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Should India consider shifting to bulk food grain storage system? – A conceptual frame work

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ABSTRACT

India has conventionally adapted to bag system for food grain storages. The available grain storage facilities in the country are far too low compared with the huge productions. The total permanent food grain storage facilities available with the government and privately owned warehouses are only 24.7±4.3% of the total production, leaving nearly three quarters of the food grains to be stored in unorganized sector and unscientifically. This paper discusses the advantages of India moving to bulk storage system from the current bag storage practices. Easy automation, simple operation and effective fumigation are some of the advantages of bulk system compared with bag system. The adverse effects of ambient weather changes on the stored grain will be minimized by nearly eight times in a bulk storage system than in a bag system. The possible ways of successfully moving to bulk storage system by introducing a bulk chain are also discussed. Following are the two options for the move: (i) converting the existing facilities to bulk storage, and (ii) introducing fully automated bulk chain. Converting existing warehouses to bulk storage requires some initial investment but will help effectively using the already created facilities and increasing the storage capacity by nearly two fold. When new facilities in the form of bulk chain are created, fully automated galvanized iron bins may be introduced. A bulk chain for storage must start at the local collection centres and must extend up to the distribution points. In-bin drying facilities, tipper type bulk truck transports and rail wagon transports, fumigation and grain handling facilities must become part of such bulk chains. The shifting must be based on sound scientific principles. Elaborate research works need to be initiated to study the effects of local weather conditions on the safety of food grains stored in such bulk facilities.

Key words: Bag storage, Bulk chain, Bulk storage, CAP storage, Warehouses

India's food grain production has witnessed a phenomenal growth since its independence 70 years ago. Initially, after independence and till nearly the middle of 1960's the growth of grain production was sluggish. The production rose by a meagre margin of 30 million tonnes during that time (IndiaAgristat, 2016). In the late 1960's, the production was more than doubled, in just one decade owing to introduction of concept of green revolution (IndiaAgristat, 2016). Introduction of high yielding varieties, suitable application of sufficient fertilizers and plant protection chemicals, efficient irrigation water and crop management, continuous advancement of agricultural technologies, introduction of climate resilient, drought tolerant varieties and timely government interventions have helped the country to reach an all-time high grain harvests of 263 million tonnes in 2014-15 crop year (Chaturvedi et al., 2015). Rice and wheat, the stable foods for the people, are the major crops of India. The total production of rice and wheat in 2014-15 were 105.3 million tonnes and 94.9 million tonnes, respectively. Food grain production has continuously kept in pace with the growth of population (Fig. 1). Based on long term food grain production and the population in different periods, India has been maintaining a nearly constant gross per caput food grain availability of 197±16 kg throughout the post-independence period.

On one hand, India boasts of superlative productions of food grains and on the other hand, the availability

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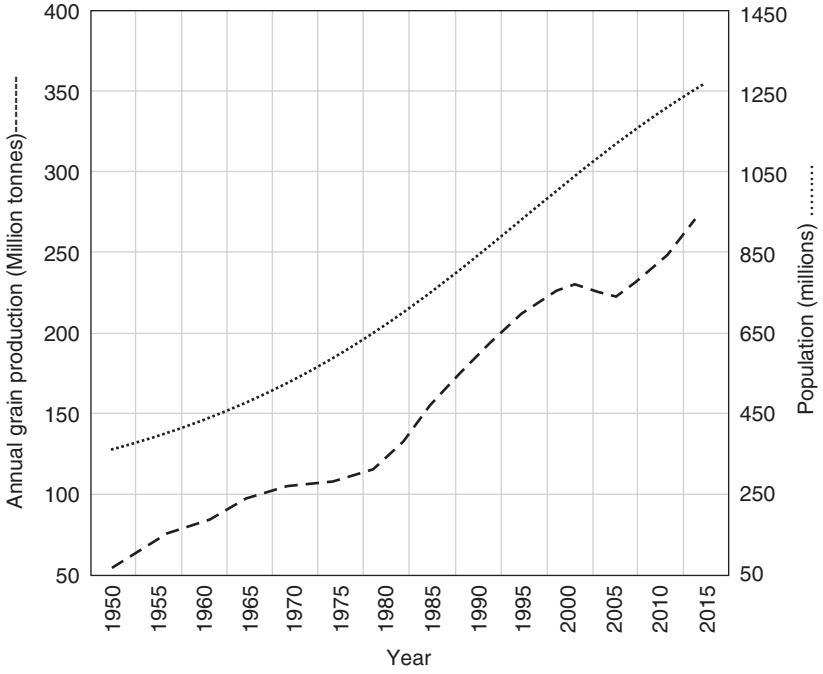

Fig. 1. India's success in continuously increasing its grain production to feed the fast growing population in the past 7 decades (India Agristat, 2016)

of food for nearly 30% of the population is grossly inadequate. Excessive postharvest losses and ineffective distribution system are the major causes for this. A recent survey conducted by the Indian Council of Agricultural Research (ICAR) concludes that the post-harvest losses to the food grains range from 6 to 8% and that of fruits and vegetables range from 12 to 18% (Jha et al., 2015). The total loss is equivalent to INR 920 billion (US $14.2 billion) per year. Losses during grain storage account for 6% due to the lack of proper storage facilities (Sharon et al., 2014). India loses nearly 12 to 16 million tonnes of food grains annually worth about USD 4 billion. This is sufficient to feed nearly 10% of India's population, meaning 10% of India's food demand can be met only by safely storing grains and by minimizing storage losses. Majority of the losses occur at the farm level. Poor storage facilities and not adopting to scientific methods of storing grains are the major causes for such huge losses.

GRAIN HANDLING AND STORAGE IN INDIA

The grain handling and storage facilities in the country are grossly inadequate. The food grains are stored in the farm, in privately owned storage facilities and in government warehouses. Nearly 60 to 70% of total food grains produced in the country are stored by the farmer in his farm (Kanwar and Sharma, 2003). The rest of the grains sent for public distribution are procured by State Warehousing Corporations (SWC) and Central Warehousing Corporation (CWC). They act as the agents for the Food Corporation of India (FCI) (Rathore, 2016).

On-farm storage

Farmers and rural families store a minimum stock that will be required for the consumption of the family and, in many instances, the stocks required as seed for the next crop. The percentage of grains retained at the farm level and the period of storage are functions of consumption and marketing pattern, farm and family size and the yield per unit land owned (Rajendran, 2016). In most circumstances, farmers bag the grains in gunny bags of around 50 or 60 kg capacity and stack in the house (Fig. 2). When heating or infestations are observed the grains are spread on a floor for aeration for a day or two, then bagged and stored. The estimated postharvest losses at the farm level are 3.82% by weight or nearly 10 million tonnes at current production levels (Basavaraja et al., 2007).

Storage at government level for public distribution

The FCI is the largest food grain trading and distributing agency in India and probably the largest supply chain management system in Asia. The FCI was set up in 1965 under the Food Corporation Act 1964. It operates through 5 zonal offices and 26 regional offices. Each year, the FCI purchases roughly 15 to 20% of India's wheat output and 12 to 15 % of its rice output (Singh and Abhijit, 2011). The purchases are made from the farmers at the Minimum Support Price (MSP), the rates declared by the Government of India from season to season. The difference between the purchase

Fig. 2. Bagged food grains are stored along with other articles in a typical farmer's residence

price and the sale price and the internal costs are reimbursed by the Union Government in the form of Food Subsidy. The annual subsidy in 2011 was around INR 10 billion (Sud, 2011). There is no limit for procurement in terms of volume. The food grains procured by FCI and its associated agencies must strictly adhere to the quality norms laid down by FCI which is called as the Fair Average Quality (FAQ) specifications. The food grains thus procured are issued to the State Government nominees at the rates affirmed by the Government of India for further distribution under the Public Distribution System (PDS) or Targeted Public Distribution System (TPDS).

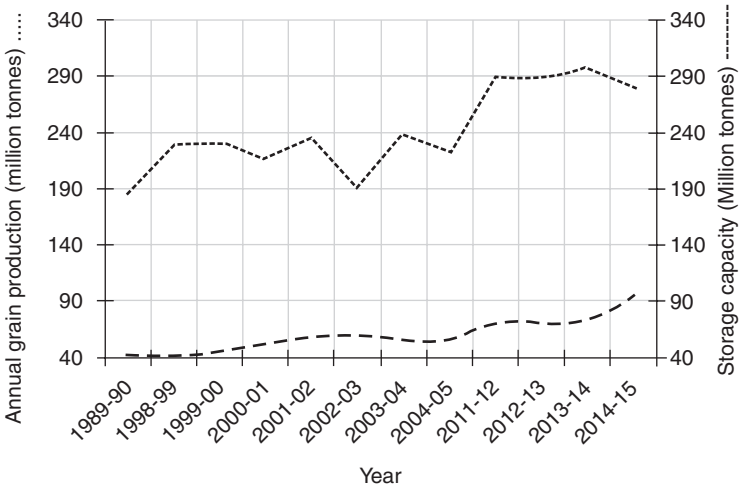

Fig. 3. A comparison of annual grain production and the total available storage capacity in publicly owned or hired warehouses (India Agristat 2016)

The FCI does not hire storage warehouses from CWC, SWC State agencies and private parties. The total storage capacity with FCI in 1970 was 0.28 million tonnes (Anon. 2016 a) and it rose to 94.5 million tonnes in 2016. Of this, 35.7 million tonnes capacity are owned by FCI and the rest are hired (Anon. 2016 b). The current storage capacities owned by the FCI and the organizations hired by FCI are shown in Table 1. The storage space available in the country is far below the total food grain production (Fig. 3). The total storage capacity available in the country is only around 24.7±4.3% of the total food grain production during the last several decades (IndiaAgristat, 2016). This leaves nearly three-fourths of the grains handled and stored in unorganized sector and in unscientific manner.

The FCI is the only government agency entrusted with movement of food grains from the procuring states to consuming states through a network of storage infrastructure owned or hired. These food grains are distributed by the state governments through TPDS and other welfare schemes (OWS). Normally four months requirement of food grains for issue under TPDS and OWS are called as operational stocks and the surplus over this is treated as the buffer stock (Bhartendu et al., 2015). Both the buffer and operational stocks are merged in the same warehouses and are not distinguishable.

Table 1. Total current food grain storage capacities owned by FCI and the organizations hired by FCI

Name of the organization	Storage capacity (million tonnes)
Food Corporation of India	15.64
Central Warehousing Corporation	10.09
State Warehousing Corporations	23.46
State Civil Supplies	11.30
Cooperative Sector	15.07
Private Sector	18.97
Total Storage Capacity in the Country	94.53

**Source:* Bhartendu, 2015

STORED GRAIN MANAGEMENT IN WAREHOUSES

The storage warehouses are permanent concrete buildings with cement floor and have either asbestos or galvanized iron roofs laid on an "A" frame. Adequate ventilation in the form of windows is provided. These warehouses are usually rodent and bird proof. The bagged food grains are kept on wooden crates or PVC pallets to avoid moisture creeping in from the floor. The bags are stacked in a 4 × 3 stack arrangement (Fig. 4). Each of the stacks is 9.0 m long and 6.0 m wide. Usually the bags are stacked to a height of 18 to 22 bags. A bag stack will have a height of 5.0 to 6.0 m. Each stack holds about 150 tonnes of food grains and in a normal warehouse of about 90 m long and of 30 m wide, around 5,000 tonnes of food grains are stored.

Proper aeration, cleaning and brushing of food grain bags are done regularly. To protect the stored grains from insect and microbial attacks, the stocks are treated with malathion and with deltamethrin. Malathion is sprayed on walls, alleyways, bags and surfaces. A malathion water solution of 3 L with a dilution ratio of 1:100 is spayed in an area of 100 m^2 (Anon. 2016 d). Deltamethrin at a dilution of 120 g in 3 L of water is sprayed over a 100 m^2 area to avoid cross infestation (Anon. 2016 d).

If infestation or traces of it are observed, the grains are fumigated with aluminium phosphide (Anon. 2016 c). Aluminium phosphide tablets @ 3 tablets/tonne of grain are used to control infestations.

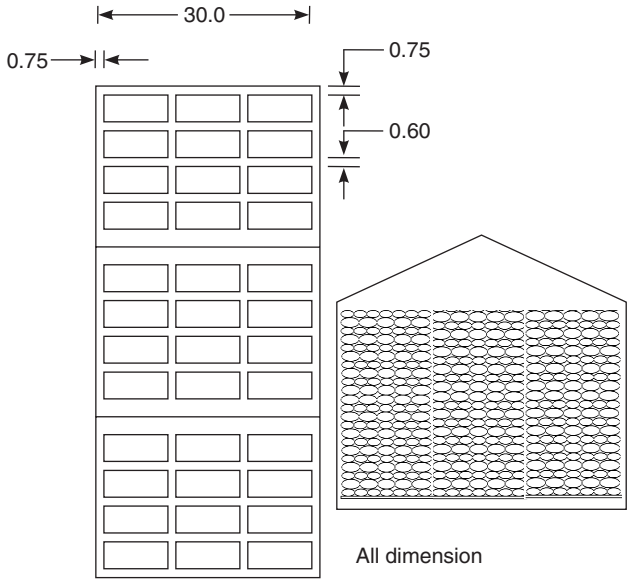

Fig. 4. A schema of a 4 × 3 stack arrangement in a warehousing facility. Normally 18 to 22 bag height stacks are followed. All dimensions are in m.

Gas proof covers made of polythene based materials are used to cover the stacks. They are sealed to the floor either with sand bags or with mud and in some instances using the combination of both. Covering, sealing, application of fumigant and uncovering are cumbersome operations requiring huge manpower and time. The safety of the person applying these chemicals is also in question. When the covers are used year after year, several pot holes develop due to handling and become highly leaky. Because of leaky covering and inefficient application methodologies, the insects develop resistances for the chemicals requiring increased dosage or increased exposure time every year.

COVER AND PLINTH (CAP) STORAGE

During bumper harvests and when the permanent warehouses are completely filled with stocks, the excess grains stocks are stored in temporary storage facilities called as Cover and Plinth Storages (CAP). In CAP, the bagged grains are stored in stacks on crates in an open space (Fig. 5) and covered with polythene sheets on 5 sides with the bottom open for aeration. This makes the grains prone to attack by rodents, birds and pests. Unexpected rainstorms and weather changes make matters worse and cause great losses. Every year huge quantities of food grains stored in temporary storage facilities go waste. As per estimates an additional 35 million tonnes permanent warehousing capacity is required immediately (Chaturvedi et al., 2015).

JUTE BAGS FOR STORING GRAINS

Fig. 5. Bags of food grains are being stacked for preparing a typical cover and plinth (CAP) storage in an open space

India has traditionally adopted to store grains in jute bags. On an average, the grains are bagged and unpacked 6 to 10 times before it reaches the consumer. These cumbersome bagging and unpacking operations require enormous manpower, time and money. The grain filled jute bags are transported using trucks from grain collection centres to the storage warehouses; from the warehouses to the rice mills or flourmills, from the mills to the warehouses as milled rice or flour and finally from the warehouses to the TPDS shops for distribution. While loading and unloading from the trucks, the bags are handled using metal hooks by the labourers. The multiple handling using hooks and multiple stitching while bagging are causes for short shelf life of the jute bags and huge spillage of grains.

Furthermore, the jute bags become important sources of infestation. They absorb moisture easily when the relative humidity of the surrounding atmosphere is high and become brooding places for microbes that attack stored grains. Bag storage is highly labour intensive. The rising labour costs and non-availability of labourers are discouraging factors to continue with bag system of storage. Slow rate of handling, ineffective fumigation, high operating costs, high rodent loss potentials and high chances for re-infestation are other major objections to the bag system. Flexibility in storing different commodities in the same space and low capital cost are the only two good advantages of bag system of storage.

BULK HANDLING OF FOOD GRAINS

Compared with bag storage systems, bulk storage has several advantages. Some of the important ones are discussed here.

Effects of ambient condition changes on bulk

grains and bag stacks: The stored grains are easily affected by the changes in the ambient relative humidity (RH) and the temperature. Paddy grain, for example, stored at 32ºC and at 79% RH will attain a moisture content of 14.5% (Wimberley, 1983). The same grain will reach a moisture content of 12.2% when the ambient RH is 65%. This leads to a huge weight loss of nearly 23,000 tonnes for every million tonnes. On the other hand, if the ambient RH reaches nearly 90%, the paddy grains will attain a moisture content of 17.3% leading to the risk of microbial attack. Keeping other conditions constant, the heating or cooling of grain due to increase or decrease in the ambient temperatures and the moisture gain or loss due to the ambient RH increase or decrease are directly proportional to the exposed surface area. A typical 150 tonnes bag stack placed in storage warehouses has a plain surface area of about 220 m^2. This area will be much higher if the undulating bag surfaces exposed to ambient are taken into consideration. In a silo without a plenum chamber, only the top surface may be exposed to moisture absorption or desorption from the ambient. A typical 6 m diameter bin holding paddy grains will have an exposed surface area of only 28.3 m^2 or nearly eight times lower than in a bag stack. Therefore, keeping other conditions constant, a bag stack will be at a risk of gaining or loosing moisture at nearly eight times faster than a bulk stored grain.

The heating or cooling of the grains due to changes in ambient temperatures will nearly remain constant because a storage silo of 6 m diameter and 8 m height holding 150 tonnes paddy grains will have an exposed surface area of 206 m^2 (including the top surface and the surface area of the wall of the bin) which is nearly the same as in bag stacks.

Easy and effective fumigation: Fumigating a bag stack requires elaborate arrangements like the covering sheet, sand bags or mud for sealing, high labour requirement and huge time loss. The effectiveness of fumigation is also very poor due to leaky covers. While, a bulk stored grain can easily be fumigated by applying the fumigant through the plenum chamber. In non-airtight bins only the top surface needs to be covered with a plastic sheet. In airtight conditions recirculation of fumigant is possible. A huge labour and time saving is possible and the costs of replacement of covering material once in few years are eliminated. Fumigation is more effective than bag stacks requiring lower dosage than in a bag stack. The health conditions of the labours are seriously affected due to leaky bags and the closed environment. This problem will be substantially reduced in fumigating bulk stored grains.

In-bin aeration and drying: Aeration and drying facilities can easily be added to a bulk storage system. Dryers are not commonly used in Indian grain storage facilities except in mills where parboiled paddy is dried using mechanical dryers. Currently, when drying becomes unavoidable, the grains are unpacked and spread on a yard floor for sun drying. This is not only unhygienic, but requires also huge labour and time. Bulk storage facilities with in-bin drying arrangements will become a boon to the nation in reducing the avoidable loss due to high moisture grains. Aeration in cool nights will help in making the grain temperatures uniform and avoid moisture migration and the eventual quality loss. All these are not possible in a bag storage system.

Reduction in cross contamination: In a bag storage, warehouse grains procured from various geographical locations are stored in the same facility. Owing to this practice, cross contamination from grains of different sources is possible. This is completely eliminated in a bulk storage system.

Automation and labour saving: A bulk handling system can easily be automated at any scale and can effectively be operated by one or two skilled workers. Handling becomes very rapid and the spillages are reduced drastically. The labour costs can be reduced appreciably. Recurring expenditures on replacing worn out jute bags will be saved. Government agencies spend nearly INR 5,000 million (US $85 million) every year for replacing the worn out jute bags.

In a well maintained bulk facility, the losses to rodents are totally eliminated. The possibility of re-infestation is eliminated if the facility is properly treated before loading. High initial costs and inflexibility in storage are few disadvantages of the bulk handling system.

INTRODUCTION OF "BULK CHAIN"

India must consider introduction of bulk chain for grain storage if the country has to take the benefits of bulk storage over the bag system. A bulk chain, ideally, need to start from the farm. But due to the current farm sizes and farmers' economic status, a farmer may not have sufficient facility to transport in bulk to the nearest collection centre called as "mandi". Alternatively, the bulk chain may start from the mandi.

Ideally and conventionally galvanized steel bins of flat or hopper bottom types with suitable grain handling facility must be provided for introducing the bulk chain. Elaborate research efforts are needed to understand the effects of local weather conditions on the stored grains. Particularly, in a hot weather, overheating and over drying of grains near the wall portions may lead to the breakage of rice while milling.

India enjoys several types of weather conditions: tropical, coastal, warm hilly weathers, sub-tropical, temperate, arid and semi-arid and cool hilly weather conditions. The requirement of bins, their design and the management of grains stored in these bins will vary between different weather conditions. Based on the experiences of other countries, cool and medium dry weather is safe for storing grains than other weather conditions. Placing huge facilities in such locations and moving the grain based on demand may be an option to explore. Bins designed based on functional requirement in different weather conditions will help to store the grains safe in all the weather conditions. In a tropical region, for example, a double walled bin will help reducing the heating of grains near the wall.

India has a huge network of very large number of bag storage warehouses. These warehouses cannot be abandoned. They can, however, be converted as bulk storage facilities. A conversion requires grossly the following alterations: (i) placing the aeration ducts and the unloading augers beneath the existing floor; (ii) closing all the windows and doors except providing one large entry door; (iii) sealing all the existing holes, cracks and crevices; and (iv) providing ventilation openings near the top with facility for completely sealing them when fumigation is done. Converting existing storage facilities to bulk storage will help to realize all the benefits of a bulk storage system. When grains are stored in such converted storage facilities, the total surface area exposed to ambient weather conditions is reduced by nearly half compared with when bag stacks are used. Therefore, the heating of grains due to ambient temperature changes will be reduced by half.

In addition to these, the space requirement will be reduced by nearly two times. A typical bag storage facility having 90 m length and 30 m breadth holds 5,000 tonne of grains. About 12,000 warehouses are required for storing a stock of 60 million tonnes. Converting existing warehouses as bulk storage facilities and assuming the grains are stored to a height of 6 m, the total number of warehouses to store the same quantity of grains will be reduced to 6,200. If all the 12,000 warehouses are converted as bulk storage facilities, then the total storage capacity of the country will increase from 60 million tonnes to 117 million tonnes.

A bulk chain also requires the conversion of existing transport facilities to handle the grains in bulk. The trucks and rail cars used for transporting bags will have to be converted. Trucks with tipper facilities, warehouses with facilities to load and unload the grains directly from the rail car are some of the important changes required in the transporting system.

THE WAY FORWARD

As has been discussed in the previous sections the storage capacities available in India are far too few compared with the food grain production. Conventionally bag storage system is adopted. Bag storage system has several inherent disadvantages. India must consider moving to bulk storage system. This conversion requires two pronged approaches: (i) converting existing bag storage facilities to bulk storage, and (ii) introducing a bulk chain. Initially few storage warehouses across different climatic zones may be converted to handle the grains in bulk. Once their suitability and advantages are time tested by experience, then all the storage warehouses may be converted to handle the grains in bulk. Converting the existing facilities to bulk store grains will increase the storage capacity of the country by nearly two times. A bulk chain starting from collection "mandi" to the final distribution point may be introduced in addition to converting the existing storage warehouses. A bulk chain will have elements like bulk transport facilities, both in trucks and rail cars, galvanized iron bin storage facilities, aeration and where appropriate, drying provisions in few bins in each of these facilities, and completely or partially automated grain handling systems in each of the facilities.

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