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Sino-Australia Cooperation in Grain Storage Technology ——an Example of Successful Institutional Cooperation

Li Jian[1], Niu Xinghe[1*], Guo Daolin[1], George Srzednicki[2] and Yuan Zuoyun[1]

Abstract: The paper summarises nearly two decades of collaborative research on grain postharvest between Chinese and Australian scientists and engineers. The four major projects conducted during that time were focusing on grain quality management through application of efficient pest control measures and drying. The joint work of the researchers from both countries resulted in the adoption of various techniques by the grain industry in China. A list of lessons learnt from the development and implementation of these four projects summarises the experience that both sides gained from several years of collaboration.

Key words: grain storage, grain protectants, phosphine fumigation, in – store drying

Introduction

Institutional cooperation is playing a very important part in international technology transfer and cooperation, from traditional area such as irrigation to high-tech field like aerospace research. Among them, technical cooperation aiming at overcoming poverty, feeding people with enough food in developing countries by improving farming and minimising postharvest losses have recently become of increasing concern for the UN and many of its member countries.

China is the world's largest country in terms of population and also the largest grain producer. Sustainable grain production and food safety are possibly of more significance than in any other country in the world. Great efforts towards enhancing agricultural technology cooperation with developed countries have been invested in both increasing grain production and reducing postharvest losses since the end of the 20th century by the Chinese government.

Australia is one of the important wheat producers and exporters, as well as important significant hard wheat trading partner of China. It is also one of the countries leading in grain storage especially in stored grain pest control.

Technological cooperation between SAG (State Administration of Grain of China) and ACIAR (Australian Centre for International Agricultural Research) has existed for nearly 20 years. The cooperation focused on grain storage and especially on pest control and in-store drying, Tangible results were obtained in both areas, leading to significant benefits to the grain industry in China but also to some extent in Australia.

Overview of Grain Storage Technology Cooperation between ACIAR and SAG.

Grain storage technology cooperation between SAG and ACIAR dates back to 1990s starting with the project Integrating Grain Protectants into Storage Pest Management (ACIAR PN:9035)'. This project was followed by a series of ACIAR-SAG collaborative projects, namely Phosphine Resistance in Insect Pests of Stored Grain (ACIAR PN:9415)', In – store Drying of Grain in China (ACIAR PN 9437)' and Integrating Effective Phosphine Fumigation Practices into Grain Storage Systems in China, Vietnam and Australia (ACIAR PN 98137).

All the above projects were proposed by Australian scientists with the assistance of Chinese scientists and mainly funded by ACIAR, Chinese relevant governmental organisation, SAG, formerly part of the Ministry of Internal Trade, was ACIAR's counterpart for those projects in China, and also provided financial supports, experimental sites and technical staff for the projects.

The list of institutions from both Australia and China involved in the projects is shown in Table 1. The objectives of these projects are shown in Table 2.

1. *COFCO Science and Research Institate*
8/F, Tower B, COFCO Plaza, 8 Jianguomennei Avenue, Beijing, China, 100005 [* *niuxinghe@ cofco. com*]
2. *School of Chemical Sciences and Engineering, The University of New South WalesUNSW Sydney, NSW* 2052 *Australia*

Table 1. Institutions involved in the four collaborative projects

Project	Australia	ChinaACIAR
ACIAR PN 9035	Queensland Department of Primary Industries; CSIRO Entomology.	The State Administration of Grain; Chengdu Grain Storage Research Institute.
ACIAR PN 9415	Queensland Department of Primary Industries	The State Administration of Grain; Chengdu Grain Storage Research Institute; Henan University of Technology; Guangdong Provincial Grain Research Institute.
ACIAR PN 9437	The University of New South Wales.	The State Administration of Grain; Chengdu Grain Storage Research Institute; Heilongjiang Provincial Grain Bureau; Sci. & Tech. Co. ,China Grains & Oils Group
ACIAR PN 98137	The Agricultural Production Systems Research Unit; Grainco Australia Pty Limited.	The State Administration of Grain; Henan University of Technology; Chengdu Grain Storage Research Institute; Guangdong Provincial Grain Research Institute.

Table 2. Objectives of the four collaborative projects

Project	Objectives
ACIAR PN 9035	To promote integration of grain protectants into storage pest management in P. R. China.
ACIAR PN 9415	To determinate resistance of main stored grain pests to phosphine in China and to search for corresponding strategies.
ACIAR PN 9437	To develop a technically and economically attractive drying and storage system for maize in Northeast China and to adapt existing in – store dryers for paddy to the subtropical conditions of Southern China.
ACIAR PN 98137	To prolong the service life of phosphine as a major fumigant and to enhance the effect of application of phosphine in the fumigation of stored grain

All of the projects were based in China and Australia. Most of the project activities took place in China in labs of universities and research institutes, as well as grain stores,

As an example, activities of ACIAR PN 9035 project as described by Chudleigh[1] were:

In Australia: the further enhancement of an expert system that had been developed by CSIRO.

In China:

■ Assessing the extent of resistance to the most commonly used grain protectant, malthion;

■ Determining the rates of fenitrothion and deltamethrin that might be used under Chinese storage conditions in order to improve the range of protectants available for Chinese grain storage;

■ Adaptation to Chinese conditions and extension of an Australian expert system in China.

For each project, ACIAR nominated a Project Coordinator, a Project Leader, and Project Scientists from one or two Australian research institutions or universities, SAG nominated a Project Officer, a Project Coordinator and a Project Team normally coming from different research institutes and universities.

Within each project, one or two technologies were transferred from Australia to China through initial training or demonstration tests. Then further research work, especially experiments were carried out mostly by the Chinese teams headed or supervised by Australian scientists. Once the technologies were verified under Chinese conditions or modified to fit the Chinese conditions, relevant technologies were distributed to Chinese grain storage industry through larger scale training, demonstration or even by incorporating into Chinese regulations or standards.

Duration of the implementation of projects was normally three to five years; an additional one to two years extension was allowed in case of failing to achieve the predicted results or delays in project equipment supplies etc.

Outputs of Grain Storage Technology Cooperation between ACIAR and SAG

All of the four projects have been successfully implemented and reached or exceeded their initial objectives, through the efforts of Australian and Chinese scientists under the leadership of ACIAR and SAG. The main achievements of the four projects can be de-

scribed as follows:

ACIAR PN 9035 Project

■ Data on major pest problems, the pesticide resistance status of individual pests, and the grain protectants most effective against them were acquired;

■ As a result of the study, application of protectants such as fenitrothion, deltamethrin and malathion has been greatly increased and applied to 10% of stored grains, Dosage of malathion application has been decreased by 60% (from 30ppm down to 10ppm) in China, by mixing malathion with deltamethrin;

■ On the basis of CSIRO's expert system, a Chinese version of stored grain pests control expert system was developed and widely distributed in the Chinese grain storage industry.

ACIAR PN 9415 Project

■ After a series of tests, 70 ppm was found to be the minimum concentration for effective phosphine fumigation under Chinese conditions, This finding was adopted by the Chinese Regulations for Re-circulating Fumigation;

■ It was found that the resistance of major stored grain pests such as *Rhizopertha dominica* (Fabricius), *Sitophilus oryzae* (Linnaeus) and *Cryptolestes ferrugineus* (Stephens) to fenitrothion was independant from that of phosphine, As a result, the application of phosphine and grain protectants would be helpful to slow down the development of resistance of stored grain pests to fenitrothion under appropriate conditions;

■ The inheritance of resistance of stored grain pests to phosphine was controlled by two or more genes, which behaved as incompletely dominant and noninterlocked, Results of this study were of much significance to fully understanding of resistance and increasing the service life of phosphine.

ACIAR PN 9437 Project

■ Thermo-physical properties of the most common maize variety in northern China and the hybrid japonica rice varieties in southern China were determined; climatic data from the regions where the project was implemented were recorded. The thermo-physical properties of maize and rice and the climatic data were incorporated into an existing drying simulation model to make it suitable for drying simulation under Chinese conditions;

■ Two automatic controllers for in-store grain drying in China were developed and installed; existing grain storage facilities were modified and in-store grain drying experiments in northern and southern China were conducted in continuous three or four years[2];

■ A rapid test for determining ergosterol levels in stored rice grain was developed; Chinese language training courses in grain drying were conducted six times in China and once in Australia;

■ As a result of the project activities, a portable in-store drying ventilation equipment with automatic control system for large scale flat warehouses was developed by the project team from Chengdu and the innovative ventilation systems were put into use in some grain depots (see Fig, 1). Meanwhile, a radial ventilation system for in-store drying in large-size silos was developed by the project team from Heilongjiang.

Fig 1 Photographs of portable ventilation system for in – store drying

ACIAR PN 98137 Project [3]

■ On the basis of achievements of ACIAR PN 9415 project, resistance to phosphine in major stored grain pests was further studied;

■ Chinese National Standard for Phosphine Fumigation was developed taking advantage of the project outputs;

■ Tests on re-circulating fumigation in well sealed large flat stores with a mixture of phosphine and 5% carbon dioxide were conducted and pest killing data was recorded;

■ Re-circulating fumigation in bulk grain covered with plastic film was studied, and this technique has been widely used in many grain depots in southern China;

■ Effects of phosphine adsorption of wheat, paddy and maize on phosphine concentration were studied. The results of the study were very helpful for the determination of minimum dosage of phosphine application in large-scale grain stores.

In general, both sides, but especially China, have benefited significantly through nearly eighteen years technical cooperation.

■ Chinese grain storage technologies including integrated management of stored grain pests and in-store drying have been improved through the application of achievements gained from these projects;

■ Experience that Australian scientists gained from project activities in China, has also enriched their knowledge on grain storage science and might be used in Australia as well as in other collaborating countries;

■ Technology transfer and communications in the field of grain storage between the two countries have been enhanced, which also helps for better mutual; understanding of each other's grain industry and for the promotion of cooperation in grain trade business.

Experience gained from Implementation of the Projects

Through implementation of the four projects, considerable experience was gained on how to conduct a successful project, The main points can be summarised as follows;

■ In order to properly select project topics, preliminary feasibility studies and sufficient exchanging of ideas between partners are necessary, which set the basis for the successful implementation of the project、Before proposing each project, ACIAR had sent Australian scientists to China to get to know the situation of Chinese grain storage technologies and found that integrating storage pest management, better understanding of phosphine resistance in insect pests of stored grain, and preserving quality during drying were priorities in the further development of Chinese grain storage and drying technologies;

■ Training is very helpful for the better understanding of project objectives, methods of research, and thereafter dissemination of projects achievements for the partners in developing countries;

■ Periodical discussions through seminars, meetings during the implementation of projects are more important than just issuing reports. Face to face discussion provides a good platform for exchange of ideas and helps to find out what has been achieved and what has to be improved;

■ Modification or improvement of transferred technologies to fit to the conditions in developing countries is also important. The development of portable in-store drying ventilation equipment with automatic control system for large scale flat warehouses was a good example;

■ Governmental organisations or institutions play a very important part in coordinating project activities by providing financial supports, experimental conditions, as well as dissemination of project achievements etc;

■ Postharvest operations like drying and fumigation are carried out seasonally, project activities must be well planned in order not to miss the most appropriate time for experiments;

■ Procurement, manufacturing and long distance shipping of project equipment are time consuming. Purchase and/or manufacture equipment locally when applicable will cut the project budget and supply the equipment in time.

Acknowledgements

The authors of this paper would like to acknowledge the support of ACIAR and SAG during the two decades of collaboration.

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