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On Purdue Improved Cowpea Storage (PICS) technology: Background, mode of action, future prospects

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A R T I C L E I N F O

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A B S T R A C T

Hermetic or airtight storage of grain to suppress development of destructive populations of storage insect pests is an ancient technology that is finding modern applications in developing nations. Unprotected cowpea grain can be destroyed by unchecked growth of the bruchid, *Callosobruchus maculatus* (Walp). If the grain is kept in triple-layer hermetic plastic bags, losses are averted. The history, development and mode of action of triple-layer bagging for cowpea storage is reviewed here, as are lessons learned while bringing the technology to low-resource farmers in the developing nations of West and Central Africa. The success of the technology owes in part to the engagement of low resource farmers at virtually all stages of development, testing and extension of the technology.

1. Introduction

1.1. On the long history of hermetic storage

Ten thousand years ago our ancestors began to change the way they got their food. Band by band, tribe-by-tribe, wandering stone-age peoples who had lived as hunter–gathers since time immemorial settled into lives as sessile Neolithic farmers (Cunningham, 2011). By cultivating wild cereals on fertile ground they produced in most years a cornucopia of grain compared to what they got in the old days of seasonal—and often sparse—gathering. The food supply for the family thereby became distinctly more stable. By domesticating wild pigs, cattle and goats and also having grain to fatten them they ensured themselves a supply of meat and hides more dependable than they could ever get by catch-as-catch-can hunting.

Every new technology brings with it problems we don't anticipate. That abundant grain our Neolithic farmers produced had to be stored. Storage had to be for long periods—ideally, for up to a year, till the next harvest or still longer. But storing grain in a way that retains its value as food or as seed for next year's planting isn't easy. It has to be dried and protected from water; otherwise it will sprout, mold and spoil. If birds and rats reach it, they devour it, befoul it or carry it away. Most insidious of all are insects. Having begun to infest the grain before it is harvested, they slip in unseen when it is moved into the storehouse. Or they wait in the empty granary, lingering survivors of last year's harvest, ready to attack their new food supply when it comes spilling in. With an abundance of food in the granary, insect populations grow quietly and out of sight. They increase manifold at each generation and their generations are short, often only a few weeks, until, one day, someone notices that their numbers seem to have exploded. The distraught early farmer, upon opening her store and discovering her insect-ravaged and moldy grain, groans in despair and wrings her hands in worry about how she will feed her hungry children in the months to come. It is a picture as old as farming, a sad snapshot, one that can still be taken today across much of Africa.

1.2. How to deal with this problem of insects in storage

One of the earliest postharvest grain storage technologies made use of underground pits. Pits offered benefits. They kept the grain safe from birds, rodents and goats. They could be made with large capacity. They could be used year after year. They were easily camouflaged and thus hidden from the eyes of thieves and marauders. Best of all, they stopped insect populations from exploding.

No insect problems in pits? Why not?

Even in antiquity alert observers knew that storage of grain in pits protected the grain from insects. Two thousand years ago Marcus Varro, the Roman agriculturalist, wrote, "… *the weevil does not breed where the air does not reach*" and …"*Those who keep their grain under ground in the pits …… should remove the grain some time*

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after the pits are opened, as it is dangerous to enter them immediately, some people having been suffocated while doing so." (Varro, 1918). Varro knew that fresh air was essential for storage insects to survive and multiply, and that the air in a grain-filled pit loses its freshness to the point of being dangerous to humans.

1.3. A note on cowpea and Africa

Cowpea—called black-eyed pea in the USA—is the most important legume in Africa, at least from the point of view of economics (Langyintuo et al., 2003). Some 5.3 million metric tons of the dry grain were produced in Africa in 2010 with 87 percent of it produced in only three countries, Nigeria, Niger and Burkina Faso (Anonymous, 2012). Called "niébé" in much of the major cowpea growing area of West Africa, the crop thrives on the poor soils common there. Cowpea plants fix nitrogen, lessening their dependence on soil fertility. They yield well even when rainfall is erratic and minimal, down to 300 mm. The grain, protein-rich and bean-like (Fig. 1A), contains on average about 25 percent protein (Nielsen et al., 1993). Cowpea grain provides a good nutritional complement to the typical cereal-based or root and tuber-based diets. For the rural and urban poor, meat or fish aren't daily fare, but cowpea is the best available substitute—sometimes it is called "poor man's meat". Cowpea leaves, which can be eaten fresh, when dried are as rich in protein as the grain. Cowpea hay gathered after pod harvest makes excellent fodder. In many areas cowpea is thought of as a woman's crop; they grow it to feed their families and to generate a little cash by selling their surplus in local markets. In West Africa cowpea has traditionally been intercropped with sorghum or millet. In recent years there appears to be a trend for it to be grown more and more as a sole crop, by men.

Fig. 1. A. Cowpea grain as it should look after threshing. Large white seeds with rough seed coats are the preferred form for trade, most of which is restricted to Africa. B. Cowpea grain that has been exposed to cowpea bruchids for about three months. Emergence holes are present in every seed. The abundant white spots of the seed surfaces are hatched eggs.

1.4. A new CRSP project — the reasons for it

In the summer of 1986 the Technical Committee of the USAID-supported Bean/Cowpea Collaborative Research Support Program (CRSP) decided to create a new project focusing on post-harvest storage of cowpea grain. The B/C CRSP consisted of: (i) a Management Office based at Michigan State University; (ii) a Technical Committee, and; (iii) a dozen or so individual projects with host countries in Africa or Latin America. Each individual project addressed a separate constraint to either common bean or cowpea production and utilization. Each CRSP project consisted of a university-associated US team linked to a host country team based at a National Research Program facility or University in a developing nation. The purpose of the CRSP was to spur institutional development and research in host countries while at the same time benefitting the US institutions and their stakeholders by supporting research, training, germplasm enhancement, and novel technology. CRSPs were a way for USAID to achieve its development mission by leveraging the intellectual firepower and energy of American universities.

By late 1986 the B/C CRSP was supporting agronomic and cowpea-breeding research in several West African countries. These projects focused mainly on increasing yields. There were additional CRSP projects dealing with (1) village mills for postharvest processing of cowpea grain; (2) cooking, processing and food science, and; (3) cowpea integrated pest management (IPM) to manage field pests. The CRSP Technical Committee recognized that if CRSP cowpea production-related projects were successful, more grain would become available. It would have to be stored, sometimes for long periods, before it could be utilized or sold for a good price. But the committee also knew that beetles of the family Chrysomelidae (subfamily Bruchinae—commonly called "bruchids" and sometimes "weevils") can destroy unprotected cowpea grain within a few months after it is put into on-farm storage (Fig. 1B). Farmers in West and Central Africa had no practical, useful and economical way to store their grain to prevent these losses. Instead, they sold their cowpeas at harvest, when the price was at the low point for the year. Months later, when they needed cowpea protein for their families, they had to go back to the market to purchase it. By then it was selling at much higher prices—in some years double or more the price they had sold it for (Abbott, 1982.) Millions of ordinary farm families in the cowpea-growing countryside were chained to the treadmill of "sell low, buy high" mainly because they couldn't store their grain.

In November of 1986 the Bean/Cowpea CRSP Technical Committee asked Larry Murdock, insect physiologist and Professor of Entomology at Purdue University, to go to Cameroon to assess the problem—northern Cameroon being where the prospective new cowpea storage project might be based. Murdock went in the company of UC Riverside professor and plant physiologist/breeder Prof. Anthony "Tony" Hall, Chairman of the B/C CRSP Technical Committee, and Dr. Russell Freed, CRSP Deputy Director.

This team's visit led to a new CRSP project called "Postharvest Preservation of Cowpeas by Low Resource Farmers in Cameroon involving Purdue University and the Institut de la Recherche Agronomique (IRA) of Cameroon as partners. Murdock was US Principal Investigator while Dr. Zachee Boli, Chief of the IRA Maroua Station, served as administrative head of the Cameroon Team. Moffi Ta'Ama—a Togolese ex-patriate agronomist working in Cameroon—initially led the technical work in Cameroon. The US team consisted of Murdock, Prof. Richard Shade, entomologist, Dr. Jane Wolfson, ecologist, and Dr. Laurie Kitch, cowpea breeder with