

The current situation and development of grain storage technologies and facilities for Chinese farmers

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Abstract

In China, the amount of grain stored on farm is about 40% of the total yield every year. The loss of grain during storage is serious due to the lack of proper grain storage facilities and technology. The losses of farm grain storage could reach nearly 20 million tons every year. In this paper, the current situation and development of grain storage technology and facilities for Chinese farmers was presented. A series of policy and research work for reducing the losses of farms' grain storage were initiated. Large scale farms are developing quickly in China and new storage warehouse and mechanized facilities should be developed. The new storage technology and methodology to meet the need of large scale farmers were introduced, and the new policy will also be discussed in this paper.

Keywords: farmer's grain storage, storage facility, reduce loss

1. Present situation and problems of farmer's grain storage in China

Since ancient times, Chinese farmers have stored grain, food and clothing in case of war and natural disasters. After grain harvest, many rural households give priority to storing enough grain to feed their families for one year. In some regions, farmers even keep all of their harvested grain for their own use. According to data provided by the State Administration of Grain, in recent years grain storage of national rural households was about 50% of the total grain output every year, and the annual ending stocks have reached about 250 million tons. The average grain storage was about 1,200 kg per rural households, but varies in different regions, for example, Northeast China Heilongjiang province and Jilin province, which are the main producing areas, it was more than 5,000 kg, but about 500 kg in Hainan province.

In most regions of China, because of crude facilities and low-level storage technology, the damage caused by rodents, insects, mycotoxins and other factors are serious, especially in the main producing areas. According to a sampling survey by State Administration of Grain, the loss ratio of the national farmers grain storage was 8% or so on average, and the annual grain loss was about 20 billion kg, equivalent to the grain output from a piece of fertile land of about 41 billion m². Among the main grain varieties of farmers grain storage, the average loss ratio of corn was the highest which reached about 11%, paddy about 6.5% , and wheat about 4.7%. The main causes of the loss were rodents 49%, mildew 30% and insect pests 21%. The most serious region of grain storage loss was in Northeastern China, with an average loss ratio of about 10.2%, followed by about 8.8% in the northwestern region, about 7.4% in the middle and lower reaches of Yangtze River, and about 5% in the Huang-Huai-Hai region. Grain storage conditions were poor with little promotion of scientific grain storage technology. All these factors led to decline in grain quality and risks to food safety.

As an example we cite investigations by the food sector in 2007 for the main corn producing area Liaoning province in Northeast China, the main wheat producing area Shandong province in the North China Plain, and the main paddy producing area Sichuan province in the Yangtze River Basin. In Liaoning province, about 10 billion kg of grain was stored by

farmers annually, accounting for 57% of the total grain output, and the main grain types were corns and paddy. Corns stored more than three months was 65 to 70% of the total output, and its storage in the whole province was about 7.3 billion kg. Paddy stored more than three months was 66% to 71% of the total output, and its storage in the whole province was about 2.8 billion kg. The traditional method of grain storage in Liaoning province was to use a simple wooden granary, or put corns on the ground in bulk and stack, and to put the paddy in bags and then stack indoors. These grain storage methods resulted in great loss after the harvest of about 8% to 15%. If estimated by the minimum of 8%, farmer's annual grain storage loss in the whole province would be about 800 million kg, equivalent to the grain output from a piece of farmland of about 1.33 billion m². Farmer's grain storage in Sichuan province was about 11.5 billion kg, accounting for 36% of the total grain output in the province. The perennial average grain storage per rural household was 1,000 to 2,000 kg, even up to more than 3,000 kg. The main grain type was paddy. Farmers' grain storage facilities were wooden cabinets, wooden barrels and bamboo utensils which couldn't meet the requirements of thermal-insulation and were susceptible to damage. The loss ratio of farmer's grain storage was 8.6%. If estimated by 8%, the whole province would lose 900 million kg of grain one year, equivalent to the grain output from a piece of farmland of about 1.2 billion m². Farmer's grain storage in Shandong province was about 20 billion kg, accounting for about 50% of the total grain output. The main grain variety was wheat. The traditional method of grain storage was to put in woven bags and stack, without or partially with the capability of anti-rodents, anti-insects and anti-moisture. According to the typical survey on 2,168 rural households in Shandong province by Shandong Grain Bureau in 2006, the households had grain storage of 2.35 million kg. The average loss ratio was 6.7%. The annual wheat loss of per household was about 63 kg, or a total loss of about 1.3 billion kg.

The main causes to the great loss of grain storage are as follows: farmers' grain storage facilities were too crude; the damage from rats, birds, insects, and mildew were serious; farmers lacked the basic knowledge and the practical technical measures to prevent and control insects and mildew; relevant departments and enterprises didn't provide technical support and service. Therefore, it's an urgent task to research and develop advanced and practical scientific grain storage facilities, and supply technology support. This will improve the conditions and the technical level of grain storage, increase output and income for the farmers, and improve national food safety (NDRC, 2011).

2. Granary of R&D and application for farmer's grain storage in China

In order to improve grain storage technology in our country, the primary task was to carry out R&D of the granary type and facility. Since 2004, our country has launched the *Food Production-increasing Technology Project*, and the issue *integration demonstration of the reduce loss technology on farmer's scientific grain storage*. This was a joint effort of Chengdu Grain Storage Research Institute, Henan University of Technology, and food research institutions in Liaoning, Heilongjiang, Hunan and other province. According to the grain storage characteristics of the three Great Plains, the Northeast Plain, the North China Plain and the Middle-lower Yangtze Plain, ten kinds of advanced and practical farmer grain storage facilities were developed. Since 2007, China has arranged the central subsidy and investment to launch the special project of scientific grain storage. Before the summer harvest in 2011, nearly 2 million rural households from 25 provinces (including autonomous regions and municipalities) like Liaoning, Jilin, Hebei, Shandong, Sichuan, Hunan, etc. had been equipped with new grain storage facilities. It was estimated that the 2 million sets of grain storage facilities would store about 4 billion kg of grain, and reduce loss by 5% on average, therefore reducing 260 million kg of the grain storage loss annually, equivalent to an increase

of 326.67 million m² of theoretical farmland, and would add an income of 500 million Yuan for farmers. By the implementation of the project and following the leading role of the farmers who did the demonstration, traditional grain storage concepts had been changed and they have gradually realized that the damages caused by insects, mildew and rats would not only lead to the quantity loss of grain, but also seriously influence the safety of grain quality. The greatly enhanced awareness of scientific grain storage laid a foundation to ensure the national grain quantity and the quality safety.

By the implementation of the project, many new types of granaries were made for the farmers in different regions. In the main grain producing areas like the North China Plain and the Middle-lower Yangtze Plain, a color plate assembly granary and galvanized steel plate granary were mainly employed. The steel net rectangular granary and the round granary were used in the Northeast China Plain. The wooden skeleton metal granary made from raw material obtained locally were developed and promoted in Xinjiang region.

According to *construction standards of farmer's small granary* (LS, 2009) and *general atlas of farmer's small granary* issued by State Administration of Grain, farmers' small granaries are divided by the materials into the four categories: the metal plate granary, the metal net granary, the polymer materials granary and the brick and concrete granary. The metal plate granary is farmer's small granary mainly made of metal plates. The typical granaries are the color plate assembly granary, the double color plate insulation, the hot-dip galvanized or aluminized steel plate, etc. It's suitable for farmers in all regions to store paddies, wheat, corns, and other raw grain with safety moisture content. The metal net granary is farmer's small granary mainly made of metal nets. The typical granaries are the round non-skeleton steel net, the round skeleton steel net, the rectangular steel skeleton, the wooden skeleton metal net, etc. It's suitable for farmer's storage of the maize cob with moisture content lower than 25% in the northeast region and the east of Inner Mongolia Autonomous Region. The polymer materials granary is farmer's small granary mainly made from polymer materials. The typical granaries are the polyethylene plate assembly granary, the glass fiber reinforced plastic granary, the PVC soft granary, etc. It's suitable for the farmers in all regions to store paddies, wheat, corns, and other raw grain with safety moisture content. The brick and concrete granary is farmer's small granary mainly made of bricks, concretes or precast reinforced concrete slab. The typical granaries are the general brick and concrete granary, the under-staircase brick and concrete granary, the cement board assembly granary, etc. It's suitable for the farmers in the southwest region to store paddies and other raw grain with safety moisture content.

At present, the main granaries with a capacity of 10 tons at most for farmers to store wheat, corns, paddies, and other raw grain in small-scale are as follows. The color plate assembly granary is farmer's small granary made of single color plates and able to be installed and folded in stack. The volume is 1.5 m³ and it can hold 1,500 kg of wheat or 1,100 kg of paddy with safety moisture content. The hot-dip galvanized or aluminized steel plate granary is farmer's small granary made of the hot-dip galvanized or aluminized steel plate and able to be installed and folded in stack. The volume is 1.5 m³ and it can hold 1,000 kg of paddy with safety moisture content. The round skeleton steel net granary is farmer's small round granary made of metal skeleton and metal net. The volume is 14 m³ and it can hold 7 tons of maize cob with high moisture content in northeast region. The rectangular steel skeleton granary is farmer's small rectangular granary made of the metal steel skeleton and metal net. The volume of the rectangular steel skeleton granary promoted in Liaoning, Jilin, Heilongjiang and other provinces is 12 m³ and it can hold 6 tons of maize cob with high moisture content (about 4.2 tons of corn kernels). The granary with a volume of 22 m³ developed by Jilin province can store about 10 tons of maize cob.

The wooden skeleton metal net granary is farmer's small granary made of the wooden skeleton and the metal net. The volume is 1.4 m³ and it can hold more than 1 ton of wheat with safety moisture content. It is mainly applied in Xinjiang Autonomous Region. The general brick and concrete granary or the under-staircase brick and concrete granary is farmer's small granary constructed by a mixture of bricks and concrete or by using the space under the interior staircase. It is mainly applied in the south region. Among the 2 million sets of the grain storage facilities manufactured during the special project of farmer's scientific grain storage, there are 1.15 million sets of the color plate assembly granary, accounting for 58%; 350,000 sets of the rectangular steel skeleton granary, accounting for 18%; 200,000 sets of the hot-dip galvanized or aluminized steel plate granary, accounting for 10%; 160,000 sets of the steel net drying granary, accounting for 8%; 100,000 sets of the wooden skeleton metal net granary, accounting for 5%.

3. Technical improvement requirements and practices of farmer's new grain granaries

Based on the large-scale promotion and application of the above granaries, and under the specific circumstances of grain varieties, storage habits, ecological condition for grain storage, etc., in practice, every region had a series of technical improvements and innovations of farmer's small grain storage granaries to make them more complete in some aspects like function, material saving, convenience of storing grain, sturdiness and durability, etc. By improving the design and manufacturing process, the pipeline operations and the large-scale production have been achieved.

3.1. Material saving, sturdiness and durability

Shandong Rizhao Guo'en Co., Ltd. chose the general plate to reduce the cost of materials. All the materials were from Wuxi United Iron and Steel Co., Ltd, and two kinds of color plates with the setting width of 1,000 mm and 1,200 mm were adopted. The color plates of 1,200 mm were employed in the lower part, the bottom and the cover of the granary; the color plates of 1,000 mm in the middle and upper part of the granary. At the same time, the company improved the supporting parts and fastened the seams connection. The cover was formed by one-time stamping and riveted of flat seams to enhance the stability. The polyethylene spiral grain outlet or the buckle cover type grain outlet was convenient for the grain outlet. Inside the granary, polyethylene plastic bags were placed to achieve the airtight storage of wheat. The No. 12 iron wire with more than 300 mm meters long was used to wrap around the seams connection to improve the tensile strength of the granary. While in Zhejiang Taizhou Zhongsui Electrical Co., Ltd, the color plate assembly granary was made of cold rolled sheet with a width of 0.6 mm produced by Shanghai Baosteel Group Corporation and was made by one-time stamping forming. The vent settings and the overall spray made the granary sturdy and beautiful and anti-corrosion. The grain outlet was equipped with the stainless steel tube connecting the granary by welding. The setting of simple gate valve made the opening easy and flexible.

3.2. Function improvement for easy grain storage

Heilongjiang Zhongliang Storage Technology and Engineering Co., Ltd. developed two types of the round steel net granary, JSWD-200 (with a capacity of 20 m³, holding 15 tons of corn kernels) and JSWD-500 (with a capacity of 50 m³, holding 37 tons of corn kernels), with more reasonable and strong structure. The granary was partially manufactured and assembled on site. The grain could be put in from the outlet installed either on the side wall or on the top of the granary. The big capacity met the demands of farmer's grain storage in the northeast region. It could store maize cob, corn kernels and paddy with safety moisture content. Inside the granary JSWD-500-I, there was a ventilated cage for natural or mechanical ventilation,

making the ventilation very convenient. The color plate assembly granary, produced by Zhejiang Taizhou Zhongsui Electrical Co., Ltd, added the ventilation ducts for ventilation and dehumidification. There were two floors in the bottom, and the mezzanine had reinforced support. The ventilation ducts were set to connect the outside. Inside the granary, the bottom plate with ventilation holes and the cover with scattered pores formed the ventilation and dehumidification channel. The improved measures solved the problem that the grain was hard to store because of the moisture in the monsoon climate regions of middle temperature and high humidity or high temperature and high humidity.

3.3. Pipeline operations and large-scale production

Hebei Cangzhou grain machinery factory combined the molds, the pneumatic equipment and the electric equipment together and designed three sets of molds. By the color plate stamping molding technology, the production process was integrated into pipeline operations, and the efficiency and automation of production were improved. The process of feeding the pipeline only took 45 seconds, which greatly reduced the workload. At the same time, the ways of production and distribution were changed. A feeding group worked with 2 to 4 processing groups. The processed semi-finished products such as covers, cylinders, bottoms, etc. were transported to every processing group allocated near the farmers. Then the processing group assembled on site and then delivered to the farmers at home. Each automobile could hold 700 sets; therefore the transportation cost was greatly reduced. The fully automated production line invested by Hubei Jingmen Yewei Co., Ltd. could produce a small granary per minute. The cover and the bottom were formed by drawing die set. The cylinder adopted the new vertical spinning technology, and was embossed and pressed with eight ribs around it, so that the stereo sense was strong, and not easily deformed. At the bottom of the granary, 24 ribs were molded for ventilation and anti-moisture. The granary was fabricated using food grade PVC materials, which made it transparent enough to observe the grain situation. Changchun Xuyang Group in Jilin province established a standardized and pipeline-operated processing base to assemble granaries, with a capability of producing 200 sets of the rectangular steel skeleton granary every day.

4. Prospect of R&D and P&A of farmer's scientific grain storage facilities

With the constant improvement of R&D and the larger-scale P&A (promotion and application) of farmer's new grain storage facilities, based on the application of standard granaries such as the color plate assembly granary, the rectangular steel skeleton granary, the steel net drying granary, the wooden skeleton metal net granary, the hot-dip galvanized steel plate granary, etc. in the future, according to farmer's grain storage demands of different grain varieties in different regions, especially the large rural households demands after the intensive land management, the innovation and improvement of the grain storage granary types and the application of new materials should be accelerated. It is necessary to create more granary types under strict standard, reducing the cost, and enhance scientific grain storage.

4.1. The research on granary type and technology should be continued and strengthened to implement the serialization and standardization of the granary type.

Suitable granaries should be developed according to the intention and usage of grain storage in different regions to meet demands of different grain types in different regions. In the northeast region, the farmers mainly store grains as commodity grain for three months or so. In the region of Yangtze River and south China, the farmers store grain mainly as food and feed grain. Also, because of the characteristics of temperature and humidity, ventilation is required. In the northwest and southwest regions, the farmers store grain mainly as food and feed grain, and need to store for a at least one year. Large-scale production in any region

requires a storage capacity of 100 to 300 tons and its supporting grain drying and cleaning equipment.

4.2. The guidance work of the grain storage should be carried out, and the social responsibility to serve for farmer's grain storage

The food department should take advantage of the technology to understand farmers grain storage varieties, quantity, quality, and other information, and carry out technical guidance and tracking service for grain storage, Then we need to gradually establish an archival information system including the entire system in order to expand the coverage of scientific grain storage, and emphasize R&D, training, and application convergence of scientific grain storage technology. Thuds would benefit millions of rural households.

The enterprises manufacturing farmer's grain storage facilities should increase the research efforts, strengthen the quality control, complete the production process, better the product quality certification, continuously improve the product quality and after-sales service, and reduce the production costs to make their products the famous-brand products in farmers' mind, and then gradually realize the transition from the products demonstration and promotion by the government subsidies to the market sales purchase.

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References

- LS. 2009. LS/T8005-2009: Standard for small-scale farm bin construction. Food engineering construction industry standards in People's Republic of China.
- NDRC., 2011. NDRC trade [2011] No. 587: *"Twelve Five" special construction plan on farmer's scientific grain storage*. National Development and Reform Commission.