UNIVERSITY LICENSING OF INTELLECTUAL PROPERTY IN DEVELOPING COUNTRIES: A CASE STUDY OF THE PURDUE IMPROVED CROP STORAGE (PICS) TECHNOLOGY

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Abstract

With five million bags sold in the 2007-2015 period and thousands of rural vendors, the Purdue Improved Crop Storage (PICS) bags have been a very successful innovation for African and Asian farmers. The primary Purdue University intellectual property (IP) in PICS is the trademark. The goal of this study is to describe the role of PICS trademark licensing in the PICS success. Some key points from the study:

- *Trademarking PICS seems to have been an effective strategy for combating low quality imitators.* Initially, PICS trademarking was suggested by a Nigerian PICS manufacturer as a way to manage imitators. While several large manufacturers have made their own version of the triple layer PICS bag, none of those larger businesses tried to use the trademark. The small "backyard" manufacturers who tried to use the trademark stopped when sent a cease and desist letter by Purdue. Anecdotal accounts indicate that West African farmers have confidence in PICS trademarked bags and prefer to buy them to store their crops.
- *As donor funding wound down for PICS projects, the trademark became the main mechanism for Purdue support to manufacturers and licensees.* The trademark license provides a formal, legal structure within which that relationship can function. In a context where national institutions are weak, many manufacturers and distributors find that technical support from Purdue attractive. The support provided ranged widely from help with manufacturing problems to facilitating succession when a licensee died without leaving succession plans.
- *PICS has shown that African and Asian licensees are willing to pay license fees, but the transactions and opportunity costs are high on both sides.* Those transactions costs include bank wire fees, exchange costs, staff effort and informal taxes required for the paperwork. In the developing country context where cash is hard to come by and work capital perpetually lacking, there is a real opportunity cost of sending some of that money out of the country, instead of reinvesting it in the business.

- *The sustainability of the PICS brand probably requires moving management outside of the university.* University business processes are slow and cumbersome. Management costs are high because of public sector accounting and personnel rules. University faculty and staff have many responsibilities; they cannot devote full time to commercialization of an innovation.
- *The most durable impact of the PICS project is in the private investment in developing the next generation of hermetic grain storage for smallholder farmers.* Twenty years ago those companies would have dismissed the idea of developing grain storage technology for small holder farmers. The perception was that smallholder farmers lacked the entrepreneurial motivation and/or the cash flow to be a substantial market. PICS showed the business community that there is a market on smallholder farms for technologies that solve their problems.

Keywords: agriculture, technology, intellectual property, licensing, stewardship

JEL Codes: 031, 034, Q16

University Licensing of Intellectual Property in Developing Countries: a Case Study of the Purdue Improved Crop Storage (PICS) Technology

Preface *- This case study was developed by two individuals who were participants in the commercialization of PICS hermetic bag grain storage technology in West and Central Africa. Lowenberg-DeBoer is a faculty member at Purdue University and has been involved in grain storage research since the early 1990s. Most of his early grain storage work was funded through the USAID Bean/Cowpea Collaborative Research Support Program (CRSP). He was the Principal Investigator of the PICS I project funded by the Bill & Melinda Gates Foundation. Musa has been involved with grain storage since the mid-1990s. His doctoral research funded by the Bean/Cowpea CRSP was on consumer preferences for cowpea including their tolerance for storage damage. As a faculty member at Bayero University Kano (BUK) he played a key role in developing the PICS supply chain in Nigeria. Consequently, this case study will involve participant observation and has the advantages and disadvantages of that methodology.*

Introduction - The Purdue Improved Crop Storage (PICS) technology has been a remarkable success, but the reasons for that success are only starting to be studied. A key part of the PICS strategy was trademark registration for PICS and licensing of that trademark, but no study as yet addressed the intellectual property (IP) management strategy of PICS. The goal of this case study is to describe the PICS intellectual property experience, generate hypotheses that can be tested with a broader range of research based technologies and identify the information needed to implement that hypothesis testing. This study will be useful for anyone involved in commercializing research based technologies in developing countries, including development professionals, university faculty and research organization faculty, staff, and commercialization personnel, and businesses considering opportunities in the developing world.

Several studies have tried to identify the factors in PICS success and lessons learned, but none so far have focused on the role of IP management on the commercialization of this technology. Coulibaly, et al. (2012) did case studies of the PICS supply chain development in the ten countries in West and Central Africa where commercialization was launched in 2007. The supply chain study noted that PICS has been unusually successful in creating a for-profit supply chain for its technology with local manufacturing and over 1000 vendors throughout West and Central Africa. It also identified supply chain problems in managing a highly seasonal product (only used during harvest time), inventory management, and pricing. Baributsa et al. (2014) review the extension model which used thousands of village storage demonstrations combined with radio, TV and other media to build farmer and trader awareness of PICS technology. A descriptive case study by Partnering for Innovation (2015) linked PICS success to identifying the right private sector manufacturing and distribution partners, building demand through public demonstrations of bag effectiveness and partnerships with donor funded food security and economic development projects. The PICS case study by Sonka et al (2016) focused the role of markets, entrepreneurship and supply chain development. The Management Systems International (MSI) study (2016) of PICS commissioned by USAID was limited to Kenya and identified the commercial strategy of the manufacturer as the key constraint to scaling in that country. The MSI study explained that the Kenyan manufacturer was surprised by the success of PICS bag sales and could not increase production fast enough to meet demand. The Coulibaly et

al. (2102) and Baributsa et al (2014) studies were internal initiatives led by the PICS team at Purdue. The other studies cited above were done by independent organizations. These studies describe the highly effective technology that is an almost perfect solution for on-farm grain storage by smallholders, praised the demand building village and market public storage demonstrations reinforced by use of electronic and paper media, and recognize the advantages of the PICS profit driven supply chain development approach. The studies differ in their identification of the factors that inhibited scale up (e.g. pricing strategy, choice of distributor and manufacturer), but all the constraints identified in some way revolve around the relationship between the source of the technology (i.e. Purdue University) and the in-country commercial partners. This relationship is legally defined in terms of IP rights and obligations.

In a historical perspective, intellectual property and technology licensing was created to encourage innovation. Patenting gives the inventors exclusive rights to use the technology for a certain period of time (20 years in the USA) in return for disclosing the details of the technologies. It encourages invention in two way: 1) by rewarding inventors with a period of exclusive use and 2) by making the details public information so that subsequent improvements can be made starting from the best available technology. Trademarking allows users of products, technologies and services to identify those with superior quality. Trademarking is not time limited. A trademark is valid as long as it is defended by the owner. "Defended" in this case means that someone making unapproved use of the trademark must be notified to "cease and desist" and that if the unapproved use continues court action must be initiated. One of the on-going costs of defending a trademark is a subscription to something like the Thompson and Reuters Trademark Watch that alerts trademark holders of potential misuses of their mark.

Purdue University policy is that most IP developed by employees in the course of their employment is owned by institution (Purdue University, 2016). Employees who think they may have an innovation that qualifies for legal protection are required to make a disclosure to the Purdue Research Foundation (PRF) and the Foundation makes a decision on what IP protection to pursue (if any). University policy divides equally any net revenue from commercialization of Purdue IP between: 1) the creators, 2) the department or administrative unit originating the IP and 3) a university fund to support research and development (Purdue University, 2015). USAID policy recognizes the right of the university to claim intellectual property developed in the course of USAID funded research, while also providing the agency with a broad license to use the IP as it sees fit (USAID, 2014). The BMGF's Global Access Policy (undated) allows organizations and individuals generating IP to retain ownership while requiring development of a project specific strategy for assuring adequate supply, pricing and partnerships to achieve the charitable objectives of their funding. It should be noted that the invention, testing and commercialization of PICS bags spans a period of about 30 years and Purdue, USAID and BMGF IP policies were evolving throughout that period.

Licensing of research based agricultural IP in the developing world is rare. Most of the licensing reported is for crop varieties developed by conventional breeding and protected under the Plant Variety Protection Act, but there is no detailed case studies of that variety licensing process. Richard et al (2013) review patents for plant varietal innovations and never mention licensing in the developing world. Minura (2006) outlines the University of California Berkley

strategy for socially responsible licensing, gives examples of agricultural biotechnology that has been licensed but does not provide information on commercialization. Unfortunately, biotechnology in African has bogged down in the politics of genetic engineering. For example, the African Agricultural Technology Foundation (AATF - http://www.aatf-africa.org/) was set up to handle the licensing of industrialized country biotechnology in Africa. It has licensed some genes for research, but none of the genetically modified seeds have been commercialized so far. AATF is facilitating the licensing of some conventionally bred crops. For instance, it is in the process of helping to commercialize an Imazapyr resistant maize in Kenya, but that resistance is naturally occurring and was originally identified by the agro-chemical company BASF (AATF, 2014). Kuhlmann and Zhou (2015) describe the legal and regulatory issues with crop variety licensing in East Africa, but not the business side of managing that IP. Some research based medical and pharmaceutical innovations have been licensed in the developing world and have gone through the commercialization process to reach customers (e.g. Hotez et al., 2013, Busang et al, 2011). Agricultural research institutions might learn from the medical literature on socially responsible licensing in developing countries (e.g. Ashley and Effort, 2008). The lack of detailed licensing examples in the developing world is the primary motivation for writing the PICS licensing story.

Case studies can provide insights into complex phenomena, but it is difficult to use case study approaches to develop generalizable knowledge. By their nature case studies are focused on one instance of a phenomena and they usually consider a wide range of factors that interact to affect that phenomena. It is impossible to generalize from one case study. As the number of case studies of a given phenomenon increases confidence in the conclusions also increases, but that conclusion never has the comfort level provided by statistical testing. Yin (2003) suggests that case studies can be very useful early in research initiatives to generate hypotheses to be tested with a broader range of cases and to identify the information needed for that hypothesis testing.

Because licensing of agricultural technology in Africa by research organizations is rare, and given the gap in understanding the potential role of licensing in the success of the PICS technology, the objectives of this case study are to:

1) Describe the PICS licensing experience in Africa,
2) Identify the key decisions in that process and the implications of those decisions for PICS adoption,
3) Suggest hypotheses to be tested with other research based technologies commercialized in developing countries and
4) Outline the information needed to test those hypotheses.

PICS Licensing Experience -PICS triple bagging technology was invented in the late 1980s by Dr. Larry Murdock, Purdue University Entomology Department, his students, Purdue colleagues, and collaborators in the Cameroonian Institute for Agricultural Research for Development (IRAD). It grew out of research funded by the United Stated Agency for International Development (USAID) through the Bean/Cowpea Collaborative Research Support Program (CRSP). PICS bags have three layers: an outer layer of ordinary woven polypropylene and two inner liners of high density polyethylene (HDPE) 80 microns thick. The bags work because there are usually insects in the grain when it comes the field at harvest. Insects have a

high metabolic rate and when they are sealed in hermetic containers they quickly use all the oxygen. Depending on the insect species, the insects either die or go dormant. Either way they do not cause storage damage. Retail prices of the bags vary from country to country, but they are typically in the range of US$2 to US$3 for 100 kg bags. Survey data suggests that the average bag is used three times before it develops too many holes to be easily repaired with tape. PICS bags have been tested and shown effective with a wide range of cereals, grain legumes and oilseed. The PICS bag mechanism is described in more detail by Murdock and Baoua (2014). The August 2014 issue of the Journal of Stored Product Research is devoted to hermetic grain storage research using PICS bags.

African and Asian plastic manufacturers and local entrepreneurs produced and sold almost five million triple-layer bags from 2007- 2015. They are used primarily for on-farm storage by smallholder farmer families who benefit from more and better quality food for home consumption and higher income due to more flexibility in marketing. In an unusual strategy PICS established storage bag manufacturing in 12 African countries and distribution networks driven by local private sector manufacturers and ag-inputs dealers. The PICS team demonstrated the triple bag storage value proposition in 31,000 villages in 10 countries in Nigeria, Niger, Burkina Faso, Ghana, Mali, Senegal, Cameroon, Benin, Togo and Chad in the 2007-2012 period. The technology cut weevil damage losses virtually to zero, increased grain value as pest-free stored food or sold as a commodity when needed, eliminated pesticide risks, and created new micro-credit markets with the grain as collateral. The average monetary benefit of this technology has been estimated at about US$150 per household per season - doubling the annual income of many farmers (Moussa et al, 2014). For cowpea alone, PICS bags increased the cash flow for West African farmers about $34 million in the 2012-13 storage year.

Purdue led research on cowpea storage started in Cameroon in 1987 with farm surveys identifying the key problems related to cowpea (Murdock et al., 2003). A timeline of PICS intellectual property experience is in Table 1. In the surveys the farmers identified cowpea storage as the key constraint. They noted that cowpeas are very vulnerable to insect infestation in storage, but selling immediately after harvest is not profitable because the prices are typically very low at that time. If they tried to store cowpea for later sale, the chance of insect infestations was high. Consequently, many Carileroonian farmers only grew enough cowpea for family use in the period around harvest. They said they would grow more if they could store and sell at a more profitable time.

Table 1 - Timeline of PICS Intellectual Property

Approximate Date	Event
1987	The Bean/Cowpea CRSP grain storage project launched in Cameroon and triple bagging research started.
Late 1980s	Purdue Office of Technology Commercialization decides not to patent triple bag storage.
1993	First triple bagging extension bulletin published. First public disclosure of the triple bag technology.
1993	First economic analysis of Bean/Cowpea CRSP cowpea storage in northern Cameroon (Schultz, 1993).
1994	First discussions with plastic manufacturers about commercializing bags for grain storage.
2003	First publication of cowpea consumer preference research that showed substantial price discounts for cowpeas damaged in storage (Langyintuo et al., 2003).
2004-2005	Cowpea storage technology adoption surveys in West and Central Africa that showed wide spread interest in triple bagging and lack of appropriate bags.
2006	Triple bagging concept note submitted to Bill & Melinda Gates Foundation.
May, 2007	Purdue Improved Crop Storage Project funded by the Bill & Melinda Gates Foundation.
August, 2007	First PICS bags ordered by Purdue to be made to specification by FASOPLAST in Ouagadougou, Burkina Faso. Placed in consignment with vendors in Burkina Faso and Niger.
January, 2008	Initial discussions with Lela Agro and Ets. Thera Salifou about manufacturing and distribution.
Mid-2008	Procurement agreement signed between Purdue, Lela Agro and Ets. Thera Salifou requiring PICS logo and specifications.
January, 2009	Trademarking PICS logo suggested by Lela Agro Managing Director Hassan Fawaz.
July, 2009	PICS procurement agreement signed with Leopold Gansou for Benin and Togo.
Mid 2009	PICS procurement agreements with three vendors in Mali.

Table 1 -Timeline of PICS Intellectual Property (continued)

Approximate Date	Event
November, 2009	Purdue Improved Cowpea Storage trademark intellectual property disclosed to Purdue Research Foundation (PRF) by Murdock and Lowenberg-DeBoer.
Jan. 2010	PRF files assignment of PICS trademark to the Trustees of Purdue University.
May 2010	Purdue signs joint PICS distributor agreement with Etablissement (Ets.) Thera Salifou and Lela Agro.
June 2010	PICS distributor agreement with Seedshop Company, Ghana.
Mid-2010	PICS distributor agreement with, FASOKABA and Agri-Sahel, Mali, Ets Husa in Niger and two vendors in Tchad
Oct. 2010	PICS distributor agreement signed with GIC DEMRI, Cameroon.
June, 2011	PICS distributor agreement with Seedshop Company, Ghana, terminated.
June, 2011	PICS distributor agreement signed with BOUTAPA, Burkina Faso.
July, 2011	Distributor agreements signed with two vendors in Ghana.
Sept. 2011	PICS distributor agreement signed with BOUTAPA, Burkina Faso, to replace Ets. Thera Salifou.
May, 2012	PICS licensing discussion with A to Z Textiles in Arusha.
Mid-2012	Purdue signs PICS distribution agreement with Momar Syll, Senegal.
Oct. 2012	Purdue signs PICS distribution agreement with Consumer Experience, a Kenyan company.
Dec. 2012	Purdue Board of Trustees transfers PICS trademark back to PRF.
Oct. 2013	Purdue Improved Crop Storage US trademark filed through PRF. Research in the PICS3 project showed that the bags can be used for all kinds of grain.
Mid-2013	Consumer Experience PICS license terminated.
Mid-2013	PICS license signed with Eco-Plastics, Kigali, Rwanda. This was a non-royalty license because donor funding was available through a USAID Partnering for Innovation project.

Table 1-Timeline of PICS intellectual Property (continued)

Approximate Date	Event
July 2013	Lela Agro Regional PICS license signed.
Nov. 2013	Purdue signs PICS license with Bell Industries in Kenya.
Feb. 2014	Purdue signs PICS license agreement with NAP Seeds, Nepal.
Feb. 2014	Lela Agro signs sublicense agreements in Burkina Faso, Mali and Senegal.
March, 2014	Purdue Improved Crop Storage US trademark applications filed for the OAPI, WIPO, Gambia, Uganda, Tanzania, Malawi, Nigeria and Cape Verde.
June 2014	Purdue Improved Crop Storage US trademark registered.
June 2014	First PICS license fee payment received by Purdue from Lela Agro, $12,800.
Oct.-Nov 2014	Purdue staff travel to Benin and Togo to resolve succession issues that arose on the death of PICS licensee Leopold Gansou. New sublicenses signed with Lela Agro.
Feb. 2015	NAP Seeds sends PICS license fee payment of $500.
March 2015	Lowenberg-DeBoer appointed representative of PRF for negotiating PICS licenses.
March 2015	Eco-Plastics signs a new PICS license agreement requiring royalty payments.
July 2015	COFISAC Senegal wires 2014 sublicense fee payment of 52392 FCFA to Lela Agro.
July 2015	Milestone review of Lela Agro license agreement finds that efforts to promoted PICS in new countries are inadequate and Purdue should return to direct licensing in those areas.
Sept. 2015	Purdue signs direct PICS licensing agreements in Mali, with vendors formerly under Lela Agro sublicensing. AGRISAHEL Mali pays 2014 sublicense fee of 150, 800 FCFA to Lela Agro.
Dec. 2015	End of PICS 1 signaled personnel changes in the PICS project. Decision made to retain PICS license management within Purdue and to have it managed by Baributsa, who leads the PICS3 team.
May 2016	Exception approved for PICS to standard Purdue intellectual property licensing revenue allocation.

In response to farmer concerns, the triple bagging technology was invented and reduced to practice as part of a suite of non-chemical technologies developed by the Bean/Cowpea CRSP Purdue-IRAD team led by Murdock (Murdock et al, 1997; Diaz-Hermelo et al., 2002; Murdock et al., 2003; Murdock and Baoua, 2014). The research was based in a study of indigenous cowpea storage methods and the initial steps were to test various options in research station trials at the IRAD station near Maroua, Cameroon, and on the Purdue University campus in West Lafayette, IN, USA. Three techniques that proved quite effective were mixing cowpea with wood ash in storage, triple bagging and a solar heater to disinfest cowpea before storage. Coating cowpea with oil or storage with traditional botanticals were also tested, but found either to be unreliable or to have significant side effects (e.g. affecting the taste of the cowpea when cooked). In 1990 and 1991 triple bagging, solar disinfestation and ash storage were tested with farmers in villages near Maroua. By 1991 the team was confident enough to publish extension bulletins to extend the use of these storage methods (Kitch and Ntoukam, 1991 a, b; Ntoukam and Kitch, undated). These bulletins are the first public disclosure of the technologies.

It should be noted that at the time, ash storage and the solar heater received more scientific attention than triple bagging. An ash storage paper was published in 1991 (Wolfson and Murdock, 1991). A solar heater paper was published in 1992 (Kitch et al.). Triple bagging was described in Bean/Cowpea internal reports, but the earliest research publication seems to be Murdock et al (1997). This may be because of the triple bagging seemed to lack novelty. Hermetic storage was an ancient technology. The cost-effectiveness of this simple technology only gradually became evident through both laboratory testing and adoption surveys.

Invention Disclosure - The triple bag history as told by Murdock indicated that a triple bagging invention disclosure was made to PRF and that they decided not to file for a patent because: 1) hermetic storage was not a novel idea and 2) profit potential was negligible for a product that would be used mainly by smallholder farmers in Africa. This account fits the PRF policy at the time of focusing on university IP that had the potential to generate substantial revenue for the institution. Because hermetic grain storage is an ancient practice, patenting it may have seemed like a stretch to PRF staff. The innovation of the CRSP team was in using locally available materials to hermetically store grain in a way that culturally acceptable. It should be noted that Murdock was aware of the possibility of patenting his inventions. During the same period, he was one of the inventors of an ultrasonic monitoring device to detect insects in stored grain (Shade et al., 1990). This biomonitor device was disclosed to PRF, patented by Purdue (U.S. Patent No. 4,809,554), and licensed to Dow Agro Sciences.

The context of the PRF decision about triple bagging was the 1980 Bayh-Dole Act which allowed research institutions to retain ownership of inventions created in the course of federally funded research. Prior to that act most inventions made using federal funds were owned by the federal government and essentially became public goods. In the late 1980s universities were still the process of adapting to the new opportunities and responsibilities created by Bayh-Dole. At the time the culture of public goods research was still strong in the US Land Grant Universities (LGUs) and particularly robust among faculty who focused on research in developing countries. Many LGU faculty and administrators felt that IP ownership would limit access to the innovations by the poor in developing countries and that royalties charged for IP licensing would

increase the cost to those who had little ability to pay. Understanding of the role of IP in creating sustainable supply chains in developing countries was only beginning in the late 1980s.

Extension Issues - In the mid-1990s spreading use of the CRSP storage technologies was perceived as an extension problem. The challenge was to identify which storage technology was best for each group of users (i.e. farmers, grain traders) and to teach them how to use those technologies (Murdock et al., 1997). Triple bagging used whatever plastic bags were available in local markets. Availability of bags was a problem in villages, but some kind of heavy duty plastic bag was usually available in regional capitals like the market in Maroua. In the mid-1990s CRSP researchers, J. Lowenberg-DeBoer and George Ntoukam, made a trip to Douala, the economic capital of Cameroon, to meet with plastics manufacturers about increasing bag supply. They found several factories capable of producing the bags, but manufacturers did not understand of the potential demand for grain storage bags. The Douala factories were ready to produce bags for a firm order accompanied by downpayment, but unwilling to get involved in bag distribution and retailing.

Throughout the 1990s and into the 2000s, Murdock and colleagues sought ways to extend the cowpea storage technology to a wider range of users. They made the storage brochures available in English, French and Fulfulde. The brochures were photocopied and reprinted by NGOs and national extension services throughout West and Central Africa. They wrote countless extension oriented concept notes and proposals without success. The Bean/Cowpea CRSP which funded the development of the storage technologies told them that CRSP funds were intended for research, not for extension.

Also throughout the 1990s and the following decade, economic evidence accumulated indicating that cowpea storage was a key bottleneck and that better storage could be very profitable for farmers. Some of that evidence came in the form of cowpea consumer preference studies showing large and consistent discounts for cowpeas showing storage damage (Langyintuo et al., 2003; Langyintuo et al., 2004; Faye et al., 2004; Faye et al., 2006; Mishili et al., 2009, Ibro, 2011). Another source of evidence came from cowpea storage technology adoption and impact assessment studies (Diaz-Hermelo et al., 2002; Boys et al., 2007; Moussa et al., 2011). The adoption and impact studies showed substantial adoption in some areas, high returns to farmer investment in the cowpea storage technologies and constraints to adoption. In particular, the study by Bokar Moussa for his M.S. thesis at Purdue done in 2004 (but not published until 2011), showed two key constraints:

1) Farmers did not understand the principles of hermetic storage. For instance a common anecdote heard while surveying farmers was that they tried to store cowpeas in used sugar or Portland cement bags, but that insects still infested the grain. They did not realize that sugar and Portland cement bags are vented and therefore not hermetic. This information confirmed the extension focus of the CRSP cowpea storage team.
2) Heavy duty plastic bags were not widely available, and manufacturers and suppliers of agricultural inputs did not understand the potential demand for the bags. For instance, in Burkina Faso Moussa found farmers trying to use for storage very thin low density polyethylene bags originally manufactured for packaging dry cleaned clothes.

Gates Foundation Call -In August 2006 the BMGF issued a call for value chain projects that would increase incomes of smallholder farmers through adoption of improved technologies (BMGF, 2006). Based on the accumulated scientific results on the efficacy of triple bagging, the farmer interest in the technology shown in the adoption studies and the growing awareness of the importance of supply chain development for agricultural inputs, a team of Purdue faculty submitted a concept note. The triple bagging concept note was among 1315 concept notes received by the Foundation and it as among about 45 asked for full proposals. A full proposal was submitted in January 2007 by Joan Fulton and J. Lowenberg-DeBoer, Ag Economics; and Larry Murdock and Barry Pittendrigh, Entomology. The proposal does not mention IP and at that time the Foundation did not ask about IP. The proposal implicitly assumed that triple bagging was a publically available technology.

While the extension side of the PICS proposal was quite detailed, the triple bag supply chain plan was vague. It outlined a strategy for developing a supply chain plan. The proposal does not mention licensing as a key mechanism in that supply chain development. The paragraph in the proposal was:

> *"Linking Plastics Manufacturers with Entrepreneurs and Entrepreneurs with Farmers* - During the first year of the project we will meet with African plastics manufacturers to ensure that they will have sufficient production of plastic bags for the cowpea harvest season. We will purchase triple-layer cowpea storage bags from regional plastics manufacturers and place them on consignment with merchants in shops and markets in or close to villages where demonstrations are occurring. Demonstrations will include information on where to obtain storage materials locally. After the initial consignment is sold we will either find a local entrepreneur who wants to serve as the intermediary with the plastics manufacturers or link the local merchants directly with the manufacturers. Ultimately the bag supply system will be self-sustaining because of its profitability. The main focus for this linkage activity will be in the first and second year of the project. The knowledge gained during the first two years will then be applied in subsequent years. The project team will visit plastic bag manufacturers in years three and four to identify and find solutions for problems that they are encountering serving this market. The number and nature of the entrepreneurs handling the triple-layer storage bags will vary depending on the structure of local trade in the region which in tum depends on ethnic groups and physical factors (e.g., climate, topography, roads). Typically large villages will have a "general store" which has a wide range of products and serves a trade area including outlying villages and hamlets. Our goal is to ensure that the general stores in the larger villages carry the triple-layer storage bags, just as they carry seed treatment pesticides during planting season. During harvest season, when demand for the triple-layer bags is greatest, it is expected that some other entrepreneurs in the small villages will also carry the storage bags. Our target is that the number of entrepreneurs involved is roughly equal to the number of villages or 28,678 in the major cowpea production area." (PICS proposal to BMGF, 2007, p. 10).

In May 2007, the BMGF and Purdue signed a five year agreement to implement the PICS proposal. The goal of the project was that with five years 50% of cowpea grain stored on farms would be in hermetic storage, mainly triple layer bags. It focused on the ten countries in West

and Central Africa that produce most of the world's cowpeas: Senegal, Mali, Burkina Niger, Tchad, Cameroon, Nigeria, Benin, J:ogo and Ghana. Initially the project was led by Fulton and in addition to Lowenberg-DeBoer, Murdock and Pittendrigh, the team included Natalie Carroll, from the Youth Development and Ag Education Department, to provide expertise on extension methods; and Lisa Maurer, Food Science, to provide expertise on plastics and food packaging. Partner organizations included: the National Agricultural Research Institute of Niger (INRAN), the National Institute for Agricultural and Environmental Research (INERA) of Burkina Faso, the Institute for Agricultural Research for Development (IRAD) of Cameroon, the International Institute for Tropical Agricultural (IITA) headquartered in Nigeria, and World Vision which is a major faithbased NGO. From the beginning PICS was an international, multidisciplinary effort.

PICS Specifications Developed - Because the West African cowpea harvest starts in September, the team quickly went into action. Fulton and Carroll, with Ibrahim Baoua and Tahirou Abdoulaye, INRAN, focused on developing the extension plan for the first year with activities Niger and Burkina Faso. Lowenberg-DeBoer worked with Murdock on the manufacturing. Clementine Dabire, INERA, identified a plastics manufacturer in Burkina Faso, FASOPLAST. At the time a plastics manufacturer had been just established in Maradi, Niger (i.e. Niger Plastique), but that factory never became functional. Until that time experimentation had used the heavy duty plastic bags commercially available at the time. To order bags manufactured a specifications were needed. Murdock, Lowenberg-DeBoer and Dabire worked with FASOPLAST staff to develop that specification. Murdock suggested that the bags should use thick high density polyethylene (HDPE) to make it difficult for insects to pierce the liners. Trial and error with a range of plastic thicknesses at FASOPLAST converged on 80 microns as the optimal thickness. This was thick enough to resist insects, but still flexible enough to be folded for an air tight closure. The optimality of the 80 micron thickness was later confirmed by Dabire and colleagues (Sanon et al., 2011). The first year the bags were 50 kg capacity because the team reasoned that 50 kg is about the maximum size bag that can be moved by one person.

The PICS acronym was developed by brainstorming among the team at Purdue in the summer of 2007. They wanted a short, easily remembered word that did not have negative connotations in any of the West and Central African languages. The original acronym was for Purdue Improved Cowpea Storage.. The "C" was replaced with "Crop" when latter research and experience showed that the bags were useful for storing all kinds of grains, oil seeds and grain legumes. The PICS logo was created by Purdue Ag Communication and used on those 2007 bags. The initial project funded by the BMGF became known as the PICS project and in 2012 when a second project was funded by the BMGF, that original project became known as PICSl. The second project was known as PICS2 and a third project funded by the BMGF in 2014 to extend triple bagging to maize storage in Africa is known as PICS3.

Quality control in 2007 was in the form of unannounced visits by INERA staff to the FASOPLAST factory to measure liner thickness and visually assess liner plastics composition. An 80 micron thickness HDPE liner should be almost opaque white. If it is transparent too much LDPE has been added to the mix. Purdue staff also randomly checked bag quality during their visits. This approach to external quality control was continued throughout the PICS 1 project.

Someone employed by Purdue or associated with Purdue visited the factory and/or retail shops to

randomly check liner thickness and visually assess plastics composition. Some of the PICS manufacturers had their own internal quality control.

The first commercial triple layer bags for cowpea storage were placed on consignment with vendors in Niger and Burkina Faso in September 2007. Most of the bags were placed with NGOs, farmer organizations or national extension offices because it was felt these organizations were in close contact with farmers and because the ag input supply system in the two countries was not well developed at the time. There were no well-established chains of ag input supply shops. The exception to that pattern was in Gourcy, Burkina Faso, where PICS partner AFRICARE consigned the bags with a local merchant with a one room general store.

The first year experience showed that farmers were intensely interested in the bags and that commercialization through for-profit business had greater potential than through NGO, farmer associations or extension. The merchant in Gourcy sold 600 bags, more bags than any other single consignee, and he remitted the PICS share of funds promptly. The other consignees showed only sporadic sales and it was very difficult to obtain the PICS share of the proceeds. Some of the consignees never did fully pay for the bags consigned. This convinced the PICS team that they should seek opportunities for PICS bags sales through for-profit shops.

Changes after the first year - The other key outcome of the first year experience was the switch to 100 kg bags. When Lowenberg-DeBoer visited pilot villages in early 2008, the farmer expressed their satisfaction with the triple layer bag storage, but they had one suggestion. They wanted 100 kg bags. Lowenberg-DeBoer objected that 100 kg bags were too heavy for one person to carry. They responded that "We live in the village. There is always someone to help." This is a classic case of misunderstanding the market needs. The PICS team based at Purdue looked at the bag capacity from a North American perspective and the assumption that one person should be able to move the bags. The Africans assumed that there would usually be someone to help. There is also a strong economic argument for 100 kg bags because a 100 kg PICS bag costs only about 10% more to manufacture than a 50 kg bag. With a 100 kg bag the buyer gets double the capacity, for only about 10% higher cost, compared to a 50 kg bag. Thereafter PICS has made mostly 1OOkg bags, with the exception of: 1) bags for seed which is a higher value product, 2) bags for World Food Program and other food security agencies because of high breakage of 100 kg bags when handled by laborers, and 3) countries like Malawi where 100 kg bags are banned for worker safety reasons.

With the 2007 PICS experience, the team planned a substantially larger year two extension effort with demonstrations planned in 5829 villages in Niger, 2724 villages in Burkina Faso and 100 villages in Nigeria. For a university led project, the PICS plan to have activities in almost 8000 villages in a year was astounding. Most university based projects limited themselves to pilot projects of at most ten villages. To create a bag supply for these almost 8000 villages they turned to the local business community. There were discussions with various businessmen in Niamey and Ouagadougou, but most were in the import-export business. They did not have strong links to the village shops and local markets that would need to sell PICS bags. Finally, in January 2008 Lowenberg-DeBoer met with Thera Salifou, a Burkinabe businessman originally from the Bobo-Dialassou area and Ahmed Adam Kaumi, Lela Agro International Marketing Manager from Kano, Nigeria at a meeting organized by Dramane Konate, the PICS business

consultant for Burkina Faso, in a small office at the back of Thera Salifou's bakery in Ouagadougou. Konate knew Salifou and Kaumi because they sometimes prayed at the same mosque in Ouadougou. The common language of the group was French, but because Salifou's French was not strong he often communicated with Konate in Dioula. Kaumi speaks good French for a Nigerian businessman, but on occasion he would ask for clarification from Lowenberg-DeBoer in English or Hausa. At this meeting Lowenberg-DeBoer outlined the PICS vision and the dream of marketing the bags in villages throughout Burkina Faso and Niger.

Salifou was a long-term customer of Lela Agro. He purchased woven PP sacks from FASOPLAST and from Lela Agro. He had started to buy from Lela Agro because they could often deliver sacks to Ouagadougou at a lower price than FASOPLAST could supply them. He claimed to have a network of shops and vendors in Burkina Faso to which he supplied sacks and good links into similar networks in Niger. Salifou said that he was interested in selling PICS bags through his network, but that he lacked the capital to pay the 50% down payment require by Lela Agro at the time of order.

Back at Purdue in the late winter 2008, Lowenberg-DeBoer discussed the problem with the Purdue business manager assigned to the project. As a US public university, Purdue could not make loans. They agreed on a plan to prepay for PICS bags. This mechanism ran through the Purdue Procurement Office. In 2008 Purdue provided prepayment for 50% of the manufacturing cost of 60,000 bags in Burkina Faso and 60,000 in Niger. Purdue needed some of the bags for planned village demonstrations. At five bags per village demonstration, plus a few for research and samples, they needed about 30,000 bags in Niger and about 15,000 in Burkina Faso. The value of any bags that Purdue did not need for demonstrations, samples or research would reimbursed to Purdue when the bags were sold in late 2008. Essentially, this provided the half of the cash flow for Salifou to order the planned 300,000 bags. To reduce transactions cost, the Purdue prepayment was paid directly to Lela Agro in Nigeria. A joint procurement agreement was signed by Thera Salifou, Lela Agro and Purdue. That agreement specified use of the PICS logo, plus it specified the bag size and liner plastics composition (i.e. HDPE).

In spite of the fact that Salifou never paid his portion of the down payment, Lela Agro showed their commitment by manufacturing and shipping 100,000 bags to Burkina Faso and 95,000 bags to Niger. The distribution network promised by Salifou turned out to be sparse in Burkina Faso and almost non-existent in Niger. In 2009 Kaumi negotiated with merchants in Niger to take over unsold inventories there and pay Lela directly. Purdue signed an agreement with Salifou with the aim of selling the bags in inventory and recouping the funds for prepaid bags that had not been used by the project.

The informal process of vetting Thera Salifou was characteristic of how other PICS licensees were selected. In most cases, they were selected by Purdue faculty members on the PICS team after a short interview and perhaps a visit to their factory or shop. No financial information was collected. References were not sought in the business community. For manufacturers the pool of potential partners was relatively small in most countries; only a few companies had the capacity to make both the woven sacks and the liners. In some cases, the manufacturers were obliged to outsource one of the other component. However, most of the licensees are distributors and there the pool of potential licensees was large.

In November 2008, there was a change in PICS leadership. Fulton stepped down as PICS l project director and Lowenberg-DeBoer took over PICS l at that time. He continued to the end of PICS 1 in 2015. PICS extension methodologies were well developed by this time, but the supply chain strategy was evolving. Consequently, the focus was on the supply chain development. Detailed case studies of the supply chain development in each of the ten PICS 1 countries can be found in Coulibaly et al (2012).

Trademark Suggested to Help Manage Imitators - It is said that "imitation is the sincerest form of flattery" and in that sense PICS has never lacked for flattery. From the first bags in 2007, there have been imitators. Some were entrepreneurs who assembled triple layer bags from sacks and LDPE liners purchased in the market. Others have been factories who specifically manufactured "knock off ' bags, sometimes to PICS specifications, but usually reducing liner thickness and using more LDPE to reduce costs. In January 2009 Hassan Fawaz, Managing Director of Lela Agro, suggested that PICS be trademarked as a tool to control low quality imitations. He originally suggested that Lela should register the bags in Nigeria initially and then in all the ECOWAS countries. That suggestion was discussed at Purdue and in November 2009, Murdock and Lowenberg-DeBoer followed university policy and made a PICS trademark disclosure to the Office to Technology Commercialization (OTC) within PRF. At the time OTC focused on innovations that would provide revenue for the university through licensing. OTC staff listened, but apparently were not convinced that the triple bagging trademark would generate revenue. In January 2010, PRF assigned the PICS trademark to the "Trustees of Purdue University" so that trademark registration could be carried out through the university office of Marketing and Media. This is the office that handled licensing of the Purdue name and logo for souvenirs and sports paraphernalia. A trademark application was filed with the US Patent and Trademark Office. When that trademark was granted, application was made for trademarks in the countries thought most likely at the time to be PICS markets including: all the countries that are members of the African Intellectual Property Organization (French acronym = OAPI), Nigeria and Ghana. OAPI members are Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Djibouti, Gabon, Guinea, Guinea Bissau, Ivory Coast, Mali, Mauritania, Niger, Senegal, Togo, and Equatorial Guinea. The OAPI process is quite efficient. One application registers the trademark in most of the francophone countries of West and Central Africa. The trademark application costs, and associated legal expenses were paid from PICS 1 project funds as part of the supply chain development effort.

The other PICS product change that occurred in 2009 was a lengthening of the sacks. The original PICS bags made in 2007 had an outer woven sack 70 cm x 117 cm and liners that were 70cm x 127 cm. This size was based on the dimensions of woven bags commonly sold in the West African markets with a margin added to allow the bags to be tied off. Feedback from customers in Nigeria was that this was not large enough to hold 100 kg of their cowpeas. Tests were conducted at the Kano IITA station by Prof. Musa Shehu, Bayero University, filling bags with 100 kg of cowpea and estimating the margin needed for tie off. It was decided to lengthen the both the sack and liners. The new dimensions for 100 kg bags were determined to be 135 cm x 70 for the sacks and 137 cm x 70 cm for the liners. It should be noted that the PICS license does not specify dimensions, but rather triple layer with 2 HDPE liners 80 microns thick. Licensees can and occasionally do make a 50 kg bags.

In Year 3 (2009-2010) of the project a full scale plan for village demonstrations was outlined for Nigeria, Mali, Togo and Benin. The plan include an effort to reach some villages in Burkina Faso and Niger that had not been reached in years 1 and 2. Procurement agreements were signed in Nigeria, Benin and Mali to facilitate the production of bags. The Benin distributor supplied bags for Togo. The agreements continued to specify use of the logo, bag dimensions and liner plastics composition. Because the PICS trademark was not yet approved licensing agreements were not signed. Those agreements included prepurchase payment provisions. In spite of increasing concern about slow or non-repayment of prepayment for bags beyond those needed by the project, the prepayment was an effective way to convince new PICS distributors to handle the bags.

In February 2010 it became clear that Salifou was unlikely to repay the prepurchase funding that he received and Purdue engaged legal counsel in Ouagadougou. A court order was obtained against Salifou and about half of the unpaid balance was repaid. This was much more than anyone familiar with West African legal systems expected, but still a major loss for the project. As PICS l went into new countries in subsequent years, the prepayment mechanism was not used. Distribution agreements were signed in 2010, 2011 and 2012 outlining the expectation for PICS distributors, including the use of the logo, bag dimensions and liner plastic composition. There were explicit or implicit commitments by PICS to purchase bags for extension, sample and research activities through the distributor. Purchasing for project purposes provided an assured initial market and early cash flow, but avoided the need for repayment. The distribution agreements were signed at Purdue through the Procurement Office.

PICS Sustainability after donor funding - In2012, the original end of PICSl was fast approaching and the PICS team debated how to make continue PICS after the end of donor funding. The group recognized that the PICS brand had value. There were anecdotal accounts of farmers refusing to buy generic or self-branded triple bags, because they were not confident that their grain would be well preserved. In April 2012 an internal discussion document outlined five options:

1) Abandon the trademark as a tool that helped launch the technology in Africa, but which has now outlived most of its usefulness.
2) Spinning off PICS to a US based for-profit business or a non-profit organization.
3) Transferring the trademark to a major NGO or the corporate social responsibility (CSR) unit of a large corporation.
4) Sign new agreements with PICS distributors in West and Central Africa to pay a fee that would support continuing to defend the trademark.
5) An agreement with a for-profit non-US company or NGO to manage the trademark on behalf of Purdue and the PICS partners.

That internal discussion document summarized the argument for and against each of these options as follows:

"Abandoning the trademark is the fall back strategy if we cannot come up with a better alternative, but it would entail a major loss of momentum for the technology and a loss of Purdue

credibility in the region. Spinning off PICS to a US based private business or organization has been intensively discussed, but no convincing plan has emerged. The cost of manufacturing the bags in the US and shipping them throughout the world is prohibitive. The potential demand for technical support from PICS bag users elsewhere in the world will be highly irregular and can be satisfied (as it is now) by contracts with Purdue or consulting by individual faculty. The only scenario in which a US based PICS business seems to have potential would be if a market for the bags could be established among organic grain growers in industrialized countries. A few US growers have expressed interest, but that market would require a substantial effort to develop. The PICS supply chain has been discussed with many NGOs and with several corporate social responsibility initiatives (e.g. Dow Agro, Sumitomo). In general the NGOs do not understand the supply chain issues; and fail to see how this kind of commercial activity would fit into their organization. The CSR units usually understand supply chain issues, but are reluctant to be involved with something commercial. CSR is often focused on generating good public relations for the parent company and PICS may be too commercial to be a useful in developing a positive image of the parent company among the general public.

Major constraints to alternative #4 include:

a) Resistance from African distributors to paying a distributors fee. Such licensing fees are not common in West and Central Africa. Because the PICS technology is not patented and because it is easily reproduced, some of them will decide to manufacture under their own brand.
b) The high transactions costs of transferring funds from West and Central Africa to the US.
c) The high cost of monitoring trademark violations in Africa. Diligent monitoring would require regular visits by Purdue staff to Africa. Trademark owners can lose the rights to their trademark if they do not monitor and defend the trademark." (PICS Team, 2012)

After intensive discussion it was decided to pursue option #4 in the hopes of generating enough revenue through license fees to continue defending the trademark and support Purdue engagement with PICS after the end of donor funding. To reduce management costs, the option of licensing PICS to an African company or organization was discussed. That African entity would have lower personnel costs and because it would be closer to licensees than Purdue would have lower travel costs. As an experiment is was decided to accept an offer from Lela Agro to become the PICS licensee for all of West and Central Africa. At the time Lela Agro was by far the largest manufacturer of PICS, making about 90% of the worldwide production. Lela had shown its commitment to PICS by supplying bags to PICS distributors who had trouble making the 50% down payment, by committing their staff time and company resources to promoting PICS, and by paying for radio and TV time. The licensee agreement that was signed in July 2013 included:

- Exclusive rights to use the PICS trademark in Nigeria, Cameroon, Benin, Togo and Niger. These are the countries that were regularly supplied at that time from the factory in Kano.
- A non-exclusive right to market PICS bags through the rest of West and Central Africa.

- The right to sublicense the trademark in those countries which had their own plastics manufacturing capacity.
- An expectation that Lela would develop PICS markets throughout the region and especially in those countries where PICS was not yet marketed.

It should be noted that the original decision to give Lela Agro the PICS license for Nigeria was criticized and the decision to sign a regional license was the target of many of the same critics. This criticism was voiced most strongly by an organization called Research in Use (RIU) funded by the UK Department for International Development (DFID). They argued that the PICS market would develop more quickly in Nigeria if there was competition within the country with multiple licensees. The PICS response was that a single license in the country was best way to give someone an incentive to invest in market development. The likely result of internal competition would be a race to the bottom on quality as they compete on price. In any case, if PICS bag prices in Nigeria were too far out of line, it is likely that someone would start importing bags from other manufacturers (e.g. Ghana, Burkina Faso).

Reregistering the trademark for all grains - Also in 2012 the BMGF funded PICS2 which focused on research to confirm effectiveness of the bags for grains other than cowpea. Farmers had been using the bags for all kinds of grains since the initial introduction in 2007, but the PICS team and the Foundation felt that the effectiveness should confirmed before the technology was extended to millions of farmers for all kinds of crops. As part of this shift to a broad potential market, there was a discussion of the logo. Should a new logo be designed and registered? Or should "cowpea" be replaced? After some discussion of alternatives it was decided to replace "cowpea" with "crop". This allowed PICS to continue with the same acronym and build on the brand recognition that had already been developed.

As part of the PICS2 funding process the BMGF required submission of a "Global Access Plan," that would facilitate access to the technology by the smallholder farmers and other developing country citizens. That plan outlined the status of the PICS IP and the post project-commercialization plan. One new element in that plan was an explicit recognition of the product life cycle and how it applied to PICS. The last paragraph of the Global Access Plan stated:

> "The planning horizon for this post-project plan is roughly 20 years from the end of PICS2. Inevitably, African farming systems will change and new storage technologies will be developed. For instance, if the size of African farms grew, they might switch to bulk handling of grain (instead of bags) since there are alternative hermetic storage technologies available for bulk grains. New plastics that are less permeable to certain gases or that are repellent to insects would also change the technology landscape. The technology may outlive this 20 year planning horizon, but the strategy does not count on a longer life." (Purdue University, 2012). ,'

By this time PRF was under new leadership and had a broader view of its mission. It now included commercialization of all Purdue innovations. The PRF mission now included "getting innovations into the hands of people who need them." They recognized the reputational value of technologies commercialized in Africa for Purdue and for PRF. In December 2012, the Purdue Board of Trustees transferred the PICS trademark back to PRF.

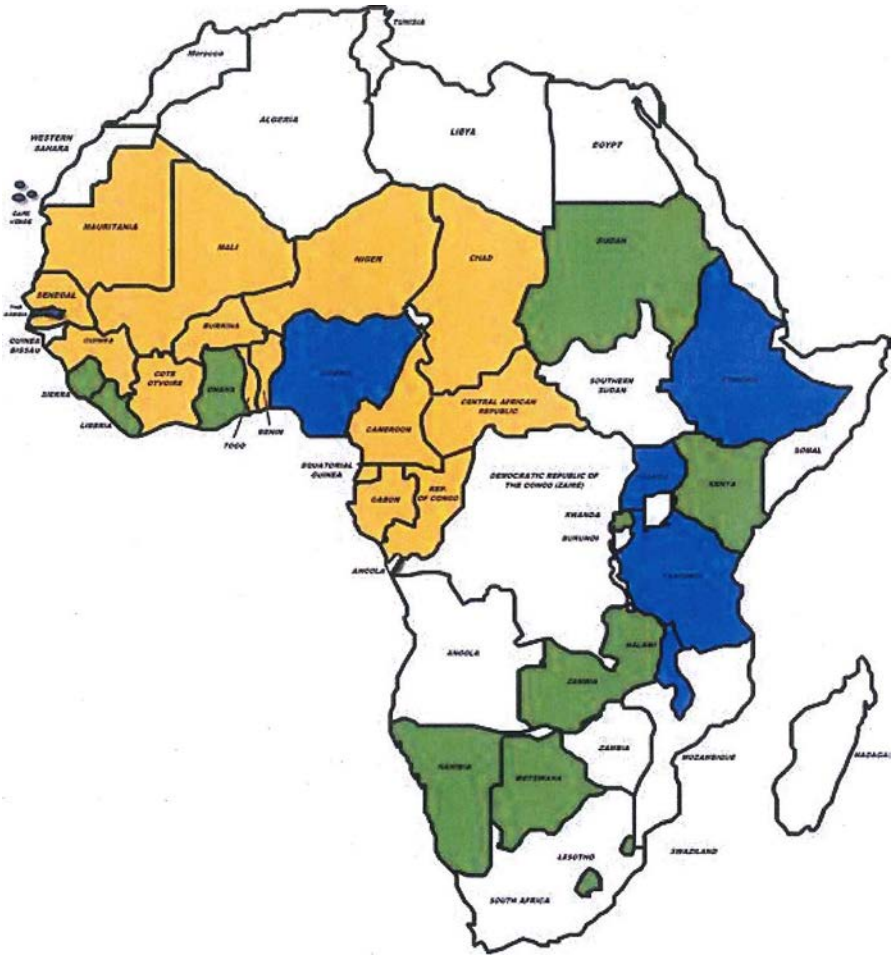
In October 2013 a new trademark registration was made to change "cowpea" to "crop" in PICS. The plan was to register this modified trademark in the OAPI countries, the World Intellectual Property Organization (WIPO) countries (i.e. Ghana, Sudan, Kenya, Rwanda, Namibia, Zimbabwe, Zambia, and Malawi), and several countries that are not member of either OAPI or WIPO (i.e. Nigeria, Ethiopia, Uganda and Tanzania). This trademark reregistration was paid for from PICS l project funds under a no-cost extension which continued until 2015. The map of countries with PICS trademark registration at the end of 2015 is in Figure 1.

As the PICS licensing became more formal, the duration became more defined. The procurement agreements used in 2008 and 2009 did not have a defined duration, but focused on the activities for a given crop season. The distributor agreements were usually automatically renewable given mutual agreement. The initial PICS licenses had five year terms, renewable with good performance. Later PICS moved to one year licenses for new licensees and then the five year duration renewable.

PICS beyond West and Central Africa - When PICS bags became commercially successful in West and Central Africa, they started to attract interest outside the region. In 2011 Purdue applied for and was granted a stage 1 Development Innovations Ventures (DIV) grant from USAID to determine a PICS supply chain could be created in Afghanistan. To test the potential interest, PICS bags were manufactured in Herat and used in USAID and USDA project. Because of the war time conditions many projects and NGOs were giving away agricultural inputs as part of humanitarian aid. That made development of a PICS supply chain difficult. However, it was discovered that PICS bags are very useful for storing dried fruits and nuts until they are packaged for consumer retail sale, and one company in Herat was paying a premium to farmers who delivered dried fruits and nuts to them in PICS bags. In 2016 a PICS license was signed with a distributor in Herat. The demand seems to be mainly from humanitarian aid organizations and fruit and nut growers.

In 2012 a CSR project of the Japanese company SUMITOMO approached PICS about supplying bags to Kenya. A hundred bags were shipped from West Africa for trials to a Kenyan company call "Consumer Experience" run by a SUMITOMO employee. A PICS distribution agreement was signed with consumer experience in October 2012. USAID Partnering for Innovation approached the PICS team about a pilot project to introduce PICS in Rwanda. A no-royalty PICS license was signed with the Rwandan company, Eco-Plastics, in mid-2013. The license in Rwanda was no royalty because it was argued that USAID funds were available to pay Purdue costs in Rwanda during the project life. In March 2015 Eco-Plastics signed a royalty bearing PICS license agreement. The PICS team decided in 2014 that in the future all license should be royalty bearing because it was too difficult to switch to royalties after the business had been operating for several years without royalty payments.

PICS TRADEMARK COUNTRIES



LEGEND	
Property Management Affiliation	
Madrid	
OAPI (African Organization for Intellectual Property)	
NA	

Figure 1 - PICS Trademark Map – Late 2015

In late 2013, the PICS team applied to Partnering for Innovation for support of a PICS introduction in Kenya. The Partnering for Innovation due diligence visit to Kenya revealed the weakness of Consumer Experience. At the time it was a start-up company operating from warehouse space in a Nairobi industrial park. It had no rural distribution network. Apparently it has been set up by a SUMITOMO employee to profit from his company's CSR activities in Kenya. PICS terminated the agreement with Consumer Experience and signed a PICS license agreement with Bell Industries in November 2013. By 2015 Bell Industries had become the second largest PICS distributor worldwide.

Based on the Kenya due diligence experience Partnering for Innovation staff questioned the "technology stewardship" of Purdue in continuing to manage PICS commercialization from within the university. In their minds good technology stewardship required putting management of commercialization in the hands of the organization best placed to bring that innovation to the people who needed it. Universities were not created or structured to commercialize technology and so should spin it off to an organization that has a comparative advantage in that arena. For new agricultural technologies in Africa that might be a business oriented NGO, an African business or a multinational business. None of this was new to the PICS team. They had been discussing spinoff options for several years, but had not identified any organization that they felt would do a better job than the university.

When a PICS license was signed with Lela Agro in 2013, PRF put out a press release which was circulated worldwide. Late in 2013, the PICS team was contacted by NAF seeds in Nepal. They inquired about licensing the PICS trademark. In January 2014, Lowenberg-DeBoer made a due diligence visit to Nepal to determine if NAF Seeds had the capacity to develop the PICS market in that country. In short, NAF Seeds had been the distributor for a competing brand of hermetic grain storage bags made by a company called GrainPro in the Phillipines. The GrainPro bags used a proprietary plastic that is almost oxygen impermeable. The HDPE in PICS bags allows a very small amount of oxygen to pass. Because of the special plastic the Grain Pro bags are usually much more expensive than PICS bags and have been most successful for high value crops like coffee where the cost of the bag is very small compared to the value of the product. The GrainPro bags were particularly expensive in Nepal because of high import tariffs. Nepalese farmers liked GrainPro bags, but thought they were too expensive. NAF Seeds was looking for a hermetic grain storage bag that could be manufactured in Nepal at a lower cost. Lowenberg-DeBoer found that NAF Seeds had access to plastics manufacturing in Baratpur owned by a relative of the NAF Seeds owners, they had a network of agricultural input supply shops that they owned selling seed, fertilizer, pesticides and other inputs, and they supplied ag inputs to a number of independent ag input supply shops. A license agreement was signed with NAF Seeds in February 2014. The NAF Seeds license is notable because it is so far the only PICS licensee that has been successful without direct donor support. In 2015, NAF seeds was the third largest PICS distributor worldwide.

Assessment of the Regional Licensing Experiment -An informal evaluation of the Lela Agro performance under the PICS license was done in mid-2015 and the PICS team at Purdue met to discuss options. The assessment was that Lela had done a good job in continuing to supply the markets that could be supplied from the Kano factory. They had paid for some PICS advertising

in Nigeria and they had invested in creating "depots" in Gombe and Niger states. But they had not invested in expanding the PICS market in outlying countries or in countries not yet served by a PICS distributor. They had signed some sublicense agreements in countries with plastic manufacturing capacity. In early 2014 Lela Agro signed PICS sublicense agreements in Senegal, Mali and Burkina Faso. Those licensees signed somewhat reluctantly. It was clear that they valued the connection to Purdue and feared that connection would be lost if they were sublicensed to Lela Agro. The Ghana PICS distributor delayed signing a sublicense agreement with Lela Agro, preferring to continue operating under his existing distributor agreement with Purdue. In mid-2015 the northern Ghana distributor signed a royalty bearing PICS license agreement with Purdue and a new distributor was added in Techiman in central Ghana, also a royalty bearing license agreement. As a result of this assessment of Lela Agro performance the PICS team decided:

1) West Africa distributors outside the Lela exclusivity zone should be given the option to return to a Purdue direct license with a 2% royalty, and
2) An effort should be made to convince plastics manufacturers in Senegal, Mali and Burkina Faso to become PICS licensees.

The argument for licensing manufactures centers mainly on the synergy between manufacturing and distribution, the fact that in West and Central Africa the manufacturers tend to be better capitalized than the potential distributors. Distributors who order bags made to order are expected to provide 50% down payment and the balance on delivery (or shortly after). This creates a cash flow problem because the bags my not be sold for month (or sometimes years). The manufacturers who also distribute (like Lela Agro) have an advantage in that their working capital requirement is limited to raw materials and labor. They have more flexibility in covering the overhead costs and the profit to the company.

In September 2015, Lowenberg-DeBoer visited Burkina Faso, Mali and Senegal to speak with the PICS distributors and the PICS manufactures there. Since the beginning of PICS the manufactures in these countries have made to specification PICS bags distributed by other businesses. Lowenberg-DeBoer had in depth discussions with the manufacturers and all three decided that they should stick to their core competency of manufacturing and not venture into distribution.

The existing PICS distributors in Burkina Faso, Senegal and Mali were unsettled by the discussions with the manufacturers. They felt that they had invested in building the PICS market and should be rewarded. In Mali the two PICS licensees eagerly embraced the idea of moving back to a direct PICS license, even if that mean going to a 2% royalty. They wanted to have direct access to support from Purdue if needed. The other distributors expressed interest in moving to a Purdue direct license, but that had not be negotiated as of the end of 2015.

A recurrent question is who owns the PICS IP and who shares the license? In a legal sense that is an easy question. The trademark is registered in the name of PRF is allocated based on PRF rules. In an ethical sense it is a more difficult question. Researchers from the Cameroonian Institute for Agricultural Research for Development (IRAD) played an important part in the original research. Faculty from several departments at Purdue helped develop the

PICS brand. PICS manufacturers and distributors from several West African countries provided ideas and feedback that helped to fine tune the product. While the current licensing model and rates make it unlikely that PICS will ever produce enough revenue (beyond what is needed to support licensees) to share, there is an ethical and moral obligation to manage the PICS IP in a way that is consistent with the original goal to improve grain storage and thereby food security for smallholder farmers in the developing world.

There is good evidence that PICS trademark licensing has achieved its original goals of helping to protect the licensees from low quality competitors trying to compete solely on price. There are many imitators, but none of the substantial companies tried to use the PICS logo. They made their own version of the PICS bag, sometimes using PICS specifications, sometime their own design, but with a generic or self-branded. Only a few small operators tried to use the PICS logo and they quickly stopped production after being sent cease and desist letters from the PICS team at Purdue.

PICS License fees paid - One of the objections to licensing technology in Africa is the difficulty in convincing businesses to pay license fees. All African countries have legislation enacting intellectual property rights, but these laws are widely ignored. Even for those willing to pay, the transactions costs of making the transfer are high. The PICS 1 experience shows that license fees can be collected, but it is not an easy process. As of the end of 2015, PICS had collected two license fee payments: one from Lela Agro in June 2014 of $12,800 and another from NAF Seeds in Feb. 2015 of $500. Those funds were retained at PRF until a decision was made about their allocation. In 2015 Lela Agro delayed payment because of the chaos in Nigeria linked to Boko Haram, Ebola and the presidential elections. Bell Industries argued for a delay in license fee payments so that they would reinvest in PICS market development. As of the end of 2015 neither Bell, nor Lela Agro, had paid the outstanding license fees. In Africa most business is based on personal relationships and it might be argued that license fees were paid under PICS 1 because of the relationships between the business people and the PICS team. It is not clear if license fees will be paid when there are personnel changes in PICS at Purdue.

One of the complications of managing the PICS licenses within the university is that the standard allocation of license fee revenue required one third to stay with PRF to be reinvested in research and innovation, one third to the departments that generated the intellectual property and one third to the "inventors" personally. The original discussion of the PICS license assumed that all the license fee funds could be used to support PICS licensees. The original 1% license fee was estimated based on what barebones support for PICS licensees would cost assuming that it would be done by university employees on university time (i.e. that PICS only had to support travel costs). Because of resistance in Africa to paying any license fees, the license fee should appear to be negligible. Under the standard Purdue allocation of revenue, none of the license fee revenue was directly available to support PICS license commitments. In mid-2016 an exception to the Purdue standard license revenue model was approved in which all revenues up to $30,000 would be used to cover commitments to PICS licensees and the remainder would be allocated as indicated under the standard allocation policy. This exception takes some of the immediate pressure off and would allow the license fee funds accumulating in PRF to be used, but does not

solve the problem of how to support PICS licensees in the future. As the number of PICS licensees grows, managing those licenses will require more than $30,000 per year.

From the moment PICS was introduced there were imitators, but after PICS had showed that there was a viable market among smallholder farmers for storage technology some of them started doing research and development on the next generation of hermetic storage bags. Those companies include:

- Vestergaard Frandsen -headquartered in Switzerland, but manufacturing mostly outsourced to Vietnam
- GrainPro -headquartered in the US, but with manufacturing in the Philippines
- A to Z Textiles -headquarters and manufacturing at Arusha, Tanzania
- Kuraray Asia Pacific, Japan
- Oxy-Low Systems, Netherlands

Each company seems to be pursuing a different path. Vestergaard-Frandsen considered licensing PICS technology, but decided that the profit potential was greater with an insecticide impregnated woven sack. They are exploring the potential for liners within that sack. GrainPro's most successful product seems to be the "Cocoon" for large scale grain storage and have been trying to adapt their model for bag storage by smallholder farmers. They use a proprietary oxygen impermeable plastic that increases the cost of their product and makes manufacturing in Africa difficult. A to Z Textiles has introduced a single liner hermetic storage bag (i.e. a woven sack with one liner) and an insecticide impregnated woven sack with one liner. With the large scale trader and food security agency market in mind, several companies are experimenting with alternative bag closure systems that would reduce labor for closing bags and allow the bags to stack flat in warehouses. Because they know that the smallholder farmers market is very price sensitive all are looking to reduce costs. It can be argued that the most durable impact of PICS is the entry of these for-profit companies into development of improved grain storage technology for smallholder farmers.

In 2015 PICS was so successful that many donors considered their funding role completed. PICS was a commercial product and should function in a commercial world. At most they might fund local NGOs and national extension in the developing world to train farmers in the use of hermetic storage when there is a public good to be achieved. The era for grant funding to Purdue for PICS seems to be drawing to an end. Given that situation, there was a renewed round of interest in the potential for spinning off a company and there were discussions with the venture capital community. The whole PICS team met with the Entrepreneurs in Residence (EIRs) from the Purdue Foundry (http://vvvvw.purduefoundry.com/). Lowenberg-DeBoer had discussions with MNS Advisors and the Soros Group. The feedback from those discussions can be summarized as:

1) PICS alone is too small to be a viable for-profit spin-off based in the US. Economic viability is possible only with a portfolio of technologies to be commercialized in the developing world. There are economies of scale in commercialization and synergies in having one organization handling several innovations.

2) The commercialization of PICS can no longer be handled from within the university. University processes are too .cumbersome and too expensive. University staff have many responsibilities and cannot devote full time to managing the PICS licenses. Faculty are motivated by discovery and scholarship, not by the day-to-day grind of running a business. The natural tendency of faculty may be manage technologies for grant funds that generate scholarship, awards and other recognition.

Given that feedback there was profound difference of opinion among the PICS team. Some wanted to explore the potential for a company or NGO that could include PICS with a portfolio of Purdue technologies moving toward commercialization. Others were content to manage PICS for the remaining grant opportunities and eventually stop defending the trademark when grant potential was exhausted.

Given the difference of opinion on PICS license management and the definitive end of the PICS l project in 2015 there was a change of personnel. Lowenberg-DeBoer stepped out of his role managing the PICS licenses. Dieudonne Baributsa was named the new PICS license manager. Baributsa is an associate professor in the Entomology Department. He has been involved with PICS since 2009 when he was hired to come to Purdue as the PICS team leader. This personnel change was also accompanied by a decision by Purdue to continue to manage the PICS license from the university, at least for the time being.

Hypotheses - One of the key roles of case studies is to develop hypotheses that can be more rigorously tested in future studies. Some hypotheses growing out of the PICS licensing experience are listed in Table 2. Testing any of these hypotheses would require data on multiple technology introductions. Conclusions would be firmer with more observations. The measure of commercialization might be discrete or continuous depending on the definition of commercialization. For example, any innovation that sells over 1 million units might be classified as commercial. Alternatively, the measure of commercialization might be the number of users, the number units sold over a certain period (i.e. first five years), sales revenue or other. Ideally, these hypotheses would be tested with only agricultural technologies, but to increase the sample size it might be useful to include medical, energy, and other technologies that have been introduced in developing countries.

Hypothesis #1 requires data on multiple technologies with and without patents. For discrete data this might be analyzed with PROBIT or LOGIT models. The coefficient estimates would provide a statistical test of whether the patent effect was statistically significant. The marginal effects would provide an estimate of the change probability of commercialization with patenting. Continuous measures of commercialization might be analyzed as sales or revenue equations with patenting, trademarking, and other characteristics as independent variables.

Hypothesis #2 would require data on multiple technologies with and without trademarks. The analysis would be similar to Hypothesis #1.

Hypothesis #3 would require multiple observations on research based technologies with commercialization managed directly from the institution or spun off to a business or NGO. In this case the research institution involvement will probably be a continuous variable such as the

number of years after invention that a technology was spun off to management outside of the university or research institution.

Hypothesis #4 would go beyond Hypothesis #3 in requiring information on the type of management that occurred within the university or research institution. Was that management directly by a faculty member or researcher, or by a staff member hire for management skills? Was a committee of faculty members or researchers directly involved in the management or strictly in a advisory role.

Table 2 – Hypotheses Generated Concerning Technology Licensing and Subsequent Commercialization Success in Developing Countries

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Hypothesis #1:

HO: Among research based technologies developed by universities and public sector research institutes, patented technologies are more likely to be commercialized.

HI : Patenting has no effect or a negative effect on commercialization of a technology.

Hypothesis #2:

HO: Among research based technologies developed by universities and public sector research organizations, trademarked technologies are more likely to be commercialized.

HI : Trademarking has no effect or a negative effect on commercialization of a technology.

Hypothesis #3:

HO: Among research based technologies developed by universities and public sector research organizations, successful commercialization is most likely when the university or research organization is involved with the commercialization process.

HI : University or research organization involvement in commercialization either has no effect or a negative effect on the likelihood of successful commercialization.

Hypothesis #4:

HO: Among research based technologies developed by universities and public sector research organizations, successful commercialization is most likely when the university or research organization licensing the patent or trademark and that licensing process is manage in a businesslike way, not in a collegial manner.

HI: University or research organization involvement in commercialization is most likely to be successful if managed collegially (i.e. via a faculty or research committee).

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Conclusions -PICS has been a successful effort to introduce a new research based technology in the developing world. It is difficult to find another example of a research based agricultural technology in the developing world that has millions of customers and sales counted in millions of units. But the track record of IP management in this effort is mixed. It is the classic case of "is the glass of water half empty or half full"?

There is good evidence that PICS trademark licensing has protected the licensees from low quality competitors trying to compete solely on price. There are many imitators, but only a few that tried to use the PICS logo. The few who tried to use the PICS logo on their bags, quickly stopped production after being sent cease and desist letters from Purdue.

There is more argument about whether the PICS market developed more quickly because PICS was typically licensed to a single entity per country. Some critics, in particular RIU in Nigeria, have argued that more PICS licenses should have been signed to create competition. The PICS response has been that a single license per country or major region within a country gives that licensee incentive to develop the market by investing in publicity, public demonstrations, media, and relationships with government agencies. The PICS team also countered that if prices get out of line competition is still possible across borders.

The most contentious issue has probably been whether Purdue should have spun off PICS management? In particular, the USAID Partnering for Innovation staff argued that good technology stewardship would require the university to spin off PICS licensing to a more business oriented entity at the end of the first PICS project. At that point there was proof of concept. By original end date of PICS in 2012 there was evidence of the commercial demand for PICS bags and the willingness of farmers to buy them. Later feedback from social venture capitalists was that management within the university was a key constraint to PICS commercial success. Concerns about university management of PICS included: slow and cumbersome management processes, university staff have many responsibilities and cannot devote their full attention to PICS commercialization, inadequate vetting of new licensees, and lack of capacity for verifying quality control after the end of donor funded projects.

The PICS team would counter that they had discussions with both for profit companies and not-for-profit organizations about taking over the commercialization of PICS. The for-profit companies did not think the PICS model had enough profit potential. Both companies with whom talks were extensive entered the grain storage bag market in Africa with an insecticide impregnated bag which they felt was harder to copy and hence offered more profit opportunity. The typical business model of business and entrepreneurship oriented NGOs (e.g. Technoserve, ACDINOCA, CNFA, IFDC) is to get donor grants to provide training and services to entrepreneurs. They do not typically run the businesses directly. The PICS team also explored the potential for launching either a for-profit company or a not-for-profit based in West Lafayette to manage the PICS license, but never came up with a convincing business model for a PICS only start up. Consequently, the university decided to continue managing the license in-house.

One option that was only partially explored before the PICS personnel changes at the end of PICS 1 was for the university to spin. off an organization that would handle the commercialization of a portfolio of new technologies targeting developing countries. This might be for-profit or not-for-profit. Handling multiple technologies would give the organization economies of scale and some degree of stability. An organization focused on a single innovation (i.e. PICS) lives or dies with that innovation. An organization handling multiple technologies has a better chance of finding the winners. At the time this discussion was launched in late 2015, Purdue had multiple innovations in the pipeline (e.g. solar and biomass fired grain dryers; low cost grain moisture measurement devices; equipment for small scale low investment grain processing). Unfortunately, the multiple technology organization required more development time and more investment than was available as PICS l wound down at the end of 2015. Perhaps it is something the university will revisit in the future.

One other question is whether it would have been better for the university to patent the triple bagging technology? Patenting would have made the licensing discussions easier. Most discussions of PICS licensing started with questions about the patent status. Most developing country business people seem to have an understanding of what patents are and how they are useful in business, in spite of the fact that all types of intellectual property are widely ignored in the developing world. The concept of trademarks is not as well understood in developing country business circles and required long explanations. In fact, patenting of PICS is probably a moot point. Because of the long lag between invention in the late 1980s and commercialization starting in 2007, the patent term would have been expired by the time it was needed in licensing discussions.

In fact, the real value of the PICS license to African and Asian licensees was probably not in the intellectual property, but in the management and technical support provided through the license. The African and Asian PICS manufacturers operate in an environment of weak public and private institutions. If they have a technical problem in manufacturing, an issue brought to them by customers or management challenges there are few local resources. For many of them the option to call on Purdue when they had a problem was worth the license fee.

Overall, the Purdue intellectual property management of PICS struck an important balance. The trademark allowed Purdue to develop a branded high quality product with a reputation for reliability, but it did not stop entrepreneurs from experimenting with other specifications (e.g. one liner, thinner plastic, more LDPE). The trademark strategy facilitated what is probably the longest lasting impact of PICS which is the fact that many companies are now manufacturing hermetic grain storage bags for African farmers and some are investing in research and development of improved grain storage bags. The trademark strategy facilitated this proliferation of hermetic grain storage business by showing there is a potentially profitable market for the bags and by not constraining their use of the technology. As long as they did not use the PICS logo they were free to market any type of hermetic grain storage bag. In the end it will be the market that decides the number of liners, thickness of plastic and plastic composition that best responds to the needs of the farmers, grain traders and others that wish to store grain.

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