Modeling on Grain Storage System and Measurements

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Abstract

The main function of storage in the economy is to even out fluctuations in market supply, both from one season to the next and from one year to the next, by taking produce off the market in surplus seasons, and releasing it back onto the market in lean seasons. The post-harvest losses in India amount to 12 to 16 million metric tons of food grains each year which amounts to more than Rs 50,000 crores in monetary terms. Natural contamination of food grains is greatly influenced by various environmental factors such as type of storage structure, temperature, pH, moisture, etc. Safe grain storage methods play an important role in preventing losses which are caused mainly due to weevils, beetles, moths and rodents. It is estimated that 60-70% of food grain produced in the country is stored at home level. The storage methods range from mud structures to modern bins. The materials used include paddy straw, wheat straw, wood, bamboo, reeds, mud, bricks, cow dung etc. Outdoor storage of grains is done in structures made of bamboo or straw mixed with mud. For small-scale storage of grains the *PAU bin*, *Pusa bin* and *Hapur tekka* can be employed. For safe and scientific storage it is important to carefully select the storage site, storage structure, undertake cleaning and fumigation, ensure proper aeration of grains followed by regular inspection of grain stock. Traditional methods of storage can be categorized into temporary storage methods and long-term storage methods. Under temporary storage, aerial storage, storage on the ground, or on drying floors, and open timber platforms can be used, whereas under long term storage methods, storage baskets (cribs) made exclusively of plant materials, calabashes, gourds, earthenware pots, jars, solid wall bins, and underground storage can be employed. There are some alternative storage technology at farm/village level, which are sacks, metal or plastic drums, alternative solid wall bins (pusa bin, burkino silo, USAID silo, concrete/cement silos, metal silos, and synthetic silos). Bulk storage of produce is done in warehouses. Warehouses are scientific storage structures especially constructed for the protection of the quantity and quality of stored products. The warehouses are owned by Food Corporation of India (FCI), Central warehousing corporation (CWC) or the State Warehousing Corporations (SWC). Under bulk storage, sealing and aeration play important role. The benefits of sealed stores are such that the small costs involved during initial construction (negligible in many cases) should not warrant consideration. Aeration may be ambient or refrigerated, based on the requirements. Pests usually occur non-randomly in stored grain. Over 420 standard test methods, including at least 75 internationally-applicable methods, are available to test the quality of stored grains. Of the wide range of properties used for testing, the bulk density and the foreign matter are commonly assessed for most types of grains. The value of bulk density for the same grain varies with the differences in equipment design and procedural detail employed. Measuring moisture content is another important parameter which should be considered during quality analysis of grains. The

factors should be considered when selecting a meter to determine moisture content are resolution repeatability, reliability, stability/drift of measurements, range of commodity, range of moisture content, sample weighing, ambient effect and sample size. The indigenous storage structures are not suitable for storing grains for very long periods. Thus improved storage structures and scientific storage of grains in form of warehouses is the need of the hour to strengthen traditional means of storage with modern inputs and to provide cheaper storage to farmers so as prevent enormous storage losses.

Key words: Grain storage methods, Traditional storage, Bulk storage, Quality measurement methods

1 Introduction

In most countries grains are among the most important staple foods. However they are produced on a seasonal basis, and in many places there is only one harvest a year, which itself may be subject to failure. This means that in order to feed the world's population, most of the global production of maize, wheat, rice, sorghum and millet must be held in storage for periods varying from one month up to more than a year. Grain storage therefore occupies a vital place in the economies of developed and developing countries alike. The market for food grains is characterized by fairly stable demand throughout the year, and widely fluctuating supply. Generally speaking people's consumption of basic foods such as grains does not vary greatly from one season to another or from year to year. The demand for grain is 'inelastic', which means that large changes in the market price lead to relatively small changes in the amount of grains which people purchase. Market supply, on the other hand, depends on the harvest of grains which is concentrated within a few months of the year in any one area, and can fluctuate widely from one year to the next depending on climatic conditions. New varieties that have shorter growing periods, and variation in climatic conditions and farming systems in different regions of a country, can help to even out the fluctuations in market supply. But even in a country such as Indonesia, which has diverse climatic and farming conditions and where 90 per cent of rice land is under short duration high yielding varieties, about 60 per cent of production is harvested within a three month period (Ellis et al. 1992). The main function of storage in the economy is to even out fluctuations in market supply, both from one season to the next and from one year to the next, by taking produce off the market in surplus seasons, and releasing it back onto the market in lean seasons. This in turn smooths out fluctuations in market prices. The desire to stabilize prices of basic foods is one of the major reasons why governments try to influence the amount of storage occurring, and often undertake storage themselves.

2 Grain Storage Losses in India

According to World Bank Report (1999), post-harvest losses in India amount to 12 to 16 million metric tons of food grains each year, an amount that the World Bank stipulates could feed one-third of India's poor. The monetary value of these losses amounts to more than Rs 50,000 crores per year (Singh, 2010).

Natural contamination of food grains is greatly influenced by environmental factors such as type of storage structure, temperature, pH, moisture, etc (Sashidhar et al, 1992). Types of structure used, length and purpose of storage, grain treatment (e.g. parboiling) and pre-storage practices are all important variables affecting storage losses. The importance of these regional and crop variations immediately determines certain necessary characteristics of crop storage research (Greeley, 1978).

During storage, quantitative as well as qualitative losses occur due to insects, rodents, and micro-organisms. A large number of insect pests have been reported to be associated with stored grains. The occurrence and numbers of stored grain insect pests are directly related to geographical and climatic conditions. Pest infestation in grains is affected by moisture content of grains, relative humidity, temperature, storage structure, storage period, processing, hygienic condition and the fumigation frequency followed. Almost all species have remarkably high rates of multiplication and, within one season, may destroy 10-15% of the grain and contaminate the rest with undesirable odors and flavors. Insect pests also play a pivotal role in transportation of storage fungi (Sinha and Sinha, 1990). The major pests of stored grains include beetles (*Callosobrunchus* sp, *Trogodermagranarium*, *Tribolium confusum*), weevils (*Acanthoscel idesobtectus*), moth (*Corcyra cephalonica*) and rodents. The control measures include two types of treatment – prophylactic and curative. The prophylactic treatment involves the use of pesticides like Malathion (50% EC), DDVP (76% EC) and Deltamethrin (2.5% WP). Curative treatment involves use of fumigant aluminium phosphide to control infested stock or godown in airtight condition. For controlling rodents rat cages, poison baits and use of rat borrow fumigation is recommended (India Agronet, 2009).

3 Grain Storage Methods

Grain storage plays an important role in preventing losses which are caused mainly due to weevils, beetles, moths and rodents (Kartikeyan et al, 2009). It is estimated that 60-70% of food grain produced in the country is stored at home level in indigenous storage structures. The percentage of overall food crop production retained at the farm-level and the period of storage is largely a function of farm-size and yield per acre, family-size, consumption pattern, marketing pattern, form of labour payment, credit availability and future crop expectations (Greeley, 1978).

The storage methods range from mud structures to modern bins. The containers are made from a variety of locally available materials differing in design, shape, size and functions. The materials used include paddy straw, wheat straw, wood, bamboo, reeds, mud, bricks, cow dung etc. Grains can be stored indoors, outdoor or at underground level (Channal et al, 2004).

Outdoor storage of grains is done in structures made of bamboo or straw mixed with mud. Bamboo structures are used for storing unthreshed and threshed paddy. *Gummi* is an outdoor structure used for storing grains. This structure is made with bamboo strips or locally available reeds. It is usually circular or hexagonal in shape and plastered with mud. The base on which the structure is constructed is also made up of reeds or in some cases with stone slabs. The roof of the structure is usually made from loose straw. The structure is placed on a raised platform. Bamboo structures made on a raised timber or stone platform protect grain from rat damage and prevent moisture absorption from the ground (Channal et al, 2004).

For safe and scientific storage it is important to carefully select the storage site, storage structure, undertake cleaning and fumigation, ensure proper aeration of grains followed by regular inspection of grain stock. For small-scale storage of grains the *PAU bin, Pusa bin* and *Hapur tekka* have been proposed. The PAU bin designed by Punjab Agricultural University is a galvanized metal iron structure. The capacity ranges from 1.5 to 15 quintals. Large scale grain storage is done in CAP and silos. CAP Storage (Cover and Plinth) involves the construction of brick pillars to a height of 14" from the ground, with grooves into which wooden crates are fixed for the stacking of bags of food grains. The stacks are covered with 250 micron LDPE sheets from the top and all four sides. Food grains such as wheel, maize, gram, paddy, and sorghum are generally stored in CAP (cover and plinth) storage for 6-12 month periods. It is the most economical storage structure and is being widely used by the FCI for bagged grains. The structure can be fabricated in less than 3 weeks. It is an economical way of storage on a large scale (India Agronet, 2009).

3.1 Traditional Methods

These can be categorized into temporary storage methods and long-term storage methods (FAO, 1994).

3.1.1 Temporary Storage Methods

Such methods are quite often associated with the drying of the crop, and are primarily intended to serve this purpose. They assume the function of storage only if the grain is kept in place beyond the drying period.

Aerial Storage**:** Maize cobs, sorghum or millet panicles are sometimes tied in bundles, which are then suspended from tree branches, posts, or tight lines, on or inside the house. This precarious method of storage is not suitable for very small or very large quantities and does not provide protection against the weather (if outside), insects, rodents, or thieves (Ref: FAO,1987).

Storage on the ground, or on drying floors**:** This method can only be provisional since the grain is exposed to all pests, including domestic animals, and the weather. Usually it is resorted to only if the producer is compelled to attend to some other task, or lacks means for transporting the grain to the homestead.

Open Timber Platforms**:** A platform consists essentially of a number of relatively straight poles laid horizontally on a series of upright posts. If the platform is constructed inside a building, it may be raised just 35-40 cm above ground level to facilitate cleaning and inspection. Platforms in the open may be raised at least 1 metre above ground level. They are usually rectangular in shape, but circular or polygonal platforms are common in some countries.

3.1.2 Long-term Storage Methods

Storage baskets (cribs) made exclusively of plant materials**:** In humid countries, where grain cannot be dried adequately prior to storage and needs to be kept well ventilated during the storage period, traditional granaries (cribs) are usually constructed entirely out of locally available plant materials: timber, reeds, bamboo, etc. Under prevailing climatic conditions most plant material rot fairly quickly, and most cribs have to be replaced every two or three years - although bamboo structures may last up to 15 years, with careful maintenance.

Calabashes, gourds, earthenware pots**:** These small capacity containers are most commonly used for storing seed and pulse grains, such as cowpeas. Having a small opening, they can be made hermetic, by sealing the walls inside and out with liquid clay and closing the mouth with stiff clay, cow dung, or a wooden bung reinforced with cloth.

***Jars*:** These are large clay receptacles whose shape and capacity vary from place to place. The upper part is narrow and is closed with a flat stone or a clay lid: which is sealed in position with clay or other suitable material. Generally kept in dwellings, they serve equally for storing seeds and legumes. So that they may remain in good servicable condition, they should not be exposed to the sun and should not be either porous or cracked.

***Solid wall bins*:** Such grain stores are usually associated with dry climatic conditions, under which it is possible to reduce the moisture content of the harvested grain to a satisfactory level simply by sun-drying it. The base of a solid wall bin may be made of timber (an increasingly scarce resource), earth or stone. Earth is not recommended because it permits termites and rodents to enter. The better base is made of stone.

***Underground Storage*:** Practiced in India, Turkey, sahelian countries and southern Africa, this method of storage is used in dry regions where the water table does not endanger the contents. Conceived for long term storage, pits vary in capacity (from a few hundred kilogrammes to 200 tonnes). Their traditional form varies from region to region: they are usually cylindrical, spherical or amphoric in shape, but other types are known (Gilman and Boxall, 1974). The entrance to the pit may be closed either by heaping earth or sand onto a timber cover, or by a stone sealed with mud

3.2 Alternative storage technology at farm/village level

3.2.1 Sacks

Wherever grain is grown on a commercial basis, buying agencies often issue empty sacks to producers so that they may be filled on the farm. The buying agency may then collect the bagged grain from the farm, or the producer has to deliver it to the nearest collection point. In either case, the producer has to store the sacks of grain for some time before they are sold. During this period precautions have to be taken to ensure the safety of the grain and maintain its quality.

At the very least, the bagged grain must be kept off the ground to prevent spoilage by translocating water and/or termites. Low platforms, tarpaulins or plastic sheeting may serve this purpose; but if there is a risk of damage by rodents or other animals, high platforms fitted with rodent barriers should be used. If there is a risk of rain during the temporary storage period the bags should be covered with waterproof sheeting (but not all the time if the grain has a moisture content much in excess of 12%). Alternatively, the sacks of grain should be stacked on dunnage or waterproof sheeting, away from walls, in a rodentproofed barn. The need for chemical methods of pest control should not arise if the storage period is short.

Where sacks are used for domestic grain storage, similar conservation measures should be adopted. However, it will be necessary to employ some form of insect pest control. Second-hand sacks must be thoroughly cleaned and disinfested before use.

3.2.2 Metal or Plastic Drums

Drums are often used as storage containers in the house and serve notably for the storage of cereal seeds and pulses. Plastic drums are used intact or after having the upper part cut off to facilitate loading and unloading. Otherwise, plastic lends itself poorly to adaptation because it is relatively weak: at most, a lockable outlet can be added. If the lid is tight fitting and the drum is completely filled with grain, any insects present will deplete the oxygen in the drum and die. Metal drums can be adapted for domestic grain storage in a similar way. A removable lid permits easy loading; but it is also possible to weld half of the lid to the rim of the drum, and provide a riveted hinge on the remaining half of the lid so that it alone can be opened. Fitted with a padlock, such a modified drum is more secure. To make a store of greater capacity, two metal drums can be welded together end to end and fitted out as described above. Well modified and/or fitted with gaskets, metal drums can also be made airtight. Inaccessible to rodents, efficient against insects, sealed against entry of water, drums make excellent grain containers. However, they should be protected from direct sunshine and other sources of heat to avoid condensation by being located in shaded and well ventilated places.

3.2.3 Alternative Solid Wall Bins

In some countries grain storage workers, rather than modifying traditional storage structures, have developed significantly different storage bins. A few examples of these are described below.

***The "Pusa" bin*:** Developed by the Indian Agricultural Research Institute (I.A.R.I.), these silos are made of earth or sun-dried bricks; they are rectangular in shape and have a capacity of 1 to 3 tonnes. A typical "Pusa" bin has a foundation of bricks, compacted earth, or stabilized earth. A polyethylene sheet is laid on this, followed by a concrete slab floor 10 cm thick. An internal wall of the desired height (usually 1.5 to 2 metres) is constructed of bricks or compacted earth, with a sheet of polyethylene wrapped around it. This sheet is heat-sealed to the basal sheet, and the external wall is then erected. During the construction of the wall an outlet pipe is built into its base. The concrete slab roof is supported by a wooden frame and, like the floor, is constructed of two layers separated by a polyethylene sheet. During its construction, a man-hole measuring 60 x 60 cm is built into one corner. The "Pusa" bin has been widely adopted in India, and has been demonstrated in some African countries. It gives good results when loaded with well dried grain.

***The "Burkino" silo*:** Based on a traditional dome shaped type of bin, this silo is constructed with stabilised earth bricks. Various models and capacities are available. The base is made of stabilised earth resting on the ground or on concrete pillars. The domeshaped roof is also made of stabilised earth bricks, using special wooden formers. The technique of making a dome-shaped roof is not easy to master, and usually has to be done by skilled masons. A variant has been developed with the roof resting upon a wooden frame, which can be erected by unskilled farmers.

***The "USAID" silo*:** This silo is based on the "Burkino" silo and examples have been erected in Nigeria; holding one tonne of maize grain, the silo rests on stone or concrete pillars supporting a reinforced concrete slab 1.5 metres in diameter. The walls are made of stabilised earth bricks and are plastered inside and out with cement reinforced with chicken wire mesh. The top is domeshaped with a central round opening, and covered with a cone-shaped earthen cap. This is plastered with cement, and rests on bamboos or on a metallic drum base. An outlet door, consisting of a 15 x 30 cm plate 1.5 mm thick which is smeared with grease for easy sliding, is let into the base concrete slab.

Concrete/cement silos**:** Such silos are 'cement rich', and often include other materials which normally have to be imported into developing countries. Therefore they are potentially (and usually) expensive structures, which can be seriously considered only when improvements to traditional storage bins cannot be practically applied. Their redeeming feature, given that they are properly constructed and used, is that they are robust and should give many years of satisfactory service.

Metal Silos**:** Economically valid for storing large quantities (over 25 tonnes), metal silos are often regarded as too costly for small scale storage. Nevertheless certain projects have been successful in introducing small metal silos, of 0.4 to 10 tonne capacity, at farm/village level in developing countries: Swaziland (Walker, 1975), and India (Anon, 1982), to mention just a few. Metal silos are reported to have been used on farms and in villages in Guatemala for over 50 years (Breth, 1976) and in Swaziland, on a small scale, for possibly longer.

Synthetic Silos**:** Various attempts have been made to develop small scale storage bins, using synthetic materials such as butyl rubber (O'Dowd, 1971) and high density polyethylene (CFTRI, 1975). However, such bins proved to be either too expensive or prone to damage by pests. Also the management level required by such storage facilities is probably too high for most rural situations.

3.3 Bulk Storage

Bulk storage of produce is done in warehouses. Warehouses are scientific storage structures especially constructed for the protection of the quantity and quality of stored products. The warehouses are owned by FCI, CWC or the SWCs. The Central warehousing corporation (CWC) was established as a statutory body in 1957. The Central Warehousing Corporation provides safe and reliable storage facilities for about 120 agricultural and industrial commodities. It is the largest public warehouse operator in the country. It also offers services in the area of cleaning and forwarding, handling and transportation, procurement and distribution, disinfection services, fumigation services and other ancillary activities i.e. safety and security, insurance, standardization and documentation (India Agronet, 2009).

Separate warehousing corporations were also set up in different States of the Indian Union. The areas of operation of the State Warehousing Corporations (SWCs) are centres of district importance. The total share capital of the State Warehousing Corporations is contributed equally by the concerned State Govt. and the Central Warehousing Corporation. Apart from CWC and SWCs, the Food Corporation of India (FCI) has also created storage facilities. The Food Corporation of India is the single largest agency which has a capacity of 26.62 million tonnes.

3.3.1 Sealed stores

When a new grain store is being planned, there should be no question as to whether or not it should be possible to seal it effectively to make it air-tight for fumigation. The benefits of sealed stores are such that the small costs involved during initial construction (negligible in many cases) should not warrant consideration. Despite claims to the contrary, there are no disadvantages to building sealable stores, and when circumstances arise where ventilation is required (e.g. to aerate the grain), ventilators can be provided to allow this to be done.

Fumigation of grain is much cheaper and more effective than the use of chemical protestants, and residue problems are avoided. Furthermore, once fumigated, grain in a sealed store can be maintained free from insects because the sealing prevents access for reinfestation. 100% mortality can only be achieved if grain is fumigated in properly sealed stores, which are routinely tested to check their gas-tightness.

Diurnal temperature variations cause pressure changes in the air inside the store, and it is usually uneconomical to design stores (in particular their roofs) to withstand the pressure differentials that can occur. Some means of ventilating sealed stores is thus necessary to avoid these pressure exceeding safe values. Pressure-relief valves should be pressure actuated; in other words they should remain sealed when pressures are below the critical value. One option is to use an oil bath with a baffle extending below the liquid surface such that air-pressure inside the store will displace the oil and allow air to pass below the baffle. Non-evaporative oil should used for the purpose.

3.3.2 Aeration

Ambient Aeration: Aeration is a process of forcing air through grain to reduce its temperature. It is a very useful storage management tool which can preserve grain from deterioration, especially where the moisture content of the grain is above its safe level. Aeration can be used as effectively in sealed stores as in unsealed ones - sealed stores merely requiring the provision of an air-exhaust ventilator which can be sealed whenever fumigation is to be carried out.

Refrigerated Aeration: Aeration with refrigerated air achieves much lower temperatures when ambient conditions are warm. It is an expensive method of disinfestation compared to fumigation, but can be justified for storage of grains such as malting barley and seed grains in hot conditions, where maintenance of germination viability is important. Technically, the requirements are the same as for ambient aeration, except that no fan control is required since the system will operate 100% of the time until the temperature front has passed through the grain mass. An evaporative cooling system is used to reduce air temperature and to remove moisture. It is useful to place the fan between the cooling unit and the store, so that heat from the fan can be used to raise the air temperature by a few degrees, thus reducing its relative humidity and minimizing risk of grain wetting.

By recirculating the cooling air, it is possible to maintain a sealed storage system. In this way the grain may first be fumigated to render it insect-free, and then cooled to preserve quality, with the fumigant still present.

4 Grain Quality Measurements

Batches of grain are rarely uniform in quality even when regarded as acceptable. Pests usually occur non-randomly in stored grain. Consequently the only sure way of obtaining complete and accurate information about the grain is to carry out a total examination. This may be possible if the quantity to be examined is small, but is usually neither practical nor economical when a large quantity is involved. The choice is either not to examine the consignment at all or to take samples to obtain some information, acknowledging that anything less than a total examination is bound to affect the accuracy of the results.

With over 420 standard test methods, including at least 75 internationally-applicable, it is apparent that there is a large diversity in grain character. This is obvious when considering the range of uses for grain: paddy to produce milled rice, barley for malting, durum wheat for pasta production etc. Many assessments are commodity-, product- or end user-specific. Of the wide range of properties, bulk density and foreign matter are commonly assessed for most types of grain. In addition, the influence of moisture content on other grain qualities, as well as the simple economic fact, makes it important for quantification.

4.1 Bulk Density

All equipment for the determination of bulk density have features of (a) causing the sample material to fall from a standard container through a standard height into a standard volume weighing bucket, (b) leveling the surface of the material in the weighing bucket in such a way as not to influence its packing and (c) weighing the loaded bucket. However, differences in equipment design and procedural detail can result in very different values for bulk density, even when the same grain sample is used. It is essential, therefore, that only one type of apparatus is used for determining bulk density. ISO 7971 is a standard reference method with results expressed as mass per hectoliter.

The bulk density of a sample of grain can also be affected by the presence of foreign matter, and varies with mc. Consequently, it is standard practice to remove as much foreign matter as possible by sieving samples before carrying out bulk density determinations, and also to measure the mc of the sieved material.

4.2 Foreign Matter

Most grain quality standards state that the screens in sieves used for the assessment of foreign matter content should consist of perforated metal plate conforming to specifications laid down by national or international standards organizations. Such specifications cover the composition and thickness of the metal plate, the shape and dimensions of the perforations, and the arrangement of the perforations on the plate.

Operating Capacity of Sieves

The efficiency of a sieve is dependent upon two factors: the dimensions of the apertures in the screen, and the proportional volume of material which will not pass through the apertures. As a general rule, the percentage sieving area of a screen with small perforations is less than that of a screen with larger holes, and its capacity for sieving efficiently is correspondingly reduced. Also, for a perforated metal screen of fixed specifications the sieving efficiency falls off markedly if the volume of material which will not pass through the apertures exceeds a certain quantity. Table 1 shows the recommended volume of grain that should be placed on a screen, to maintain its sieving efficiency.

Table 1 Grain Sieves, 200mm Diameter, Maximum Loadings

Nominal aperture (mm)	Recommended volume of load (cm^3)	Typical grain equivalent
8.0	500	300g Maize
4.0	350	250g Sorghum
2.0	200	150g Wheat
1.0	140	100g Millet

Source: International Standard ISO 2591-1973

4.3 Moisture Content

The standard test method (ISO 712) for the determination of mc in cereals is by mass loss in a hot-air oven. The method is time-consuming and a variety of rapid methods have been developed for day-to-day use. These range through accelerated heating by infra-red source gravimetric tests to almost instantaneous readout by electronic moisture meter. Of the latter, two types are common; resistance and capacitance meters.

It is recommended that grain-handling agencies avoid using a mixture of meter types, because this can lead to conflicting results. Instead, the meter best suited to their particular requirements should be selected. The following factors should be considered when selecting a meter to determine moisture content:

Resolution - the ability of the meter to differentiate between moisture contents which are very close in value. Some meters have the ends of the scale compressed i.e. the scale is not linear. The resolution of the meter is therefore relatively poor for high and low readings.

Repeatability - a measure of the meter's ability to give a constant reading when the same sample is tested several times. Capacitance meters, due to variations in grain packing, may not produce such accurate results as resistance meters, which normally use a more homogeneous ground or compressed sample.

Reliability - a measure of variation between meters when measuring the moisture content of the same sample. Meters should be regularly checked and calibrated to ensure reliability.

Stability/drift of measurements - affects the frequency of the need to calibrate the meter against the standard test method.

Range of commodity - calibrations will be necessary for all the commodities of interest, and the meter must be capable of accommodating them.

Range of mc - in general, resistance meters cannot measure low mc i.e. lower than approximately 9%, whereas capacitance meters can - to 1 or 2% in some cases.

Sample size - meters use differing size of test samples: larger samples give more accurate results, and require fewer replications.

Sample weighing - most capacitance meters require the sample to be weighed, thus introducing an extra variable (and extra cost).

Ambient effect - meter readings vary with temperature, and correction is required. Some meters automatically display the corrected moisture content.

Producers of grain will have a number of uses for their produce; as food for the family or livestock, for seed, or for sale. The trade of grains can cover a large area entailing a variety of end usages. A number of end-users would benefit from the uniformity of supply associated with the use of grain standards, such as the commercial producers of food products e.g. beverages, baked products and animal feed, or the procurers for food security reserves. It is difficult to judge whether the setting of standards for these varied uses can best be carried out by the relevant industry rather than a government regulatory body, or a combination of the two. Whatever method is used to formulate the standards, it gives a clear message of quality requirements to producers, and it should provide a more uniform and regular supply for the end users.

Given that the formulation of standards is the best system for providing information to grain producers and end-users, they should be based on factors which both consider important and which are easily recognizable and unambiguous. The selection of grades must allow clear steps which can be easily differentiated and represent a clear change in value and end-use. Standards should be built on those characters that can be accurately and uniformly measured, and interpreted. To assist this process, terminology must not be difficult to understand.

5 Conclusion

The grain production has been on the rise with better facilities in terms of seeds, technology, fertilizers, pesticides and irrigation but associated is the loss of grains which has also increased. Around Rs 50,000 crores every year are lost due to improper storage of food grains. Natural contamination of food grains is greatly influenced by environmental factors such as type of storage structure, temperature, pH, moisture, etc. At any given time 60-70% of grains is stored on the farm in traditional structures like Kanaja, Kothi, Sanduka, earthern pots, Gummi and Kacheri. However indigenous storage structures are not suitable for storing grains for very long periods. Here in lies the significance of improved storage structures and scientific storage of grains in form of warehouses. These provide safe and economical means of grain storage for long durations. Need of the hour is to strengthen traditional means of storage with modern inputs and to provide cheaper storage to farmers so as prevent enormous storage losses.

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