holders to keep their stored seeds safer for years by following biological and natural methods was recorded. Even though these methods have not undergone any significant changes in practice due to their better results, the communities still use them to the extent they need. These methods and the value of use shown in Table 4.3 with respect to regions and storage structure, the value mentioned in the table by the numerical 1,2,3,4, and 5 represents the percentage of use of each treatment for particular storage structure in each district, in this 1 represent 20% the same 2, 3, 4 and 5 represent 40, 60, 80 and 100% respectively.

3.3.2 Moisture

Storability of the seeds majorly influenced by, moisture (Delouche, 1977). Moisture test (Chidambaram & Mathur, 1975), was done to seeds collected from different storage structures stored for different storage periods. Using Oswa Moisture meter, the test was completed, and values were recoded.

3.3.3 Germination Test

The germination process is affected by external factors such as germination time and the absence or presence of light, which can aid or inhibit germination. Four hundred seeds were used for the test from each sample (Devihalli *et al.*, 2005), as standard setup, placed in lab condition for fifteen days as an observation period. Observation and watering are done in an interval of time. Four types of germination tests were conducted to know the germination capability of the samples. Tests are Standard Blotter (SB)

method, Sand Method, paper towel method (PT) and Brick and Gravel method (B&G). ISTA (International Seed Testing Association) standardized and recommended these tests.

SB Method Test

To conducted SB method plastic Petri dishes was used, In The lower lid, a wet blotter sheath using distilled water and twenty-five paddy seeds were placed in order with 5-6cm distance, closed by the upper lid, four hundred seeds of each sample were used to conduct test as standard by ISTA. This setup was placed for observation in the incubation chamber for seven days with an interval of observation, and distilled water used for watering.

Sand Method Test

This test was conducted in a plastic tray of which 70cm length, 45cm width and 15cm in height, it was filled by washed sand for about 12cm as sowing bed. Each tray was used to sow twenty-five seed, each seed was sowed at 5cm deep and between every seed 8cm distance was maintained. Distilled water was used for watering. 100 seed used for test from each sample (Devihalli *et al.*, 2005) as standard setup, placed in lab condition for fifteen days as observation period. Observation and watering were done in interval of time. Germinated and non-germinated seeds were noted for further analysis.

Paper Towel Method

Using germination paper this test was conducted, Twenty-five seeds were used per paper. Five seeds were placed vertically as one set on wet paper and rolled in over

each set like this all seeds placed. Each end rolled paper was folded and closed by a rubber band. Watering done on paper during the interval of time.

Brick and Gravel Method

This test was conducted in a plastic tray of which 70cm in length, 45cm in width and 15cm in height, it was filled with washed sand for about 12cm as a sowing bed. Small pieces of brick and gravels were randomly spread on the surface. Each tray was used for sowing twenty-five seeds each seed was sowed at 5cm deep and between every seed 8cm distance was maintained, distilled water was used for watering. Germinated and non-germinated seeds number were noted for further analysis.

Following formula was used to calculate the germination percentage for all the above-mentioned tests.

$$\text{Percentage of Germination} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds plated}} \times 100$$

3.3.4 Insect value

The activity of insects during the storage time was common irrespective of storage type and region. The insect activity represents the stored seed quality and longevity so the analysis of effectiveness of storage structures is necessary. Storage time of six, nine and twelve months was considered for analysis.

3.3.5 Mycoflora

Storage fungi are one of the major factor which need to consider for the betterment of seed quality and storage longevity because more fungal activity (Magro & Adler, 2014), may lead to maximum damage in storage conditions. So, to analyze this, the SB method are germinated seed sample was subjected to observation and calculations of the percentage of storage fungi infestation. A binocular microscope was used to observe mycelium and spore-bearing structure to record common storage fungi grown on seeds. The recorded fungi sample was identified and authenticated by Prof. M Krishnappa, Mycologist, Department of Applied Botany, Jnana Sahyadri, Kuvempu University, Shankaraghatta, Karnataka.

3.3.6 Rodents Value

The rodent's activity and its damage were considered to record in all the region. Seeds are food for rodents also so the storage structure must have structural capability to control them. To analyze effective ness in controlling rodents by storage structure the rodent’s activity was observed with respect to storage time of six, nine and twelve months.

3.3.7. Comparison Analysis Between the Storage Structure with Respect to the Following

3.3.7.1. Design

The storage structure character has to be considered (Maity *et al.,* 2020). The design of the storage structure involves its structural effectiveness, which means the

structure's durability, flexibility to use in different size, materials and labor for construction.

3.3.7.2. Cost

For its construction and maintenance, the cost of the particular structure needs to be considered to select an economically beneficial structure as the peoples are in different economic statuses.

3.3.7.3. Storage capacity

The storage capacity of individual structure is one more parameter considered in the selection of storage structure, which can increase and decrease as per the required. The quantity of storage also influences on seed health.

3.3.7.4. Ventilation

Ventilation involves the exchange of air from storage space to the outer environment properly ventilated structure helps to keep seeds healthy and avoids microbial activity.

3.3.7.5. Temperature

The temperature in the storage structure impacts microbial and insect activity the seeds metabolic rate also gets varied, Temperature difference (Magro *et al*., 2019) and its effects were observed.

3.3.7.6 Maintenance

Maintenance of the storage structure is the key action done to improve the storage structure's life also to avoid any contamination, here, we explained its effectiveness, longevity, repair cost and time.

3.3.7.7 Mass loss

Moss loss involves the loss of stored seeds, usually when kept for long-term storage. It can be analyzed by calculating the quantity of seed damage after storage for a known time.

3.3.4.8 Transport

Transportation, this comparison gives the utility nature of the structure, whether the selected structure itself can be used to transport are not. If it is use in what quantity and how good it was also recorded.

3.3.7.9 Technology Adaptation

Technology adaptation was considered to check whether the storage holder used advanced machines or techniques to overcome some fundamental problems during storage.

4. RESULT

4.1. Traditional Storage and Treatments Methods

4.1.1 Traditional Seeds Treatment Followed Before and During Storage

Several traditional seed treatments used in all our study regions were listed in Table 4.1. Out of these number of treatments (T) some were followed before the storage and, some were during the storage to protect and prolong the stored commodities. They are as follows,

- Seed dry (T1): Drying of seed was most common and followed hundred percent as a pre-treatment method in all regions before storage to store in any type of structure, dry under the sun and shade was common.
- Ash treatment (T2): It was a good old treatment currently fewer people were following. The burned wood ash was used to make a layer at the bottom (rarely also as an upper layer). This treatment was considered for the storage structures like PW, PC, KB and KM. Its use for PW was observed in SMG for KB in CKM and KOG.
- Red soil (T3): Use of red soil was found only in CKM for constructing PC. Here concrete was used to construct bricks, and red soil was smeared on the wall for about two inches thick. They used red soil considering its economical and for its, coolness and aeration ability.

- Cow dung (T4): Tt was used to protect the seeds in these parts of the people. As a treatment, cow dung was mixed with seeds and dried under sunlight and kept in storage this process done only in small-scale to keep the seed for sowing in next season. For large storage, this cow dung was used to smear on the storage structure

wall, and this method was used only for KB type of storage. A number of small discs made of cow dung and dried these were placed on top of stored seeds in KM

- Sugar cane bark (T5): The sugar cane bark is also in use here the crushed and very well-dried bark was collected and placed in the inner side of the storage structure like PW, PC and KB. Follow of this method was found quite a few numbers in SMG, CKM and HAS.
- Lakki Soppu (T6): The plant named Lakki Soppu (*vitex negundo* L.) was collected in their surroundings to use as an insect repellent. During storage, the fresh or dried leafs with its branches with few centimeters in length are placed on the surface of the stored seeds layer. It was used in PW and PC in most parts of all the districts and for KM by a few storage holders in CKM.
- Garlic (T7): As an insect repellent the garlic (*allium sativum* L.) was used during the storage time. The numbers garlic clove are separated and spread on the surface of the stored seeds layer. It was used in most parts of all the districts for PW, PC, KB and KM and for a few of JB and PB.
- Red Chilly (T8): It was used to avoid insects but the users were found very less some of observation done that only for JB bags.
- Dry Ginger (T9): This method was used by very few storages holder.
- Neem (*Azadirachta indica*) (T10): It was the other one in most use at the storage time, fresh or dried leaves were used to place on the surface of the stored seeds bed in the storage structure. It was used by most villagers of all the districts for PW, PC, KB and KM and for a few of JB and PB.
- Fumigation (T11): It was used most commonly in all the regions for all structures, especially for JB and PB as these bags are kept without any covering. Fumigation was very much needed during the cold environment. The fumigation method was

followed to keep the storage space warm, which helps to decrease the moisture content. In the PW, PC, KB and KM the smock was made to fill within the chamber for a certain period by blowing it manually. Neem leaves, garlic, dry lakki soppu or compour was used for the smock.

Table 4.1: Traditional seeds treatment followed before and during storage

Storage type	District	TREATMENT BEFORE STORAGE					TREATMENT DURING STORAGE					
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
PW	SMG	+	+	-	-	+	+	-	-	-	+	+
	CKM	+	-	-	-	-	+	-	-	-	+	+
	UK	+	-	-	-	+	+	-	-	-	+	+
	HAS	+	-	-	-	-	+	+	-	-	+	+
	KOD	+	-	-	-	-	+	-	-	-	+	+
PC	SMG	+	-	-	-	-	+	-	+	+	+	+
	CKM	+	-	+	-	-	+	-	+	-	+	+
	UK	+	-	-	-	-	+	-	+	-	+	+
	HAS	+	-	-	-	-	+	+	+	-	+	+
	KOD	+	-	-	-	-	+	-	+	-	+	+
KB	SMG	+	-	-	+	+	-	-	-	+	+	+
	CKM	+	+	-	+	+	-	-	-	-	+	+
	UK	+	-	-	+	-	-	-	+	-	+	+
	HAS	+	-	-	+	+	-	-	+	-	+	+
	KOD	+	+	-	+	-	-	+	-	-	+	+
KM	SMG	+	-	-	-	-	-	+	-	+	+	+
	CKM	+	-	-	-	-	+	+	+	-	+	+
	UK	+	-	-	-	-	-	-	-	-	+	+
	HAS	+	-	-	-	-	-	+	-	-	+	+
	KOD	+	-	-	-	-	-	-	-	-	+	+
JB	SMG	+	-	-	-	-		-	+	-	+	+
	CKM	+	-	-	-	-	-	-	+	+	+	+
	UK	+	-	-	-	-	-	+	+	-	+	+
	HAS	+	-	-	-	-	-	+	+	-	+	+
	KOD	+	-	-	-	-	-	+	+	-	+	+
PB	SMG	+	-	-	-	-	-	+	+	-	+	+
	CKM	+	-	-	-	-	-	+	+	-	+	+
	UK	+	-	-	-	-	-	+	+	-	+	+
	HAS	+	-	-	-	-	-	+	+	-	+	+
	KOD	+	-	-	-	-	-	+	+	-	+	+

‘+’ Present, ‘-’Absent

T1-Seed Dry, T2-Ash (Wood), T3-Red Soil, T4-Cow Dung, T5-Cane Bark, T6-Lakki Soppu, T7-Garlic, T8-Red Chili, T9-Dry Ginger, T10-Neem Leaf, T11-Fumigation.

4.1.2 Traditional Storage Methods Observed

4.1.2.1 Panatha Constructed by Wood

Panatha, constructed by wood, was found made in various sizes and provided with a number of chambers. The entire structure was found placed on the rock blocks at each corner and at the middle (for better support) of the structure to elevate the platform from the ground level. Most of the structures were protected by a roof, and the roof legs were made stand on the top beam of the same structure (Fig.4.1), so the whole design looks like one piece. A big structure was found with six chambers (Fig.4.3). The other details about the structure are represented with the help of schematic diagram Fig. 4.2 and Fig. 4.4.

Figure 4. Panatha Structure Made of Wood and Its Schematic Diagrams

Fig. 4.1 Panatha Made of Wood Three Chambered Structure.

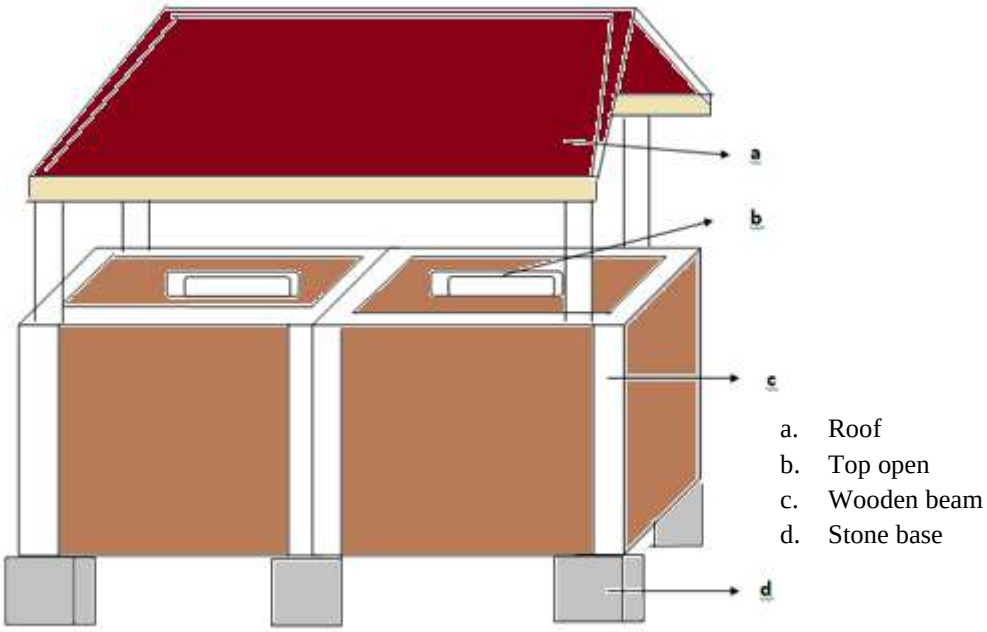


Fig. 4.2 Schematic diagram of Panatha made by wood two chambered structure with roof.

Fig. 4.2 Panatha made of wood six chambered structure.

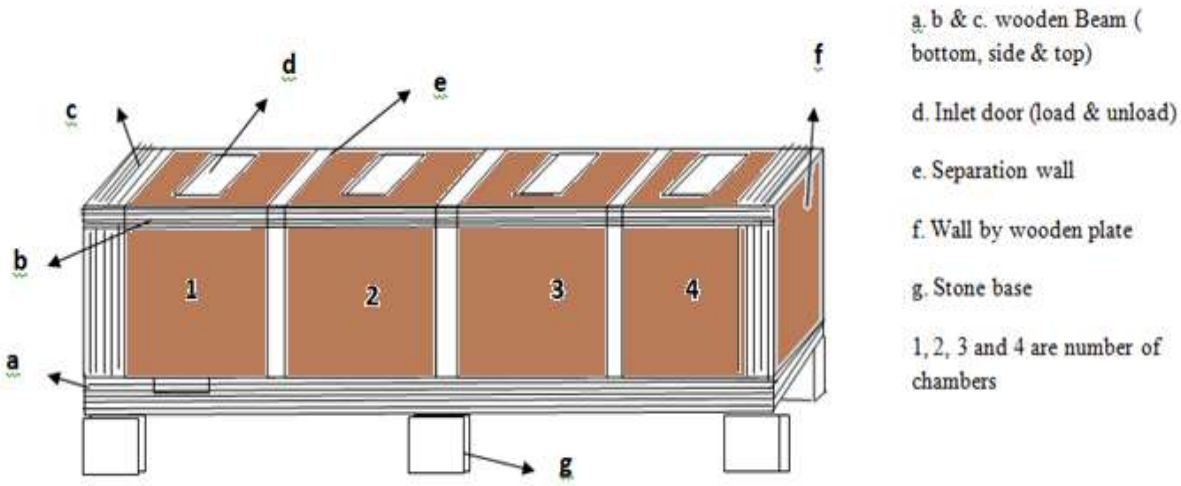


Fig 4.4 Schematic diagram of Panatha made by wood four chambered structure without roof.

4.1.2.2 Panatha Constructed by Cement and Brick

Panatha constructed with Cement and Brick, is a structure gaining preference these days the numbers of storage holder are also found good. These structures had only one chamber in it (no structure was recorded with more than one chamber). The structures built within the house are commonly absent with its roof as in Fig.5.1 and Fig.5.2 represented the schematic diagram. To only those structures which built away or attached to the house from outside were had roof protection, this kind of roof have an opening for loading and structure provided with another small opening on the side wall (any one side) at the lower bottom to draw seeds from the chamber (Fig..5.4). Still, some of the structure found had only a bigger top opening which used both for load and unload (Fig.5.3). The schematic diagram in Fig.5.5 shows more structural details.

Figure 5. Panatha Structure Made of Cement and Brick and its Schematic Diagram

Figure 5.1. Panatha of Cement and Brick made open top like structure.

a. Top open (load & unload)
b. Side wall

Figure 5.2 Schematic diagram of Panatha of Cement and Brick made open top like structure.

Figure 5.3. Panatha structure made of Cement and Brick provided with opening at bottom to unload.

Figure 5.4 Panatha structure made of Cement and Brick top closed

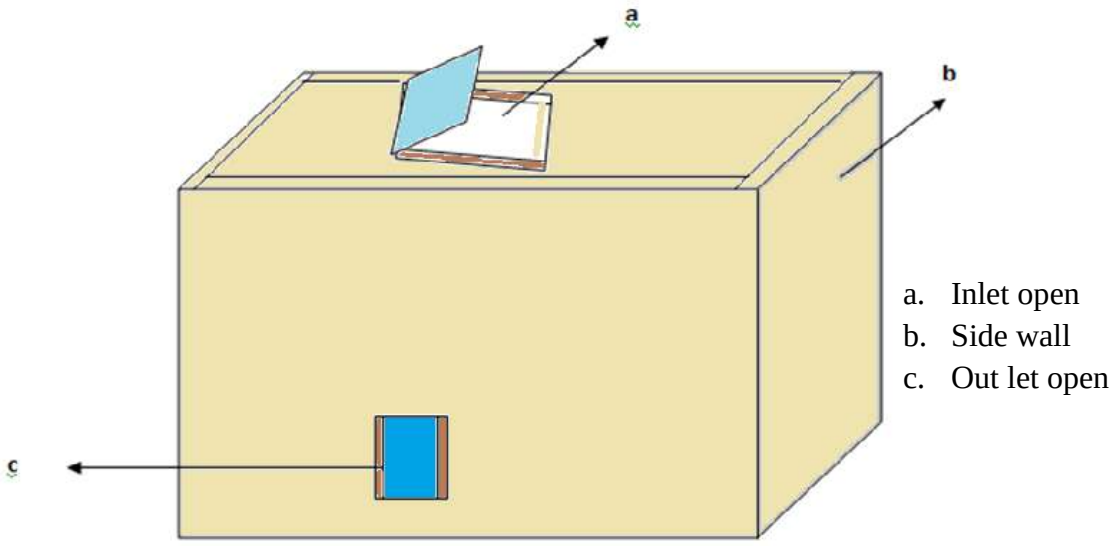
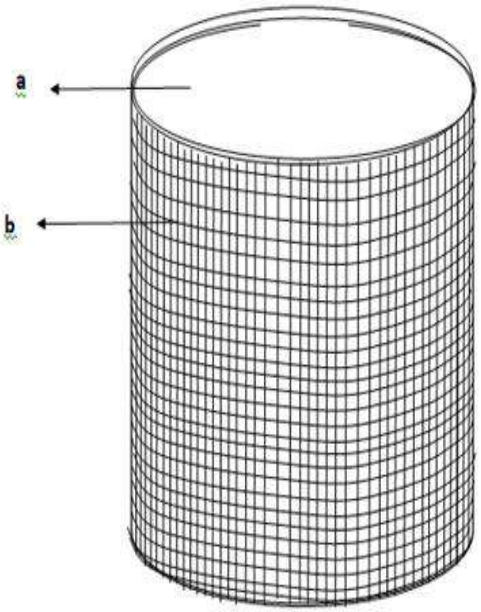


Figure 5.5 Schematic diagram of Panatha structure made of Cement and Brick provided with opening on top to load & small opening at bottom to draw seeds.

4.1.2.3 Kanaja Made of Bamboo

Kanaja Made of Bamboo are the structures that have become less in preference during these days so the numbers of users were found less. Kanaja structure had only one chamber built in a cylindrical form. By the external appearance, bamboo strips are noticeable, which got smeared with cow dung (Fig.6), but in some cases cleaned, fine red soil was used. The schematic diagram (Fig.6) represents the structure and details.

Kanaja Made of Bamboo.



a. Top open (load & unload)
b. Side wall

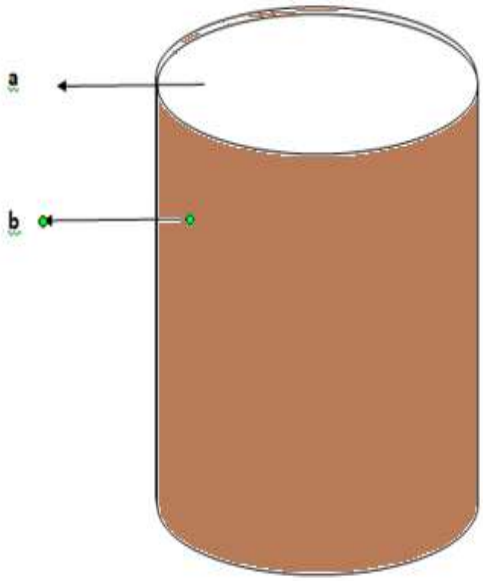
Schematic diagram of Kanaja Made of Bamboo.

Figure 6. Kanaja Made of Bamboo and its Schematic Diagram

4.1.2.4. Kanaja made of Metal Sheath

Kanaja made of metal sheath are now replaced the use of bamboo. The storage holder had a good opinion but the users are few. As Kanaja of bamboo this also had only one chamber in cylindrical form. The chamber was painted outside (Fig.7) and the top was covered with a thick plastic sheath by some storage holder, schematic diagram in Fig.7 represents the structure and details.

Kanaja Made of Metal sheath.



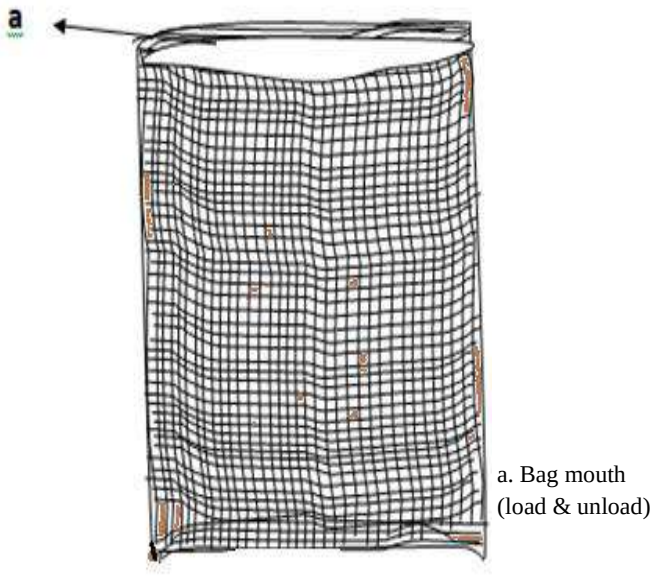
Schematic diagram of Kanaja Made of Metal sheath.

Figure 7. Kanaja Made of metal and its Schematic diagram

4.1.2.5. Jute Bag

Jute bag kind of storage method used regularly by the storage holders these bags are light in weight, and usually, fifty or hundred-kilogram capacity bags were used. The number of bags increases as the total quantity of stored seeds increases. All the filled bags (Fig.8) are kept in one side in the front room in their house or a storage room built for this. Schematic diagram (Fig.8) shows the structure.

Jute Bag lot.



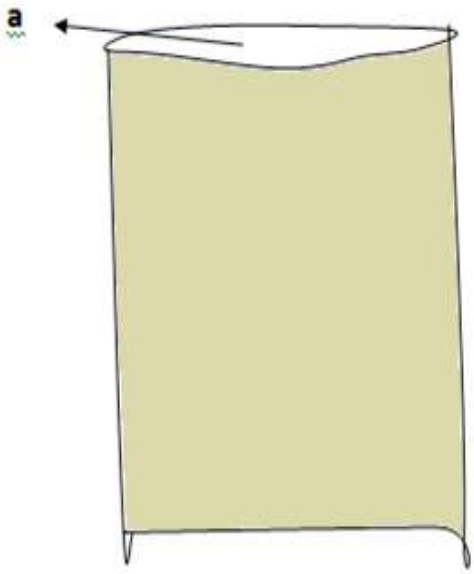
Schematic diagram of Jute bag.

Figure 8. Jute bag and its Schematic diagram

4.1.2.6. Polythene bag

Polythene bag was also regularly used by the storage holders these bags are light in weight, and usually, twenty-five-, fifty- or hundred-kilogram capacity bags were used. Number of bags increases with the quantity of storable seeds. The filled bags (Fig.9) were placed at one side of the front room in their house or storage room. With the few storage holders, it was observed that a plastic sheath was used to cover the bags. Fig.9 represents the schematic diagram of the bag.

Polythene bag lot.



a. Bag mouth (load & unload)

Schematic diagram of Polythene bag.

Figure 9. Polythene bag and its Schematic diagram

4.2 Fieldwork

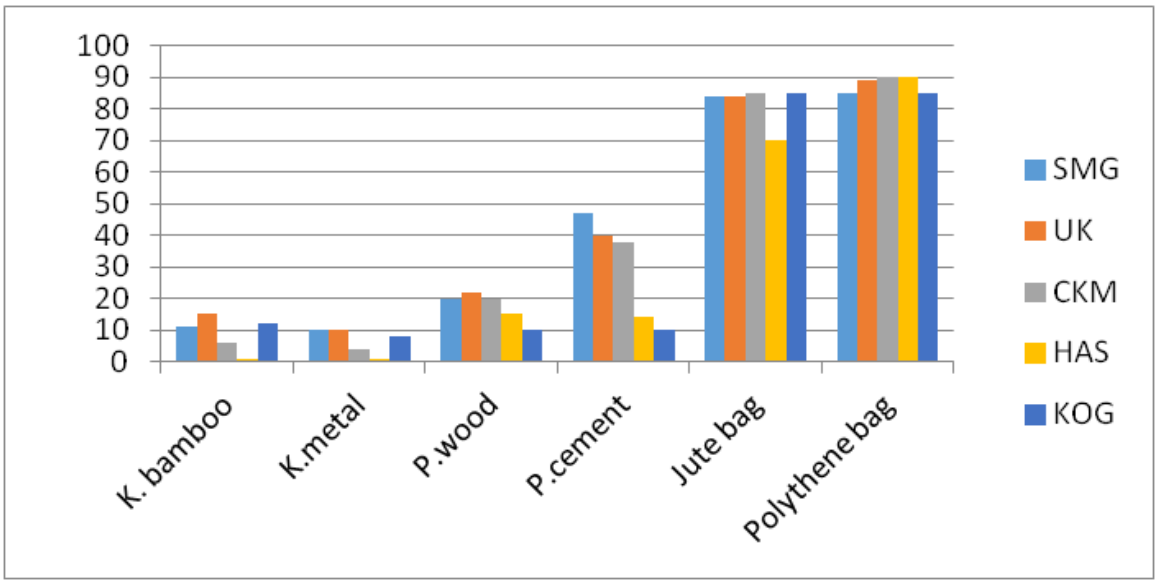
The visit done to meet the storage holders in villages of taluks in the five districts of the Malnad region found using traditional structures in huge numbers. Table 4.2 and Fig.12 shows toral avg percentage of use of the particular structure in each district Fig.13 shows the collected paddy sample. Panatha of wood in UK -22%, SMG-20%, CKM-20%, HAS-15 and KOD-10% was recoded. Panatha of cement and Brick was found 47% IN SMG, 40% -UK, CKM-38, HAS-14 and 10%. Kanaja of bamboo was observed in minimum numbers compare to others in HAS-01. Kanaja of metal quite good compare to this and maximum recorded in SMG (10%). Jute bag stands as second best with 85% in CKM and KOD 84% in SMG. Polythene bags are most preferred by all 90% in CKM & HAS in 89% in UK and 85% in SMG as well as KOD.

Table 4.2: Storage units observed in all districts

Type of storage structure	**Avg. Storage unit recorded in respective district**				
	SMG	**UK**	**CKM**	**HAS**	**KOG**
Panatha of wood	20	22	20	15	10
Panatha of cement &Brick	47	40	38	14	10
Kanaja of bamboo	11.3	15	06	01	12
Kanaja of metal	10	10	04	01	8
Jute bag	84	84	85	70	85
Polythene bag	85	89	90	90	85

values are in average

Fig.10 Average storage units observed in all districts.



K.bamboo- Kanaja of bamboo, K.metal-Kanaja of metal, P.wood-Panatha of wood, P.cement- Panatha of cement, SMG-Shimoga, UK- Uttara Kannada, CKM-Chikkamagaluru,HAS-Hassan, KOG-Kodagu.

Fig.11 Paddy seed samples collected

4.3. Stored Seed Analysis

4.3.1 Biological and Natural Methods Used

The knowledge present among the storage holders to keep their stored seeds safer for years by following biological and natural methods was recorded. Even though these methods have not undergone any significant changes in practice due to their better results, the communities still use them to the extent they need. These methods and the value of use shown in Table 4.3 with respect to regions and storage structure The value mentioned in the table by the numerical 1,2,3,4, and 5 represents the percentage of use of each treatment for particular storage structure in each district. 1 represent 20% the same 2, 3, 4 and 5 represent 40, 60, 80 and 100% respectively. The paddy has to be dried for better and long-term storage for this, they use sunlight as the natural source and are done before storage in any structure, the value of use was 5 which is highest compare to any others. Second best use was the plant source that's Lakki soppu, because of easily availability in the local area as a weed, it is used in PW, PC, KB and KM to the value of 2.5. There is a consistency in use of fumigation by natural herbs found in all regions, but the value of use is 1 because an interval of time a few months or year was there between two consecutive uses. The next best selection is dry chilly in JB and PB bags they put some chilly to avoid insects, most probably this method was used when they store paddy for themselves, other than this in most regions, chilly are used to spread over the surface of stored seed in chambered structures, the maximum value of its use is 0.5. Neem leaves used for a value of 1 this is also most preferred biological solution. The use of cow dung and cane sugar became very rare among the regions in SMG, CKM and HAS, so the use value remains 0.1 to 0.2.

Table 4.3 Shows the Value of Biological and Natural Methods Used in All Districts with Respect to Storage Structure

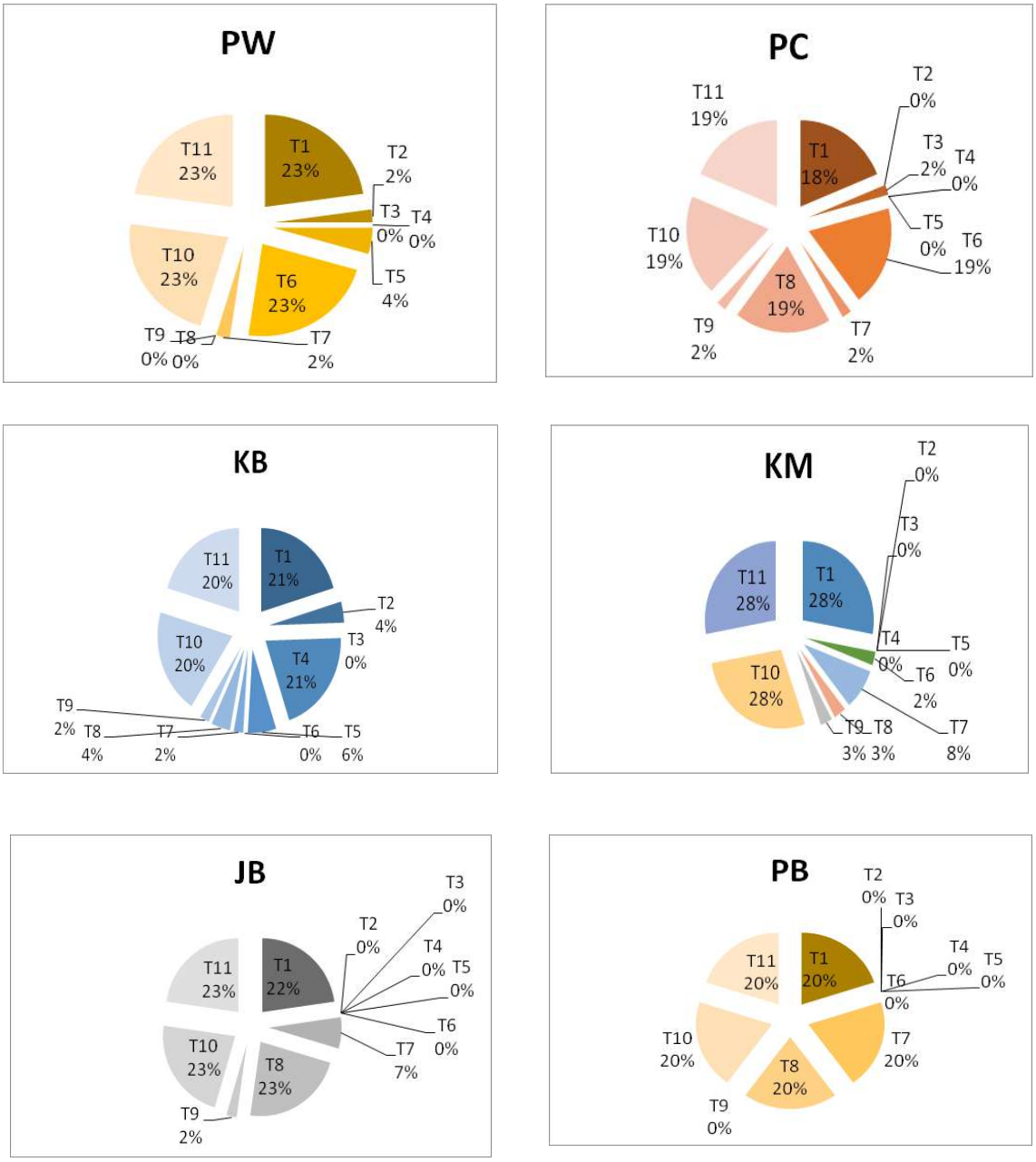
Storage type	District	Value of use										
		VT1 SEED DRY	VT2 ASH	VT3-RED SOIL	VT4-COW DUNG	VT5-CANE BARK	VT6-LAKKI SOPPU	VT7-GARLIC	VT8-RED CHILLI	VT9-Dry ginger	VT10-NEEM LEAF	VT11-FUMIGATION
PW	SMG	5	0.2	-	-	0.2	2	-	-	1	1	1
	CKM	5	-	-	-	-	1.5	-	-	0.3	1	1
	UK	5	-	-	-	0.1	1.5	-	-	-	1	1
	HAS	5	-	-	0.1	-	2	0.1	-	-	1	1
	KOD	5	-	-	-	-	2	-	-	-	1	1
PC	SMG	5	-	-	0.1	-	2.5	-	0.5	1	1	1
	CKM	5	-	0.1	0.1	-	2	-	0.5	-	1	1
	UK	5	-	-	-	-	2	-	0.2	0.5	1	1
	HAS	5	-	-	0.1	-	2	0.1	0.2	1	1	1
	KOD	5	-	-	0.1	-	2	-	0.2	-	1	1
KB	SMG	5	-	-	-	-	-	-	-	-	1	1
	CKM	5	0.2	-	-	-	0.2	-	-	-	1	1
	UK	5	-	-	-	-	-	-	0.5	0.1	1	1

	HAS	5	-	-	0.1	0.1	0.2	-	0.2	-	1	1
	KOD	5	0.1	-	-	-	0.2	0.2	-	-	1	1
KM	SMG	5	-	-	-	-	-	0.2	-	1	1	1
	CKM	5	-	-	-	-	1	0.1	0.1	1	1	1
	UK	5	-	-	-	-		-	-	0.5	1	1
	HAS	5	-	-	-	-	-	0.1	-	-	1	1
	KOD	5	-	-	-	-	-	0.1	-	0.6	1	1
JB	SMG	5	-	-	-	-	-	-	0.1	-	0.1	1
	CKM	5	-	-	-	-	--	-	0.1	-	-	1
	UK	5	-	-	-	-	-	1	0.1	-	-	1
	HAS	5	-	-	-	-	-	1	0.1	-	-	1
	KOD	5	-	-	-	-	-	1	0.1	-	1	1
PB	SMG	5	-	-	-	-	-	-	0.1	-	1	1
	CKM	5	-	-	-	-	-	0.8	0.1	-	.1	1
	UK	5	-	-	-	-	-	0.8	0.1	-	1	1
	HAS	5	-	-	-	-	-	0.8	0.1	-	0.1	1
	KOD	5	-	-	-		-	0.9	0.1			

Value.1=20%, 2+40%, 3=60%, 4=80%, 5=100%

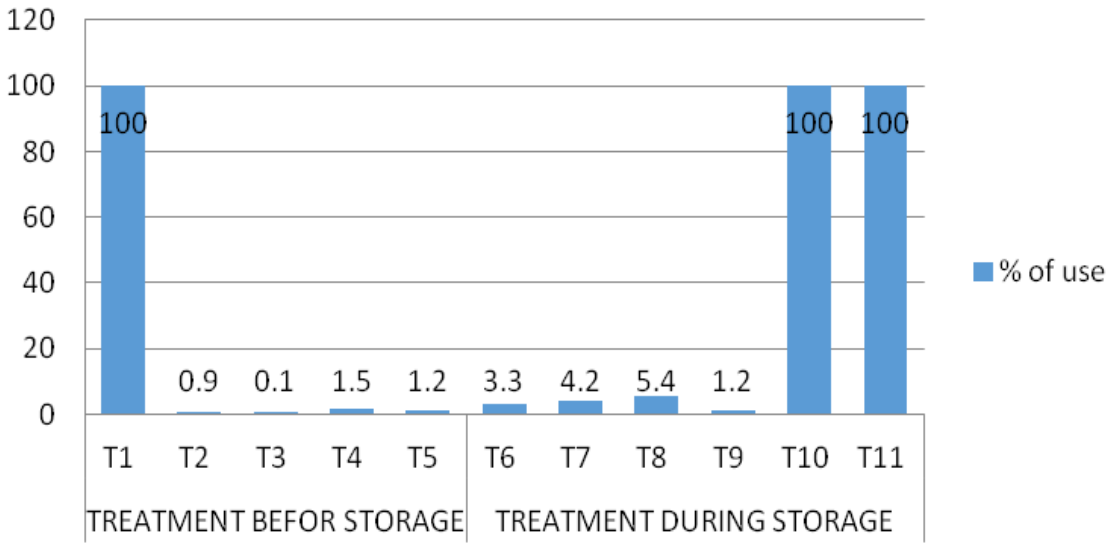
VT1-SEED DRY, VT2-ASH(WOOD), VT3-RED SOIL, VT4-COW DUNG, VT5-CANE BARK, VT6-LAKKI SOPPU, VT7-GARLIC, VT8-RED CHILLI, VT9-DRY GINGER, VT10-NEEM LEAF, VT11-FUMIGATION.

Figure 12: Pie chart shows % of each traditional seed's treatments followed before and during storage to all six storage structures



T1-Seed Dry, T2-Ash (Wood), T3-Red Soil, T4-Cow Dung, T5-Cane Bark, T6-Lakki Soppu, T7-Garlic, T8-Red Chili, T9-Dry Ginger, T10-Neem Leaf, T11-Fumigation.

Figure 13: Shows % of Traditional Seeds Treatments Followed Before and During Storage in all Districts



T1-Seed Dry, T2-Ash (Wood), T3-Red Soil, T4-Cow Dung, T5-Cane Bark, T6-Lakki Soppu, T7-Garlic, T8-Red Chili, T9-Dry Ginger, T10-Neem Leaf, T11-Fumigation.

4.3.2 Moisture Value

The moisture value of the sample was recorded and mentioned in the tables. It was classified based on storage time duration.

Table 4.4 shows the moisture value of samples stored for six months in PW, PC, KB, KM, JB and PB in all districts.

- Samples stored in PW in three taluks SA, TH and HO of SMG had 11.7, 11.8 and 11.7, respectively in UK taluks SS, HKB and AKY with 11.8, 11.8 and 11.3, respectively. In CKM, SR and MU had 11.8 and 12. In HAS for taluk SAK it was 11.8 and in KOD taluks SO, MA and VI had 11.8, 11.7 and 11.9 respectively.
- The samples stored in PC in three taluks SA, TH and HO of SMG had 11.7, 11.9 and 11.3, respectively in UK taluks SS, HKB and AKY with 11.7, 11.6 and 11.3, respectively. In CKM, SR and MU had 11.9 and 11.2. In HAS for taluk SAK it was 11 and in KOD taluks SO, MA and VI had 11, 11 and 10.6 respectively.
- From the samples stored in KB in three taluks of SA, TH and HO of SMG had 11.6, 11.8 and 12 respectively. In UK, taluks SS, HKB and AKY with 11.6, 11 and 10 respectively. In CKM, SR and MU had 10 and 9.9. In HAS for taluk SAK it was 9 and in KOD taluks SO, MA and VI had 9, 9.1 and 9.1 respectively.
- The samples stored in KM in three taluks SA, TH and HO of SMG had 11.5, 11.7 and 12, respectively. In UK, taluks SS, HKB and AKY with 11.5, 11.2 and 11.5, respectively. In CKM, SR and MU had 11.5 and 11. In HAS for taluk SAK it was 11 and in KOD taluks SO, MA and VI had 11, 10.2 and 10.2 respectively.
- Seed samples stored in JB in three taluks SA, TH and HO of SMG had 11, 11 and 11, respectively. In UK taluks SS, HKB and AKY with 11.2, 11 and 11,

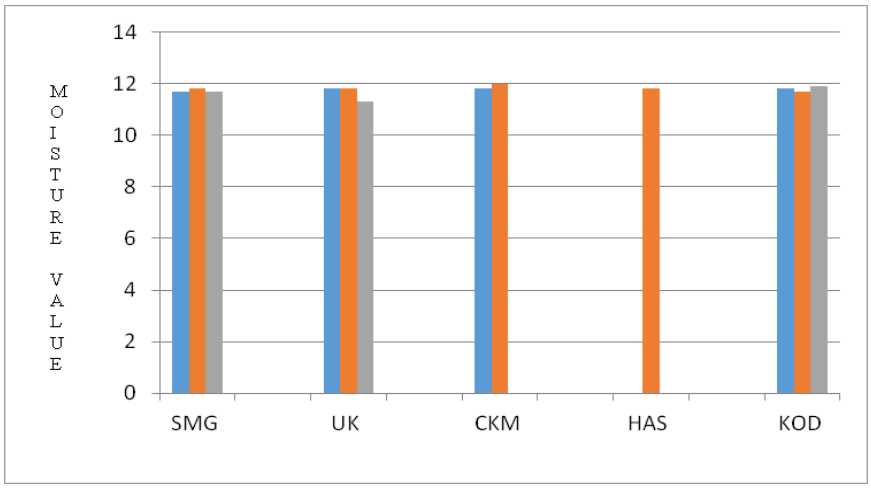
respectively. In CKM, SR and MU had 10 and 10 In HAS for taluk SAK it was 11 and in KOD taluks SO, MA and VI had 10, 10 and 10 respectively.

- Samples stored in PB in three taluks SA, TH and HO of SMG had 11.9, 11.9 and 11.9, respectively. In UK taluks SS, HKB and AKY with 9.4, 11.9 and 11.8, respectively. In CKM, SR and MU had 12 and 12 In HAS for taluk SAK it was 11.8 and in KOD taluks SO, MA and VI had 11.9, 11.9 and 11.8, respectively.

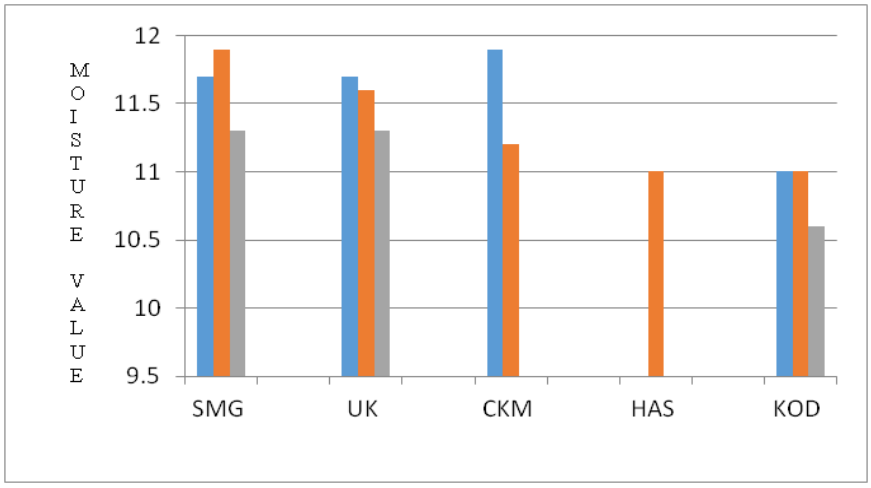
Table:4.4 Moisture Value of The Different Samples Stored for Six Months in Different Storage Structures in All Districts

Storage Type	Six months sample									
	SMG		UK		CKM		HAS		KOD	
	Sample	MV	Sample	MV	Sample	MV	Sample	MV	Sample	MV
PW	SA	11.7	SS	11.8	SR	11.8	SAK	11.8	SO	11.8
	TH	11.8	HKB	11.8	MU	12			MA	11.7
	HO	11.7	AKY	11.3					VI	11.9
PC	SA	11.7	SS	11.7	SR	11.9	SAK	11	SO	11
	TH	11.9	HKB	11.6	MU	11.2			MA	11
	HO	11.3	AKY	11.3					VI	10.6
KB	SA	11.6	SS	11.6	SR	10	SAK	9	SO	9
	TH	11.8	HKB	11	MU	9.9			MA	9.1
	HO	12	AKY	10					VI	9.1
KM	SA	11.5	SS	11.5	SR	11.5	SAK	11	SO	11
	TH	11.7	HKB	11.2	MU	11			MA	10.2
	HO	11.7	AKY	11.5					VI	10.2
JB	SA	11	SS	11.2	SR	10	SAK	10	SO	10
	TH	11	HKB	11	MU	10			MA	10
	HO	11	AKY	11					VI	10
PB	SA	11.9	SS	9.4	SR	12	SAK	11.8	SO	11.9
	TH	11.9	HKB	11.9	MU	12			MA	11.9
	HO	11.9	AKY	11.8					VI	11.8

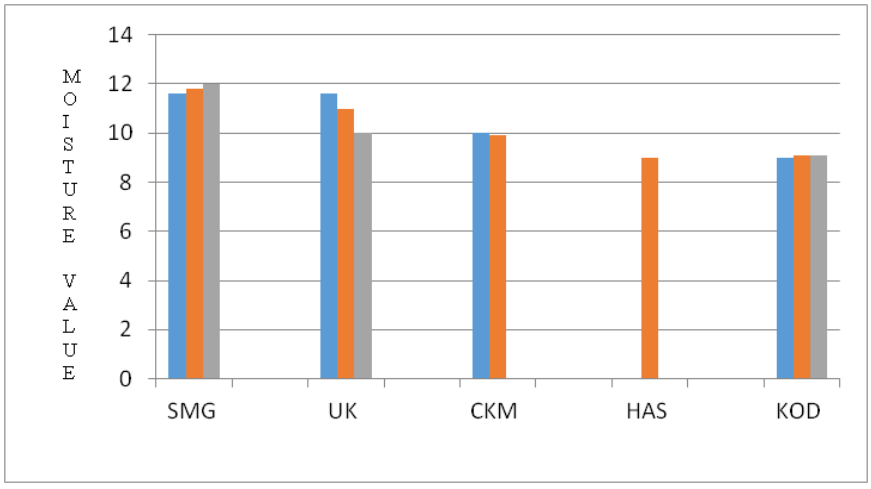
Fig 14. Moisture percentage of Six months sample



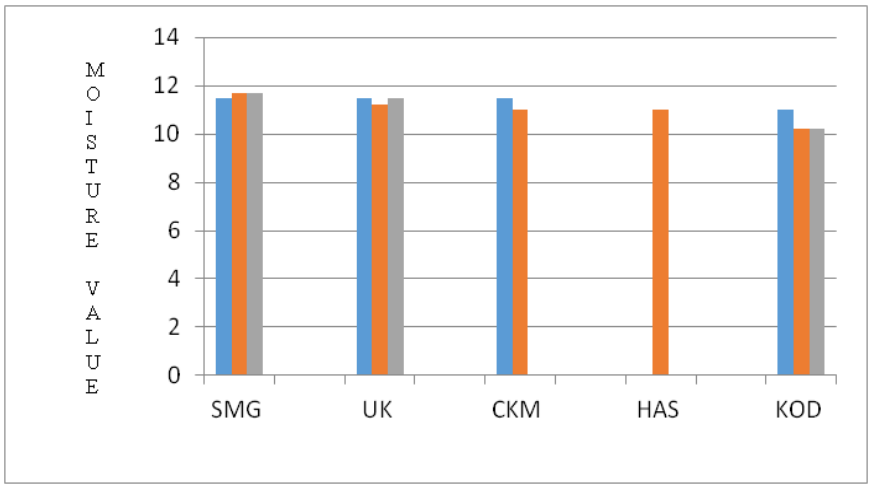
MOISTURE PERCENTAGE OF PW SIX MONTHS SAMPLE FROM ALL DISTRICS



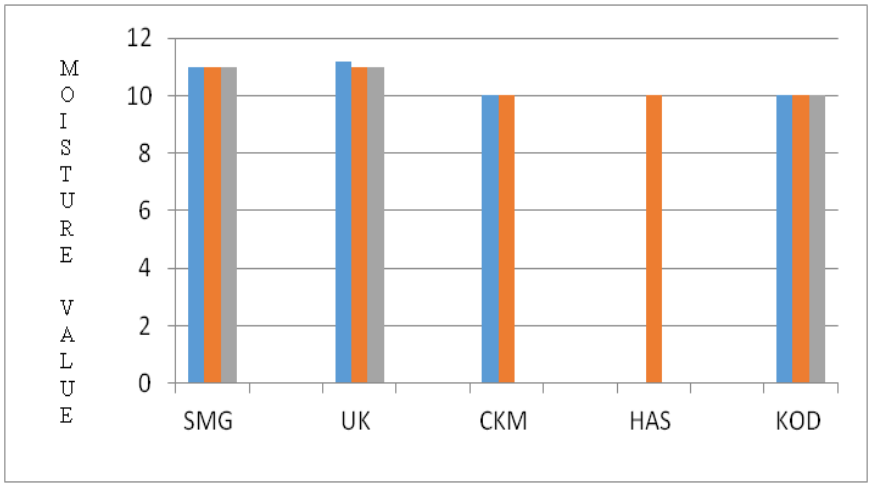
MOISTURE PERCENTAGE OF PC SIX MONTHS SAMPLE FROM ALL DISTRICTS



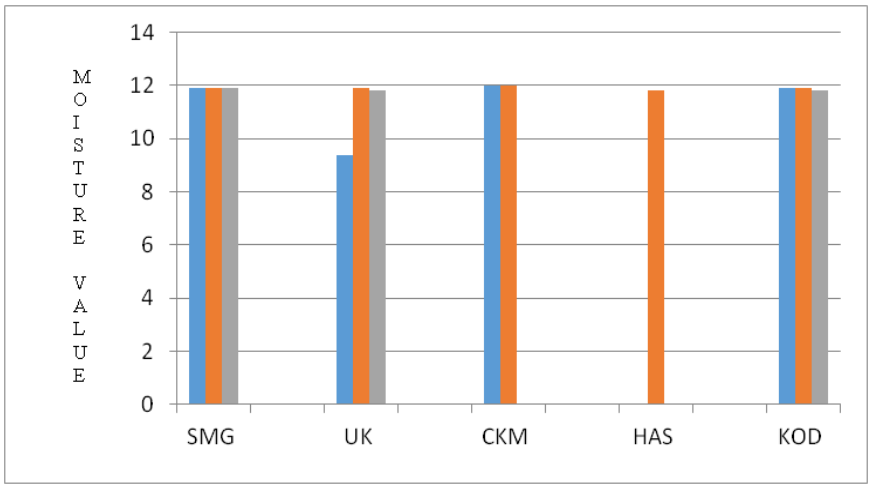
MOISTURE PERCENTAGE OF KB SIX MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF KM SIX MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF JB SIX MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF PB SIX MONTHS SAMPLE FROM ALL DISTRICTS

Table 4.5 shows the moisture value of samples stored for Nine months in PW, PC, KB, KM, JB and PB in all districts.

- Samples stored in PW in three taluks SA, TH and HO of SMG had 8.5, 9.1 and 8.9, respectively. In UK, taluks SS, HKB and AKY with 9, 9 and 9.1, respectively. In CKM, SR and MU had 9.9 and 9. In HAS for taluk SAK it was 8.9 and in KOD taluks SO, MA and VI had 9, 9 and 9.3 respectively.
- The samples stored in PC in three taluks SA, TH and HO of SMG had 9, 9.1 and 9.1, respectively. In UK. taluks SS, HKB and AKY with 9, 9.2 and 9, respectively. In CKM, SR and MU had 9 and 9. In HAS for taluk SAK it was 11 and in KOD taluks SO, MA and VI had 9, 8.7 and 8.8 respectively.
- From the samples stored in KB in three taluks of SA, TH and HO of SMG had 8.5, 8.8 and 9, respectively. In UK. taluks SS, HKB and AKY with 8.5, 8 and 6, respectively. In CKM, SR and MU had 8 and 7.5. In HAS for taluk SAK it was 7.7 and in KOD taluks SO, MA and VI had 8, 8 and 8 respectively.
- The samples stored in KM in three taluks SA, TH and HO of SMG had 8.5, 8.8 and 8, respectively. In UK, taluks SS, HKB and AKY with 8.8, 8.3 and 8, respectively. In CKM, SR and MU had 8.9 and 8.4 In HAS for taluk SAK it was 8.2 and in KOD taluks SO, MA and VI had 8.5, 8.5 and 8, respectively.
- Seed samples stored in JB in three taluks SA, TH and HO of SMG had 9, 9 and 8.9, respectively. In UK taluks SS, HKB and AKY with 9, 9.1 and 9 respectively. In CKM, SR and MU had 8.7 and 8.2 In HAS for taluk SAK it was 8.2 and in KOD taluks SO, MA and VI had 8.8, 8.6 and 8.8, respectively.

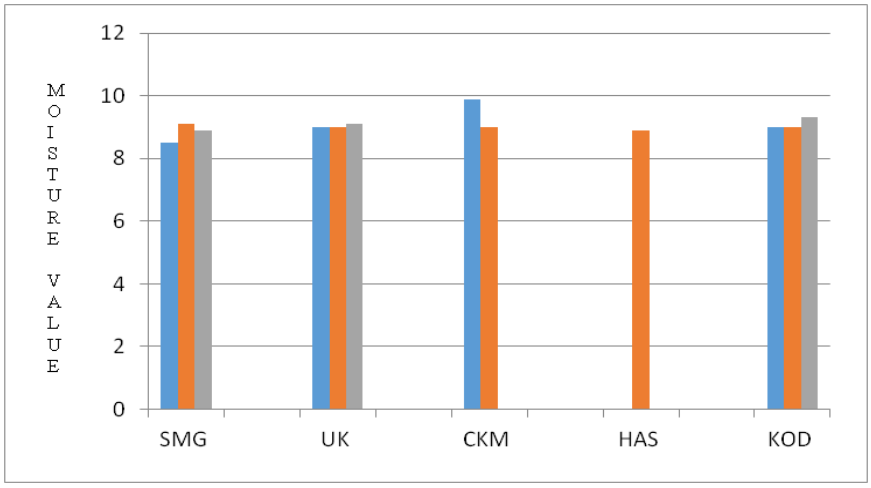
Samples stored in PB in three taluks SA, TH and HO of SMG had 9.2, 9.9 and 9.9, respectively. In UK, taluks SS, HKB and AKY with 9.4, 9.9 and 9.6, respectively.

In CKM, SR and MU had 9.9 and 9.2 In HAS for taluk SAK it was 9.1 and in KOD taluks SO, MA and VI had 9, 9 and 9, respectively.

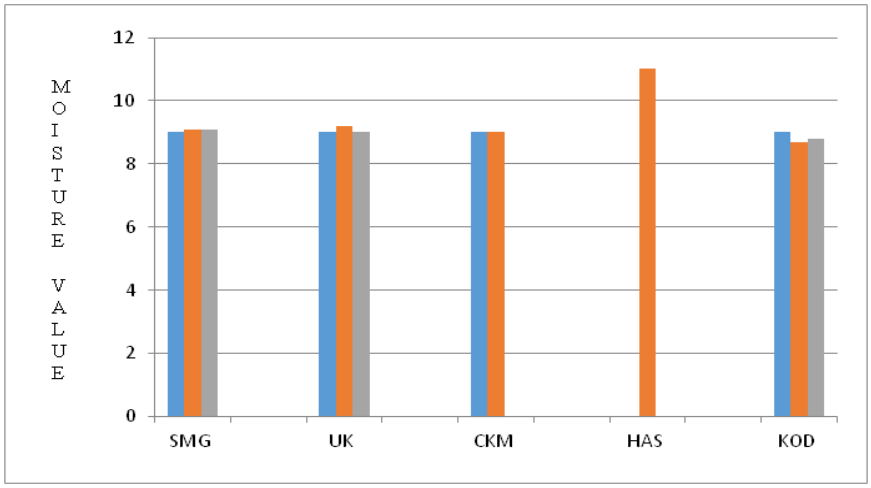
Table 4.5: Moisture Value of The Different Samples Stored for Nine Months in Different Storage Structures in All Districts

Storage Type	Nine months sample									
	SMG		UK		CKM		HAS		KOD	
	Sample	MV	Sample	MV	Sample	MV	Sample	MV	Sample	MV
PW	SA	8.5	S&S	9	SR	9.9	SAK	8.9	SO	9
	TH	9.1	HKB	9	MU	9			MA	9
	HO	8.9	AKY	9.1					VI	9.3
PC	SA	9	S&S	9	SR	9	SAK	11	SO	9
	TH	9.1	HKB	9.2	MU	9			MA	8.7
	HO	9.1	AKY	9					VI	8.8
KB	SA	8.5	S&S	8.5	SR	8	SAK	7.7	SO	8
	TH	8.8	HKB	8	MU	7.5			MA	8
	HO	9	AKY	6					VI	8
KM	SA	8.5	S&S	8.8	SR	8.9	SAK	8.2	SO	8.5
	TH	8.8	HKB	8.3	MU	8.4			MA	8.5
	HO	8	AKY	8					VI	8
JB	SA	9	S&S	9	SR	8.7	SAK	8.2	SO	8.8
	TH	9	HKB	9.1	MU	8.2			MA	8.6
	HO	8.9	AKY	9					VI	8.8
PB	SA	9.2	S&S	9.4	SR	9.9	SAK	9.1	SO	9
	TH	9.9	HKB	9.9	MU	9.2			MA	9
	HO	9.9	AKY	9.6					VI	9

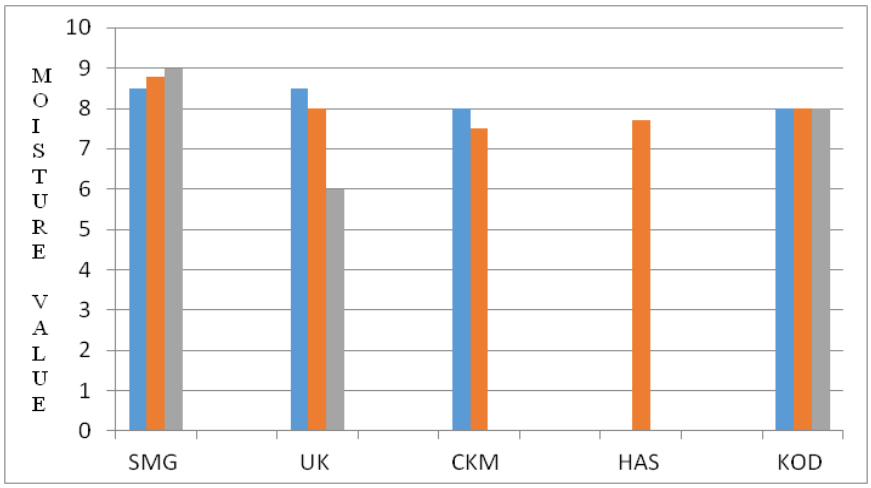
Fig 15. Moisture percentage of Nine months sample



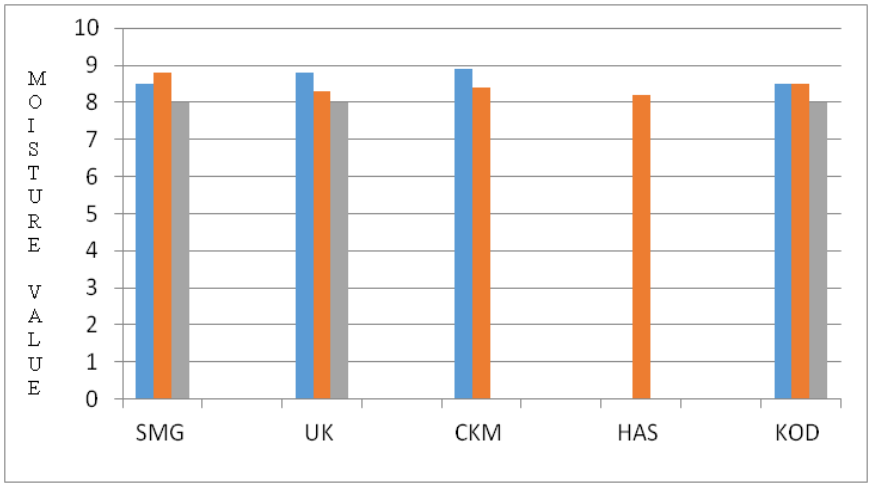
MOISTURE PERCENTAGE OF PW NINE MONTHS SAMPLE FROM ALL DISTRICTS



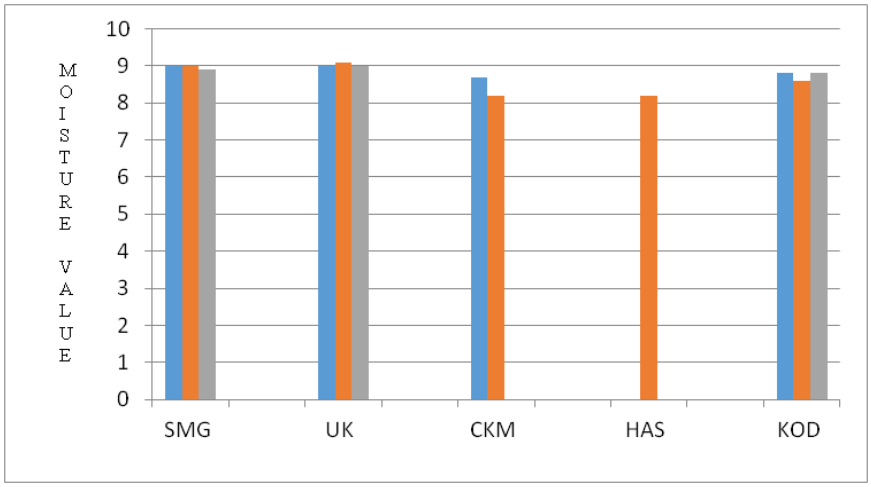
MOISTURE PERCENTAGE OF PC NINE MONTHS SAMPLE FROM ALL DISTRICTS



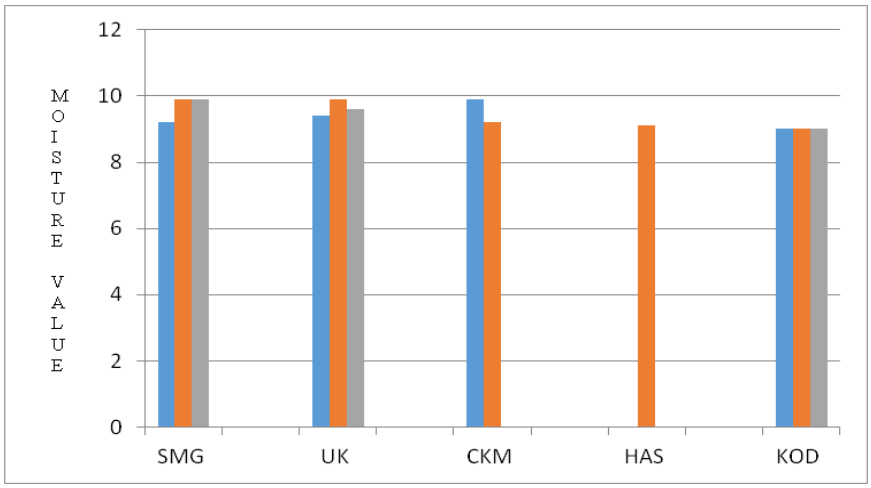
MOISTURE PERCENTAGE OF KB NINE MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF KM NINE MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF JB NINE MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF PB NINE MONTHS SAMPLE FROM ALL DISTRICTS

Table 4.6 shows the moisture value of samples stored for Twelve months in PW, PC, KB, KM, JB and PB in all districts.

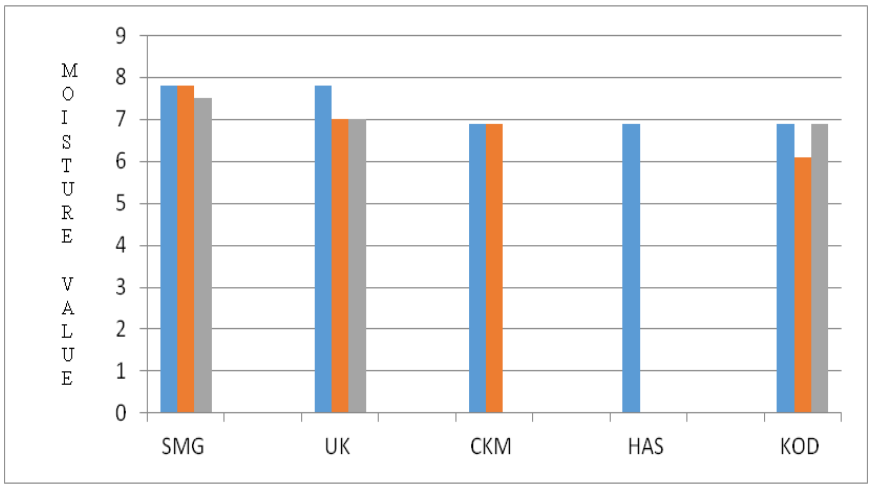
- Samples stored in PW in three taluks SA, TH and HO of SMG had 7.8, 7.8 and 7.5, respectively. In UK taluks SS, HKB and AKY with 7.8, 7 and 7, respectively, in CKM, SR and MU had 6.9 and 6.9. In HAS for taluk SAK it was 6.9 and in KOD taluks SO, MA and VI had 6.9, 6.1 and 6.9 respectively.
- The samples stored in PC in three taluks SA, TH and HO of SMG had 7.8, 7 and 7.6, respectively. In UK taluks SS, HKB and AKY with 7.8, 7 and 7.3, respectively, in CKM, SR and MU had 7.2 and 7.1. In HAS for taluk SAK it was 7 and in KOD taluks SO, MA and VI had 7, 6 and 7 respectively.
- From the samples stored in KB in three taluks SA, TH and HO of SMG had 6, 6 and 6 respectively. In UK. taluks SS, HKB and AKY with 6, 6and 4.5 respectively. In CKM, SR and MU had 6 and 5.2. In HAS for taluk SAK it was 5 and in KOD taluks SO, MA and VI had 5.1, 5.1 and 5 respectively.
- The samples stored in KM in three taluks SA, TH and HO of SMG had 6.5, 6.5 and 6.1, respectively. In UK. taluks SS, HKB and AKY with 6.2, 6.6 and 6, respectively. In CKM, SR and MU had 6 and 6 In HAS for taluk SAK it was 6 and in KOD taluks SO, MA and VI had 6.2, 6.1 and 6, respectively.
- Seed samples stored in JB in three taluks SA, TH and HO of SMG had 6.7, 6.6 and 6.7, respectively. In UK taluks SS, HKB and AKY with 7.1, 6 and 6.6, respectively. in CKM, SR and MU had 6.8 and 6.4 In HAS for taluk SAK it was 6 and in KOD taluks SO, MA and VI had 6, 6 and 6.1, respectively.

- Samples stored in PB in three taluks SA, TH and HO of SMG had 7, 7.2 and 7, respectively. In UK. taluks SS, HKB and AKY with 7.2, 7 and 7, respectively, in CKM, SR and MU had 6.4 and 6.4 In HAS for taluk SAK it was 6.8 and in KOD taluks SO, MA and VI had 6.4, 6.5 and 6.4 respectively.

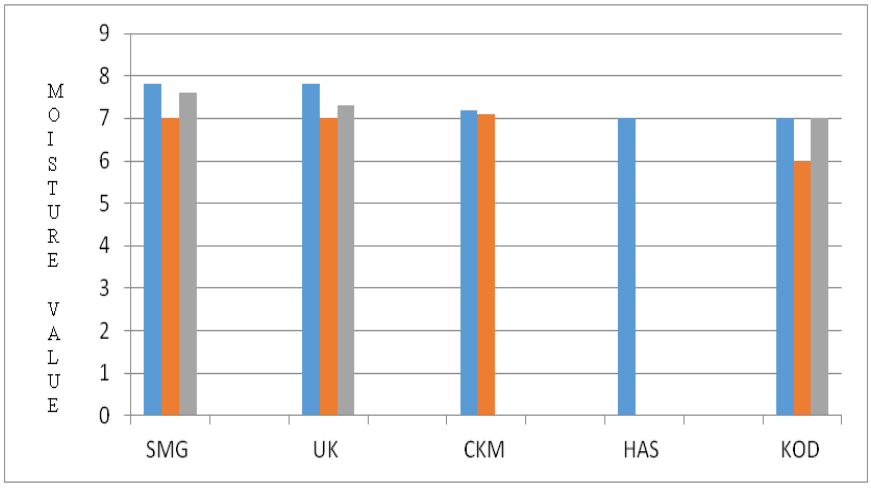
Table 4.6: Moisture Value of The Different Samples Stored for Twelve Months in Different Storage Structures in All Districts

Storage Type	Twelve months sample									
	SMG		UK		CKM		HAS		KOD	
	Sample	MV	Sample	MV	Sample	MV	Sample	MV	Sample	MV
PW	SA	7.8	S&S	7.8	SR	6.9	SAK	6.9	SO	6.9
	TH	7.8	HKB	7	MU	6.9			MA	6.1
	HO	7.5	AKY	7					VI	6.9
PC	SA	7.8	S&S	7.8	SR	7.2	SAK	7	SO	7
	TH	7	HKB	7	MU	7.1			MA	6
	HO	7.6	AKY	7.3					VI	7
KB	SA	6	S&S	6	SR	6	SAK	5	SO	5.1
	TH	6	HKB	6	MU	5.2			MA	5.1
	HO	6	AKY	4.5					VI	5
KM	SA	6.5	S&S	6.2	SR	6	SAK	6	SO	6.2
	TH	6.5	HKB	6.6	MU	6			MA	6.1
	HO	6.1	AKY	6					VI	6
JB	SA	6.7	S&S	7.1	SR	6.8	SAK	6	SO	6
	TH	6.6	HKB	6	MU	6.4			MA	6
	HO	6.7	AKY	6.6					VI	6.1
PB	SA	7	S&S	7.2	SR	6.4	SAK	6.8	SO	6.4
	TH	7.2	HKB	7	MU	6.4			MA	6.5
	HO	7	AKY	7					VI	6.4

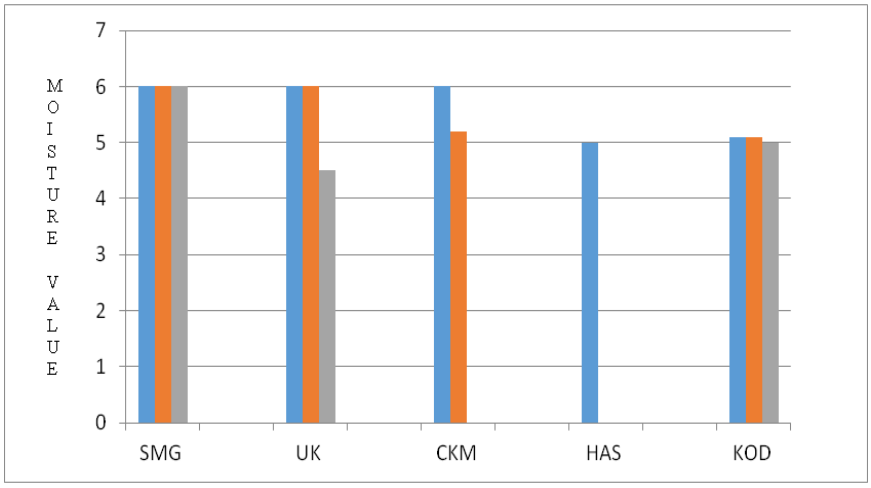
Fig 16. Moisture percentage of Twelve months sample



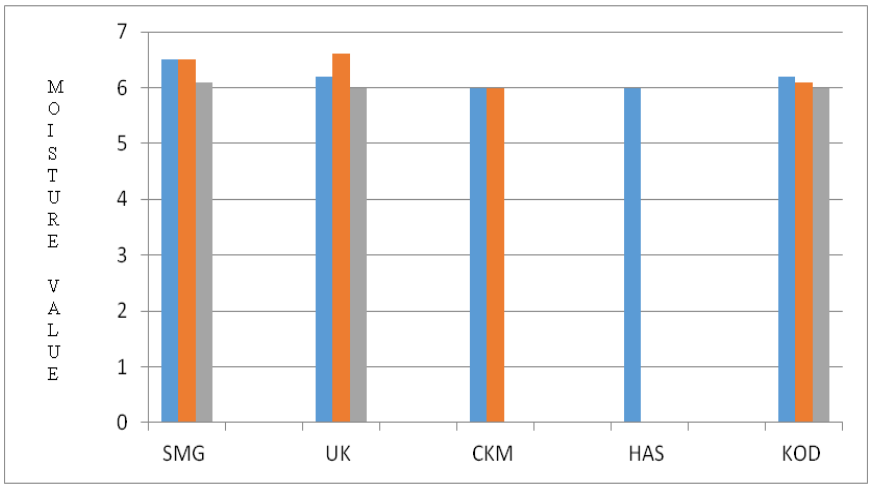
MOISTURE PERCENTAGE OF PW TWELVE MONTHS SAMPLE FROM ALL DISTRICTS



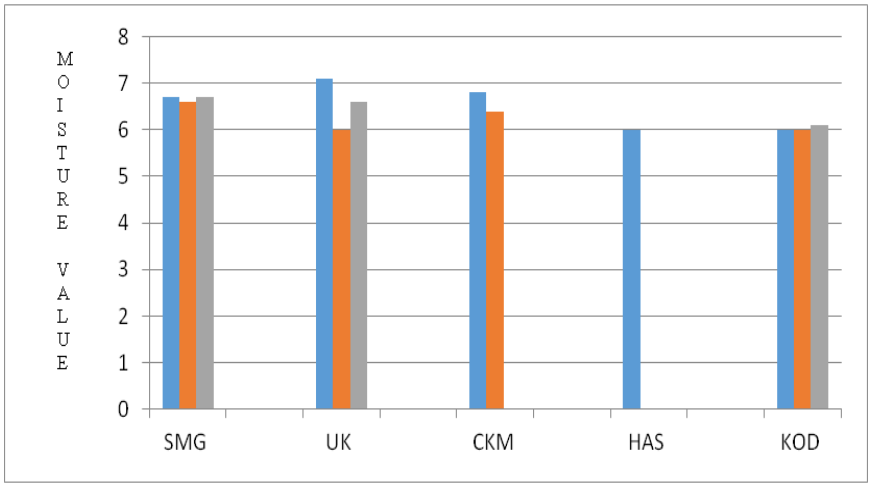
MOISTURE PERCENTAGE OF PC TWELVE MONTHS SAMPLE FROM ALL DISTRICTS



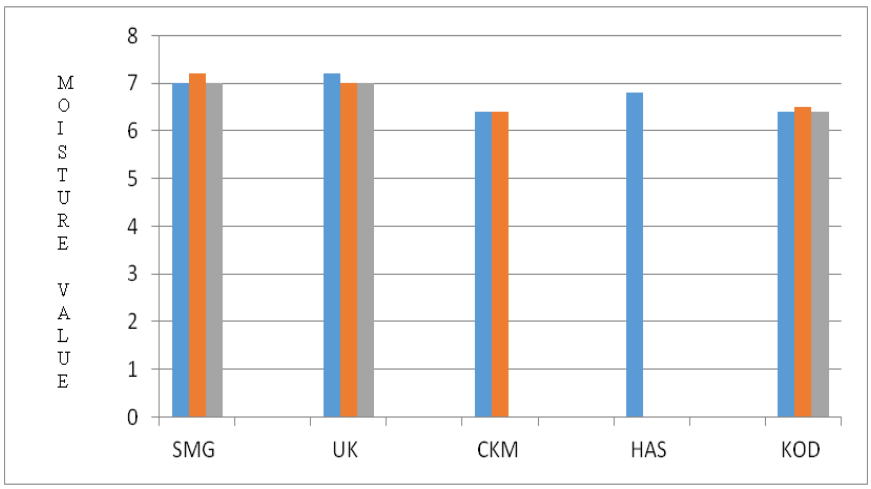
MOISTURE PERCENTAGE OF KB TWELVE MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF KM TWELVE MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF JB TWELVE MONTHS SAMPLE FROM ALL DISTRICTS



MOISTURE PERCENTAGE OF PB TWELVE MONTHS SAMPLE FROM ALL DISTRICTS

4.3.3 Germination

Table 4.7 shows the germination percentage of samples stored for Six months in PW, PC, KB, KM, JB and PB in all districts, the result given for the germination tests of Standard Blotter (SB), Sand (SN), Paper Towel (PT) and Brick and Gravel Method (B&G).

PW samples stored for six months showed the good percentage of germination in SB method it was a maximum of 93.3% present in (SR, SAK and MA) minimum in HKB sample from UK with 82.2%. By SN method, the maximum was 86% in three samples (TH, SR & SAK) and the minimum in 82.5 in four samples (SA, AKY, MA & VI). From PT found 85.5% as the maximum and 81.5 was the minimum. And from B&G method, the maximum of 82% was recorded by eight samples, minimum of 80%.

PC samples showed a percentage of germination in SB method maximum of 92-93% and as a minimum of 89% observed in MA of KOD. In SN 88% was the maximum, and remained samples percentage lice between 73-83% means there was a ten percent difference. From PT test maximum of 88% and a minimum of 75 % were recorded. B&G method value remains between 73 to 83.5% as minimum and maximum. KB samples by SB method showed good percentage of germination no much difference was there for six months of storage because the value was between 90 to 93%. But in SN it was 79 to 87%. In PT the value was 86% as the maximum and 81% as the minimum. In B&G value lice from 79 to 81.3%. KM samples shown percentage of germination in the SB method maximum ranges between 81 to 84.8%. In SN, 85.7% was the maximum. From PT test observed a maximum of 80% and a minimum of 78 %. B&G method value remains between 76 to 78% with a two percent difference. JB samples showed a percentage of germination in SB of 93%. By the SN

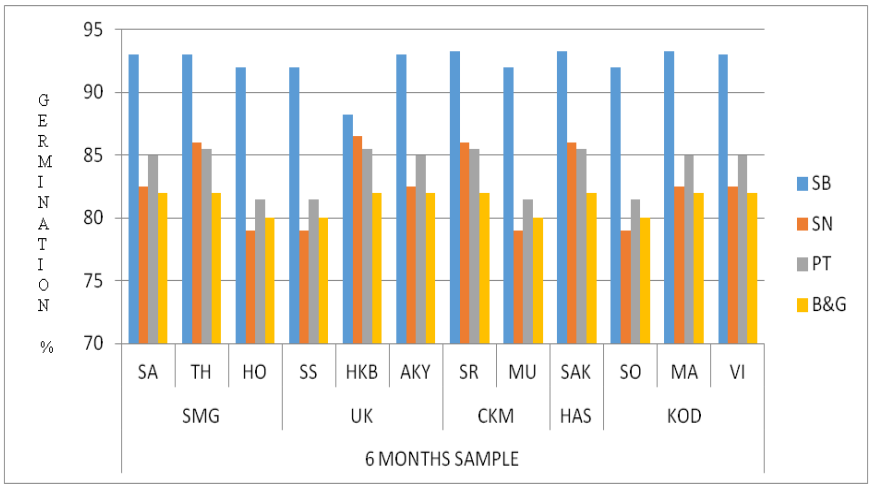
method a maximum of 88% was shown. From PT test maximum of 88% and by the B&G method, its value was 72 to 83.5%. PB samples showed that the percentage of germination in SB was around 93% in most samples. By SN method its 86.5% as the maximum, PT test value had of 81 to 86% and by the B&G method maximum of 82% was observed.

Table 4.7 Germination percentage of the different samples stored for Six months in different storage structures in all districts

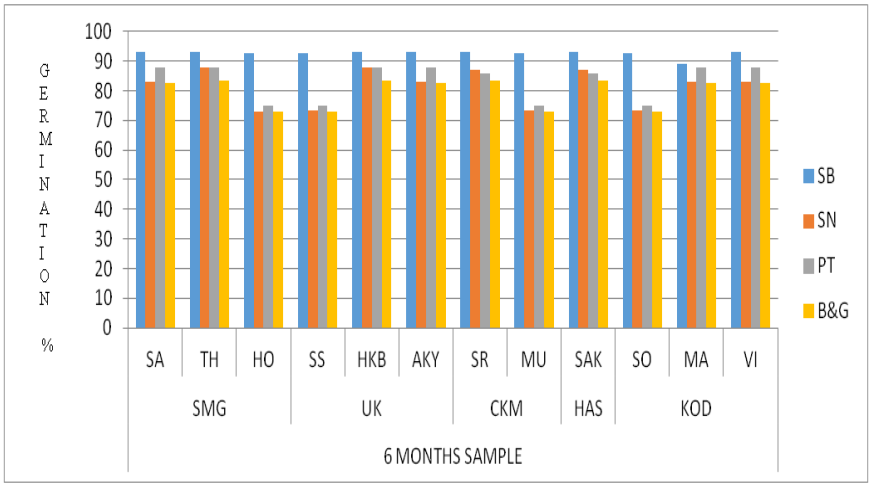
STORAGE		6 MONTHS SAMPLE											
		SMG			UK			CKM		HAS	KOD		
	Test	SA	TH	HO	SS	HKB	AKY	SR	MU	SAK	SO	MA	VI
PW	SB	93	93	92	92	88.2	93	93.3	92	93.3	92	93.3	93
	SN	82.5	86	79	79	86.5	82.5	86	79	86	79	82.5	82.5
	PT	85	85.5	81.5	81.5	85.5	85	85.5	81.5	85.5	81.5	85	85
	B&G	82	82	80	80	82	82	82	80	82	80	82	82
PC	SB	93	93	92.6	92.6	93	93	93	92.6	93	92.6	89	93
	SN	83	88	73	73.3	88	83	87.2	73.3	87.2	73.3	83	83
	PT	88	88	75	75	88	88	86	75	86	75	88	88
	B&G	82.5	83.5	73	73	83.5	82.5	83.5	73	83.5	73	82.5	82.5
KB	SB	92	92	92	90	92	92	93	90	93	90	92	92
	SN	80	79	86	87	79	80	79	87	79	87	80.4	80
	PT	82	81.5	86	86.1	81.5	82	83	86.1	81.5	86.1	81	82
	B&G	79	80	81.3	80.5	80	79	80	80.5	80	80.5	77	79
KM	SB	81	84	83.8	83.5	84.8	81	84	83.5	84	83.5	83	81
	SN	81	85	85	85	85.7	81	85	85	85.2	85	80.6	81
	PT	80	78	78	78	78	80	78.2	78	78	78	80	80
	B&G	78	77	77	77	76	78	75	77	77	77	77.6	78

JB	**SB**	92.5	92.5	93	92	92.5	92.9	91.8	92	91.9	92	92.5	92.9
	SN	73.7	73	88	88	73.7	73.7	72.7	88	73.7	88	73	73.7
	PT	75	75	87	87	75	75	75.2	87	75	87	75.3	75
	B&G	73	72	83.5	83.5	73	73	71	83.5	73	83.5	71	73
PB	**SB**	92	92	93	93	92	92	89	93	92	93	92.9	92
	SN	79	86	86.5	86.5	86	79	79.5	86.5	84	86.5	79	79
	PT	81	86	85.5	85	86	81	79	85	83	85	81	81
	B&G	81	81	82	82	81	78.9	76.8	82	76.8	82	81	78.9

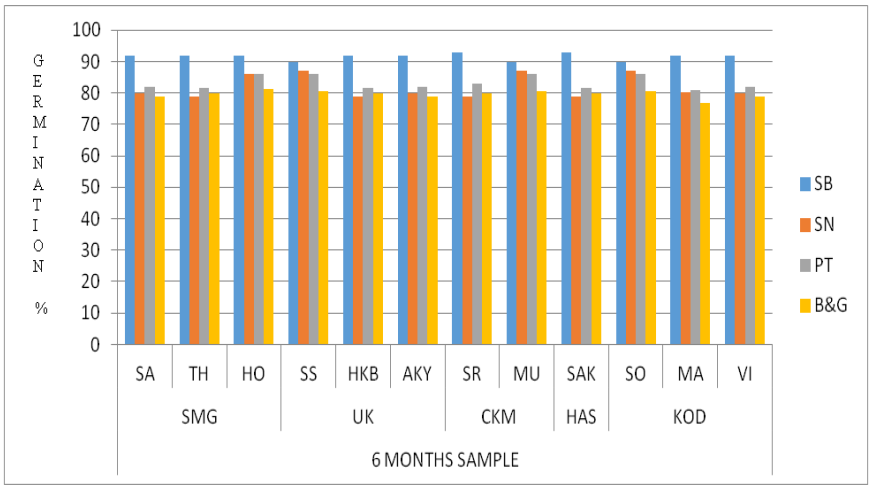
Fig 17. Germination percentage of Six months sample



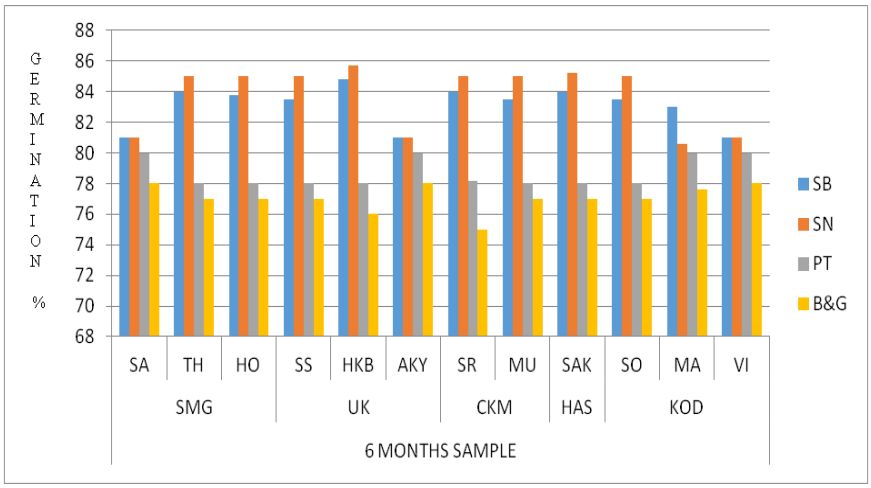
GERMINATION PERCENTAGE OF SIX MONTHS SAMPLES IN PW



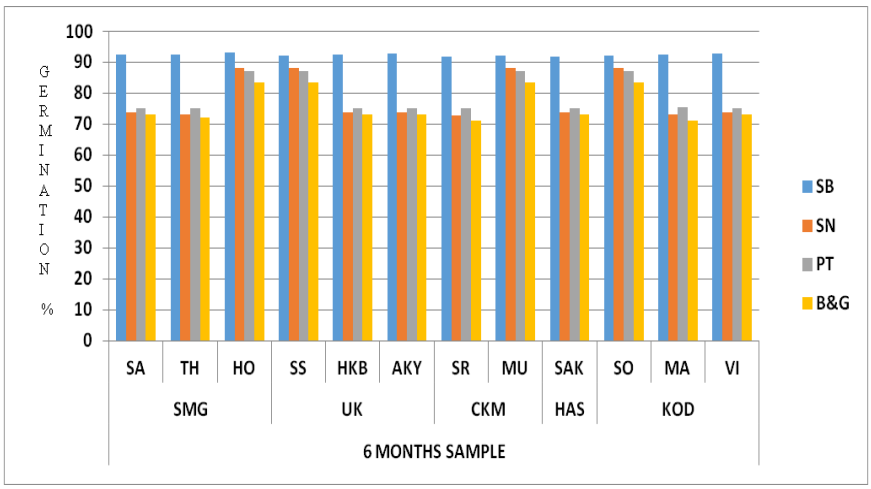
GERMINATION PERCENTAGE OF SIX MONTHS SAMPLES IN PC



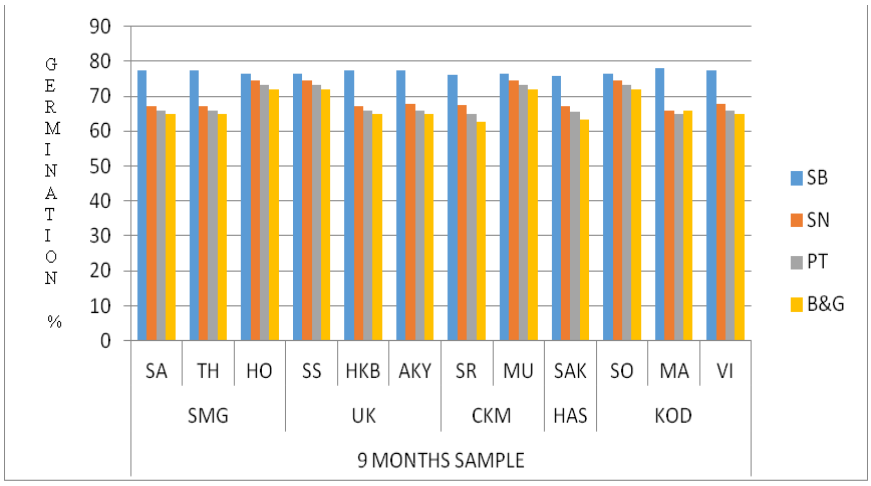
GERMINATION PERCENTAGE OF SIX MONTHS SAMPLES IN KB



GERMINATION PERCENTAGE OF SIX MONTHS SAMPLES IN KM



GERMINATION PERCENTAGE OF SIX MONTHS SAMPLES IN JB



GERMINATION PERCENTAGE OF SIX MONTHS SAMPLES IN PB

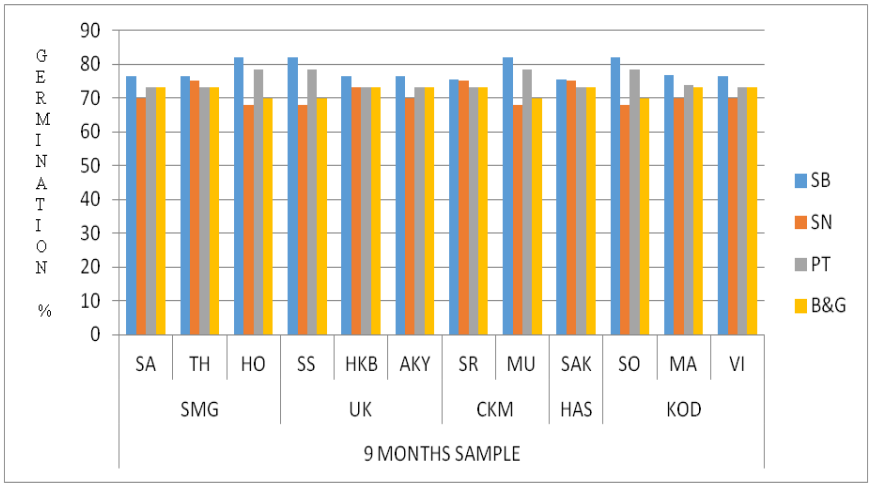
Samples stored for nine months showed the lesser percentage of germination compared to the six months sample stored in all types of structure in Table 4.8. The PW samples shown maximum of 82% in SB, 75% in SN, 78.5% in PT and 73% B&G methods. the minimum of 75% in SB, 68% in SN, 73% in PT and 70% in B&G methods. With these values its came to know that the germination ability get affected. This decline was observed in the PC sample also, in SB, its 78%, SN-75%, PT-77.4% and by B&G 70.2% by. In the KB sample, a maximum of 82.8%, 68.5%, 66.8 and 68.4 was observed by SB, SN, PT and B&G methods, respectively. But in KM, it reduced because of the cold effect by the structure so a maximum of 53.3%, 67%, 52% and 49% were shown by the sample in SB, SN, PT and B&G methods, respectively. In bags of JB and PB, it was a little better with 78.6% and 77.9% in SB, 75.6% and 74.5% in SN, 77% and 73.3% in PT and 75.8% & 72% in B&G methods minimum percentage had the difference of around 2%.

Table 4.8 Germination percentage of the different samples stored for Nine months in different storage structures in all districts

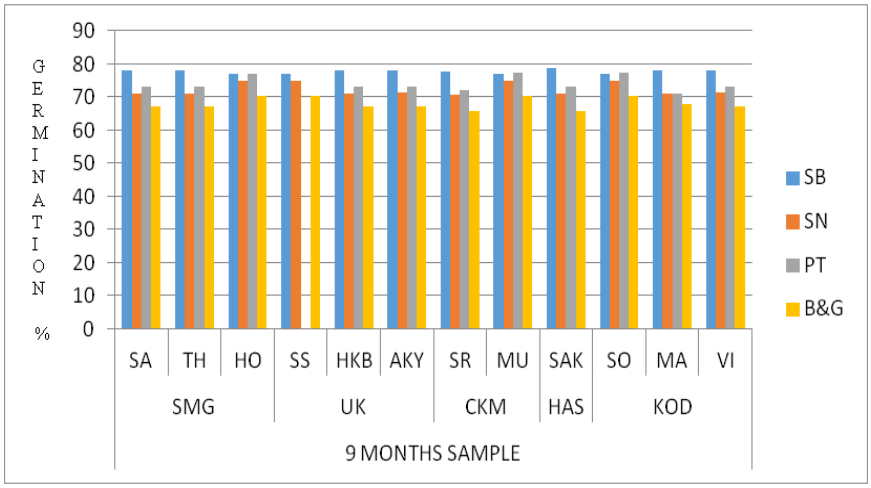
STORAGE		9 MONTH SAMPLE											
		SMG			UK			CKM		HAS	KOD		
	Test	SA	TH	HO	SS	HKB	AKY	SR	MU	SAK	SO	MA	VI
PW	SB	76.5	76.5	82	82	76.5	76.5	75.5	82	75.5	82	76.7	76.5
	SN	70	75	68	68	73	70	75	68	75	68	70	70
	PT	73	73	78.5	78.5	73	73	73	78.5	73	78.5	73.8	73
	B&G	73	73	70	70	73	73	73	70	73	70	73	73
PC	SB	78	78	77	77	78	78	77.6	77	78.7	77	78	78
	SN	71	71	75	75	71	71.4	70.8	75	71	75	71	71.4
	PT	73	73	77	77,4	73	73	72	77.4	73	77.4	71	73
	B&G	67	67	70.2	70.2	67	67	65.7	70.2	65.7	70.2	68	67
KB	SB	81.7	82	77.5	77.7	82	81.7	82.8	77.7	82.8	77.7	81.1	81.7
	SN	68.5	68	67	67.2	68	68.5	68	67.2	68	67.2	68.5	68.5
	PT	79	78.5	66	66.8	78.5	79	78.5	66.8	78.5	66.8	79.5	79
	B&G	69	70	64.4	62.4	70	69	70	62.4	70	62.4	68.4	69
KM	SB	53	53.5	53.5	53	53.5	53	53.5	53	53.5	53	56	53
	SN	50	67	67	67	57.8	50	65.9	67	65.9	67	51	50
	PT	50	51	51	51	52	50	51	51	51	51	50	50
	B&G	48	47	47	46.6	47	48	47	46.6	47	46.6	49	48

JB	**SB**	77	77	78	78.6	77	77	78.6	78.6	78	78.6	77	77
	SN	60	60	71	71	75	60	75.1	71	75.6	71	60.6	60
	PT	77	77	73	71.9	77	77	75	71.9	75	71.9	77	77
	B&G	70	70	67	65	70	75.8	68.9	65	68.9	65	70	75.8
PB	**SB**	77.5	77.5	76.5	76.5	77.5	77.5	76.1	76.5	75.8	76.5	77.9	77.5
	SN	67	67	74.5	74.5	67	67.8	67.4	74.5	67	74.5	66	67.8
	PT	66	66	73.3	73.3	66	66	65	73.3	65.6	73.3	65	66
	B&G	65	65	72	72	65	65	62.6	72	63.4	72	65.7	65

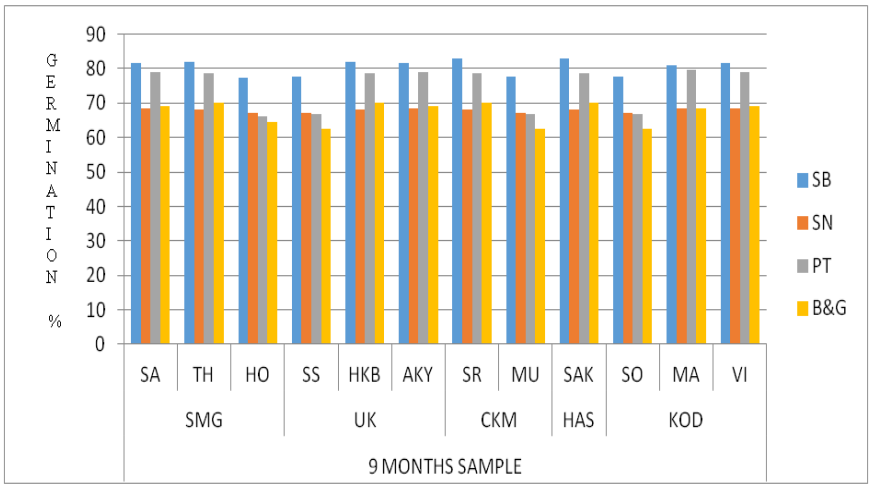
Fig 18: Germination percentage of Nine months sample



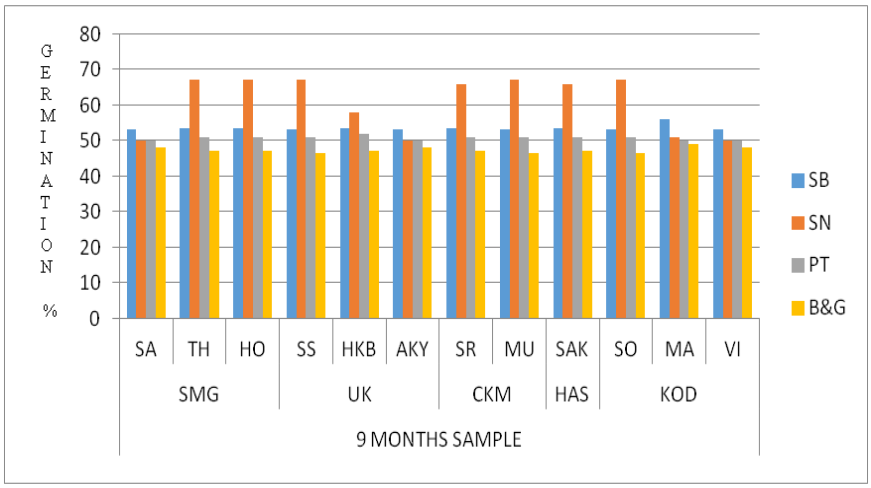
GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN PW



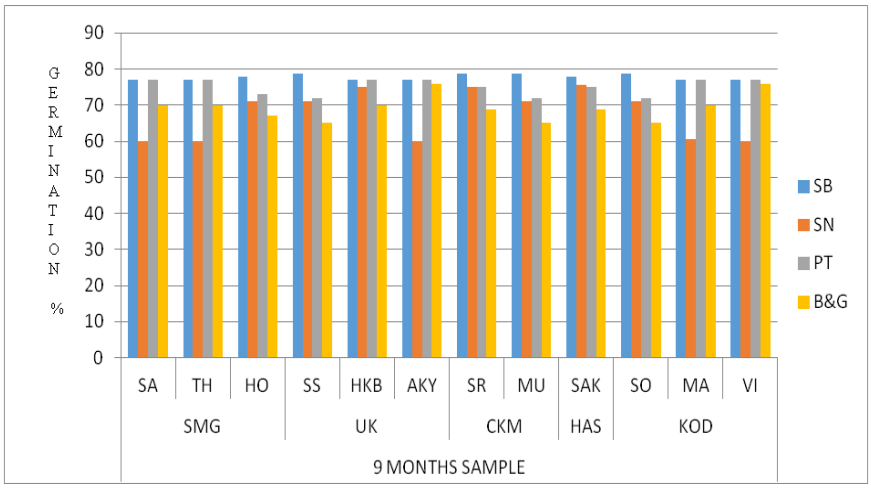
GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN PC



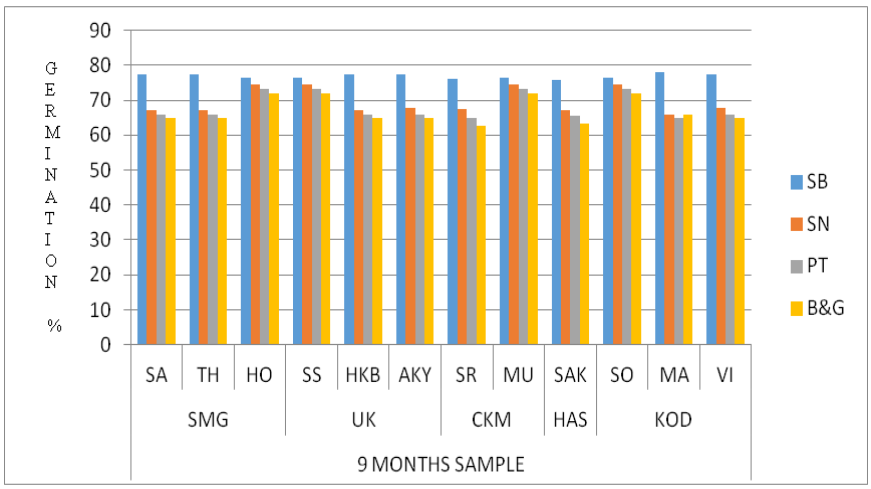
GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN KB



GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN KM



GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN JB



GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN PB

Samples stored for twelve months in all types of the structure show the percentage of germination as in Table 4.9 can notice the difference in value compared to six and nine samples, which was about 30 to 15%, respectively. The PW samples shown maximum of 61% & minimum 60.7% in SB, in SN it is of 51% 43%, in PT, its 52-44% and by B&G methods, 43%. The same similar value difference was observed in the PC sample also, in SB maximum of 55.3%, in SN-45%, PT-44.7% and by B&G at 38%. In the KB sample, a maximum of 63.5%, 46%, 52%, and 45% as minimum, 45%, 33.7%, 33%, and 30% were observed by SB, SN, PT and B&G methods, respectively. The KM stored sample showed a maximum of 32%, 32%, 24% and 25% of germination by SB, SN, PT and B&G methods, respectively. In JB maximum percentage and minimum was 55.7% and 47 in SB, 45% and 35% in SN, 44.5% and 43.5% in PT, 40.1% and 38% in B&G tests was recorded. PB sample showed germination percentage maximum and minimum in SB was 60.7% as and 44.3% in SN 51% and 33%, in PT 44% and 33%, in B&G 43% and 30%, so it can notice that ability of germination declining as the storage time progress it more prominently observed in B&G method for all the samples.

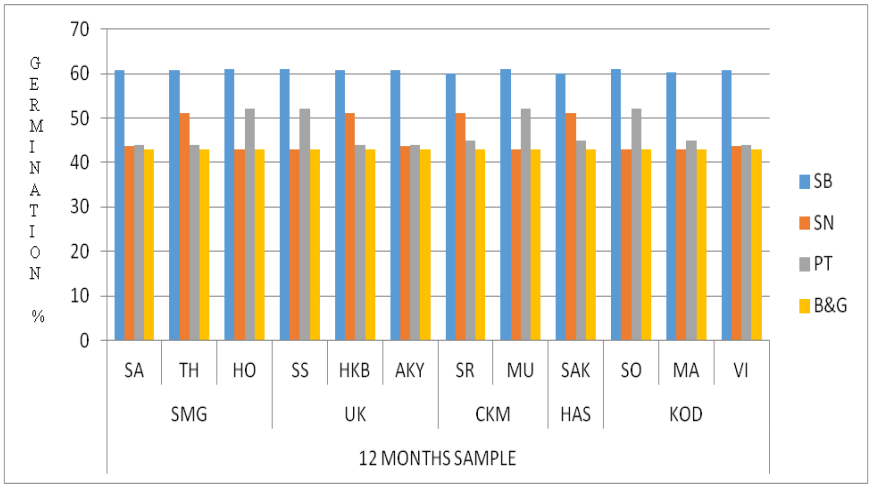
Table 4.9. Germination percentage of the different samples stored for Twelve months in different storage structures in all districts

STORAGE		12 MONTH SAMPLE											
		SMG			UK			CKM		HAS	KOD		
	Test	SA	TH	HO	SS	HKB	AKY	SR	MU	SAK	SO	MA	VI
PW	SB	60.7	60.7	61	61	60.7	60.7	60.1	61	60	61	60.3	60.7
	SN	43.7	51	43	43	51	43.7	51	43	51	43	43	43.7
	PT	44	44	52	52	44	44	44.8	52	44.8	52	45	44
	B&G	43	43	43	43	43	43	43	43	43	43	43	43
PC	SB	55	55	47.5	47.5	55	47	55.1	47.5	55.4	47.5	55.3	47
	SN	41	41	45	45	41	41	42	45	41	45	41	41
	PT	44	44	44	44	44	44	42	44	44.7	44	43	44
	B&G	39	39	40	40	39	39	38	40	38	40	39	39
KB	SB	63.5	61	45	46	61	63.5	60.5	46	60.6	46	63.5	63.5
	SN	45	43	33.7	33.7	42.2	45	43.5	33.7	43	33.7	46	45
	PT	50	52	33	33	52	50	52	33	52	33	50	50
	B&G	45	43	30	30	43	45	43	30	43	30	45	45
KM	SB	29	31	31	31	31.4	29	32	31	32	31	29.8	29
	SN	30	32	32	32	32	30	32	32	32	32	30	30
	PT	22	24	24	24	24	22	24	24	24	24	24	22

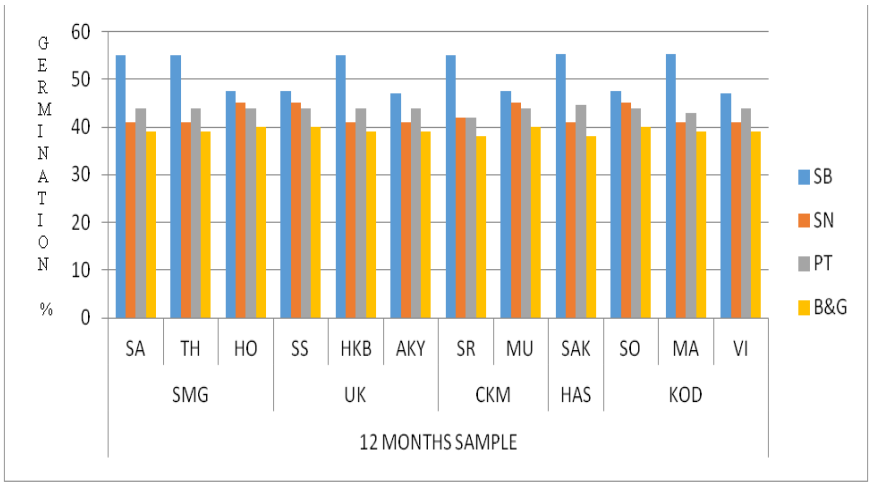
	B&G	25	21	21	21	21	25	21	21	21	21	25	25

JB	**SB**	47.5	47.5	55.7	55.7	47.5	47.5	47	55.7	47.5	55.7	47.5	47.5
	SN	35	45	41	42	45	35	45	42	45	42	35.3	35
	PT	44	44	44	44.5	44	44	43.3	44.5	44	44.5	44	44
	B&G	40	40	39	39	40	40	38	39	40	39	40.1	40
PB	**SB**	45	45	60.7	60.7	45	45.7	44.8	60.7	44.3	60.7	45	45.7
	SN	35	33	51	51	33	35	32	51	32	51	33	35
	PT	33	33	44	44	33	33	34	44	33	44	33	33
	B&G	30	30	43	43	30	34	38.2	43	38.9	43	30	34

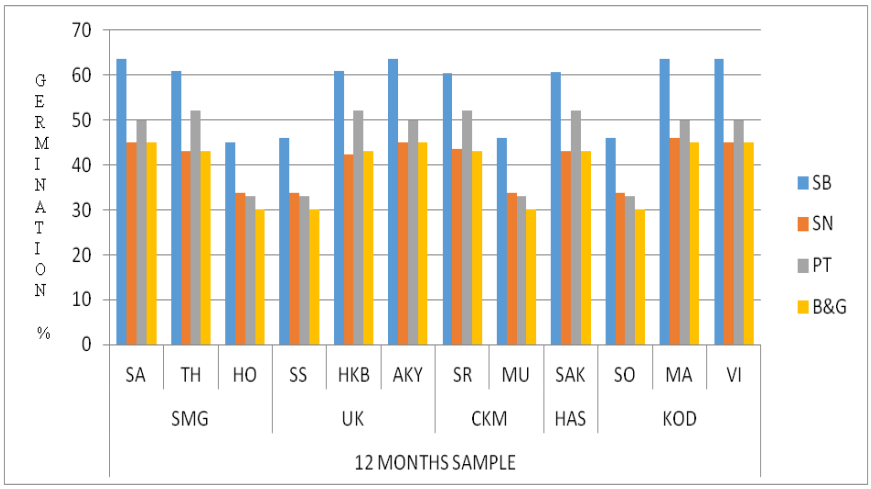
Fig 19: Germination percentage of Twelve months sample



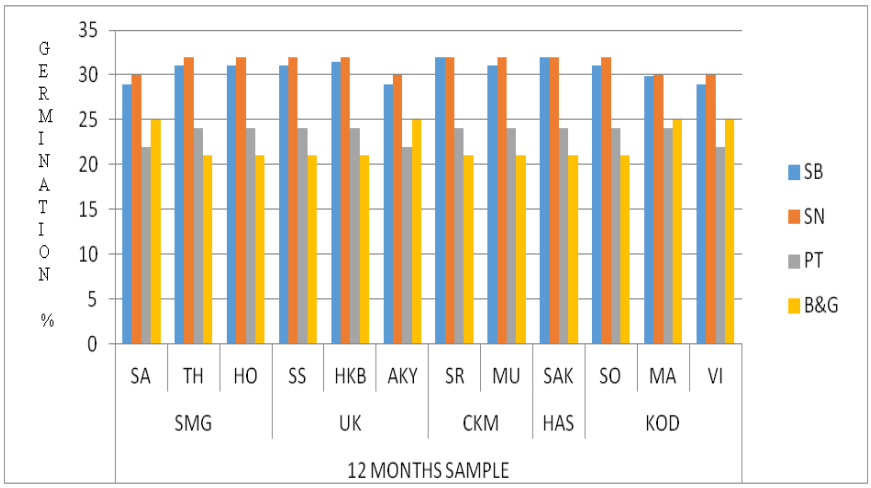
GERMINATION PERCENTAGE OF TWELVE MONTHS SAMPLES IN PW



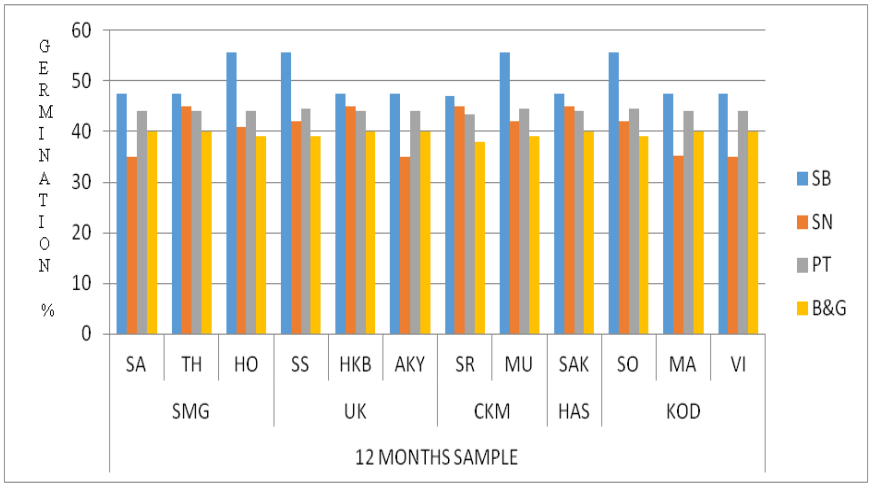
GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN PC



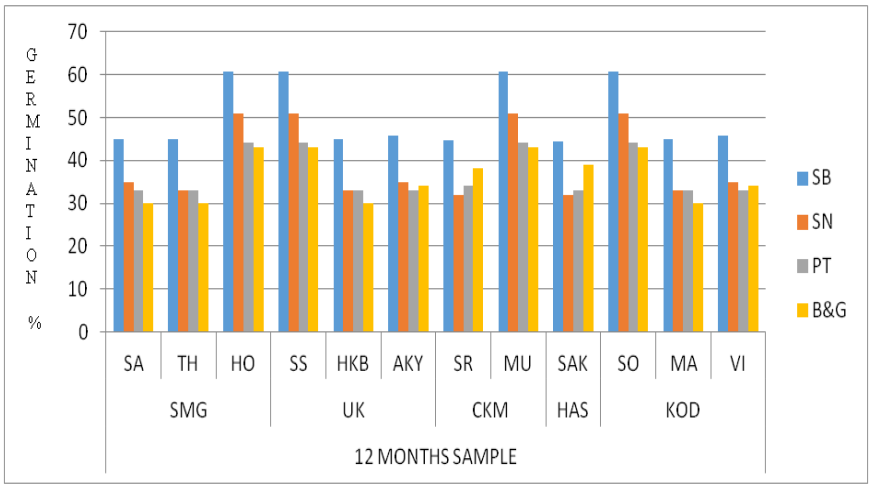
GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN KB



GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN KM



GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN JB



GERMINATION PERCENTAGE OF NINE MONTHS SAMPLES IN PB

4.3.4. Insect Value

Table 4.10 shows Insect Values present in different storage systems in the different time period with respect to districts

The activity of insects during the storage time was common irrespective of storage type and region. But it does not mean the insect activity was more because these storage structures contained it well for a few months. The most common insects are the I1-Rice moth (*Corcyra cephalonica*) and I2-Rice weevil (*Sitophilus oryzae*) the value of presence is shown in Table 4.3.4 concerning the storage time and storage type in all regions. In PW, the value of I1 was 1 in six months, and it increased to 3.6 during the twelve months. The I2 value also increased from 0.1 to 2.4 from six to twelve months, so the avg. of I1 was 3.24 in twelve months and for I2 it is 2.36.

In PC the avg. Value of I1 was 0.4 during the six months, which increased to 2.36, and the I2 showed the avg. Presence of 0.16 to 2.24 from six to twelve months, respectively in the same time duration, the I2 avg. value was 2.8. In KB the I1 and I2 avg. value increased from 0.22 to 2.58 and from 0.16 to 2.54, respectively. So as in KM, also an increase of insects was observed, but the value was low compared to others because the metal sheath absorbs cold from the surrounding, which is not such a good condition for insects, so its avg. value contained from 0.08 to 1.16 for I1 and 0.02 to 1.24 for I2 during this storage time. In JB and PB, the insect activity was very much controlled by both for up to six months and there was no sign of any insect presence in most regions. The presence of I1 and I2 was observed from a little earlier to nine months and increased to avg. of 2.02 for I1 and 2.78 for I2, respectively. So the use of these bags was common in all regions.

Table 4.10 Shows the Value of Insect Present in Different Storage Systems from All Districts

Storage type	District	Insect Value					
		6 months		9 Months		12 months	
		I1	I2	I1	I2	I1	I2
PW	SMG	1	0.1	2	0.8	3	2
	CKM	1	0.1	2	0.8	3	2.2
	UK	0.9	-	2	1.2	3	2
	HAS	1	0.1	2.2	0.8	3.6	3.2
	KOD	1	0.1	2.1	0.8	3.6	2.4
	Avg	**0.98**	**0.08**	**2.06**	**0.88**	**3.24**	**2.36**
PC	SMG	0.6	0.1	1.5	0.7	2.1	2
	CKM	-	0.1	1.6	0.7	2.2	2
	UK	0.8	0.2	1.4	0.8	2.1	2.1
	HAS	0.6	0.2	1.8	0.9	2.3	2.3
	KOD	-	0.2	1.1	1.1	3.1	2.8
	Avg	**0.4**	**0.16**	**1.48**	**0.84**	**2.36**	**2.24**
KB	SMG	-	-	1.5	1	2.4	2
	CKM	0.1	0.1	2	-	2.6	2
	UK	0.4	0.6	1.8	1	2.5	2.9
	HAS	0.6	-	1.6	0.9	2.4	2.8
	KOD	-	0.1	2	0.7	3	3
	Avg	**0.22**	**0.16**	**1.78**	**0.72**	**2.58**	**2.54**
KM	SMG	-	-	-	-	2	2
	CKM	-	-	-	0.2	1.6	2
	UK	0.2	-	0.4	0.6	1	1.1
	HAS	0.2	0.1	0.5	0.6	1.2	2
	KOD						
	Avg	**0.08**	**0.02**	**0.18**	**0.28**	**1.16**	**1.42**
JB	SMG	-	-	1	0.5	2	2.8
	CKM	-	-	1	0.7	2	2.7
	UK	-	-	1	0.6	2.1	2.8
	HAS	-	-	1	0.5	2	2.8
	KOD	0.1	-	1	0.5	2	2.8
	Avg	**0.02**	**-**	**1**	**0.56**	**2.02**	**2.78**
PB	SMG	-	-	1.1	0.5	2	2.9
	CKM	-	-	1	0.2	2.5	2.8
	UK	-	-	0.9	0.2	2.3	2.5
	HAS	0.2	-	1	0.6	2.2	2.9
	KOD	-	0.1	1.2	0.5	2.2	2.5
	Avg	**0.04**	**0.02**	**1.04**	**0.4**	**2.24**	**2.72**

4.3.5 Fungi Value in storage systems with Respect to districts

The storage fungi growth during the storage time in all types of storage structures was observed. Table 4.11 shows the total value of all fungi grown in six, nine and twelve months of storage time in all storage types of the regions. The *Rhizopus*, *Aspergillus flavus* and *Aspergillus niger*, are the common storage fungi observed the total of its growth in the PW sample of six showed avg. of 14.2 at the time of twelve months it growth was increased to avg. of 63. In PC, growth value increased during six to twelve months was avg. of 18.2 to 69.6, respectively. In KB maximum avg. value of 61.2 recorded from twelve months sample. KM samples also showed an increase in growth, with the avg. value of 21.2, 36.4, and 69.8 in six, nine and twelve months. In six months, duration JB and PB avg. growth was 18 each but later in these storage types also, increased growth was observed and the avg. reached to 66.6 and 63.6, respectively. So, the very lowest growth rate of avg. 14.2 was found PW sample during six months of storage time.

Table 4.11 Fungi Value Observed in Different Storage Systems from All Districts

Storage type	District	Fungi value		
		6 Months	9 Months	12 Months
PW	SMG	12	27	66
	CKM	12	25	68
	UK	10	24	62
	HAS	22	32	50
	KOD	15	30	69
	Avg.	**14.2**	**27.6**	**63**
PC	SMG	17	33	64
	CKM	15	30	59
	UK	19	37	71
	HAS	20	38	76
	KOD	20	42	68
	Avg.	**18.2**	**36**	**69.6**
KB	SMG	16	33	60
	CKM	14	37	65
	UK	15	33	65
	HAS	25	38	48
	KOD	12	25	68
	Avg.	**16.4**	**33.2**	**61.2**
KM	SMG	17	35	65
	CKM	20	39	71
	UK	20	39	75
	HAS	30	35	70
	KOD	19	34	68
	Avg.	**21.2**	**36.4**	**69.8**
JB	SMG	19	35	66
	CKM	20	39	70
	UK	18	35	68
	HAS	14	31	59
	KOD	19	36	70
	Avg.	**18**	**35.2**	**66.6**
PB	SMG	19	30	62
	CKM	18	32	67
	UK	18	36	69
	HAS	19	29	58
	KOD	16	30	62
	Avg.	**18**	**31.4**	**63.6**

4.3.6. Rodents Value

The rodent's activity and its damage were very minimal in all the storages in all the region. The wall of PW, PC, and KM are safe at ninety percent the KB stands next to these because of it's the thinner wall. JB and PB are the more susceptible to rodents as they are usually kept in open space and without any wall kind of protection. The activity of these was shown in Table 4.12 with the overall value in each region with respect to the particular storage structure. The avg. of rodents in PW during six months duration was 0.1 it increased to .16 and decreased back to 0.1 in 12 months due to observation and action taken by storage holders. In the same way all other structures had been taken care of so maximum of avg. value in PC was 0.12 at twelve months' time, in KB the avg. of 0.18 observed at twelve months' time, in KM there was no such damage recorded because the wall was made of metal, so rodents activity remains zero, but it may reach to avg. 0.1 hardly at twelve months' time. In the JB, the avg. remains at 0.02 in six months' time and at nine months, it reached to 0.4. As protective methods were applied, the value declined to avg. of 0.32. In PB, the rise in activity value was observed from avg. of 0.4 in six months to avg. of 0.28 in nine and avg. of 0.44 in twelve months, respectively.

Table 4.12 Rodents value observed in different storage systems from all districts

Storage type	District	Rodents Value		
		6 Months	9 Months	12 Months
PW	SMG	0.1	0.1	0.1
	CKM	0.1	0.1	0.1
	UK	-	1.2	-
	HAS	0.2	0.1	0.2
	KOD	0.1	0.3	0.1
	Avg.	**0.1**	**0.16**	**0.1**
PC	SMG	0.1	0.1	0.1
	CKM	0.1	0.2	0.1
	UK	0.1	0.1	0.1
	HAS	0.1	0.1	0.1
	KOD	0.2	0.1	0.2
	Avg.	**0.12**	**0.12**	**0.12**
KB	SMG	-	0.1	-
	CKM	0.1	0.3	0.2
	UK	0.6	0.2	0.6
	HAS	-	0.1	-
	KOD	0.1	0.1	0.1
	Avg.	**0.16**	**0.32**	**0.18**
KM	SMG	-	0.1	0.1
	CKM	-	0.1	0.1
	UK	-	0.1	0.1
	HAS	0.1	-	0.1
	KOD		-	0.1
	Avg.	**0.02**	**0.06**	**0.1**
JB	SMG	-	0.1	0.1
	CKM	-	0.2	0.2
	UK	-	0.3	0.3
	HAS	0.1	0.1	0.1
	KOD	-	0.3	0.1
	Avg.	**0.02**	**0.4**	**0.32**
PB	SMG	-	0.1	0.3
	CKM	0.1	0.2	0.2
	UK	-	1.2	0.2
	HAS	-	0.3	0.2
	KOD	0.1	0.1	0.2
	Avg.	**0.04**	**0.28**	**0.44**

4.4. Comparison Analysis Between the Different Storage Structures

As it came to an understanding, each structure had its own impact on the stored content, and each was different in its physical structure and property. Therefore, we considered some parameters to analyze their effect concerning the storage period.

4.4.1 Design

A comparison of different storage structures was made to understand the capability and interest of use among the people. The detailed expression in table 4.13 below shows how each structure design differs from the other, from construction material to its shape, placement of the structure, height of placement, additional protections, number of chambers, loading and unloading, mobility of structure and use chemicals. If we analyse the material of use, all structures were built using different materials, but the structure built by wood and cement & brick are the commonest ones. All these structures were built by skilled persons only. If we consider the shape only KB & KM are in cylindrical all other are rectangular in shape. These systems are placed outdoors and indoors, but the jute bag and polythene bags are compulsorily kept indoors. All these structures were placed on the raised platform about 3-12" inches above the ground level, but JB & PB had less height from the ground level of 0.5-1". Except for jute bags and polythene bags, other structures had additional overhead protections PW had a ceiling at the height of 3-4 feet made of wood and mud plates. The PW was the only structure with chambers; the number of chambers found was 2 to 4 and more, but the maximum of 8 chambered structures were recorded in a few storage holders' houses, which are 10 feet long and 6 feet wide. The loading done from the top in all structures, and the unloading also done from the top itself but in some of PW & PC it found a small outlet at bottom to draw seeds out and its provided closing lid made

by wood. Placement and replacement were easy in the case of jute and polythene bag, but the other structures are moveable only when they are smaller. To protect the outer surface of the structure for PW (for some), PC and KM are painted with the selected colour. These are so user-friendly that they can be replaceable to some extent if any structural damage happens.

Table 4.13 Show the Structure and Design Difference of The Storage Structures

Parameter	**Storage methods**					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
Construction materials	Wood	Cement & brick	Bamboo	Aluminium	Coconut jute	Polythene
Construction by	Skilled worker	Skilled worker	Skilled worker	Skilled worker	Purchased	Purchased
Shape	Rectangular	Rectangular	Circular	Circular	Rectangular packet	Rectangular packet
Structure placement	Indoor/ out door	Indoor/ out door	Indoor	Indoor	Indoor	Indoor
Placement above the ground level (in inches)	6-12	6-12	3-6	3-6	0.5-1	0.5-1
Structure had additional protection	Overhead roof	Overhead roof	thin wooden plate / Polythene sheath/ nothing	thin wooden plate/ Polythene sheath/ nothing	-	-
No. of chambers	1-8	1	1	1	1	1
Loading	Top loading	Top loading	Top loading	Top loading	Top loading	From one side

Unloading	From top / a small outlet at bottom	From top / a small outlet at bottom	From top	From top	Un-tag	Un-tag
Structure mobility	Fixed/ moveable	Fixed	Fixed/ moveable	Fixed/ moveable	moveable	moveable
Size alteration	Fixed	Partial modifiable	Fixed	Fixed	Fixed	fixed
Use of chemicals	-	-	-	-	-	-
Outer surface painted	For some unit	Painted	-	Painted	-	-
Design repairable	Yes	Yes	Yes	Yes	Yes	Yes

4.4.2 Cost

Cost comparison gave detail about these structures' economic challenges and benefits to the storage holders. Table 4.14 shows the construction cost (as per the storage holder mentioned) of all the structures. PW had wood as a primary material about 99% of the structure contained wood, and the remaining 1% was bolt-nut (metal) and stone used for the basement as a platform. Depending on the size, the construction charges vary, ones the construction is complete, there is no such need for maintenance for several years except the cleaning each time before the loading. PC involves material and construction coast it also needs skilled persons to build it, and the maintenance was very minimal ranging up to 500rs as paint charge or minor accidental damage. KB has bamboo charges and construction charges, which vary with the availability of bamboo and the demand by skilled persons to construct and install it. There is no such

maintenance to it if any more minor damage happens, they get solved by the users only. KM also needed skilled persons to build, and total charges cover materials and construction. As maintenance, it only needs painting to the outer surface for time intervals. JB and PB are one-time investments during purchase only, and there were no such maintenance requirements for these if there was any damage, they stitched these bags and, used as long as their threads became weaker.

Table 4.14 Show construction cost of the storage structure

Cost	Storage Methods					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
Installation	30-35k	30-35k	10-15k	8-15k	30rs	20rs
Maintenance per year	0-500rs	0-500rs	-	0-200rs	10rs	5rs

Values are in Rupees

4.4.3 Storage Capacity

Storage capacity of these structures depends upon the structure's size for PW, PC, KB and KM, but jute and polythene were pre-sized packets usually made to fill 25 or 50 or 100kgs of quantity. Table 4.15 shows the value for load capacity in these structures. To calculate the amount of storage capacity for PW and PC, the standard size considered an equal measurement of in length, breadth and height of 5 feet each and for KB and KM, the height and diameter of 5 feet are considered. We found there was no much variation in the quantity of filling between each storage structure, the range present between 4700-5000 and 3000-4700kgs kgs, respectively, but in the case of JB and PB, the bag number increases with the increase of quantity if the bag capacity

is 25 kg, 200 numbers of bag need to fill 5000kgs of, if the bag had 50 kg capacity, then 100 bags and 100kg capacity of 50 bags were required to fill the same quantity and all bags can be stored at one place.

Table 4.15 Show Storage Capacity of The Storage Structure

Storage capacity	Storage Methods					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
For Structure size 5*5*5 (L*B*H)	4700-5000	3000-470	3000-4000	2500-3000	200 bag (25 kg packet) 100 bag (50 kg packet) 50 bags (100kg packet)	200 bag (25 kg packet) 100 bag (50 kg packet) 50 bags (100kg packet)

L-Length, B-breadth, H-Height

4.4.4 Ventilation

The ventilation comparison in table 4.16 gave an understanding of the ventilation capability. A reasonable value of ventilation was observed in KB, Jute and Polythene bags, in KB even though the outer surface smeared with cow dung or red soil, through tiny pores, ventilation happens and the heat moves from the center to the outer surface and exits to surrounding. In JB and PB also, the ventilation was excellent there was no suffocation happen for the seeds. But in the case of closed PW, PC and KM, no ventilation occurred. In PC, ventilation occurs when the top is not constructed, and in KM, the top is uncovered in most of the time for ventilation. PW top has complete coverage, so for air exchange manually, the top lid is opened for some time

or according to the need, and the storage holder examines it. No extra mount needed for ventilation, and there was no record of machine used for ventilation in any structure.

Table 4.16 Show Storage Ventilation Facility of The Storage Structure

Storage capacity	Storage methods					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
	4700-5000kgs	3000-4700kgs	3000-4000kgs	2500-3000kgs	200 bag (25 kg packet) 100 bag (50 kg packet) 50 bags (100kg packet)	200 bag (25 kg packet) 100 bag (50 kg packet) 50 bags (100kg packet)

4.4.5 Temperature

The details about temperature variation and its maintenance in structures are mentioned in Table 4.17. No temperature exchange is happening with surrounding in PW, but more exchange is observed in JB and PB ware as KB and KM comes next. In PC, which does not have a top covering, the such structure had a temperature exchange facility to some extent. The temperature was more in the middle of the stored lot in PW, PC, KB, and KM it decreased as move to the periphery, but in jute and polythene bags, no such temperature variations recorded. The only option had for ventilation in PW, PC, KB, and KM was manually top opening. Suppose we check for the use of any machine to know the temperature increase in lot among the storage holders. In that case, they are not facilitated with any such machines and no biological remedy was recorded to manage temperature difference in seeds lot.

Table 4.17 Show the Temperature Maintenance Facility in The Storage Structure

Temperature	Storage methods					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
Exchange with surroundings	-	Yes, for few	Some extent	Some extent	Y	Y
Increase in seed lot	Yes, more at middle	Yes, more at middle	Yes, more at middle	Yes, more at middle	-	-
Methods to manage	Opening top	Opening top	Opening top	Opening top	-	-
Use of machine to check	-	-	-	-	-	-
Methods to check	Manual observation	Manual observation	Manual Observation	Manual Observation	Manual Observation	Manual observation
Biological Methods to manage	-	-		-	-	-

Y--- Yes

4.4.6 Maintenance

The proper maintenance done to all the structures by the storage holders details are in table 4.18. These details are mentioned based on the interaction with them. First, as maintenance, every structure was inspected to check for structural damage. If any damage was noticed, it was replaced by the storage holder, or they requested to a skilled person. It observed that all recorded structures had the option to replace their parts. Maintenance was most of the time done by the storage holder itself only in case of

major work they call for the skilled persons. The replacement cost ranges from 500rs to 2000 for KM, KB, PC and PW, respectively. As a regular maintenance cost it will be more or less 500rs for painting or any other except JB and PB. These bags are replaced with new bag if there is more damage.

Table 4.18 Show the Details of Maintenance Cost and Storage Holders Approach to The Storage Structure

Maintenance	**Storage Methods**					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
Regular observation on structure	Y	Y	Y	Y	Y	Y
Part replacement in regular	-	-	-	-	-	-
Maintain done by	Personal or skilled person	Personal or skilled person	Personal or skilled person	Personal or skilled person	Personal	Personal
Maintenance coast without any damage (in rupees)	0-500	0-500	0-200	0-500	10-15	10-15
Maximum damage coast (in rupees)	< 2000	< 1500	< 500	< 500	-	-

Y--- Yes

4.4.7 Mass loss

Mass loss was observed in all types of storage structures (Table 4.19) when stored for the long term. For the study, we took one year of storage time duration to analyze the loss of seeds.

- It was observed less than 5kg of seeds were lost by increased storage time in PW, PC, KB, and KM for the 5000kg seeds in each structure. In JB and PB it was around 0.5kg per bag.
- By insects in PC, the loss may reach a maximum of 0.5%, in PW and KM, it to 0.3% insects' activity is very much controlled in KB with 1% and in JB and PB, it is below 0.2%.
- By the rodents, up to 0.5 % of the loss was recorded in PW, PC and KB, but KM was very safe zero loss was seen but there was the loss of below 0.2% in JB and PB.
- By the microbes, the KM seeds were affected up to 3% in PW, PC and KB it was less than 2%, but in JB and PB, the loss was contained and recoded below 1%.

Table 4.19 Show the Possible Mass Loss with Respect to Different Storage Structure

Mass loss	Storage methods					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
Chance of mass loss	Y	Y	Y	Y	Y	Y
Avr. Loss when long storage (in kg)	<5	<5	<5	<5	< 0.1/bag	< 0.1/bag
By insects (in %)	0.1-0.5	0.1-0.5	0.1	<0.3	<1	<1
By rodents (in %)	0.5	0.5	0.5	-	<0.2	<0.2
By microbes (in %)	<2	<2	<2	<3	<1	<1

Y--- Yes

4.4.8 Transport

The ability of the structure to move from one place to another was mentioned in Table 4.20 by this comparison, it came to understand that not all structures are portable. PW, KB and KM are moveable when it is small size, some of PW were recorded very big, and these are un moveable, and the PC was only structure fixed to one place. The JB and PB are portable but can also be used to keep in one place for years. And the main advantage of these is that the same bags can be used for vehicle transportation. The PW, PC, KB and KM are cannot be used for transportation as a whole structure.

Table 4.20 Show the Transportation Nature of Different Storage Structure

Transport	Storage methods					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
Portable	-	-	-	-	-	-
Fixed	When in big size	Y	-	-	-	-
Is unit moveable	When in small size	-	When in small size	When in small size	Y	Y
Whole structure use for transportation	-	-	-	-	Y	Y

Y--- Yes

4.4.9 Technology Adaptation

In the table 4.21 some of the technologies are listed to check if these fit to install in existing traditional structures and also current use of technology were mentioned. But we found that there was no device in use by any storage holder for any storage method.

In the table listed some technologies which can be adopted for selected structures, they are

- Moisture meter can be used to check the moisture percentage in seed lots before and during storage in all storage methods.
- With little modification, moisture absorbing machine can be installed in the PW, PC KB and KM chamber.

- A temperature detector can be used to know the temperature in the centre and outer region of the seed lot.
- An electric heat discharger can be installed for PW, PC KB and KM.
- Chemical fumigation can be done to all methods to control insects.
- Modified refrigerators with respect to the design of PW, PC KB and KM can be used to maintain the optimum condition in the chambers.
- The air cooler is another equipment that can be installed to maintain the optimum condition within the chamber.

Table 4.21 Listed Some Adaptable Technologies to the Existing Storage Structure

Technology	Storage methods					
	PW	**PC**	**KB**	**KM**	**JB**	**PB**
Moisture detector	+	+	+	+	+	+
Moisture absorbing machine	+	+	+	+	-	-
Temperature detector	+	+	+	+	+	+
Heat absorber	+	+	+	+	-	-
Electric heat discharger	+	+	+	+	-	-
Chemical fumigant machine	+	+	+	+	+	+
Magnetic insect repellent	+	+	+	+	-	-
Modified refrigerator	+	+	+	+	-	-
Air cooler	+	+	+	+	+	+
Vetiver	+	+	+	+	-	-

‘+’ Present, ‘-’ Absent

Fig 20: Photos

Osaw Digital Seed Moisture Meter

Seed Germination Tests

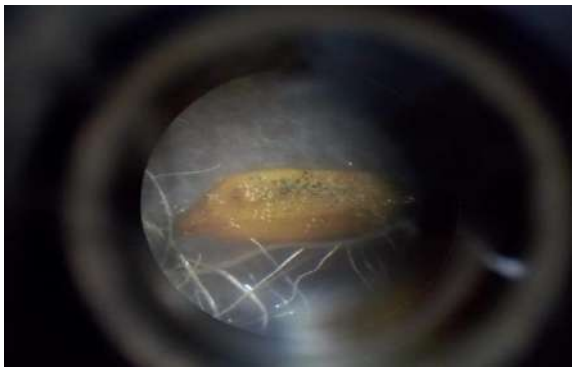
Standard Blotter Method

Sand Method

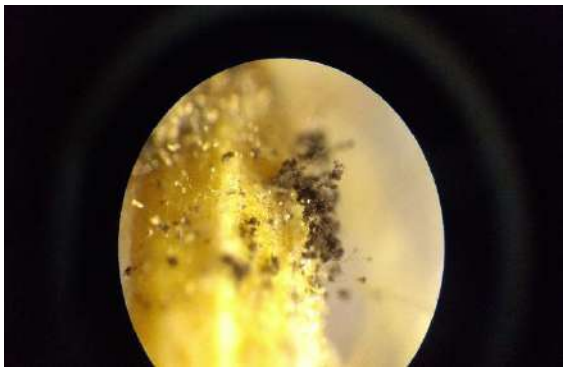
Brick And Gravel Method

Paper Towel Method

Storage Fungi



Paddy grain under microscopic view shows *Aspergillus flavus* contaminant



Microscopic view of *Aspergillus niger*

s

Paddy grain showing *Rhizopus stolonifer*

Rhizopus stolonifer

Insects

Rice moth

Rice weevil

5. DISCUSSION

Traditional knowledge is the outcome of several years of practice by the people, which have undergone many trial and error tests to have the desirable method. similarly, the traditional structure used to store paddy seeds also underwent this process. People in our study region had very effective storage methods to store for a long time, and the structures were also long-lasting. Many structures found in most are extremely in good condition even after 60-70 years (few are more than 100 years). The storage holders know that improper management will lead to the deterioration of stored seeds at a great rate, it also mentioned (Befikadu, 2014).

In our study areas, the weather conditions are very suitable for growing paddy. And from several generations, the paddy became a major food in this region, so the production was also reasonably well. The traditional knowledge about storing paddy also has a long history. People follow their traditional knowledge to select the suitable storage method. The kind of materials to use for construction, construction method (among the family who made themselves for this), and the season for installation and maintenance has been transferred from generation to generation by explanation, sometimes hand on demonstration and observations. It observed that these structures became very familiar to them and became part of their culture and had a feeling of sanctity. During special occasions, these structures are furnished as a part of respect to the stored commodity. With this, these methods can be represented as traditional methods.

The regions of Western Ghats cover five districts in Karnataka, known as Malnad region. Hills, slopes and flat landscapes are typical in these districts Shimoga, Uttara Kannada, Chikkmagalore, Hassan and Kodagu also rich in forest and human

habitat. Soil is suitable for growing many cereals, pulses, vegetables, fruits and timber plants.

We aimed to know traditional knowledge in practice by the people of the Malnad region. During our visit, it came to our understanding that the number of methods was followed as small-scale and large-scale storage, from several years, these methods have been followed in the same manner. Small-scale storages are mud pots, metal bins, plastic bins (from a few decades), bamboo baskets and cloth bags. For large scale storage they had few structures which many people trusted across the Malnad. Panatha, constructed of wood, is the most familiar large-scale storage structure in Maland for paddy, and it got a very good recognition considering its benefits and utility. A major advantage is that the construction needs wood as the primary material, which was readily available (especially in earlier days) from the forest and for construction local people are available (readily in earlier days) who learned the art of construction and this knowledge also been passed from generation to generation among them who to took this as profession. The structure can be built to the needed size can be placed in indoor as well as outdoors we got educated by Moreno *et al*., 2006 that who also observed these structural benefits in storage structures followed by Mayan farmers. Minimum care was needed to maintain it when used as long-term storage until and unless it got damaged seriously if we considered the users opinions people had a very satisfied feeling, they do recommend continuing it. It also reflected in our visit because the number of users was quite good only thing that declined the user number was that they of wood these days, which is the core material required for construction.

The modified version of Panatha of wood was constructed with cement and brick, which many people follow. Due to the unavailability of wood and for its cost-

effectiveness, people were shifting from wood Panatha to concrete structures. Skilled persons needed for construction were also readily available, and so as the materials. Another use full point was it can be built as in-door and out-door structures like the Panatha of wood. Most of the future resembles the wood structure, and the same existing structure can increase in its size by using brick and cement if needed. This method was also used for long storage. There were good opinions by the users on this in protection against rodents and for its long storage capability, so most of the storage holders using long-term stored seeds were majorly utilized for consumption. And in this and in Panata of wood husk were used as basement before storing paddy for extra safety this methods we also observed in work by (Moreno *et al*., 2006).

Kanaja is also one of the good old traditional structures people recommend for large-scale and long-term storage. These Kanaja are built by plant source, and the bamboo plant stem is the primary material used, and only skilled persons can build. The construction skills also had been passed from generation to generation among the family involved in this work; now, even other persons are also learning these skills (numbers are less). The users are very few it was observed that in some homes, existing Kanaja were not so in use they were removed and rolled and kept in the store room because of some damage and there was no interest in re-building it due to the lack of needed skilled persons and construction material.

So, people have used metal sheath alternatives to bamboo to construct Kanaja, the availability is also easy not much cost is needed for material and to build it. Among the people, there is an interest to follow it, but the number of structures observed during our visit was still reasonably good in Uttara Kannada and Shimoga district. The structure had a cold effect on the seeds attached or near the wall surface, which affects

seed health when stored for the long term so about 3% of the loss was there as per users declaration, so it will take some time among the people to adopt this method in large number. The advantages of this for its durability of the materials, easy shifting, can be built to the required size, hundred percent protection from rodents, less maintenance, can keep it open or closed, and insect activity was also minimum.

Along these structures in the study area, a few flexible lightweight containers have been in use for a long time. These are in hundred percent considered to use by people of the entire district in Malnad they are bag like structures made of coconut Jute, and Polythene material use of jute bags was also recommended for paddy by (Bhardwaj & Sharma, 2015). Different-sized bags like twenty-five, fifty and hundred kilograms are in use. These are used more because of its readily availability, durability, ease to handle, less maintenance, cost effective, can use in any season and easy to transport. The storage holders opinion about these bags are great, JB-81.6% & PB-87.8% are the usage value and there is a sign of increase of this percentage.

To analyse these traditional storage systems, we considered many parameters to find the best method out of them. The investing process about the traditional seed treatments used for paddy led us to learn about the use of plant resources and inert materials by people for treatment and their connection with nature. They arrived at the current using treatment methods by following trial and error methods and observing biological processes in nature, especially by the older generation. In the number of treatments used all over the study areas, some was used before storage, and some used during the storage. Before storage, treatments are very much considered as a precaution and must follow process, in that a method compulsorily followed by all was drying of seeds up to its safer moisture level. Brought the seeds to their safer moisture level is a

must the storage holders said this was an easy and essential process that helps majorly to avoid microbial activity and increases seed self-life, germination during storage, insect activity, and prolongs the seed health. During the visit, it was observed seed drying method was followed by everyone and shown a hundred percent (Table 4.3: total value-‘5’ for ‘VT1’) consideration by the people in all distract.

The use of cow dung was the second most popular treatment observed to protect the seeds used as material for fumigation and smearing on KB. The availability will be easy for those who had cow in their house, so the use of cow dung in their storage structure was seen. The number of houses with cows is not so huge, and currently, their number and interest are also declining, so the rate of use is less (Table 4.3 value was 0.1). The number of members in each home is also not enough to have cows and maintain it, so it will be a challenge to them, resulting in the decline of this culture. In SMG, some of the storage holders said about using sugar cane bark (crushed and dried collected from Jaggery preparation factory) in their storages like PW and PC to form a bed within the structure to form a layer below paddy husk it was prepared before storage. Many know this knowledge, but the users are very less because of some labor work it demands. Ash treatment was the other one known by all to use for the protection of seeds, ash from burned wood or cow dung was used commonly most of the time it been used as one of the seedbed layers within structures PW, PC and KM, but people who followed were found irregularly. As we come across the use of sugar cane bark and ash which gave extra safety to the seeds, people are lagging in using these they used just paddy husk many of the time, but few said they would use it if they got these materials available at the right time of bed preparation.

After all the preparations for seeds before storage, the traditional treatments will be followed during storage period to protect the seeds from insects, microbes, and adverse environmental effects. In these treatments majority of methods depend on plant-based materials, use of Lakki soppu was one such here leaf, are used because they had insect-repellent property also they readily get from their surroundings as they grow weed plants, and no extra money is needed, they pluck the plant remove the root to avoid contamination from the mud present in it and the remain part of the plant in wet or after dried condition used to cover the surface of stored seed. Use of this for few structures was found in SMG and CKM, for PW and PC, but two of the storage holders said they had been used for KM earlier, but during our visit, it was not observed.

Like this, to place on the surface of stored seed, they use red chilli (proper dried), this method was so common, and most of the storage holders preferred PW, PC, JB and PB. The percentage of use in JB and PB were less only for those bags which they kept for own use this method was followed, and the red chili acted as insect repellent. For PW and PC, these were spread a layer on the surface of stored seed, in KM they will not use because the chilly present at the wall may have a chance to absorb moisture as the metal sheath become cold during the night, if the chili gets moist it will become substratum to fungus which will spread to stored contents. Even though some precaution methods were followed, the microbial activity count be controlled at one hundred percent. So, during storage, people do fumigation to minimize its activity as much as possible. This treatment was followed for all storage structures, but the value of use from all regions was ‘1’ (Table 4.3 for ‘T11’) because this method is used occasionally.

Another most common method was the use of Neem leaves as the chili was used these were also used to mix with the seeds in JB and PB, but for PW and PC, leaves were spread on the top as a layer after the seeds was filled. Neem was well known among the people for its medicinal property with this reference this was used in storage as it controls microbial activity and also by its pungent smell, avoids insects. People have much awareness about this and its method of use all over the study area. With this, there was the use of garlic was observed in a few houses the number of garlic cloves were found mixed with the seeds and kept in JB or PB, only for the seed bags which they are using for themselves. During the interaction, we learned that even though the people knew these methods considering the time, material cost, labour and, most of the time, lack of interest these methods were not followed regularly except the drying and fumigation (Mathad *et al.*, 2013). But the transfer of this treatment knowledge to the next generation with good reference and importance, also with related cultural aspects will be done by the storage holder.

Moisture Value

The storage holders of all districts mandatorily followed the seed drying method before storage in any method they selected. This helps to lower the seeds metabolic activity and respiration rate otherwise, loss of seeds may happen (Adhikarinayake *et al*., 2006). After the harvest, they do this process in the field or any place prepared for this. Dried seeds were examined manually for their moisture level by storage holders him selves by their rudimentary methods of crushing the seed or biting it, they are quite expert in this. After come to a conclusion about the moisture level they separate them from the unwanted materials with the help of wind and then only shift to their selected storage structure. Seeds stored with this primary safety process were collected from

different storage structures, brought to the lab, and tested for moisture percentage by classifying with respect to duration of storage time as six, nine and twelve months, respectively. The results showed paddy stored in PW in all the regions for six months had retained its moisture level to the safest level of 11%. The environment in the PW was very safer, as this structure is closed one no such evaporation by the seeds takes place, and moisture from outside will not get entered. One of the important reasons for this was the thickness of the wood beam and well-dried wood was used for construction and also the provided top open are air appropriately tightened. But the seeds stored for nine months showed a decline in their moisture level to around 9%. This happened due to the seeds itself being susceptible to the natural phenomenon of losing its ability with respect to time. But this moisture level was still good for seeds to be healthy for consumption and storage for some period. As the seeds are stored for twelve months their moisture level is reduced to around 7% this is still a healthy level for seeds is suitable for consumption.

PC seeds of all the regions at six months of storage had shown a moisture level of around 11% this value matches the value of seeds in PW. The concrete walls showed its protection against variation or loss of moisture from seeds. If any little difference in the value we observed is because, in some cases, the PC top did not close, the storage holders kept open, they did it for easy load and unloading or air exchange. So as the storage time increased, the loss of moisture also increased in such PCs, and the value reached a minimum of 8.8%, but the top closed PC showed a bit more percentage to this. At the twelve months, storage time value had decreased to 6% in open PC. About this deference, storage holders had no issue because they had to shift from PW to PC due to the unavailable of wood, so they were ok with this and also by considering its other advantages.

In the KB, storage exchange of air was more compared to PW and PC, but in these, also, up to six months period there was no such difference in moisture value observed, but in the 2-3 samples it recorded 9%. In this storage system also, moisture value got reduced with time in nine months sample, it was around 8%, and in twelve months sample 5% was recorded as the maximum. In the overall study, we got only a few numbers of KB for collection some of the samples collected were taken out from KB one month earlier at the time of collection. It showed they didn't have such a level of interest in using this method as it needed bamboo for its construction, which is currently unavailable and exists are in an unrepaired condition.

Interestingly these people invented an alternative martial to bamboo, which was a metal sheath. The Kanaja, made of metal, was also cylindrical in shape but not all futures are the same as the bamboo this only resembles in shape. Here also, paddy husk was used to form a bed in structure, and the top was kept open. Rarely top was just covered by a plastic sheath or thin cardboard sheath, and the metal sheath it had impact on seeds which are adjacent to its wall, so the moisture value of six month stored seeds showed at around 11% the nine months sample around 8% at the time of twelve months it decreased to 6%.

JB has become very user-friendly it is one of the most used storage structures, up to 82% as off know. In these, also seeds get well aerated through the small hole in the bags so retain of moisture was good the six months samples had a moisture level all nearer to 11% and reached around 8% at the time of nine months and finally, at the twelve months period about 6 % of average value recorded. Comparatively, in PB bags also, moisture value was nearer to JB as the structural and functional similarities exist between these two. The six-month sample had shown the value is between 11 and 12%

but in some samples less than 11%, in nine months sample, it was 9% by most of them, and at the time of twelve months period, about 6-7% of value recorded. If we compare the difference, in PB loss of moisture was 0.5% to JB at storage time of twelve months it is a good number because the PB made of polythene and pore are more minor to JB it won't easily allow the moisture to escape from the bag.

Germination

Seeds stored in different storage structures from all the sturdy areas were collected and used to conduct germination tests, which helped us to analyse the impact of particular storage structures on seed variability. The storage structure role is very important to keep seeds safe and, to get good vigor it was also mentioned by (Modi, 2002). The seed's nature is such its viability and heath move to deterioration as time progresses, so the real challenge is to slow down this by keeping it in a protective environment. The test results gave some understanding of the impact of storage structure on the seeds. Collected seeds from a different region of each district stored in these six storage structures were classified based on storage durations like six, nine- and twelve-months samples conducted four various germination tests 1. Standard Blotter (SB) 2. Sand method (SN) 3. Paper Towel method (PT), and 4. Brick and Gravel method (B&G). The six months samples from the PW showed overall germination of about 84%, and only in the SB test maximum of 92.3% was observed. In the same structure seed, nine months sample shown a reduction in percentage reached around 73%, and a minimum observed in the B&G test of about 71%. And the twelve months sample had 48%, but these samples had shown 60% in the SB test only. So, the number was closer to half of the percentage of the value obtained from six months sample. It is clear that at one year, the seeds stored in PW had lost their viability almost to half.

The six months samples from the PC showed an overall percentage of about 81.77 from all four tests. In the SB test, its rate was a little higher (92%) than others. There was a reduction in percentage as storage time was prolonged to nine months which showed a percentage of 73.56, the minimum observed in the SN test of 70. And the twelve months sample decreased further to 48.62, up to a 39.7 of reduction. In the SB test, only these samples showed some good percentages because the seeds get no experience of resistance to grow root and shoot.

The six months samples from the KB showed an overall percentage of about 84.85 from all four tests. The high rate was again by the SB test (91%) compared to others. There was a reduction in nine months sample had, shown a percentage of 72 which is almost a ten percent reduction. And the twelve months sample decreased to 47.91 due to the storage holder's lack of attention to this storage system.

In KM samples, as we know, it may get exposed to cold by the metal sheath, the six months sample showed a percentage of 84.11 this number is near to PW. But further, with the increase of storage time to nine months, the rate reached to73.66 with some impact of the structure and lack of good maintenance was there by the storage holder, the percentage decreased more to 48.12 at the time of twelve months. However, not all the samples were responsible for this decrease; some of the samples that didn’t get extra protection on the top of KM and improper maintenance affected the total percentage.

The JB samples had no such issues as KM also they had good air exchange facility, even though the six months sample reached the heights parentage of 79, and up to nine months it was quite decently protected the sample as the test result shows just

eight percent of reductio and reached to 71.88%, but later on when the storage time of twelve months it showed 47.79% only. It observed a noticeable decrease happened.

The sample from PB showed percentage value similar to the samples of JB, which had variation at the decimal level. The SB test of six months samples shown 92% if we analyse the overall result from all the tests, it got 80.21% only. And we found an 8% difference as storage time reached to nine months the value reached to 72.42%. Further decrease of the parentage was recorded to 48.56% as the storage time crossed the twelve months. These bags have shown a fair amount of difference in germination percentage compared to PW, PC, KB and KM.

Overall germination % from all the tests in				
Storage type	**6 months**	**9 months**	**12 months**	**Avg.**
PW	84	73	49.05	75.35
PC	81.77	73.56	48.62	67.98
KB	84.85	72	47.91	68.25
KM	84.11	73.66	48.12	68.63
JB	79.81	71.88	47.79	66.49
PB	80.21	72.42	48.56	67.06

Insect Value Present in Different Storage

During the storage of the seeds for the long term in any type of traditional storage system, control of insect activity became important the storage holders are also aware of this, and they know more of its presence will damage and reduce the storage time also the health of the seeds. At the time of the visit, we observed the presence of insects like the Rice moth (*Corcyra cephalonica*) and Rice weevil (*Sitophilus oryzae*). However, some of the information given by the storage holder with their past encounter

with insect activity in their structure, we calculated the overall presence and analyze the roll of these insects on seeds with an increase of storage time.

No such presence of insects was observed at one or two months of storage time, and the storage holder opinion was also the same. As storage time increased more than two months, some insect activity was stated, especially by Rice moth in PC (top closed) compared to any other with avg. Value of 0.1, and at the time of six months, it raised to 1. Still, the minimum was observed in JB (Avg. value of 0.02) and other structure the value was below 1, insects effects shown are in mild way the storage holder also had no such worry up to six months. They have not taken any action to control it in general for six months. The Rice weevil presence was also very minimal at this time.

The insect presence was increased to avg. value of 1 % at nine months in PW maximum was recorded to 2.06% by Rice moth and from 0.8 to 0.88% by Rice weevil. And a minimum of presence was recorded in KM of 0.18% by Rice moth and 0.28% by Rice weevil because of the cold effect of the metal sheath insect growth was well restricted as these insects won't grow in the cold environment these need a particular environment to complete its life cycle. But in other structure, the environments are quite good to increase their population, so at the time of twelve months, the presence was raised to 3.24% by Rice moth and 2.36% by Rice weevil in PW, in PC to 2.36% by Rice moth and 2.24% by Rice weevil in the bags of JB and PB raised about avg. value of 2% by both Rice moth and Rice weevil was recorded. So, it observed that in the closed structure like PW and PC (closed) ones, the insects start to grow their population got increased as these systems were closed. If proper check was not done, its population increase and a loss of 2 to 3% are expected. In the case of JB and PB, the insects damage will not become more because they not easily move from one bag to another, so the

increase in population checked itself. Also, there was no such free space in the bag, and their presence was instantly noticeable to the storage holder, which made them get alert and take action to control the growth.

Mycoflora

Seeds were very much susceptible to microbes during storage time if there is no proper maintenance, it may cause severe damage. The presence and raise of moisture from its optimum level in the storage structure will activate and increase microbial growth within a short period. Very commonly observed and had more impact during the storage was by few common fungi present in all kind of storage structures: *Rhizopus stolonifer*, A*spergillus flavus* and A*spergillus niger* these were mentioned as storage fungus (Kusena *et al*., 2017). Storage holder store only well dried paddy in their structure as they know fungus can grow later, during the visit, we observed that there was no such growth even stored for twelve months in some of PW, JB and PB fungi growth appeared as normal when storage time crossed more than nine months because somehow moisture get entered. The structures are usually placed in open places this may also become one of the reasons for their presence. In the lab, SB method test used to analyze the percentage of fungi growth in different storage periods of six, nine and twelve months, respectively to the samples collected from all the storage structures from all the regions to know the growth and impact. PW samples at six months had got effect to avg. value of 14.2 (this value is sum of % of growth observed in all districts) and growth reached to avg. value of 63 at the time of twelve months this result shows that the presence of fungi sporulation was there on the surface of the seed, and it will come alive with the increase of moisture, but there no such percentage of fungi growth observed at the time of collection this means there was no favorable moisture available in PW (in some) even for a long period of twelve months.

In PC, the microbe activity was comparatively more than PW with four percent one of the reasons is most of the PC are top opened here seeds may absorb moisture from the atmosphere and also get contamination. The avg. The value of fungus growth at six months was 18.2 which increased to 69.6 at twelve months. The KB sample shows 16.4 of avg. value at six months, these structures are not at utmost care so in these fungus presences increased to 61 (avg, value) when seeds were kept for twelve months. In KM, the seeds present at the wall observed some moisture, they became susceptible quite more compared to PW, PC and KB it was confirmed as the test showed avg. value of 21.2 and 69.8 at six and twelve months, respectively. In bags JB and PB, the nature of the protective environment was almost similar to each other in PB, if moisture got entered, it won't easily evaporate, which helps fungus to grow relatively earlier than JB and the avg. growth value of 18 was absorbed in both, but 66.6 and 63.6 increase was observed at twelve months in JB and PB, respectively.

Rodents

Paddy seeds are food for creatures like rodents, so their presence around the storage structure was obvious. Their presence can become easily noticeable by their activity and physical appearance to storage holders. Their damage could become very serious in a short time, the storage holders were aware and very much alert about this. So, during the selection of structure and its material, this was also kept in mind so that constructed should become a rodent protestant. If we analyse the features of PW, PC, KB and KM, material use for its construction was very safe against rodents, so the damage was observed to be very minimum in these. The damage value observed was almost zero for KM as the metal sheath cannot get harmed by rodents even for several years. Even though the some of the value depicted in result represents only the rare

encounter of rodents when no observation was done for a long time on the storage structure. In PW, the value of its damage was observed only in a few of them where they got some chance to get enter through the inlet open, the value (avg. of 0.1 overall presences) was also very minimum at the six months and this value was almost maintained till to twelve months. In PC where few of the top opened are compared to PW, the value was more (avg. value was 0.12) this value was also maintained at the same level. In KB, the wall was thinner in comparison to PW and PC it would get damaged easily by rodents, so if proper care was not taken at immediately of time the damage will get increased, so at the time of six months, its activity was reached to avg. value of 0.16 and increased to 0.18 at twelve months. The JB and PB were kept in open space as usual, which favours the rodents, and they get effortless access to these. So, the value stands to 0.02 and 00.04 at six months, time but increased very much to 0.32 and o.44 in JB and in PB respectively as the storage period reached twelve months. This increase was just because when no such precautions were taken or treatment methods were not applied which needed to be followed during storage by the storage holders on the right time.

Structural Comparison

Each structure had its own impact on the seeds stored in them, so we considered some parameters to analyse its impact and compared the effects with each other. The storage environment largely depended on the kind of material used for the construction of the structure all six storage structures had different materials for their construction. The selected parameters are design, cost, storage capacity, ventilation, temperature, maintenance, mass loss, transportation, and technological adaptability.

Each structure's design has a big role in protecting the seeds and its durability. According to their traditional knowledge, the wood selected for the construction of PW is a well-matured tree and well-dried before use. The beam made for the skeleton of the structure was bigger (max. observed – 15x8x6 (LxBxH) in inches), which can have four chambers in it, and this was placed in a room. Some of these structures were found placed outdoor also with the roof covering. The PC was built with cement and brick with a usual wall thickness of 12 inches single chambered structures (about 8%) are found in all regions. Some of them top closed (about 20% was constructed outside the house), had extra over-roof protection. Remained are top opened PC these within found constructed in separate room attached to the house with a square or rectangular shape 98% of structures were plastered with cement, and a few of with soil observed in CKM. The KB, constructed in a cylindrical shape built by bamboo strips, had 2-3 cm of thickness with the required height (max. of 15 feet) and diameter of 4-5 feet maximum. The storage holder selected KM as a replacement to KB but it had not full filled the benefits as KB like the maximum height of KM observed was seven feet with a diameter 4 feet, even though KM is very effective in avoiding rodents, the number of users was found quite normal. These are placed within the house as top opened type only in some of the time top was cover by the storage holder. JB and PB were bags like structures made of jute of coconut and polythene, respectively these were purchased in the market they had rectangular shape the surface was about 1cm in thickness, having small opening and they are lightweight materials.

These PW, PC, KB and KM were constructed by skilled persons only if any small repair is needed, it can be done by storage holders if some major repairs need to be done, they called a skilled person. To protect the storage structure from the ground moisture effect and for the aeration at the base, these structures were placed above the

ground level PW and PC of 6-12, KB and KM of 3-6 and JB and PB of 0.5-1, feet height. All the structures were designed to load and unload from the top, and in some of PC, only small open made at the bottom to drown seeds through them its size of around 1.5 square feet. All PC and a few of PW and KM were painted.

The construction cost was different for all, the PW, PC KB and KM are one-time investments, and the cost of these depends on the size and material preferred for construction. PW and PC range between 30-35 thousand rupees, KB and KM 10-15k and JB - PB are 30-50 Rs (all the price varies with market rate). The repair cost of the PW, PC KB and KM are between 500-2000rs but JB and PB had to be replaced with new ones in case of maximum damage.

The capacity of storage is the parameter that became very important to analyse. For example, PW has a maximum of 5 tonnes, and PC has a maximum of 2-3 tonnes KB, and KM about 3 tonnes and JB and PB number of bags was used the number of bags depends on the size and total quantity of seeds to be stored.

The stored seeds need proper ventilation to keep them for a long time. The KB, JB and PB are the structure that had quite good ventilation their structure itself had a such benefit, PW had no facilities, PC of top opened had good ventilation compared to the top closed one and in KM, also inlet is the only way for the exchange of air from the system. The storage holders are also looking for possible changes or techniques to have a good ventilation facility in their existing system.

To keep the microbial and seed metabolic activity minimal and maintain temperature to its optimum level within the system which will get increased by seed respiration, microbe’s activity must be curtail. So, comparison analysis was done to

know which had the good one. In PW, there were no such facilities for the exchange of air, so the temperature increased within the seed lot at the centre temperature is more with respect to its periphery. The same condition in the top closed PC the good air exchange happens only in the top open PC. In KB, KM, JB and PB, air exchange facilities were good compared to others, in KM it from top opening. So, the temperature in the centre of the lot in KB and KM had no adverse effect (up to 6-7 months) on the seeds. But there was continuous temperature loss in JB and PB as the air exchange occurred through the pores. The storage holders manually open the top inlet in PW and top closed PC with the interval of a few months up to a few hours (24-36 hours minimum) and later close it again. The storage holders had no particular method or instrument to check the temperature level in the seed lot they just use their physical senses.

Maintenance of these structures will also keep them in good condition to make them long-lasting. The care taken by the storage holder is according to the materials used for construction. All structures require to be maintained, but there is no part replacement needed unless it gets damaged seriously, if there any maximum damage was found in PW, PC, KB and KM, skilled persons are must need to repair and its cost may be up to two thousand for PW and PC for KB and KM it around 500 rupees but there no repaired KB was found due to the lack of bamboo. In the case of JB and PB entire bag was replaced when they found maximum damage. If the bags have small patches, it was re- stitched by the storage holder himself. A minimum of about five hundred rupees is needed as a painting charge for PC and KM in two to three years for better maintenance of its outer surface.

Calculation of mass loss done from the storage holder's perspective to understand the long-term storage effect on seeds by these structures. They insisted that a maximum of five kg per year loss can expect by PW, PC, KB and KM just keeping for the long term of one year this amount of damage was not included the damage happened by insects or microbes. But by the insect, the maximum damage is experienced by seeds stored in PW and PC as these are closed structures. By the rodents, the damage value expected in JB and PB was avg. 0.2 for others structures, the value was more than this but no damage was recorded in KM. by microbes grown in structures, the maximum mass loss was seen in KM by the cold nature of the metal sheath and in others, damage value present within 2 (avg. value).

The mobility nature of these structures was checked it can be understandable by the external appearance itself that not all structures were portable. PW, KB and KM are moveable when constructed in small sizes to a nearby place, but some of the PW were constructed very big and unable to move. PC structure are also fixed to one location, and there is no chance of its mobility. The only portable structures are JB and PB these can be used to keep in one place for years, and also the same bags can be used for transportation through vehicles. The PW, PC, KB and KM cannot be used for transportation as a whole structure.

Technology Adaptation

With all these comparisons done between the structures with specific parameters, we also did a theoretical discussion on adapting technologies to these systems. As a result, some essential technology or techniques were selected to check which storage system may be suitable for adoption. One of the essential instruments needed for the storage holders would be a portable moisture meter which they can use

whenever needed to measure the moisture percentage of seeds, and it can be used for all the structures. Moisture absorbing machines can also become very much useful as the PW and PC were closed structures this machine can be used to absorb extra moisture. For to use these, they need to check the temperature level in the stored lot, so they must also need a temperature meter that is durable and handy to use. It is known that seed lot heat increases as time progresses, so it would be better if the storage holder had a heat absorber machine. One instrument that can help absorb the moisture will be heat discharger machine, which works with an electric supply that heats up the coil provided in this, which will be suitable again for top closed structures. Still, it also evaporates moisture around lot of JB and PB bags and may help maintain the optimum moisture level or stop seeds from germinating in the storage structure itself.

To avoid or control the insect, they do fumigation most of the time but for that, they need some plant-based materials which are a little difficult to collect or not all the users can have it so it's better to switch to chemical fumigation for some extent and it is suggested to use for a short duration of time only to avoid any further effect to seeds or the users. Some technologies were tried made by the magnetic instrument, which controls the insect activity within the storage structure, so with some adaptation, this can be suggested to storage holders. Modified refrigerators or air coolers can also become one of the use full instruments to maintain optimum moisture and temperature level within the system. If these are become user-friendly, they will get acceptance by the users

Suggested Technologies for Existing Traditional Storage Structures Are as Follows:

1. Closed Storage Structure Connected with Exhaust Fan

The exhaust fan can be connected to closed-type storage structures like PW and PC, which helps to remove air from the chamber during temperature inflation. Installation was easy, it was powered by electricity and could be used whenever needed. The schematic diagram in Fig 21, shows the setup of the technology. For power source, it can also be connected to solar plates Fig 22.

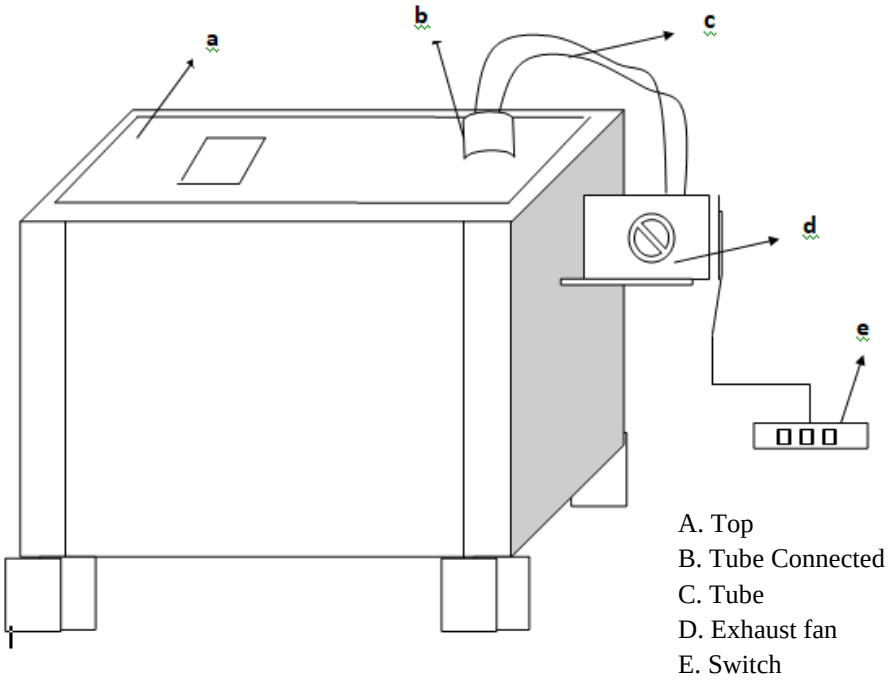
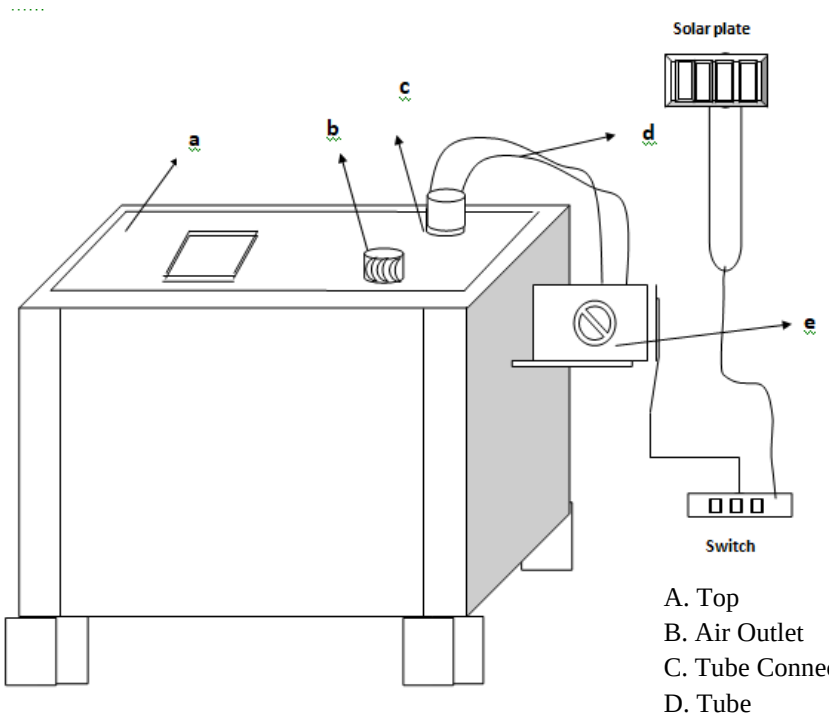


Fig 21. Closed Storage Structure Connected with Exhaust Fan



A. Top
B. Air Outlet
C. Tube Connected
D. Tube
E. Exhaust fan

Fig 22. Closed Storage Structure Connected with Exhaust Fan Solar Powered

2. Top Opened Type Storage Structure Fitted with Coil Heater

The top opened structures can be selected to install a coil heater within the structure, because control of moisture and air present in the chamber is necessary (De Vitis *et al*., 2020). One or two coils are enough for three-meter-long structure more than this, the coil numbers will increase. This installation will evaporate extra moisture from the seed lot and maintain the required temperature level (with the help of a controller) in the seed lot. This coil is electrically connected. The schematic diagram in Fig 23 shows the setup of the technology.

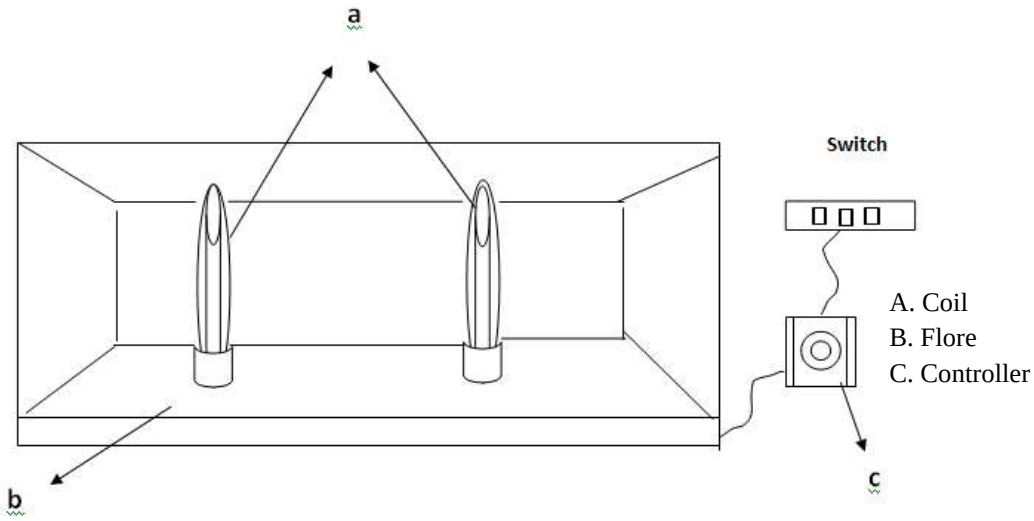


Fig 23. Top Opened Type Storage Structure Fitted with Coil Heater

3. Closed Storage Structure with Modified Extended Roof

Providing extra head space for the top closed storage structures were suggested and tested by (Adhikarinayake *et al*., 2006). It helps to contain air within the structure which acts as an absorber of heat procured by seeds during respiration, and this heat from the air gradually gets absorbed by the top storage structure wall, and the air inside gets back to normal temperature. Inspired by this here, we also suggested this to follow, which influences on seed storage longevity. Modified extended roof for PW were made of wood, and PC(top closed) were made of cement can be constructed as shown in Fig.24 For KM, the roof made of a metal sheath or paddy straw is used.

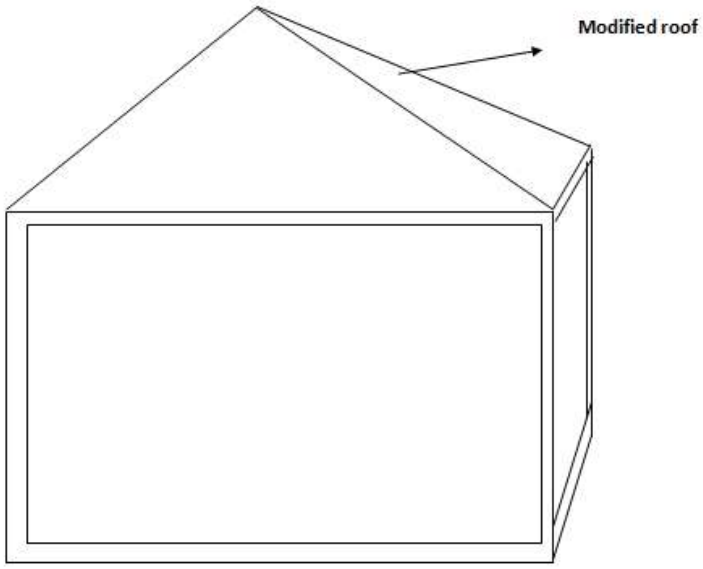


Fig 24. Closed Storage Structure with Modified Extended Roof

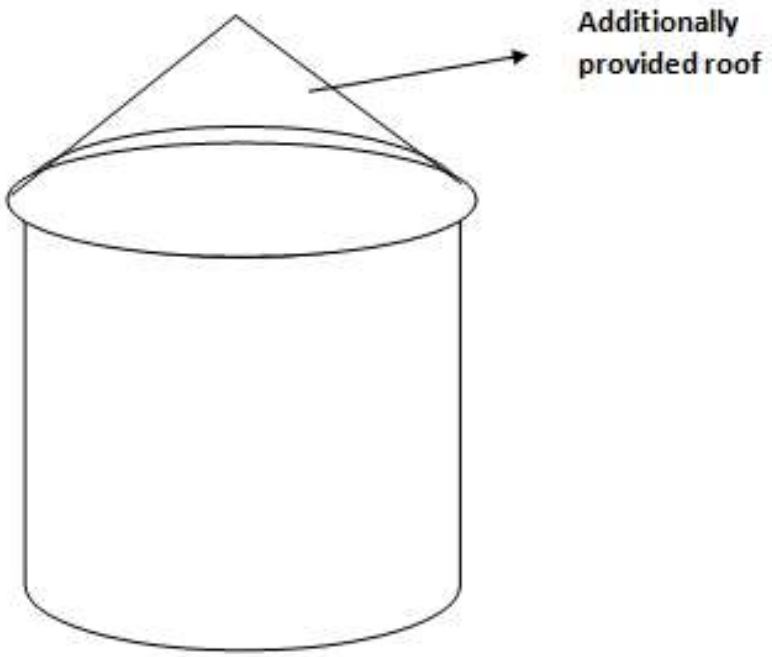


Fig 25. Extended Roof Suggested or Kanaja of Metal

4. Solar Roof Ventilation

Use of solar roof ventilation modified to whirly bird roof ventilator (Hengsadeekul & Nimityongskul, 2004). Here an exhaust spherical shaped free rotating fan was fitted on the roof which runs by current so here solar energy were used to produce electricity by solar plates Fig.26. With the controller switch the fan can use turned on or off when needed its will be a one-time investment. This technology will be good for closed larger PW and PC structures.

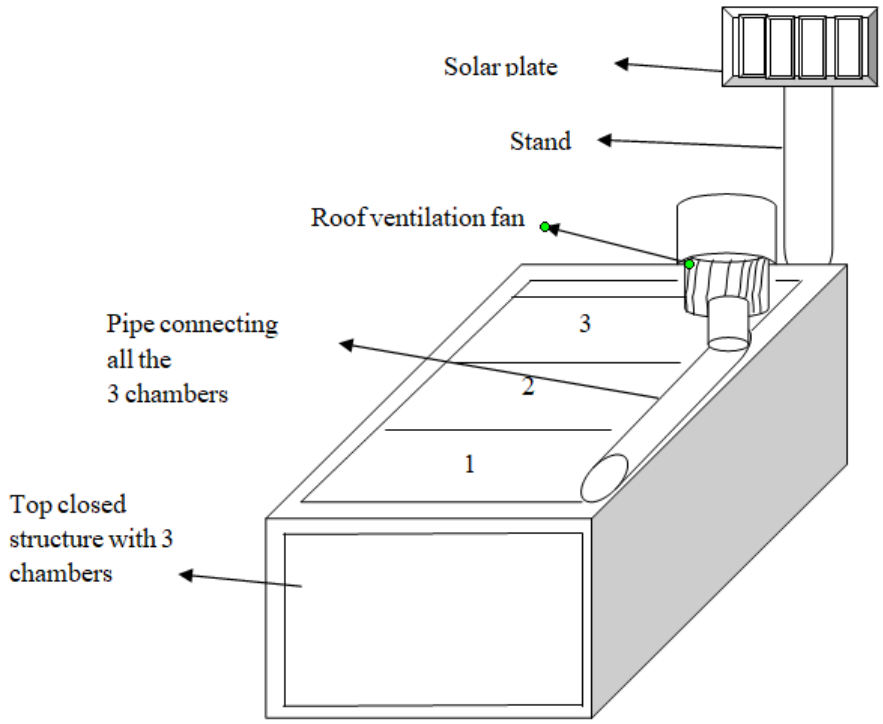


Fig. 26. Solar Roof Ventilation Installed for Many Chambered Structure

5. Small-scale AC

Small-scale AC (air conditioner) unit with CoolBot (Kumar *et al.*, 2019) technology can be installed to the closed type storage structures PW, PC and KM (if made closed). This help to manage temperature variation within the chamber, and the cool breeze will decrease insect activity (Longstaff, 1994). The schematic diagram in Fig.27 shows this technology's arrangement (installation charges may cost Rs.8-10K).

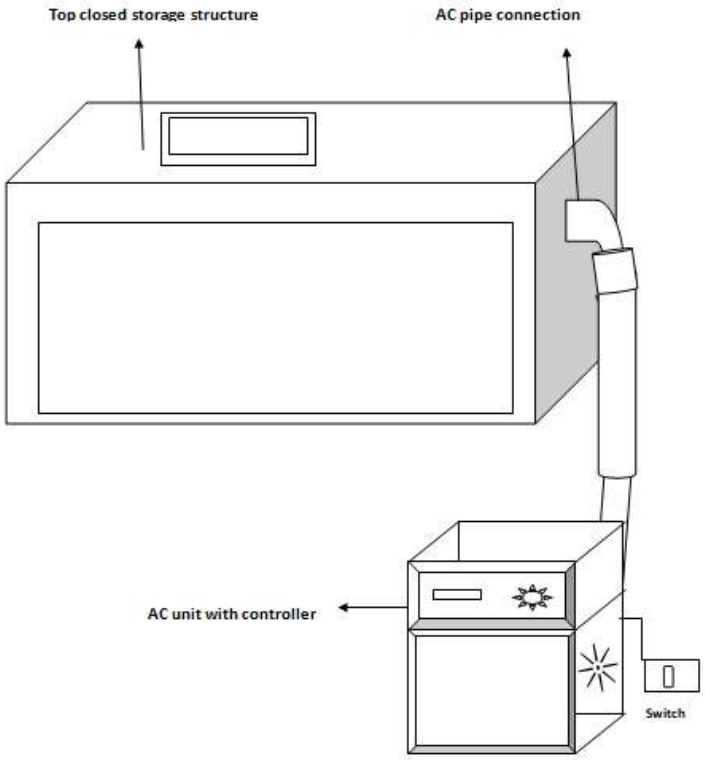


Fig. 27. Small-Scale AC Installed to A Closed-Type Storage Structure

6. Basement Coil Heater

Use of an electric heater on the floor Fig 28 of the structure (Srzednicki *et al*., 2006) will be suitable for all the structures which were closed and also, this is useful for the open type PC and KM as it provides extra facility to maintain the moisture in the seed bed

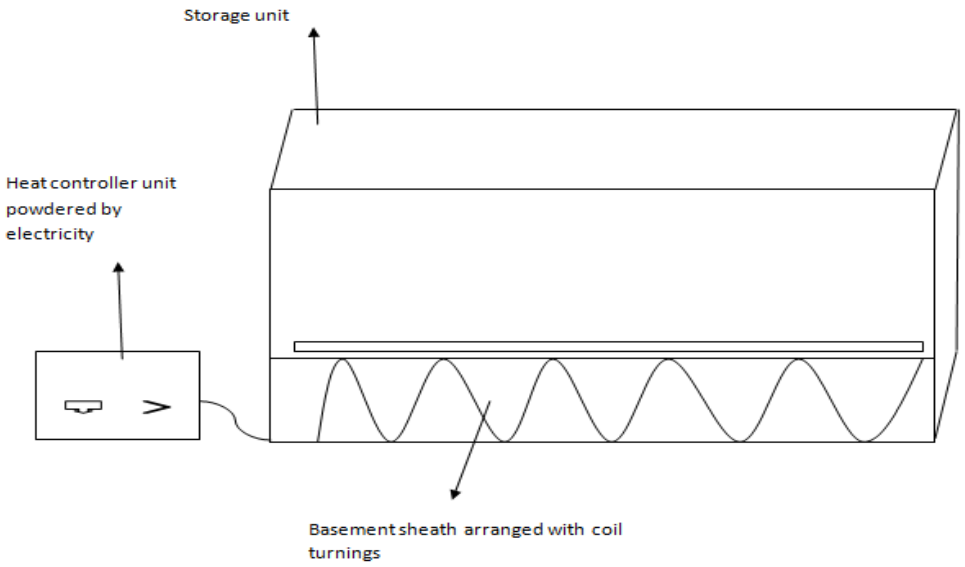


Fig. 28. Basement Coil Heater Installed

7. Small-Scale Combustion Chamber

Small-scale combustion chamber (Wijayaratne *et al*., 2009) Fig.29 made by metal produces smoke for fumigation. The paddy husk can be used as a combustion material. The smoke produced by burned husk within the metal chamber made it pass around the bag lot with a pipe connection. During the smoke supply bag lot has to be covered by a polythene sheath for an effective result. This process will help control storage insects and is suitable for bag-like structures, so we suggested it for Jute and Polythene bag users.

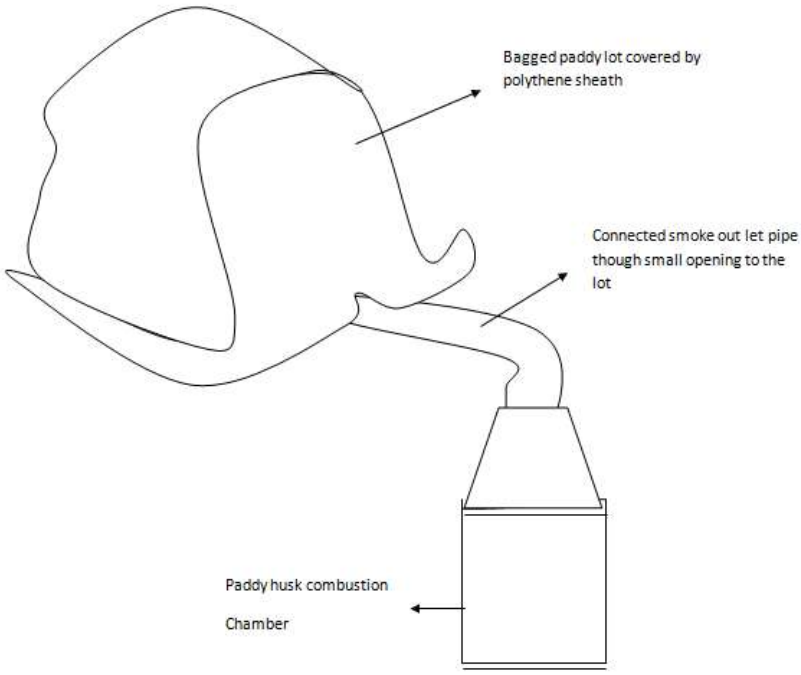


Fig.29. Small Scale Combustion Chamber

8. Low-Level Magnetic Field

Instrument which can produce a low-level magnetic field (as worked by (Longstaff, 1994)) can be installed to control the rate of insects within the stored chamber best for closed-type structures.

9. Storage Structural Treatment

Storage structure should be cleaned from time to time to remove the presence of spores, insect eggs or any materials that cause contamination. Using a slurry of Dryacide, diatomaceous earth mixed with silica aerogels and this mixture was used to coat storage structure wall (Longstaff, 1994), will be beneficial and will not produce any dust or unpleasant smell, which is a positive side of this.

10. Elevated Above the Ground Level

storage of jut bags or polythene bags on wooden or bamboo floors, which was elevated above the ground level for 4 to 5 feet, will help to get protection from rodents this kind of structure was found and studied by.(Sarangi *et al.*, 2009). Here we also recommend.

6. SUMMARY

The world population depends on rice as a food source for more than fifty percent. Production is happening in most developed and underdeveloped countries. Wide varieties of paddy are there, which were selected to grow according to the environment and field conditions. There is a lot of interest in producing different varieties by universities worldwide. Market openings are also very good, and upgrading (value-added processes) of paddy seeds at the time of sale is also happening in a good way. These were some more interest and work needed to take care of seeds during storage. Because storage is an intermediate stage between production and consumption so it must consider maintaining the consumption demand in the world, protecting for long period, making maximum use of total production, and to full fill the Nation's food security norm. And also, according to FAO, 17% of the total agricultural produce must be stored for future use.

So, the storage process had a significant role, and many types of storage systems are followed worldwide. It Started as the basic knowledge of protecting the seeds, later, it became traditional knowledge and helped in the protection of seeds in a larger scale. Now it also influencing to build modern structures. Traditional storage structures are in use till now. People not only knew about building it but also knew some biological treatment methods which enhanced the stored seeds health and storage period and protected them from insects, rodents, and microbes.

The currently followed traditional knowledge was the result of several years of trial-and-error methods of practices by the previous generations. With care, this knowledge has been passed from generation to generation till now.

Importance of this Research

Traditional knowledge is part of the culture and followed by most of the people in the world in India and in our study area also, and they had a reasonable opinion about to following them. The importance of our research includes:

- An effort to know important currently following large-scale storage methods.
- To come across the traditional biological treatments followed by the people to protect the seeds during storage.
- A better understanding of these will help to check whether it can be made even better by adding some use full techniques to the existing one. People already had an interest in following these structures. If these became user-friendly, chemical free, and more effective in protecting the quality and quantity of the seeds for a long time, they would follow these even more.

Summary of the Research

This attempt enriched us with traditional knowledge of the people and their ability to understand nature, the importance of production and the protection of agricultural produce. For example, the Malnad area had good weather conditions for growing paddy parts. The district, which comes under Malnad belt, is well known for paddy production the people do follow traditional methods to produce and store.

During this study, we learned that people used large and small-scale storage. Small-scale structures are used to store the seeds only, which they will use instantly. As per our aim we concentrated only on large-scale structures currently in use. Rectangular and spherical are the two basic shapes followed to construct these traditional storage structures. In rectangular shape, Panatha made of wood had more

than a few hundred years of history and the spherical structure Kanaja also had a long history of use. There is a good opinion and recommendation by the user about Panatha and Kanaja. Most preferences were there for Panatha for its seeds-protected ability, long-lasting, less maintenance, chamber facility, and use of wood for other purposes if they dismantled it. The modification found for wood Panatha (PW) was by Panatha of cement (PC), constructed by brick and cement. The PC installation is easy compared to the wood structure, due to the lack of quantity of wood, the storage holders are switching to Panatha of cement these days. Also, they can install it within the house.

The same situation with Kanaja also users number declined; very few were found but people still showed interest in using it. Due to the lack of bamboo and the skilled persons needed for construction now, storage holders are looking for an alternative solution. So they used a metal sheath to turn it into a cylinder-like structure as they made Kanaja of bamboo (KB). And now they are ok with Kanaja of metal (KM) even though it had some adverse effect on the seeds present adjacent to the wall. Still, this modification was followed by many as the material for construction is cheap and readily available. The bags made of coconut jute (JB) and polythene (PB) were the most considered storage structures (about 85% of both). Because of its utility natures, like can be used to store for a long term, the structure itself can be used for transportation, handy to handle, durable, instantly exchangeable and also their availability is good in the market.

Stored seeds analysis showed PW had good in keeping the seeds moisture level up to nine months. The results on germination percentage and contamination rate were also acceptable. The rodents effect was very less only the insect number increased as this is a closed-type structure. The PC also showed better results in all these qualities

and PW, so storage holders had no issue to adapting the PC over PW. Kanaja of bamboo was protected seeds for six to eight months in a good way after that microbial activity was just increased, it needs constant observation by the storge holder to defend it from rodents and structural damage. But all these problems were overcome by following PC, which provided better protection against rodents and the structure was physically stable. The seeds were also in good condition even after years of storage for consumption. It had some moisture maintenance issue and increased microbial activity, but people were proffering it. JB and PB had good ventilation, durability, user friendly, and transportation ability even though the bags are thin, they are long-lasting and can use quite hard.

Major Research Findings

Observation of structure on-sight, laboratory test results, analysis of the structure, and its comparison helped us to suggest some modifications to existing storage structures like Closed storage structure connected with an exhaust fan, Top opened type storage structure fitted with coil heater, solar roof ventilation, Small-scale AC and others they are:

- Storage holders still had very much interest in following their traditional storage methods.
- The structures found are very reliable.
- The storage holders were not facilitated with any modern instruments or techniques, and there was no attempt to think about this or to have such facilities.
- Some of the suggestions given in this work can be adaptable by the storage holder to better the structure and its stored content.

7. CONCLUSION

Storage of seeds is an essential stage in the life cycle of the seeds, naturally, it has structural protection as a seed coat. When humans start to consider seeds as a food source, natural protection is not enough to protect them for a long time, so the storage process is needed, which will play a major role in keeping and enhancing seeds health for a long time or till to use for consumption. So, from the time humans got civilized, some storage methods were also invented to protect their food commodities. As time progressed and more interaction with mother nature, people start finding some effective storage methods. These methods were transferred from generation to generation and became traditional knowledge.

This kind of knowledge was found present in all human habitats worldwide. In our study region Malnad, people were also using traditional knowledge to store their agricultural produce, and paddy is also one of them. The storage structure found in Maland region had a good history and was not just as a simple process it became part of their culture. These structures were built with plant-sourced materials, and majorly large-scale and small-scale structures are present. As we preferred to study large-scale storage structures, some important structure and seed protective treatments were found. Panatha made of wood, Panatha made of cement and brick, Kanaja made of bamboo, Kanaja made of the metal sheath, and bags made of coconut jute and polythene are the structures used to store paddy on large scale. All these structures were used in all parts of the study region with different percentages according to the interest of the storage holders.

The study revealed that PB was followed more the JB and PW PC, KM and KB are next in their list preference. If the storage holder had enough space and financial fitness, then they chose the PW. Seeds stored in all the structures showed good protection for up to five to six months. Later on, the seed naturally become tent to decline in its health condition at this time the real function of the storage structure and the challenge to the storage holder starts. But all the structures mentioned above were found suitable for seeds to store in them for more than six months in some of the places where seeds were found stored for more than 18 months in good condition.

The structures are given good feedback in protecting against microbes, insects, and rodents. The storage holder followed some plant-based traditional treatments during storage, which had good results and will not harm the storage structures. It was observed that the storage holder did not have any technical knowledge to improve the existing structure. They need knowledge and support to understand the scientific nature of their structure and the beneficial aspect of its use or to adopt appropriate techniques with a scientific approach.

They need training regarding these aspects. We compared and analyzed the structural deference, cost-effectiveness, impact on stored seeds, and the benefits of continuing it and fair interest among the storage holder on their structure.

This analysis helped us to think about the needs of the storage holder we found that they need to be provided with some portable essential devices to detect moisture, temperature variations, microbial presence, humidity, oxygen level, and seed viability which will improve the knowledge regarding their structure and its improvement in the enhancement of seed quality and longevity.

An attempt to discuss with storage holders to know about the need to have a suitable modernized standard storage structure helped us to suggest some technology adaptations for their existing structures. we suggested some like closed type storage structure connected with exhaust fan, Top opened type storage structure fitted with coil heaters, solar roof ventilation, Small-scale AC and others in this work that are useful now and in the future.

Scope for future work

Future work can be carried out in the following areas:

- Experimental studies can be carried out on the suggested technological adaptations given in the present work
- Comparison of traditional structure mentioned in this work with others can be done in their study area by researchers.
- Computerized temperature, moisture and insect activity monitoring with the required instrument can be done.
- Interaction and discussion with farmers to understand the technology they needed to apply and their perceptions about modern instruments can be done.

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Indigenous storage practices for paddy in shimoga district, Karnataka

Sunil Kumar TV[1*], Rajeshwari N[2], Krishnappa M[3], Ramesh Babu HN[4]
[1, 2, 4] Department of Botany and Seed Technology, Sahyadri Science College, Kuvempu University, Shimoga, Karnataka, India
[3] Department of Applied Botany, Kuvempu University, Shankaraghatta, Karnataka, India

Abstract
Storage of paddy is one of the important intermediate stage between production and consumption. Use of paddy is regular in daily basis in most part of the world. Storage of paddy done in many ways by considering usage. If paddy has to be transported it will be stored in bags some other methods are also used by farmer's or by storage holders. These storage methods studied in present work are following from generation to generation hence they considered as indigenous storage practices. Practices followed for storing paddy in many villages of Shimoga district were studied, each storage structure is unique and different in its method of construction, materials use and usage. Farmers or storage holders are using these methods which have retained from more than hundreds of years accordingly their capacity in maintaining the quality and quantity of stored paddy seeds.

Keywords: paddy, traditional storage, non-chemical storage, ecofriendly storage

1. Introduction
Paddy (*oryza sativa*. L) Is consumed worldwide. It is one of the staple food, grain produced and consumed by India is increasing Prakash *et al*, (2016) [9] and consumption rate also becoming more. 17% of the year food production must be stored considered security of the nation according FAO (food and agriculture organization) Xiaoli *et al*., (2008) [7]. It is easy for paddy to grow, harvest, pack, store and transport. It had good amount of nutritions, vitamins, carbohydrates and many varieties of food can be prepared, so consumption percentage is high among the world. One of the major challenges for the paddy grower is to match the need of demand within the time period, make reach for the maximum population even one in longer distance. Improper handling of postharvest processes maximize the fungal activity and mycotoxin percentage during storage was recorde by Magan and Aldred (2004) [5] so storage systems must be very good, it's very much need to consider physical and chemical properties otherwise changes occur as ages passes during storage it down grade the milling quality also Zhongkai *et al*.,(2003) [4]. For storage of paddy many more methods are followed in some part of world air tight storage are preferred in this insects and microbes get controlled by increase rate of corban dioxide within the closed system by Thilakarathna *et al*., (2005) [6]. Insects in storage container can live in temperature between 8 - 41^{0}c (Jayas and White 2003) [3]. Considering safety, quantity and transportation storage done by some methods which is following traditionally by people at their household level. In our study area 27 villages are visited and interacted with the storage holders and to farmers. Our study area Shimoga is part of Malnad region, we selected parts of shimoga region for field survey which comes under the Malnad belt. It receives more rainfall in a year, weather and land is very much suitable for paddy to grow, as rice is main course in the daily food of people of Malnad they prefer paddy to grow regularly. Farmers who growing paddy will store paddy by some of the method which became common method among them in their region, which referred as traditional storage systems. Pre storage process like drying is needed, improper drying effect on antioxidants (phenolic and anthocyanin) which lead early aging of stored rice by Lindemann *et al*., (2019), these precautions help paddy to store for longer period. It's an important decision to select good suitable storage structures which are user friendly ecofriendly and economic. Economic storage systems has to be promote more considering the poor farmer number among the nation (Mehta *et al*., 2012) [8]. Maximum quantities like several quintals of paddy can stored in these systems at household level. In early days paddy stored in panatha or kanaja are used for sowing also, as per the farmers feedback seeds stored for 3-5 months shows more than 80% of germination in field condition. There for these storage methods are very preferable ones among the farmers in Shimoga region.

2. Methodology
2.1 Field survey
During the survey we observed several storage systems which in use, most of the storage holder's preffer 2-3 type of storage system to use regularly at their household level. We done the survey in taluks of Shimoga district which comes under Malnad belt region. There are three taluk Sagara, Hosanagara and Thirthahalli come under Malnad belt. These field areas was visited during the month June-August 2019 in this visit we approached many villages of the three region and interacted with number of farmers and storage holders. Information regarding Paddy growing, variety of paddy growing, harvesting, drying and storage process are collected. Here mainly we are focusing on method of traditional storage using. So collected some important and elaborate information about storage system we got the information like type of a storage system used, the construction methodology, maintain process & cost, pre filling process, method followed to get optimum moisture in paddy before filling are noted in our data sheath. Paddy sample and storage system photos was collected. Three taluk was surveyed people of these taluk in between them sharing the information or knowledge about to choose best

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Impact of conventional storage system on germination and storage fungi of paddy in Chikkamagaluru, Karnataka

TV Sunil Kumar[1*], N Rajeshwari[1], HN Ramesh Babu[1], M Krishnappa[2]
[1] Department of Botany and Seed Technology, Sahyadri Science College, Kuvempu University, Shimoga, Karnataka, India
[2] Department of Applied Botany, Kuvempu University, Shankaraghatta, Karnataka, India

Abstract
Practice of suitable method of storage benefited to maintain the highest germination ability even to the duration of six months up to 90%. Paddy stored for a year good in quality for consumption and flour. Conventional structures recorded were constructed with locally available plant wood, bamboo, mud, coconut jute. As insect protector plant leaf, sugarcane, paddy husk was selected which been in use traditionally. Storage fungi infestation rate was fund increased more in 9 to 12 months storage time. Insect's damage was more in Panatha, although this structure had good protection against rodents and cold. SB and sand method test results was calculated and analyzed for samples, stored for three different storage period in three different storage structures.

Keywords: conventional storage, paddy germination, paddy fungi, storage fungi, paddy storage

Introduction

Rice (Oryza sativa L.) the name represent more than twenty species in the grass family. Twenty percent of the world's population consumes rice as food in daily routine in 2012 by Kim *et al.,* (2012) [9] but now in matter of nine years it increased to half of the world population (Kaur and Gill 2020) [7]. Production and consumption happen more in Asia (Cho *et al.,* 2016) [3]. Antioxidants of rice valuable in controlling the threat of diabetes (type2), cardiovascular problem and cancer (Kaur and Gill 2020) [7]. Starch is one of the major component of rice (kalita *et al.,* 2017) [7]. By Starchy endosperm activity paddy can germinate in low oxygen level even when submerged (Lee 2009) [9] this ability promoted for its cultivation globally. Quality and quantity of agriculture produce can be sustained to long period by following suitable storage method. Effectiveness of particular storage practice showed its impact on stored product. Eco-friendly storages were beneficiary to stored seeds, humans and nature. Farmers financial balance depend upon good, low cost and long lasting storages (Hengsadeekul and Nimityongskul 2004) [6]. Evading of chemicals or high-tech storage system and artificial treatment for drying and cooling will decrease the storage cost (Adhikarinayake *et al.,* 2006) [1]. Quality of stored content has to be maintained for complete utilization of total produced. To avoid influence of non chemical storage method, its better switch to conventional structures which build by using plant materials, cement and mud. By following these structures farmer will become self dependent, coast can be minimized and increase farmers earnings during off season also (Wasala *et al.,* 2016) [13]. These conventional structure was found in Chikkamagaluru region are so eco-friendly and very much sustainable for many years even during adverse environment conditions. This study was conducted on paddy samples stored in these structures for deferent time period to know their impact.

Collected paddy samples were analyzed for its viability by using Standard Blotter (SB) method and also observed common storage fungi. It was observed in result paddy stored were viable with good percentage and less affected by storage fungi. Consumption rate of this paddy was up to remarkable level and even for sowing. Chikkamagaluru region is one of the more rain fall region of Karnataka, even with these conditions mentioned conventional storage methods are very effective and safer.

Materials and method

Field work

Personal visit lead us to derive about paddy stored structure in chikkamagaluru region of Karnataka. We were interacted many farmers in many villages across. Found huge number of farmers who following conventional storage from several generations. The technology of construction had been passing from generation to generation some important regularly practicing structures were recorded and collected the seed samples.

Conventional storage structures observed

Sustainable conventional storage structures recorded are

1. 1.circular bamboo chamber named kanaja constructed by bamboo, by preparing small strips of few inches with two to three meters in length were fabricate as wall of the chamber, finally turn into cylinder like structure, required size cylinder can be made normally we observed had the of capacity 5-6 tons.
2. Rectangular storage made by using cement and brick called Panatha was one of the very common systems followed by many farmers. Wall of the chamber constructed by brick and cement and plastered by cement or mud. The size of Panatha generally up to 6-8feat.
3. Jute bag prepared by coconut jute in different sizes -25, 50, 100 & 200kg