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BRIEF 48

Adoption and Uptake Pathways of GM/Biotech Crops by Small-Scale, Resource-Poor Farmers in China, India, and the Philippines

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No. 48 - 2014

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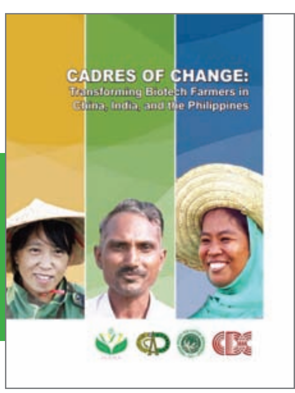

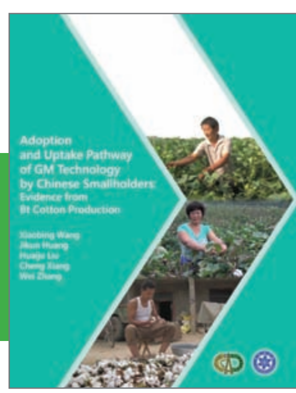

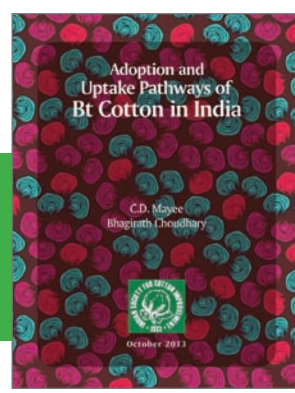

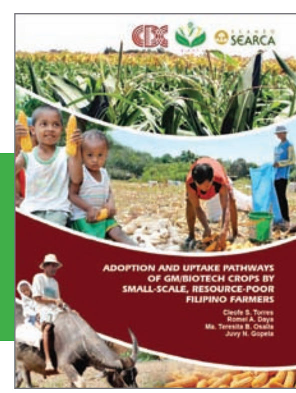

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Preface

It takes about 4 to 5 months for a cotton seed to grow, and mature into a plant with bolls ripe for picking. For a corn plant, it takes 125 days or about 4 months from emergence before the first ear is harvested. In between, nature takes its course and either rewards a farmer with a bountiful yield or leaves him with nothing to prove for his effort and investment in the field.

Brian Brett, author and farmer, says that "Farming is a profession of hope" and the research community is committed to reduce the risks that hound smallholders, particularly those who feed a hungry world. For farming does not end with the farmers. It affects a bigger number of consumers who rely on sustained production of food, feed, and fuel for their sustenance, survival, and development.

Brief 48 on the *Adoption and Uptake Pathways of GM/Biotech Crops by Small-Scale, Resource-Poor Farmers in China, India, and the Philippines* shows how modern technology has changed the "profession of hope" to one where agronomic and socio-cultural benefits rather than just promises are possible. It is an empirical testimony to how biotech crops, particularly Bt cotton in China and India and biotech corn in the Philippines, are changing the lives of small farmers, their families, communities, and even countries.

The three-country study was a collaborative work of the International Service for the Acquisition of Agri-biotech Applications (ISAAA), which was the lead proponent; the Center for Chinese Agricultural Policy, Chinese Academy of Sciences; the Indian Society for Cotton Improvement; and the College of Development Communication, University of the Philippines Los Baños. The John Templeton Foundation provided funding to this project, which enabled substantial information on farmer adoption to be obtained and made available to stakeholders.

The research confirmed that resource-poor farmers in developing countries, rather than the big farmers, are raking in the benefits. Farmers experienced higher yields, spent less on production due to the significant reduction in pesticides, and had the intangible feeling of "peace of mind," knowing that major pests would not reduce their harvest. All these result in higher income and a better quality of life. In addition, farmer profile

Preface

surveys revealed the growing feminization of biotech crop cultivation in China where women have greater involvement in farming operations. In India, young farmers are being attracted to this profession as benefits are being realized. And, in the two countries as well as in the Philippines, income levels have doubled or even tripled compared with what farmers used to get from planting conventional varieties.

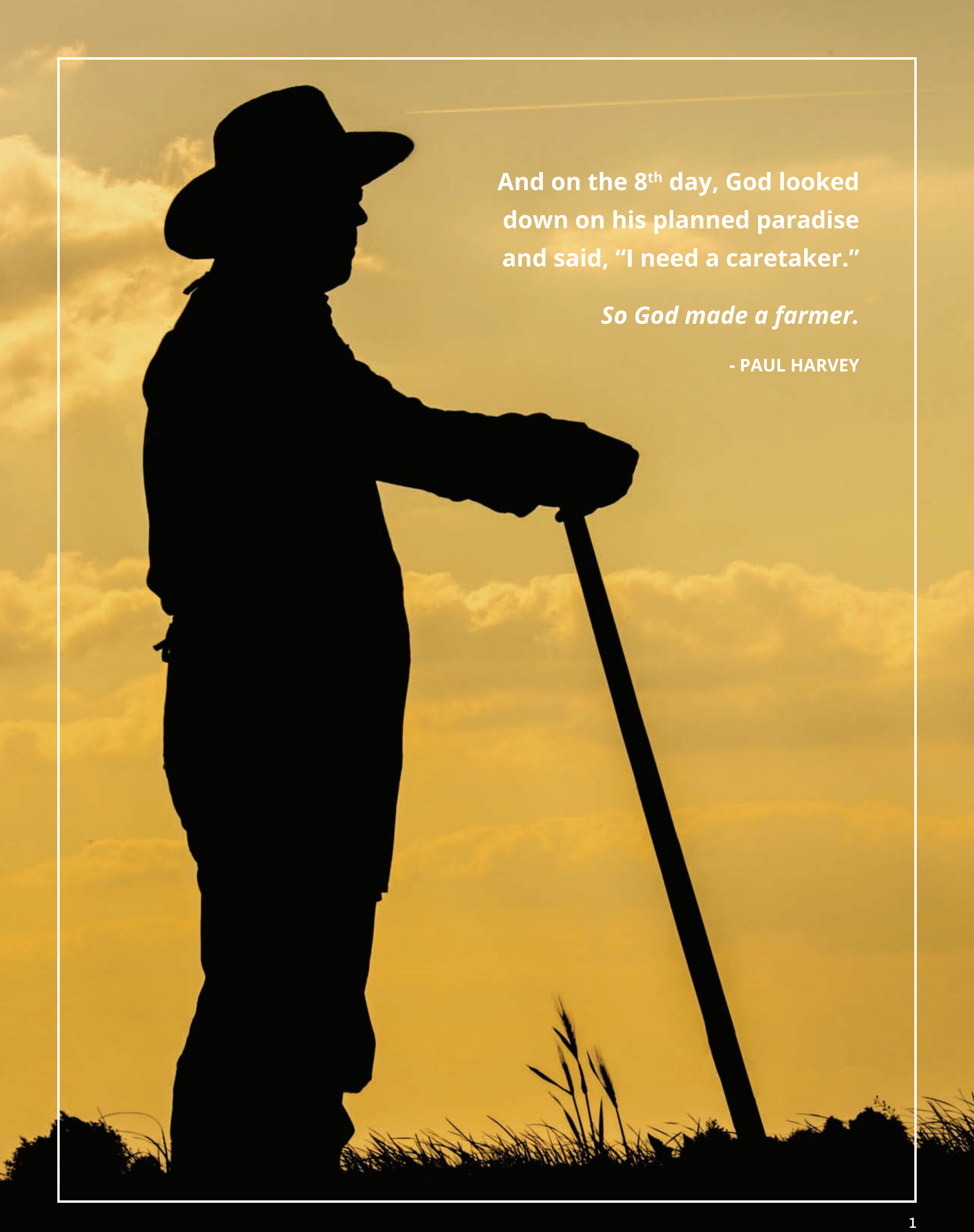
Interestingly, the study highlighted the spread of biotech crops, which was facilitated by farmers sharing the new technology within their communities and spreading the good news beyond their turf. It took progressive farmers to try a new technology to eventually convince other farmers who took a wait-and-see attitude initially but were won over by the comparative features of biotech and non-biotech crops on demonstration fields. Trust and strong ties among farmers and a communal feeling that all should benefit helped in the rapid dissemination of the technology. Nevertheless, continuous efforts need to be done to address barriers to adoption such as lack of capital, insufficient seed supply, not enough land area for cultivation, limited access to information about the new technology, and inadequate government support.

The research provides specific recommendations for each country, which other nations can benefit from in terms of designing paradigms and implementing strategies to increase and sustain farmer acceptance and adoption of biotech crops.

We acknowledge the support of several people who made this Brief possible. Ms. Teresita Rola, former editor at the International Rice Research Institute, edited the final publication while Ms. Clement Dionglay did the layout and cover design. Original and modified figures were obtained from the three country reports. ISAAA staff led by Dr. Rhodora R. Aldemita who reviewed the manuscript, provided various forms of assistance during the preparation of this Brief.

May this publication provide a useful understanding into who biotech farmers are and the process by which smallholder farmers in the developing world accept and adopt a modern technology.

Mariechel J. Navarro
Randy A. Hautea
Project Leaders


And on the 8th day, God looked down on his planned paradise and said, "I need a caretaker."
So God made a farmer.
- PAUL HARVEY

1 Introduction

The few hands that coax a seed to grow and thrive are those that feed, clothe, and provide the domestic needs of hundreds and thousands of people.

Such is the significant role of farmers worldwide. Each day, they leave their homes to tend to their farms with an optimism that the labor and resources they invest will redound to a bountiful harvest. But the onslaught of pests and diseases, the vagaries of weather, and other farm-related problems loom like an unseen enemy. With this in mind, scientists have been in the forefront of finding alternative solutions so that farmers can address the many concerns they face. One viable option is biotechnology.

Since the introduction of biotech crops in 1996, almost two decades ago, biotechnology has been considered the fastest adopted technology in the world. The growth in number of hectares in which biotech crops are grown globally has continued to increase remarkably over the years, registering an annual growth rate of 6% in 2012, or an additional 10.3 million ha over 2011. For the first time, developing countries planted about 52% of global biotech crops as compared to 48% in industrialized countries (James, 2012).

An estimated 17.3 million farmers from 28 countries grew biotech crops on 170.3 million ha in 2012. Top biotech crops were soybean, maize, cotton, and canola. Other biotech crops were alfalfa, sugar beet, papaya, squash, poplar, tomato, sweet pepper, and ornamentals such as biotech blue rose and biotech carnation (James, 2012).

More than 90% of those who grew biotech crops were small, resource-poor farmers in developing countries. This is in contrast to the general perception that big farmers from developed countries dominate the biotech scene. In fact, 85% of these farmers come from China (7.2 million), India (7.2 million), and the Philippines (375,000). Farmers plant biotech crops for various reasons: they

benefit from more convenient and flexible crop management, lower cost of production, good health and social outcomes, and a cleaner environment through decreased use of conventional pesticides. It is the developing countries that stand to benefit most from planting biotech crops as issues such as food security, climate change, and agricultural sustainability remain to be critical.

The project *Adoption and Uptake Pathways of Biotech Crops by Small-Scale, Resource-Poor Asian Farmers: Comparative Studies in China, India, and the Philippines* was spearheaded by the International Service for the Acquisition of Agri-biotech Applications (ISAAA) with funding from the John Templeton Foundation to give a human dimension to the statistics on farmer adoption and uptake pathways of biotech crops and the changes these have brought about in resource-poor farmers' lives. Adoption refers to how farmers acquire and eventually apply the knowledge and practices pertaining to the planting of a biotech crop. Uptake pathway involves the process of capturing how a biotech crop is introduced, adopted, disseminated, and shared by farmers with others (Torres et al., 2012).

Collaborators from the Center for Chinese Agricultural Policy, Chinese Academy of Sciences; the Indian Society of Cotton Improvement; and the College of Development Communication at the University of the Philippines Los Baños formed the research team. Information and insights on the following questions were sought: Who are the biotech farmers? What are the factors that farmers consider in adopting biotech crops? How have they benefitted from adopting the technology? Who influenced them in adopting biotech crops? Knowing and understanding the answers to these questions can provide an important direction and can set guidelines for integrating biotech crops in the agricultural sector.

The research provides evidence that contributes to a greater understanding of the social environment that favors biotech crop adoption, particularly in developing countries. Countries still mulling to adopt a biotech crop or add another crop in its agricultural basket of options will learn from the experiences of the three countries, especially in formulating paradigms and strategies to increase farmer acceptance and adoption.

This Brief consolidates the three individual country reports (Wang et al., 2013; Mayee and Choudhary, 2013; and Torres et al., 2013) and a monograph (ISAAA, 2013) already available in hard copy and for download at www.isaaa.org. It attempts to put in one publication the major highlights that sets into perspective biotech crop commercialization in each of the countries, focusing on farmer profile, facilitating factors and barriers to adoption, and

POSTSCRIPT:

By 2013, farmers growing biotech crops in 27 countries increased to 18 million. They planted 175.2 million hectares or a sustained increase of 3% or 5 million hectares over 2012.

uptake pathways of the technology by farmers. The discussion in this Brief, including the theoretical foundation, thus comes from these publications.

Bt Cotton in China and India

Cotton is an important agricultural crop, being the preferred cash crop of millions of small resource-poor farmers. In addition, growth in international trade has been experienced in countries that have been able to increase their global market share of cotton and textile exports. China is the world's top producer of cotton, with India coming in a close second. In addition to farmers who plant the crop, other stakeholders gain from the industry by directly or indirectly being involved in cotton production, processing, textile, and related activities.

Farmers have had a long history of cultivating the crop, but pest infestation caused by the cotton bollworm *Helicoverpa armigera* wreaked havoc on the farms significantly reducing yield and eventually, cotton production area. The introduction of modern technology enabled farmers to recover from such a misfortune. Ex-post and ex-ante studies have documented the fact that insect-resistant *Bacillus thuringiensis* (Bt) crops, as a result of biotechnological interventions, have significantly reduced pesticide use, thus resulting in a positive impact on welfare and the environment. Huang et al. (2003), Subramanian (2010), and Ali and Abdulai (2010) conclude that with Bt cotton, smallholder farmers benefit from pesticide savings, higher effective yield and less crop losses. Bt cotton adopters, on average, save on pesticides by around 56% and yield increase is around 8% in China (Huang et.al, 2002).

Since the 1980s, the Chinese government has invested substantially in the public sector to raise agricultural productivity to ensure national food security through modern biotechnology. It provides support to research and development and to human capacity building. For the 2008-2020 period, China infused about US$3.8 billion to initiate the National Genetically Modified (GM) Variety Development Program.

China became one of the first countries that commercialized a biotech crop, specifically Bt cotton in 1997. Chinese farmers had early access to two cotton varieties: one developed by the Chinese Academy of Agricultural Science (CAAS) for cultivation in Shanxi Anhui, Shandong, and Hubei provinces and the other, developed by a private company (Monsanto) for cultivation in Hebei. The favorable experience of farmers with the crop — i.e., less use of pesticide, labor-saving, and yield increase — accelerated the approval of other new varieties. The commercial release of Bt cotton expanded the cotton production zone beyond Huang-Huai-Hai to the Yangtze River and Xinjiang cotton production zones.

Table 1 shows the Bt cotton varieties for commercial release by province, over the years. Table 2 dramatically shows that, by 2005-2006, more than 20 new varieties were made available to small farmers across three production zones. Farmers are not constrained by access to appropriate seeds despite diverse agronomic conditions.

Although other biotech plants such as petunia, tomato, sweet pepper, poplar, papaya, rice, and corn have been issued safety certificates for production, Bt cotton remains to be the most successful crop adopted by farmers. Less than 10 years from its release, Bt cotton accounted for more than 65% of total cotton areas until nearly all farmers had planted it in northern China and the Yangtze River Valley in the late 2000s. Chinese farmers have a choice of varieties among those developed by local public research institutions or private companies.

China's success story is also replicated in India where commercial adoption of Bt cotton started in 2002 only on a few thousand hectares. It has since spread to nearly 10.8 million ha equivalent to 93% of the total cotton area of 12.1 million ha in 2011-12. This technology diffusion occurred despite opposition from civil society groups and legal cases that sought to delay acceptance and adoption. The issues raised against the technology include biosafety, effects

Table 1. Bt cotton varieties approved for commercial release in China, by starting year and by province

Province	Cotton production zone	Starting year	Variety	Affiliation
Anhui	Huang-Huai-Hai	1997	Bt cotton[a]	Biotechnology Research Institute, CAAS
Shanxi	Huang-Huai-Hai	1997	Bt cotton[a]	Biotechnology Research Institute, CAAS
Shandong	Huang-Huai-Hai	1997	Bt cotton[a]	Biotechnology Research Institute, CAAS
Hubei	Huang-Huai-Hai	1997	Bt cotton[a]	Biotechnology Research Institute, CAAS
Hebei	Huang-Huai-Hai	1997	NC33B	Monsanto
Henan	Huang-Huai-Hai	1999	GK-12, GK95-1	Biotechnology Research Institute, CAAS
Liaoning	Huang-Huai-Hai	1999	GK95-1	Biotechnology Research Institute, CAAS
Jiangsu	Yangtze River Valley	1999	GK-12	Biotechnology Research Institute, CAAS
Xinjiang	Xinjiang	1999	GK12, GK95-1	Biotechnology Research Institute, CAAS
Shaanxi	Huang-Huai-Hai	2004	GKz1, GKz2	Biotechnology Research Institute, CAAS
Jiangxi	Yangtze River Valley	2004	DP410B	Monsanto
			GKz17	Biotechnology Research Institute, CAAS
Hunan	Yangtze River Valley	2004	DP410B	Monsanto
Sichuan	Yangtze River Valley	2004	GKz34	Biotechnology Research Institute, CAAS
Zhejiang	Yangtze River Valley	2004	GKz18	Biotechnology Research Institute, CAAS

[a] The variety (event) is not specified.

Table 2. **The evolution in number of newly commercialized varieties, by cotton production zone and by province, 1997-2012**

Year	Huang-Huai-Hai								Yangtze River Valley					Xinjiang
	Anhui	Hebei	Henan	Shandong	Shanxi	Hubei	Liaoning	Shaanxi	Jiangsu	Jiangxi	Hunan	Sichuan	Shejiang	Xinjiang
1997	1	1	-	1	1	1	-	-	-	-	-	-	-	-
1998	0	0	-	0	0	0	-	-	-	-	-	-	-	-
1999	3	1	2	1	1	0	1	-	1	-	-	-	-	2
2000	1	2	0	1	0	0	0	-	0	-	-	-	-	0
2001	1	0	0	0	0	0	0	-	0	-	-	-	-	0
2002	2	2	7	4	1	1	0	-	1	-	-	-	-	1
2003	0	0	0	1	0	0	0	-	1	-	-	-	-	0
2004	19	18	28	28	0	10	0	2	18	2	2	2	1	0
2005	72	22	33	36	3	11	0	8	31	2	5	2	3	1
2006	74	29	61	44	24	26	0	5	20	1	18	4	4	0
2007	27	50	53	30	7	14	0	11	24	5	10	3	2	0
2008	180								53					0
2009	141								90					0
2010	92								72					0
2011	31								10					0
2012	54								69					0

of Bt on human and animal health, loss of biodiversity, and emergence of new pests. That more than 7.2 million farmers in 2012 planted the crop attests to the benefits that end-users experienced over time, despite the misinformation campaigns by opposition groups. Studies (Bennet al., 2006; Dev and Rao, 2007; Usha Rani and Selvaraj, 2008; Padaria et al., 2008; Wasnik et al., 2013 and Singh et al., 2013) clearly show that Bt cotton adoption was influenced by what the farmers saw: less use of chemical pesticides, comparatively higher yield, and significant additional income.

The Government of India has been very supportive of biotechnology as demonstrated by its support to research and development institutions, capacity building and development of GM crops. The biotech sector, through the Department of Biotechnology, Department of Science and Technology, and Council of Scientific Industrial Research, among others, has strengthened efforts to put biotech in the forefront along with the private sector.

As early as 1995, Mahyco Company obtained a cotton variety transformed with a modified *crylAc* gene from the U.S. company Monsanto. The gene was transferred to Mahyco's elite cotton hybrids by conventional breeding techniques. The Central Institute for Cotton Research thoroughly reviewed the developmental process of Bt cotton before it was approved for commercial cultivation by the Genetic Engineering Approval Committee (GEAC) of the Ministry of Environment and Forests. Several varieties were made available for cultivation to cotton farmers starting with the three Bt cotton hybrids approved for commercialization in the central and southern

Table 3. **GEAC's approval for commercial release of different Bt cotton events in India, 2002 to 2012**

No.	Crop	Gene(s)	Event	Developer	Status	Year of Approval
1	Cotton*	*cry1Ac*	MON-531	Mahyco/Monsanto	Commercialized	2002
2	Cotton*	*cry1Ac* and *cry2Ab2*	MON-15985	Mahyco/Monsanto	Commercialized	2006
3	Cotton*	*cry1Ac*	Event-1	JK Agri-Genetics	Commercialized	2006
4	Cotton*	fused genes *cry1Ab* and *cry1Ac*	GFM Event	Nath Seeds	Commercialized	2006
5	Cotton**	*cry1Ac*	BNLA-601	UAS, Dharwad & CICR (ICAR)	Discontinued	2008
6	Cotton*	synthetic *cry1C*	MLS-9124	Metahelix Life Sciences	Approved, Not placed in the market yet	2009

*Bt cotton hybrids; **A hybrid and a variety of Event BNLA-601 discontinued since 2010

cotton-growing zones, and the six Bt cotton hybrids for the northern cotton-growing zone. By 2005, a total of 20 Bt cotton hybrids for north, south and central India have been approved for cultivation, making the crop available in the whole country.

Eventually, almost 35 Indian private seed companies became sublicensees of Mahyco, enabling them to transfer the Bt gene into popular cotton hybrids. The success of Bt cotton inspired other research and development organizations to develop more biotech crops such as rice, mustard, chickpea, sorghum, and sugarcane.

By 2010, 700 Bt cotton hybrids were being marketed in India by 30 small and medium private seed companies. Table 3 shows the approval for commercial release of different Bt cotton events in India from 2002 to 2012. An event is the insertion of a particular gene into a specific chromosome.

Biotech Corn in the Philippines

The Philippines lays claim to being the only Asian country planting biotech corn. Farmer adoption of this crop has consistently been increasing since its approval for commercialization in 2002. The area planted to biotech corn was estimated at 750,000 ha in 2012, which is 16% higher than that of the previous year. In the early years of commercialization, Bt corn was adopted quickly by Filipino farmers.

Through the years and as other varieties were introduced, farmers shifted to the stacked-trait corn variety due to its combined resistance to corn borer and tolerance to herbicides. By 2012, the stacked-trait corn got a 90% share of the total hectares planted to biotech corn. On the other hand, the hectarage devoted to single-trait Bt corn variety sharply decreased by 76% in 2012. The herbicide-tolerant variety (HT) covered only 9.6% of total biotech corn hectarage. The shift from single-trait to stacked-trait variety has been observed since the latter's introduction in 2006.

Eight biotech corn events have been approved for commercialization starting with the Monsanto-developed Bt corn MON810 in 2002 (Table 4). Currently available biotech corn varieties are insect resistant (IR), herbicide tolerant (HT), and with stacked-trait or a combination of being insect resistant and herbicide tolerant (Bt/HT).

An estimated 375,000 small resource-poor

farmers benefit from growing biotech corn in 2012. Farm-level economic gains from biotech corn from 2003 to 2011 were estimated at USD 264.5 million; and for 2011 alone it was USD 93.6 million (James, 2012).

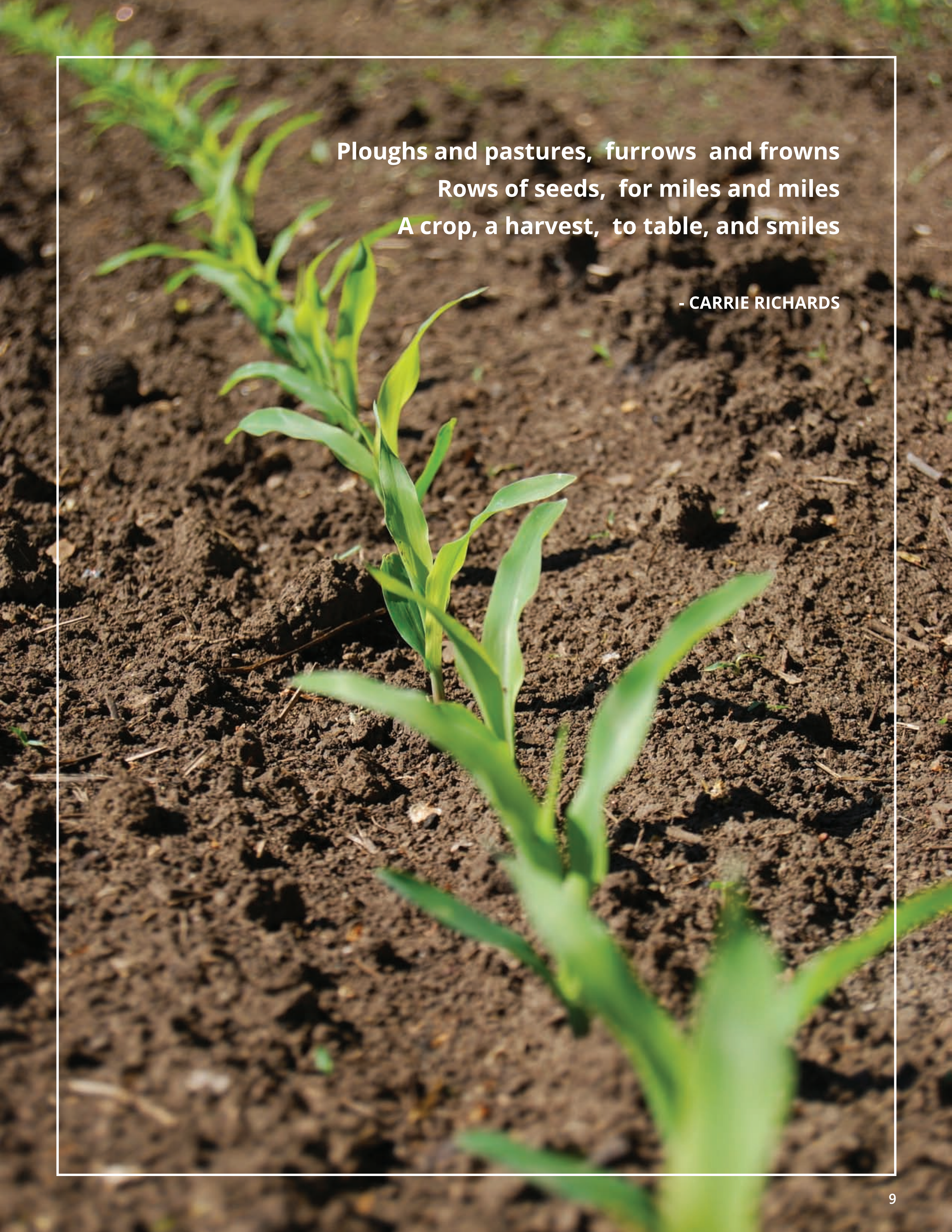
A study on the economic impact of biotech corn in the Philippines (Yorobe and Quicoy, 2006) noted significant and positive changes:

- Yield and income of biotech corn farmers were significantly higher than those of non-biotech corn farmers.
- Expenditure on insecticides was significantly lower among biotech corn farmers.
- A significant welfare effect of using biotech corn variety among corn farmers was seen in all study locations.

The consistent yearly increase in adoption of biotech corn and number of farmers planting it proves that benefits do accrue to technology users. Similar to the India case, the technology was able to thrive despite the controversy and allegations concerning safety and environmental effects.

Table 4. Biotech corn events in the Philippines

Biotech corn event	Trait	Year approved/renewed
MON810	Insect resistant (IR)	2002/2007
NK603	Herbicide resistant (HT)	2005/2010
Bt11	IR	2005/2010
MON810 x NK603	IR/HT	2005/2010
GA21	HT	2009
Bt11/GA21	IR/HT	2010
MON89034	IR/HT	2010
MON89034 x NK603	IR/HT	2011



Ploughs and pastures, furrows and frowns
Rows of seeds, for miles and miles
A crop, a harvest, to table, and smiles

- CARRIE RICHARDS

2 Research Scenario

Studies have been done on various agricultural technologies, particularly on factors that facilitate or hinder farmer adoption. Most of these studies are based generally on the diffusion of innovation theory espoused by Rogers (1962, 1983).

Theoretical Foundation

Diffusion is regarded as a special type of communication where messages are concerned with new ideas or an innovation introduced into the social system through certain channels over time. It assumes that a mix of mass-mediated and interpersonal communication strategies can move individuals from a process of awareness of the new technology through interest (I), evaluation (E), trial (T), and finally adoption (A) (Figure 1). Mass media's effectiveness increased at the awareness level and declined when used at the adoption stage. The opposite happened with the use of interpersonal communication – where its effectiveness was highest at the adoption stage and lowest at the awareness level.

Government extension workers initiate the process as change agents to influence desirable decisions toward adoption. Farmers are assumed to be rationale enough to see the value of the innovation. However, this model has been criticized as "pro-innovation, pro-persuasion, and top-down" in nature. To complement the diffusion of innovation theory, Bandura (1977) forwarded the social cognitive/influence theory. It states that people learn behavior through observation, modeling, and motivation, such as positive reinforcement. Its four tenets are as follows:

1. People learn by observing others, a process known as vicarious learning, not only through their own direct experiences.
2. Although learning can modify behavior, people do not always apply what they have learned. Individual choice is based on perceived or actual consequences of behavior.

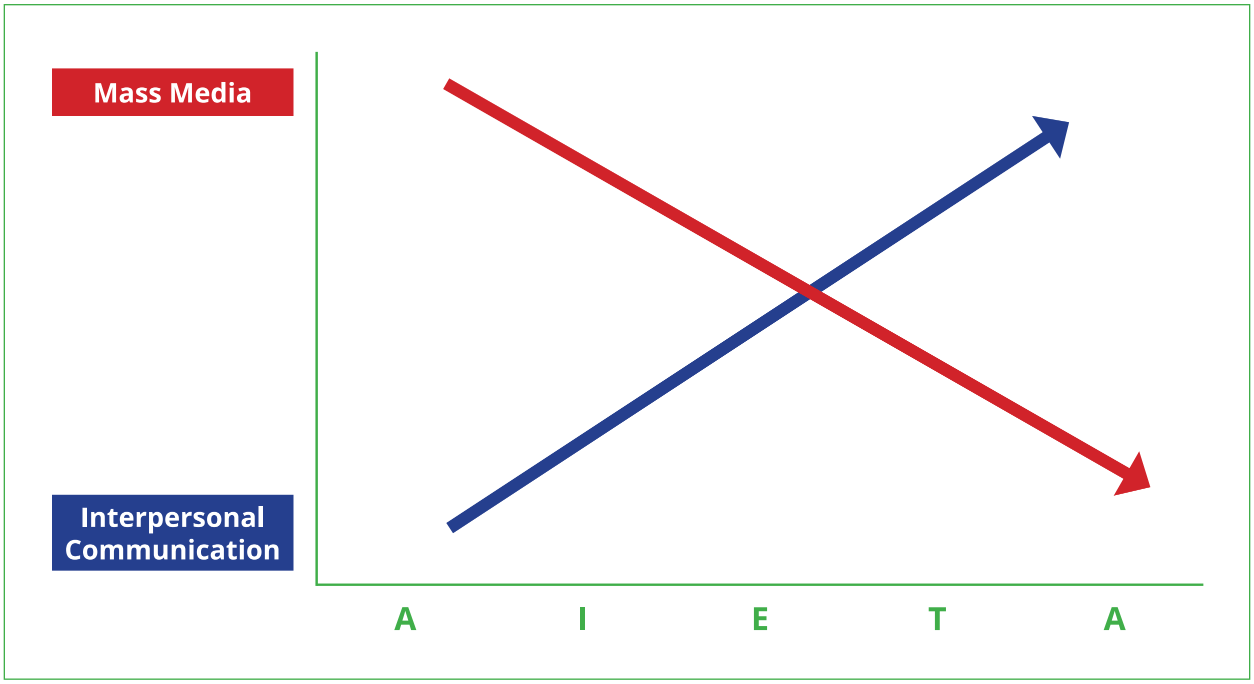


Figure 1. **The diffusion of innovation model (Rogers, 1962)**

3. People are more likely to follow the behavior modeled by someone with whom they can identify. The more the perceived commonalities and/or emotional attachments between the observer and the model, the more likely the observer will learn from the model.
4. The degree of self efficacy that a learner possesses directly affects his/her ability to learn. Self efficacy is a fundamental belief in one's ability to achieve a goal. That is, if one believes that s/he can learn new behavior, s/he will be much more successful in doing so.

The social influence theory likewise explains that people rely on the opinion of others, particularly in situations that are highly uncertain and no objective evidence is readily available.

A synthesis of findings on adoption of other agricultural technologies (groundnut, cassava, sorghum, dairy, and bananas, among others) commissioned by CGIAR (Sechrest el al., 1998) revealed the following:

- Bringing about successful adoption of innovations requires a strategy and specific allocation of responsibility.
- Adoption promotion strategies should include demonstrations of the effectiveness of innovations.
- Reliance on progressive farmers as models may be a useful part of the strategy.
- Strategies of adoption should take into account the fact that both technology and the process of its adoption are dynamic.

Another report produced by the United Nations Environment Program's International Environmental Technology Centre focused on practical methodologies and tools for promoting adoption of sound technologies (IETC, 2003). The following guiding principles,

summarized into seven Cs, were recommended:

- Context – Performance of technology depends on the environment prevailing in a given locale. In any context, technology should be assessed in terms of environmental soundness, economic viability, and social acceptability.
- Challenges – From the supply side to the demand side, barriers are likely to occur and their severity depends on prevailing circumstances.
- Choice – Technology users should be able to make informed choices by being able to identify and procure those which they deem appropriate to their circumstances.
- Certainty – Lack of certainty or consequential high level of risk are major impediments to adoption. Access to sufficient and verified information could help increase certainty and thus negate the perception that a technology is just "emerging" and hence "unproven."
- Communication – It is a requisite for harmonizing the contributions of different players in the adoption process.
- Capacity – Stakeholders and those providing the support system and enabling environment to technology adoption should have the necessary knowledge and skills to perform their tasks.
- Commitment – Where technology transfer failed, there must be a commitment to overcome the challenges and build up the capacity to do so.

Adoption Perspectives

Recent scholars argue that any approach to adoption depends on the kind of perspective that adoption drivers have about the technology users (Melkote and Steeves, 2001). One view that was attributed to "in-the-head socio-psychological factors" may prevent farmers from adopting certain innovations. These include fatalism, familism, religiosity, and lack of deferred gratification. Adoption can only occur once the farmers' traditional mindset is addressed. Another perspective states that non-psychological-based factors hinder adoption. These are external to the farmers and would include lack of financial and material inputs; lack of necessary infrastructure, such as roads, to facilitate marketing of produce; or lack of support services such as irrigation, credit sources, and postharvest facilities (Ascroft, 1973).

Learning from friends was reported to be a strong motivator for adoption (Winter-Nelson, 2012). People who farmers interact with socially would gain information on such topics as using fertilizers, trying new varieties, and installing irrigation system. Similarly, Franz (2010) noted that peer teaching was the preferred learning process by farmers. During the information-gathering stage, a farmer seeks evidence to support his decision, determines the costs and benefits of the decisions, discovers pitfalls of the potential decision, and then decides to adopt or not to adopt. In addition to farmers relying on first-hand information from their peers, they find it rewarding to be of help to their fellow farmers.

Specific to biotechnology, notably that of the use of Bt, adoption is influenced by several factors such as access or bias in the pattern of sharing, assets or ability to invest; incentives such as markets, land tenure; and poor communication among farmers, between farmers and research, extension and R&D institutions (German, 2007). Socio-cultural, technical, environmental, communication and information, according to Scanizzo and Savastano (2010), also affect adoption decisions once farmers are introduced to biotech crops.

Liu and Huang (2013) show that risk preference is statistically important to influence the adoption of biotechnology. Risk-averse smallholders adopted Bt cotton later than did their counterparts.

The present study on the *Adoption and Uptake Pathways of Biotech Crops by Small-Scale, Resource-Poor Asian Farmers: Comparative Studies in China, India, and the Philippines* is a follow-through of a seminal study (Torres et al., 2012) among farmers in selected provinces of Luzon, Philippines. Conducted by the College of Development Communication of the University of the Philippines Los Baños, the study showed that farmers' adoption and uptake pathways were strongly facilitated by peer and kinship system and were based on the shared lifeworld syndrome. Fellow farmers, relatives, and traders significantly influenced them to adopt. Traders provided them the much needed capital and also served as contract buyers of their produce. Another group of actors who influenced adoption consisted of the so-called "ambassadors." Though few in number, they were local farmer leaders who diligently visited farms and villages to introduce biotech corn, attest to its benefits, and offer technical assistance.

The prospect of higher income served as the strongest motivator for adoption. This was complemented by agronomic factors (pest resistance, good quality grains, no pesticide spraying) and social considerations (camaraderie). Being able to obtain loans from the traders and being assured of market outlets further encouraged farmers to adopt biotech corn.

Other reasons for eventually adopting biotech corn are as follows:

- They have fool-proof assurance of high yield and better income.
- Fellow farmers and relatives are already adopting the technology and they would not want to be left behind.
- There are no longer other corn seed varieties available or are being sold by the seed companies, except biotech corn.
- They would not want their farms to be infested by corn borers once all the other adjacent farms are planted to biotech corn that are already resistant to such pests.

The study indicated that uptake was scaled out when the following conditions were present:

- Many farmers were introduced to the technology at the same time.
- Fellow farmers, relatives, neighbors, and friends attested to the benefits of the technology.
- Suppliers of inputs were accessible.
- Loan providers were readily available.

- Market outlets for the produce were assured.

2013 Three-Country Farmer Adoption and Uptake Pathway Study

The basic scope of the 2011 adoption and uptake pathways study was thus expanded to include, in addition to three other provinces in the Philippines, biotech crop-growing areas in China and India. The study was conducted to analyze the dynamics of adoption and uptake pathways of biotech crops among small-scale, resource-poor farmers and the changes these have brought in farmers' lives. Factors must be identified and described thoroughly if improved adoption-diffusion policies, and strategies and expanded production of biotech crops are desired. Bt cotton was the unit of analysis in China and India while for the Philippines, it was biotech corn.

The specific objectives of the study are as follows:

1. Describe the farmer-adopters of biotech crops in terms of their (a) socio-demographic characteristics and (b) farm profile;
2. Analyze the biotech crop adoption patterns in terms of factors considered in adoption:
   - mode of adoption,
   - desire to continue planting biotech corn,
   - awareness of and willingness to plant other biotech crops, and
   - preferred characteristics of future biotech crops.
3. Assess their uptake pathways of biotech crops in terms of:
   - first information received on biotech corn,
   - sources of information,
   - attendance in trainings and workshops,
   - sharing of knowledge on biotech crops,
   - access to facilities and support services, and
   - results of innovation tree analysis.
4. Enumerate the benefits derived from and problems encountered in the adoption of biotech crops;
5. Determine the relationship between farmers' (a) socio-demographic characteristics and mode of adoption; and (b) farm profile and mode of adoption of biotech crops; and
6. Formulate recommendations by which the adoption and uptake pathways of biotech crops among small-scale and resource-poor farmers may be enhanced.

A descriptive research design using surveys and correlational studies was used to find out the nature and prevailing patterns in farmers' socio-demographic characteristics, farm profile, as well as the adoption and uptake pathways of biotech crop adopters. The correlational part determined whether a relationship existed between the socio-demographical characteristics of farmers and their adoption mode, and between their farm profile and adoption mode of biotech crops.

A participatory rural appraisal method called the innovation tree analysis (Van Mele and Zakaria, 2002) was used for the qualitative part of the study. The method enables researchers to determine how adoption of a biotech crop started and spread out in specific communities. It distinguishes various types of adopters and identifies some social, economic, political, and/or cultural factors that influence adoption, contextualization, and/or spread of an innovation. Several of these exercises were undertaken in the different study areas to identify patterns and/or uniqueness of adoption and uptake pathway in particular communities. Modifications were done based on socio-cultural realities in the area.

Attempts were made to interview non-biotech crop adopters but they made up the minority and were difficult to find in the study areas.

Figure 2. Study sites in China

Areas of Study and Respondents

China

Hebei, Shandong, Anhui, and Henan provinces located in the Huang-Huai-Hai cotton production zone were chosen as survey sites since the commercialization of Bt cotton in these areas occurred either in 1997 or 1999, when the crop was first released in the country (Figure 2). In each province, two counties were chosen because of differences in varieties of Bt cotton and cotton area. Four villages in each of the county were then randomly selected. In each village, 20 cotton smallholders were randomly selected based on a household roster. Respondents totaled 483.

Researchers had earlier conducted a similar survey in the sampled counties of Hebei and Shandong as early as 1999. Several waves of surveys until 2012 were conducted in the two provinces and eventually included Henan and Anhui. Sampled farmers were revisited during the series of surveys and a dataset called the China National Cotton Survey was developed. Data collection was done by students and staff from the Center for Chinese Agricultural Policy, Chinese Academy of Sciences and a group of Masters' students from agricultural universities. For the innovation tree pathway, one focus group discussion in one village of each county was organized. Hence, eight focus group discussions were conducted.

India

The cotton-growing states of Maharasthra, Andhra Pradesh, and Punjab were chosen to represent three distinct cotton-growing zones covering irrigated, semi-irrigated and rainfed conditions (Figure 3). A multistage random sampling was followed to select the districts, blocks (in some states called *talukas*) and villages. The survey in each state was facilitated by a coordinator who in turn was assisted by research scouts ranging from 10 to 20. A total of 2,400 farmers became the respondents of the survey.

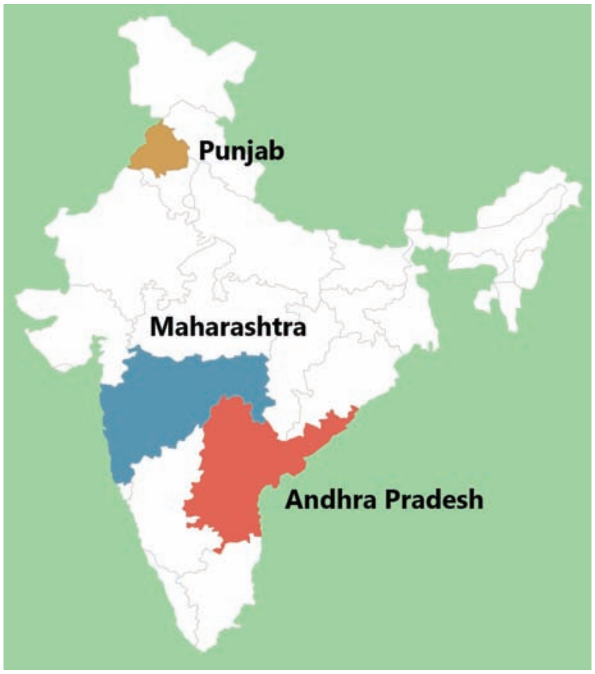


Figure 3. **Study sites in India**

The innovation tree exercise was conducted in two villages each in two districts of Maharashtra with about 20 farmers involved per village. The principal investigator was assisted by two team members from the villages.

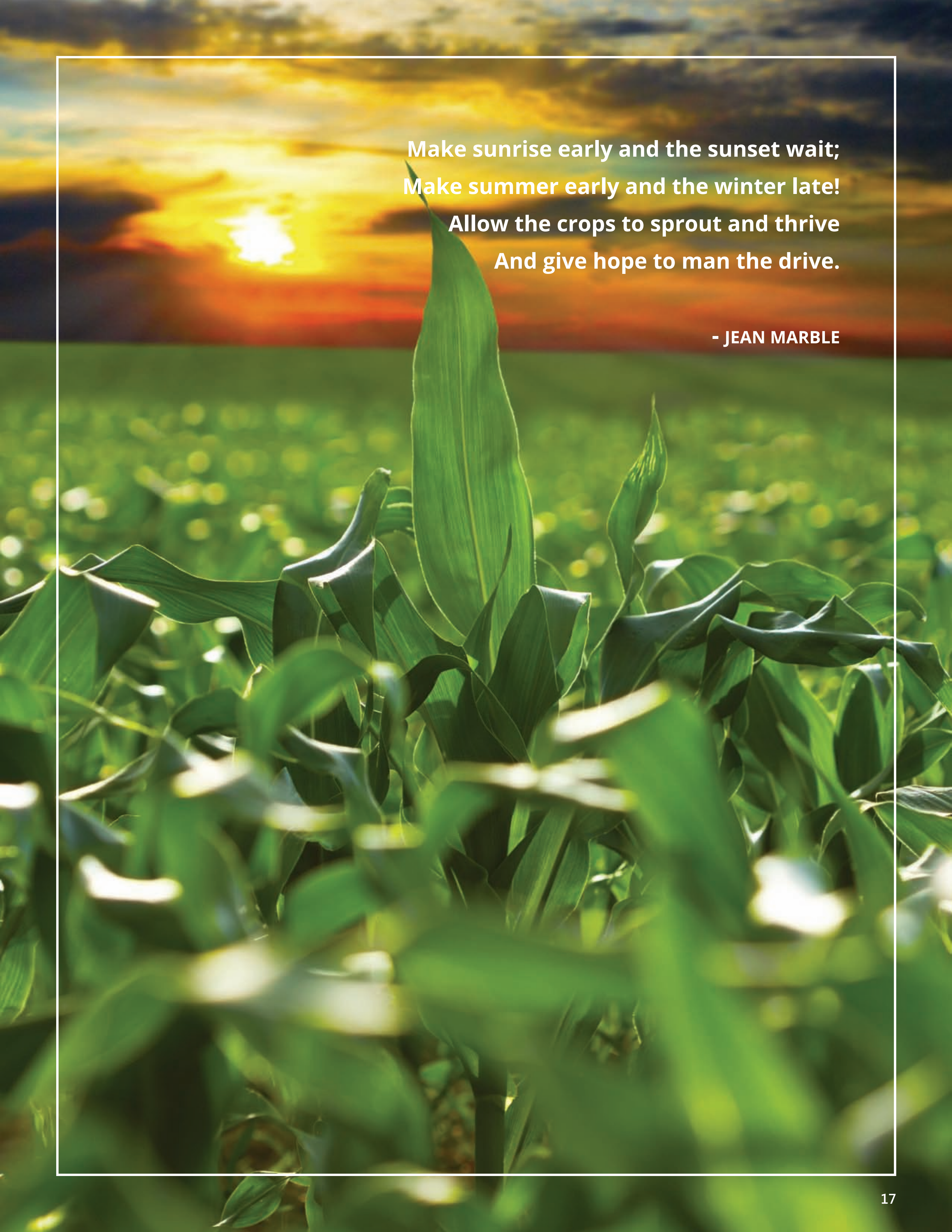
Philippines

Three major corn-producing provinces were selected to represent the major islands of the country: Pampanga in Luzon, Iloilo in the Visayas, and South Cotabato in Mindanao (Figure 4). Multistage sampling was done with the top three to four municipalities per province with the most number of biotech corn farmers. From each municipality, the top three *barangays* (villages) with the most number of biotech corn adopters were identified. The final list of 409 respondents was drawn with the help

Figure 4. **Study sites in the Philippines**

of government extension agents or farmers' associations.

To enrich the discussion, key informant interviews were also conducted with provincial and municipal agriculturists as well as extension workers who accompanied the research team to the field. A number of financiers and/or traders were also interviewed on financial and marketing systems in the area of study. For the innovation tree methodology, exercises were done in eight communities in the study areas with about 10-20 farmer-respondents each.



Make sunrise early and the sunset wait;
Make summer early and the winter late!
Allow the crops to sprout and thrive
And give hope to man the drive.

- JEAN MARBLE

3 Biotech Farmers

Who are the farmers involved in biotech crop production? This chapter profiles biotech farmers from China, India, and the Philippines.

Socio-demographic characteristics were obtained to get a profile of the respondents. In addition, researchers in the three countries included other information to better understand the farmers. Tables 5 to 7 give a glimpse of who these farmers are.

Gender and Family Participation

Married men dominate biotech farming in all three countries. In India, more than 95% of the respondents were male farmers as the work involved plowing, harrowing, planting, applying fertilizers, and spraying pesticides. Males tend to take charge of farm activities that include physical labor and marketing, although women took an active part in farm operations such as weeding, picking, and cleaning. Children had a negligible role in cotton production.

In China, although more males were into cotton farming, a growing feminization in agricultural production was noted. Field work was mainly conducted by women, enabling the men to engage in off-farm jobs. Focus group discussions indicate that the reduction in pesticide use and less labor requirement (otherwise spent for spraying) benefitted women.

In the Philippines, 75.1% of farmer-respondents were male. Land preparation (74.1%) and marketing (71.6%) were their major responsibilities. Although the women's role was mostly in food preparation and budgeting, they were seen to be increasingly getting involved in managerial tasks such as funding farm activities, deciding on inputs, and hiring laborers to work on the farm. There was low involvement of children in the farm activities.

Age

Biotech crop farmers from China and the Philippines were middle-aged and at the peak of their productive years – 40% in China were

Table 5. Characteristics of household heads, families, and farms by province, at the early stage of commercial release of Bt cotton in China

	Hebei	Shandong				Henan			Anhui		
	Bt (n=99)	Total (n=183)	Bt (n=161)	Non-Bt (n=3)	Bt & Non-Bt (n=19)	Total (n=80)	Bt & Non-Bt (n=28)	Non-Bt (n=52)	Total (n=121)	Bt & Non-Bt (n=22)	Non-Bt (n=99)
Age											
30 and below	8.16%	7.65%	8.07%	0	5.26%	16.25%	14.28%	17.31%	5.79%	9.09%	5.05%
31-40	34.69%	28.96%	30.43%	0	21.05%	28.75%	32.14%	26.92%	23.14%	27.27%	22.22%
41-50	41.84%	39.34%	37.88%	33.33%	52.63%	38.75%	39.29%	38.46%	41.32%	54.55%	38.38%
50 and above	15.31%	24.04%	23.60%	66.67%	21.05%	16.25%	14.29%	17.31%	29.75%	9.09%	34.34%
Gender											
(1=male, 0=female)	0.94	0.95	0.94	1.0	1.0	0.96	1.0	0.94	1.0	1.0	1.0
Education attainment											
(year)	8.55	6.91	6.95	5.33	6.79	7.4	7.11	7.58	6.31	6.0	6.37
Attending training program on Bt cotton											
(1=yes, 0=no)	0.46	0.30	0.30	0	0.37	0.24	0.32	0.19	0.12	0.50	0.03
Cadre											
(1=yes, 0=no)	0.06	0.09	0.09	0	0.16	0.10	0.14	0.08	0.14	0.32	0.10
Employment											
Mainly farming (1=yes, 0=no)	0.91	0.89	0.88	1.0	1.0	0.95	0.96	0.94	0.94	0.95	0.94
Family size (person)	4.0	4.0	3.97	4.33	4.16	4.5	4.53	4.48	4.41	4.68	4.35
Farm size (ha)	0.98	0.62	0.59	0.78	0.87	0.65	0.68	0.62	0.47	0.55	0.46
Cotton area (ha)	0.45	0.37	0.34	0.58	0.60	0.61	0.65	0.58	0.30	0.17	0.33

in the 41-50 age range, whereas 52.8% in the Philippines were 41-60 years old. Being in their productive years and having enough experience, Filipino farmers can easily discern "what works and what does not" in their farms. With earlier positive experiences it was easy for them to try the technology. To meet farm requirements, farmers hired laborers to do strenuous manual work. Interestingly, farmers in India tended to be younger, with 53.4% falling within the 21-40 age level. This assures the country of a steady flow of next-generation farmers who will continue to cultivate and be open to modern technology.

Education

In general, majority of the biotech crop farmers had completed at least six years of schooling as in the case of China. India has the highest number of farmers who reached secondary schooling (62%) and college (20%), followed by the Philippines with 43.3% having reached secondary school and 16.4% having gone to or completed college. In India and China, educational attainment was found to be not a strong determinant of biotech adoption, while in the Philippines, biotech corn adopters had higher level of education than their non-biotech counterparts. Chinese farmers had opportunities to attend a training on Bt cotton with some 46% in Hebei alone having

Table 6. Socio-economic profile of cotton farmers in India

Socio-demographic profile	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1,000)	%	Freq (n=1,000)	%	Freq (n=400)	%	Freq (n=2,400)	%
Age								
<20	10	01	20	02	09	02	39	1.6
21-40	500	50	529	53	252	63	1,281	53.4
41-60	421	42	398	40	124	31	943	39.3
>60	69	07	53	05	15	04	137	5.7
Gender								
Male	962	96	950	95	388	97	2,300	95.8
Female	38	04	50	05	12	03	100	4.2
Marital status								
Married	937	94	901	90	393	98	2,231	93
Single	60	06	80	08	05	01	145	6
Widow/ widower	03	71	19	02	02	01	24	1
No. of children								
None	202	20	105	11	24	06	331	13.8
1-2	610	61	513	51	224	56	1,347	56
3-4	180	18	337	34	128	32	645	26.9
>4	08	<1	45	04	24	06	77	3.3
Social category								
General	322	32	484	48	208	52	1,014	42.3
SC	76	08	64	06	44	11	184	7.7
ST	113	11	75	08	16	04	204	8.5
OBC	489	49	377	38	132	33	998	41.5
Educational status								
Illiterate	22	02	Nil	00	08	02	30	1.3
Primary (up to 5th)	25	03	180	18	84	21	289	12
Secondary (up to 10th)	673	67	610	61	216	54	1,499	62.5
Graduate	227	23	191	19	68	17	486	20.2
Post-graduate	53	05	19	02	24	06	96	4
Membership in organization								
Farmer's association	120	12	231	23	101	25	452	18.8
Cooperative	340	34	290	29	107	27	737	30.7
Women's group (SHG)	189	19	250	25	51	13	490	20.4
No membership	351	35	229	23	141	35	721	30.1

Table 7. Socio-demographic characteristics of farmers in the Philippines

Socio-demographic profile	Frequency (n=409)	Percentage
Age		
20 and below	4	1.0
21-40	114	27.9
41-60	216	52.8
61 and above	75	18.3
Subtotal	409	100
Gender		
Male	303	74.1
Female	106	25.9
Subtotal	409	100
Education		
No education	1	0.2
Elementary	146	35.7
High school	177	43.3
College	67	16.4
Vocational	16	3.9
No answer	2	0.5
Subtotal	409	100
Civil status		
Single	38	9.3
Married	348	85.1
Widow/Widower	19	4.6
Separated	4	1.0
Subtotal	409	100
Family size		
None	40	9.7
1 to 3	166	40.6
4 to 6	143	35.0
7 and above	60	14.7
Subtotal	409	100
Organizational affiliation		
Member	272	66.5
Not a member	133	32.5
No answer	4	1.0
Subtotal	409	100

undergone one. Trainings were offered by the village committee, the technology extension bureau, and seed companies. Those who attended a training, particularly those offered by the village committee, were most likely to adopt the technology.

Family size

While earlier studies showed that farm families are big, biotech crop farmers tended to have few children. In India, more than half of the farmers (56%) had only one to two children. In the Philippines, majority of the farmers (40.6%) had, on the average, four children, which was about the same as that in the Chinese household.

Membership in organizations

A large proportion of biotech crop farmers were members of organizations with India registering 79.9% and the Philippines, 66.5%. In India, grassroot organizations played a proactive role in providing farming services to communities. Self-help groups (SHGs) supported by the state governments were common in villages, with cooperatives at the state level being the most functional organization for farmers. Women farmers or wives of farmers actively join in the activities of SHGs, which actually increases the figures for female participation in cotton production. It is also interesting to note that at least 50% of farmers in Punjab and Maharashtra belonged to the "other backward class" (OBC) social category, which is part of the caste system in India.

In the Philippines, most of the respondents were also rice farmers engaged in biotech corn planting during the dry season, hence, they were also members of rice farmers' organizations.

Farming years and variety planted

Farmers in India have been farming for about 10 to 20 years but, on average, they have been involved in Bt cotton planting only for five years (it was introduced in 2002). Hence, these farmers were not new in the game but had extensive farming experience. A large number of Bt cotton hybrids were available in the market but farmers were selective in cultivating a few popular Bt cotton hybrids. A relatively quick turnabout of Bt cotton hybrids was noted due to farmers' preference based on quality and field performance. Majority of the farmers planted hybrids that were produced and marketed by different seed companies.

Bt cotton was commercialized in the four provinces of China between 1997 and 1999. Most of the farmers in China have been planting Bt cotton for more than 5 years when a survey was conducted in 2004. Assuming that they have continued planting Bt cotton since 2004, they would have adopted Bt cotton for more than 10 years. It would seem that biotech crop adoption progressed faster in China and India because almost 100% of farmers in these two countries grow Bt cotton.

Filipino farmers had about 23 years of farming. Bt corn was approved for commercialization in 2002 and about 46.5% had been planting biotech corn for the last 6-10 years. On average, farmers have been planting biotech corn for 6.85 years. Farmers planted a combination of varieties but about 69% of farmers planted stacked-trait (IR/HT) and 53.3% planted herbicide-tolerant (HT) corn in 2012. There has been a significant shift in farmer preference for stacked-trait corn over Bt corn, which was the first biotech crop introduced in the country. It would seem that it took a few years before farmers in India and the Philippines adopted the technology, but once they have positively experienced using the crop, the number of farmer adopters eventually increased over time.

Farm size

Bt cotton farmers in China had an average cultivated land area of only 0.66 ha, which is 0.06 ha larger than the average farm size in the country. Given the share of cotton area to total farm size, cotton farmers in Hebei and Shandong also diversified their production. China's government land policy sets equal distribution of land to rural households.

India and the Philippines had bigger land areas for cultivation. The average farm size for Filipino farmers was 2.7 ha which is consistent with earlier studies (Yorobe and Quicoy, 2006; Torres et al., 2012). Farmers in India had about 2.1 ha for planting their crops. Land- holdings in India did not influence or affect adoption of Bt cotton, indicating that the technology is scale-neutral in nature.

Source of capital and selling of produce

The biotech farmers' source of capital varied significantly across countries with hardly anyone using their savings for farm inputs. In India, 64% of farmers obtained capital from cooperative banks. The rest borrowed money from traders and institutional banks. It is estimated that a few still relied on money lenders and traders such as ginners and input suppliers who offered loans in cash or inputs such as seeds, fertilizers, and pesticides. To pay their loans, farmers sell their produce to them. More than 60% of the farmers sold their produce to ginners and/or traders. Another preferred way to market Bt cotton was through open *mandi* or market where almost 42% of Punjab farmers sold their cotton produce. Many cotton *mandis* have recently been upgraded to handle large quantity of cotton harvest, provide quality checks, and make instantaneous payments. In Maharashtra, however, farmers preferred to sell their cotton to cooperatives to pay off their loans.

Majority of Philippine farmers (54%) obtained loans from individuals they referred to as "financiers." These individuals agree to buy farmers' produce at harvest time. Traders and/or seed suppliers (24.4%) offer the same arrangement as financiers, often providing seeds that the farmers will plant. Farmers

hardly used their own money or savings to finance their farming operations. They felt that having a ready market for their produce through financiers or seed suppliers was the more preferable alternative. This arrangement resulted in traders/financiers getting most of the corn produce (86.5%). Traders would pick up and collect the corn produce from the farms and farmers would immediately get their payment in cash.

Net income

Farmer-respondents planting biotech crops in the three countries reported a significant increase in net income per hectare. Net income of lowland biotech farmers (PhP 20,550/ha or USD 513.75/ha) in the Philippines was twice the amount they used to earn using non-biotech corn varieties. For upland areas where total farm expense was lower, the reported income was PhP 33,630 or USD 834/ha or three times more than what they used to earn (Table 8).

In India, the average net income of Bt cotton farmers was Rs 41,837/ha (USD 804) which was significantly higher than what they used to earn prior to planting biotech crop. Farmers, in Punjab earned as much as Rs 53,139 per hectare where yield was also reported to be highest, along with Andhra Pradesh. Farmers, however, noted annual fluctuations in net income from Bt cotton cultivation due to the volatile market cotton prices even though they

Table 8. **Configuration of net income for lowland and upland farms in the Philippines**

Lowland Farms (At 1 USD = PhP 40)	
Assumptions	
Harvest	6 tons/ha = 6,000 kg/ha
Selling price	PhP 12.50/kg (USD 0.31/kg)
Total sale	**PhP 75,000/ha (USD 1,875)**
Expenses:	
Farm labor	PhP 9,850/ha (USD 246.25)
Farm inputs	PhP 32,400/ha (USD 810)
Others (rental, food, etc.)	PhP 12,200/ha (USD 610)
Total expenses	**PhP 54,450/ha (USD1,361.25)**
Net income	**PhP 20,550/ha** (USD 513.75)
Average farm size	2.7 ha
Total income	**PhP 20,550 (USD1,875)**

Upland Farms (At 1 USD = PhP 40)	
Assumptions	
Harvest	100 cavans/ha = 7,000 kg/ha
Selling price	PhP 11.00/kg (USD 0.30/kg)
Total sale	**PhP 77,000/ha (USD1,925.00)**
Expenses	
Farm labor	PhP 19,770/ha (USD 494.25)
Farm inputs	PhP 23,600/ha (USD 590.00)
Total expenses	**PhP 43,370/ha (USD 1,084.25)**
Net income	**PhP 33,630/ha** (US 513.75)
Average farm size	PhP 2.7 ha
Total income	**PhP 33,630 x 2.7 ha. = PhP 90,801 (USD 2,270.00)**

have remained above the minimum support price during the last few years (Table 9).

Farmers in China earned an average of RMB 4049/ha (USD 667) from growing Bt cotton, considered to be three times that from non-biotech cotton (Table 10). This amount was earned despite the higher production cost of Bt

Table 9. Economics of cotton cultivation in India

Particular	Maharashtra	Andhra Pradesh	Punjab	India
Seed cotton yield (kg/ha)	1,640	1,875	2,086	1,867
Gross income (Rs/ha)	69,405	75,000	88,581	77,562
Cost of cultivation (Rs/ha)	36,520	35,214	35,442	35,725
Net income (Rs/ha)	32,885	39,786	53,139	41,837

*Based on 729 respondents in Maharashtra, 602 in Andhra Pradesh, and 398 in Punjab
**Average cotton price Rs 40 to 42 per kg

Table 10. Revenue and cost (USD/ha) of Bt cotton production across provinces in China, by plot

	Total	Shandong	Hebei	Henan	Anhui
Net revenue	667.3	474.8	634.0	657.4	860.3
Total cost	1300.9	1038.0	1230.0	1313.2	2009.6
Seed	50.2	49.6	42.6	46.3	87.0
Pesticide	78.3	45.5	106.0	75.4	94.4
Labor	752.7	615.7	582.5	822.1	1189.6
Chemical fertilizer	214.8	174.7	229.7	181.6	407.0
Manure	16.3	6.0	22.3	20.1	8.2
Others	188.6	146.5	246.9	167.7	223.4
Number of plots	590	111	125	211	143

cotton, which was found to be four times that of conventional varieties. The cost of seeds was compensated for by using less labor and less pesticide.

Farm expense

In India, Bt cotton farmers spent as much as 64% of total inputs on labor, including farm operation, weeding, and picking. Cost of fertilizers and irrigation was 17%, while Bt cotton seeds and pesticides accounted for 12% and 7%, respectively. With conventional varieties, the cost of pesticides ranked highest (Table 11).

Over 70% of expenses incurred by Filipino biotech corn farmers went to farm labor, farm inputs, irrigation (for lowland farms), rentals, and food expenses. About 60% of the total farm expenses were spent for seeds, fertilizers, and weedicides (Table 12). Financiers provided the latter to farmers as a loan.

Farm labor was higher among cotton farmers in India and China than among Filipino corn farmers because picking of cotton bolls requires more labor hours than harvesting of corn. In China, 58% of total expenses went to labor, followed by chemical fertilizer (17%). Although the price of Bt seeds was about

Table 11. Cost of cultivation of Bt cotton in India

Cost of cultivation	Cost (Rs/ha)		
	MH (%)	AP (%)	PB (%)
Seed	3,633 (9.9)	4,180 (11.9)	5,383 (15.2)
Fertilizers and irrigation	6,090 (16.7)	6,200 (17.6)	5,468 (15.5)
Pesticides	2,168 (5.9)	2,736 (7.8)	2,946 (8.3)
Labor	16,071 (44.0)	10,848 (30.8)	10,172 (28.7)
Picking	8,558 (23.4)	11,250 (31.9)	11,473 (32.4)
Total	36,250 (100)	35,214 (100)	35,442 (100)

*Based on 729 respondents in Maharashtra(MH), 602 in Andhra Pradesh (AP), and 398 in Punjab (PB). Percentage cost of total is given in parenthesis.

four times more than the price of non-Bt cotton seeds (as revealed in the FGD), it was compensated for by spending less on other physical input. (See also Table 10 for expenses related to Bt cotton production.)

Biotech Crop Adoption Patterns

What do farmers consider in adopting a biotech crop? Would they plant other biotech crops in the future?

Reasons for adopting biotech crops

Biotech farmers across the three countries have different and multiple reasons for adopting biotech crops. These include agronomic, economic, and social factors.

Indian farmers considered the crop's agronomic traits critical (Table 13). Majority (86.3%) stated that freedom from bollworm spray was the topmost factor. They recalled their past experiences of frequent cotton crop failures during the 'spray or pray' period before Bt cotton was introduced. The success in bollworm management was also cited as an agronomic push by 79.2% and additional benefits such as the possibility of a second crop (pulses, vegetables and oilseeds), and early, good quality cotton harvest.

Next to agronomic factors, the economic angle was also important. High yield, higher income, and better profit margin stood out as motivations for adoption. The social factors were not as frequently forwarded as reasons for adoption, but it was worth noting that, to farmers who mentioned them, they were inspired or impressed by seeing a demonstration field, witnessing the success of others, and regarding the planting of Bt cotton as a status symbol in the community.

In the case of Filipino biotech corn farmers, economic factors, particularly higher yield and income, were the main driving force for adopting biotech corn (Table 14). Majority (83.4%) enumerated better yield and income as the main reason for adoption. This was followed by availability of financial assistance from financiers, traders, and even seed suppliers (46.9%). Lesser expense (37.7%) was also a major factor for adoption since the use of costly pesticides against corn borers has been practically eliminated. Similarly, availability of biotech corn seeds (32.2%) was an important factor that motivated the farmers to adopt. Crop resistance to pests (48.9%), good product quality (48.4%), and crop resistance to drought were agronomic factors that encouraged farmers to adopt biotech corn. While socio-cultural factors were not a major reason for adoption, there was similarity with Indian farmers in terms of being inspired by

Table 12. Sample farm expenses in biotech corn farming (lowland and upland farms) in the Philippines

Lowland expense items	Amount (PhP)
1. Labor	**9,850 (18%)**
Stable (PhP 2,000/ha)	2,000
Plowing (PhP 400 x 2 times)	800
Harrowing (PhP 400 x 2 times)	800
Planting (PhP 150 x 5 persons)	750
Fertilizer application (PhP 150 x 5 persons x 2 times)	1,500
Harvesting (PhP 4,000 lump sum or "pakyaw")	4,000
2. Irrigation (diesel) PhP 2,000/ha x 3 times	**6,000 (11%)**
3. Rentals	**3,200 (5.5%)**
Thresher (PhP 22/cavan x 100 cavans/ha)	2,200
Hauling (PhP 10/cavan x 100 cavans/ha)	1,000
4. Farm inputs	**32,400 (60%)**
Seeds (PhP 4,200 x 3 bags/ha)	12,600
Fertilizers (PhP 1,200 x 16 bags/ha)	19,200
Weedicides (PhP 600/bottle)	600
5. Food for laborers	**3,000 (5.5%)**
Total	**PhP 54,450 (100%)**
Upland expense items	**Amount (PhP)**
1. Labor	**19,770 (46%)**
Land preparation (PhP 300 x 5 persons x 2 times)	3,000
Weeding (PhP 150 x 3 persons x 2 times)	2,700
Planting (PhP 150 x 5 persons)	750
Fertilizer application (PhP 150 x 10 persons)	1,500
Harvesting (PhP 15/cavan x 100 cavans)	1,500
Drying	6,720
Marketing	3,600
2. Farm inputs	**23,600 (54%)**
Seeds (PhP 4,000 x 2 bags/ha)	8,000
Fertilizers (PhP 1,200 x 11 bags/ha)	13,200
Weedicides (PhP 1,200 x 2 gallons)	2,400
Total	**PhP 43,370 (100%)**

the success of other farmers. A psychological benefit was "peace of mind." Farmers explained this as being able to sleep soundly, knowing that corn borers would not attack their plants and that a good harvest is assured.

In China, the dramatic reduction in pesticide use was a significant reason for adopting Bt cotton. Hebei farmers, for instance, only sprayed pesticide four times in contrast to more than 25 times when planting hybrid cotton. Less labor input and higher yield

Table 13. Factors considered in the adoption of Bt cotton in India

	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Agronomic								
Success in bollworm management	820	82	721	72	362	90	1,903	79.2
Freedom from bollworm spray	891	89	780	78	398	99	2,069	86.3
Reduced spray	732	73	797	80	390	98	1,919	80.0
Early, good-quality cotton harvest	624	62	592	59	176	34	1,392	58.0
Second crop easily possible	788	79	711	71	85	21	1,584	66.0
Economic								
High yield	254	25	525	52	388	97	1,167	48.6
Higher income and better profit margin	377	38	418	42	370	93	1,165	48.6
Cost of seed	209	21	147	15	97	24	447	19.0
Reduced labor and easy picking	238	24	159	16	50	13	445	19.0
Social/Other								
Impressed by demo	326	45	181	22	130	32	637	32.6
Influenced by friend/relative	73	10	174	21	17	04	264	13.5
Witnessed the success of others	240	33	346	42	70	17	656	33.6
Status symbol of growing Bt cotton	361	50	90	11	05	01	456	23.3

*Based on multiple responses

with good quality cotton were other positive factors. Farmers were quick to adopt once the combination of new farming practices and technology proved to lower their cost and increase their yield. Table 15 shows the benefits from adopting Bt cotton in China.

Most biotech farmers in India (76.6%) and the Philippines (93.2%) intend to continue planting biotech crops. Indian farmers were motivated by higher yield and freedom from bollworm infestations, while Filipino farmers were encouraged by the increase in income.

Mode of adoption

Farmers showed different adoption practices. Some adopted the whole technology package recommended for a crop while others partially adopted a few or only specific features. In other cases, certain aspects of the technology were modified to suit their conditions or were adapted based on previous experience. Farmers in India seldom adopted the entire package of practices suggested for Bt cotton because conditions were different from those stated in the recommendations (Table 16). Majority of the farmers (60-80%) in the three states and, on average, 69.2% at the country level modified

Table 14. Factors considered in the adoption of biotech corn in the Philippines

Reason	Frequency (n=409)*	Percentage
a. Economic		
Better yield and income	341	83.4
Availability of financial assistance	192	46.9
Lesser expenses	154	37.7
Availability of seeds	132	32.3
b. Agronomic		
Crop resistance to pests	200	48.9
Good product quality	198	48.4
Crop resistance to drought	99	24.2
c. Socio-cultural		
Inspired by success of other farmers	116	28.4
Camaraderie	39	9.5
d. Psychological		
Peace of mind	102	24.9
No answer	19	4.6

Table 15. Benefits from adopting Bt cotton in China

	Hebei (n=99)	Shandong (n=180)	Henan (n=80)	Anhui (n=51)
Frequency of spraying pesticide (no.)				
In the year of planting Bt cotton	4.7	7.48	9.4	16.59
One year before planting Bt cotton	25.78	29.56	21.75	29.35
Less labor input[a] (%)	97.98	97.22	46.25	16.25
Higher yield[a] (%)	90.91	61.67	36.25	39.22
Good quality[a] (%)	–	–	48.75	19.61
Lower cost[a] (%)	87.88	82.22	80.00	83.82

Note: [a]Multiple responses

their practices to suit their specific conditions. Major modifications had to do with seed rate, spacing, soil testing, irrigation, fertilizer dosage, and pesticide application. Practices regarding land preparation, time of sowing, picking, and weeding generally followed the prescribed recommendations. None of the farmers planted refuge as per the recommendation of the Government of India. Although farmers were given non-Bt cotton packets as part of the packet of Bt cotton seeds to be used as refuge, farmers either disregarded or sold these to local retailers.

In the Philippines, only 3.9% of biotech corn farmers followed the recommended practices (Table 17). It is to be noted, however, that most of the farmers had no opportunity to learn

Table 16. Mode of adoption of Bt cotton farmers in India

Category	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Full package adoption	21	02	79	08	00	00	100	4.2
Partial adoption	122	12	221	22	19	05	362	15.1
Modification by self	744	75	96	60	321	80	1,661	69.2
No answer	113	11	104	10	60	15	277	11.5

Major modifications: Seed rate, spacing, soil testing, irrigation, fertilizer dosages and pesticide application, no refuge and changes in time of sowing
No modifications: Weed management, land preparation, picking

Table 17. Mode of adoption of biotech corn in the Philippines

Type of adoption	Frequency (n=409)	Percentage
Did not follow the technology	260	63.6
Partial adoption of technology	133	32.5
In toto/full adoption	16	3.9
TOTAL	409	100

about the recommendations since they dealt mostly with seed suppliers and traders who were not fully knowledgeable about technical information.

Awareness and willingness to plant other biotech crops

Awareness of other biotech crops in the pipeline was low in India (Table 18) and the Philippines (Table 19). In India, farmers were not aware of other biotech crops being developed or field-tested such as Bt/HT corn, beta-carotene enriched rice (Golden Rice), and Bt rice. Around 28% of them knew something about Bt brinjal. Perhaps due to their interest in cotton as a crop, they were most aware of herbicide-tolerant BG-II RRF cotton. Preferred traits for future crops were pest resistance particularly to sucking pests, disease tolerance, and resistance against weeds.

Farmers in the Philippines had low knowledge about Bt cotton, Bt eggplant, and Golden Rice, which are currently on field trial stage. However, majority were willing to plant Bt eggplant (58.4%) and Golden Rice (57.9%) once these are commercialized in the future. Their good experience with biotech corn is the probable reason why low awareness did not seem to affect farmers' intention to adopt future products. Asked about preferred characteristics of biotech crops that scientists could develop in the future, respondents said they wanted plants with pest resistance, drought resistance, and bigger stems.

Information on biotech crops

The first information that farmers in the Philippines got regarding the technology came from fellow farmers who were often the first adopters (Table 20). About 71.6% of farmers in the Philippines received information about the benefits. They did not get enough information on the features of the new variety or the necessary farming practices. The farmers of these early innovators provided proof of success that convinced their peers and were the basis of success stories that were shared with other farmers in the community. Farmers in turn shared their knowledge about biotech

Table 18. Awareness about other biotech crops and traits in India

Biotech crops	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
BG-II RRF cotton	201	20	304	30	242	61	747	31.1
Bt/HT maize	84	08	114	11	113	29	311	13.0
Bt rice	22	02	169	17	39	10	229	9.4
Bt brinjal	111	11	218	22	339	85	668	27.8
Golden rice	10	01	24	02	38	10	72	3.0

*Multiple responses

Table 19. Awareness of and willingness to plant other biotech crops in the Philippines

Item	Bt Cotton		Bt Eggplant		Golden Rice	
	Freq	%	Freq	%	Freq	%
Awareness						
Aware	40	9.8	51	12.5	54	13.2
Not aware	340	83.1	323	79.0	317	77.5
No answer	29	7.1	35	8.5	38	9.3
Total	409	100	409	100	409	100
Willingness to plant						
Willing to plant	170	41.6	239	58.4	237	57.9
Not willing to plant	80	19.6	80	19.6	77	18.8
Maybe	86	21	55	13.4	62	15.2
No answer	73	17.8	35	8.6	33	8.1
Total	409	100	409	100	409	100

corn mostly with their co-farmers and the rest with relatives. This shows the strong sense of peer system and a shared lifeworld among them. Farmers felt that benefits should be shared with all and not kept among themselves. Table 21 shows the sources of information on biotech crops. Interpersonal sources such as seed suppliers/traders (58.4%), agricultural technicians (38%), and co-farmers (30.3%) were the most dominant means for sharing information.

On the other hand, 30-52% of farmers from India said that they derived primary information on Bt cotton cultivation from input

Table 20. First information on biotech corn in the Philippines

Information	Frequency (n=409)*	Percentage
Benefits	293	71.6
Pest resistance	61	14.9
How to plant	54	13.2
New variety	5	1.2
No answer; could not recall	28	6.8

Table 21. Sources of information on biotech crops in the Philippines

Source	Frequency (n=409)*	Percentage
Interpersonal source		
Seed suppliers/traders	235	58.4
Agricultural technicians	139	34.0
Co-farmers	124	30.3
Agricultural suppliers	47	11.5
Village officials	12	2.9
Media		
TV	28	6.8
Radio	21	5.1
Newspaper	7	1.7
Internet	5	1.2
Cellphone	1	0.2

Table 22. Sources of information on Bt cotton in India

Source	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
Progressive farmers	199	20	322	32	220	55	741	30.9
Input dealers/seed companies	524	52	299	30	135	34	958	40.0
Agri officer (extension)	97	10	146	15	33	08	276	11.5
SAUs/KVKs	55	06	154	15	29	07	238	9.9
Relatives/friends	79	08	59	06	15	04	153	6.4
Media (TV/paper/magazine)	46	04	20	02	08	02	74	3.3

retailers, dealers, and seed companies (Table 22). This was to be expected as these groups actively promote Bt cotton hybrids. About 31% obtained their information on the technology from progressive village farmers with 55% of farmers in Punjab indicating so. Cotton farmers frequently shared information with their peers regarding the performance of Bt cotton hybrids, occurrence and management of pests and diseases in Bt cotton, input management strategies and input cost, and market price-related issues.

Chinese farmers got their initial information abut the technology from different sources (Table 23). Many farmers in Hebei and Shandong attributed their knowledge to the media or village committee. They were convinced by seed companies to start Bt cotton demonstration fields or use their field as seed breeding areas through the village committees. A large proportion of farmers, particularly in Henan and Anhui province (around 40%), gained primary information about the technology from technicians. The information was eventually shared with other farmers. The

Table 23. Source of Bt cotton information in China

Source	Hebei (n=99)	Shandong (n=183)	Henan (n=80)	Anhui (n=121)
Fellow farmers	5.05	21.11	21.05	51.40
Technicians	1.01	2.78	40.35	38.32
Seed suppliers	12.11	20.00	3.51	0
Others, including media and village committees	81.82	56.11	35.09	10.28
Total	**100.0**	**100.0**	**100.0**	**100.0**

role of village cadres in the diffusion of Bt cotton is very important. They coordinated with technicians to arrange trainings and convince farmers to participate in farm-related activities.

There was a relatively small percentage of farmer-respondents in India (11.3% for agricultural officers and 10.9% for other public sector extension services) and in the Philippines (34%) who gained information about biotech crops from government agencies on agriculture. It is obvious that the public institutions tasked with assisting resource-poor farmers do not play a significant role and is not a preferred channel in both countries. Instead, in both countries, farmers sought information from seed suppliers/traders.

Attendance in Trainings/Workshops

Majority of farmers (66.5%) in the Philippines have attended formal training, suggesting the high exposure of farmers to information on biotech crops (Table 24). These trainings were conducted mostly by the private sector that produces and supplies biotech corn seeds (73.2%), followed by 25% represented by government agricultural technicians. Nearly half (48.2%) indicated interest to attend other trainings on biotech corn.

In contrast, farmers in India (68.4%) have not had any opportunity to attend these trainings. Nevertheless, it is worth noting that 87% of Bt cotton farmers in Punjab reported trainings and had visited demonstration plots to learn more about Bt cotton technology. Seed companies, input dealers, and others (including progressive farmers) organized these trainings. Overall, about 70% of the farmers were keen to attend capacity-building activities on new crop technologies (Table 25).

Table 24. Attendance in trainings/workshops in the Philippines

Attendance	Frequency (n=409)	Percentage
Has attended	272	66.5
Has not attended	125	30.6
No answer	12	2.9
TOTAL	409	100

Farmers in China attended some training conducted by the technology extension bureau, seed companies, and village committees. A village committee includes 5-6 village cadres, including the village leader and accountant. Lecturers came from the technology extension bureau or seed companies. Those who did not attend the training programs felt a need to visit a demonstration farm or receive information from fellow farmers first. Nevertheless, farmers who went on to plant Bt cotton without any training relied on their experience with the crop, while others just tried it or sought the help of extension workers on specific concerns.

Table 25. Participation in capacity building activities on Bt cotton technology in India

Capacity building activity	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=800)	%	Freq (n=550)	%	Freq (n=320)	%	Freq (n=1670)	%
Yes/No								
Participated in some event	191	24	86	14	260	87	437	25.7
Not at all participated	609	76	514	86	40	13	1,163	68.4
Organized by								
SAUs/KVKs	144	18	32	05	62	20	238	14.0
Govt depts	15	02	24	04	38	12	77	4.5
Seed companies	337	42	192	32	71	25	600	35.3
Input dealers	204	25	180	30	52	18	436	25.6
Others (including progressive farmers)	100	13	172	29	77	25	349	20.5
Showed interest in capacity building	728	91	276	46	186	62	1,190	70.0

*Nearly 80% of the training conducted before 2005 was provided by seed companies and dealers. Subsequently, SAUs/KVKs and government departments also initiated capacity-building activities on wide adoption of Bt cotton by farmers.

Benefits Derived and Utilization of Income

Increased income was the primary benefit that farmers gained from planting biotech crops. During the 2011 Kharif season, farmers gained an average net income of Rs 41,837 per ha at the national level. Indian farmers gave priority to repaying loans (20.6%), buying home appliances and furniture (16.3%), and spending on house construction or renovation (16%). The purchase of a car or a two-wheel vehicle was also an investment made out of the proceeds of Bt cotton farming (Table 26).

Filipino farmers spent the bulk of their income (78.7%) on meeting day-to-day obligations and as a means to sustain their livelihood after the rice cropping season. They defined income as the amount left when everything else has been deducted from their sales. They also invested in their children's education (60.9%), house repair, and purchase of furniture (46.0%). The appliances included refrigerator, television, and computer. Farmers did not directly pay off the loans as these were automatically deducted from the sales of their harvest by the seed traders who had earlier lent money or advanced farm inputs. It is worth noting, however, that about one-fourth used their income as farm capital knowing that by so doing, they would not pay loan interest (Table 27).

The use of income as farm capital was not a popular response in the Philippines (23.3%). Farmers from India and China were silent about it. When probed on this, farmers in the Philippines said that traders and financiers assure them of their commitment to finance their farming operations. Hence, extra income is used for urgent domestic needs and for items requiring major expenses such as education of their children.

Problems Encountered

Biotech farmers in the three countries shared similar problems related mostly to the

Table 26. Extra income utilization by Bt cotton farmers in India

Items of Investment	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
House construction/ Renovation	129	13	154	15	101	25	384	16.0
Purchase TV/AC/ washing machine, household items	160	16	152	15	79	20	391	16.3
Tractor/farm implements	121	12	126	13	83	21	330	13.8
Car/two wheeler	73	07	98	10	97	24	268	11.2
Purchase of new land	17	02	48	05	04	01	69	2.9
Social commitments such as marriage and education of children	20	02	47	05	20	05	87	3.6
Repayment of loan	280	28	214	21	00	00	494	20.6
No investments made	200	20	161	16	16	04	377	15.7

Table 27. Utilization of income from biotech corn production in the Philippines

Utilization	Frequency (n=409)*	Percentage
Day-to-day expenses	322	78.7
Children's education	249	60.9
House repair and buying home furniture	188	46.0
Farm capital	95	23.3
Vehicle	15	3.7
Leisure	2	0.5

high cost of inputs and incidence of pests and diseases. Constraints such as absence of irrigation facilities (63.5%), high cost of labor (62.1%), lack of quality seeds, and price fluctuations affected farmers from India (Table 28). In Maharasthra, the absence of irrigation facilities was identified as a major constraint, and so were the high cotton price fluctuations and high cost of Bt hybrid seeds. The high cost of labor was mentioned by farmers from Andhra Pradesh as well as seed cost, labor wages, and resurgence of pests and diseases. Cotton market prices continued to be a major issue in all states as prices reached as low as Rs 3,500 per quintal (1 quintal = 100 kg) in 2009 to an all-time high of Rs 6,000 in 2011 and then down to Rs 4,000 per quintal in 2012-13.

For cotton growers in China, labor accounted for most of the input cost as it was more labor-intensive to pick cotton bolls than to harvest corn. Seed supply and lack of information

Table 28. **Constraints in the adoption of Bt cotton in India**

Constraints	Maharashtra		Andhra Pradesh		Punjab		India	
	Freq (n=1000)	%	Freq (n=1000)	%	Freq (n=400)	%	Freq (n=2400)	%
High seed cost	720	72	629	63	279	70	908	37.9
Lack of quality seed	522	52	502	50	150	38	1,174	48.9
Inadequate knowledge	343	34	353	35	89	22	785	32.7
Irrigation facilities	880	88	555	55	90	23	1,525	63.5
Pests/diseases	434	43	320	32	237	59	991	41.3
High cost of labor	555	55	692	69	244	60	1,491	62.1
Price fluctuation	781	78	304	30	87	22	1,172	48.8
Market issues	99	10	52	05	08	02	159	6.6
Lack of government support	752	75	140	14	127	32	1,019	42.5

*Multiple responses

about the technology were also problems faced by farmers.

The occurrence of pests and diseases such as plant hoppers, black bugs, worms, rats, and crickets bothered farmers in the Philippines. They had the misconception that biotech crops were resistant to all kinds of pests, fungi, or bacteria. Hence, at some point, they wondered why they still experienced problems with other pests that attack conventional varieties. Other problems, to a lesser degree, were seeds that did not germinate, the high price of inputs, and the low buying price of corn.

I believe that by my toil I am giving more
to the world than I am taking from it,
an honor that does not come to all men.
I believe that my life will be measured ultimately
by what I have done for my fellowman,
and by this standard I fear no judgment.
I believe in farming because it makes all this possible.

- Excerpts from THE FARMER'S CREED

4 UPTAKE PATHWAYS OF BIOTECH CROPS: Case Studies of Biotech Farmers

To understand and capture the pattern and/or uniqueness of adoption and uptake pathway in specific communities or villages, a series of innovation tree analyses was conducted across the three countries.

This study complements and enriches the survey data obtained through structured interview schedules. Farmers were encouraged to discuss among themselves the dynamics of adoption in their community. To maintain the authenticity of the case studies, this chapter features the process documentation from the country reports with some editorial changes for style consistency.

China

Two categories of focus group discussions were conducted. Five groups composed one category of smallholders who started to adopt Bt cotton within 3 years after initial commercialization in a province. Three groups were in the second category defined as "others."

All the groups were characterized by a rapid diffusion of Bt cotton mainly due to the favorable traits of the crop, its improved adaptation to local agronomic conditions, and other benefits. The good performance of the crop motivated farmers to adopt the technology despite having stopped cultivating conventional cotton for some years due to serious pest infestation.

Seed companies and technology developers (research institutes or biotech companies) conducted Bt cotton field trials and demonstration in cotton-producing regions and sold the initial seeds to farmers. Local public agricultural extension staff or technicians and farmer leaders were invited to these demonstration plots. The presence of these plots encouraged smallholders, notably the progressive farmers, to try the new technology. Farmers were able to visit the plots at different times of the planting season and thus were able to observe plant growth and compare it with conventional varieties. Trainings organized by technology developers and coordinated by village leaders were conducted in some villages. Bt cotton seed generation and setting up of seed purchasing contracts with the seed company were likewise facilitated by the village leaders. This motivated farmers to become the first adopters who eventually facilitated the expansion of Bt cotton in the villages. Farmers from neighboring villages eventually learned about the technology from the initial adopters.

The rapid spread of the technology during the initial years of introduction brought with it some problems, foremost of which was the inability of dealers to provide adequate seeds as demand exceeded supply. Farmers likewise delayed adoption due to limited knowledge about the technology. These barriers were addressed over time.

Dalisi village, Hebei province (Figure 5)

In 1996, some technicians from a local cotton and fiber factory paid a visit to smallholders and showed them demonstration fields in other townships. They were briefed on different production aspects over a period of time – from sowing seeds in nutrient blocks in a nursery to transplanting to harvesting the crop. Participants in the training program were convinced by the better performance of Bt cotton in the field compared with the conventional variety. Smallholders and village cadres also had special concerns on the impact of Bt cotton on other cereal crops because, in Hebei, cotton is rotated with winter wheat and has the same cultivating season as maize.

Farmers were also told that Bt cotton was well adapted to local agronomic conditions. The crop was able to suppress the bollworm population and would not affect the production of winter wheat.

In 1997, the local cotton and fiber industry signed a contract with the village cadres to collect all of the cotton after harvest. Because of risks such as early frost and bollworm infestation that may reduce yield, the industry would compensate for crop loss. The local industry was responsible for supplying Bt cotton seeds to smallholders and guiding them during production, including control of pests other than bollworm. All of the harvested cotton would be sold to them and smallholders were not allowed to save seeds for the next cropping year.

CF Fang, the only seed seller, played an important role in diffusing Bt cotton later in the village. In 1997, he cultivated Bt cotton together with his father WJ Fang. Having seen his family benefiting from Bt cotton, he started to sell the Bt cotton seeds supplied by the local market chain of Monsanto in the village a year later. Meanwhile, he also sold conventional cotton seeds. He started to learn more about Bt cotton and its production, including the quantity of pesticides needed to control cotton aphids and mirids. Acting as part-time technician, he shared his knowledge of Bt cotton to other smallholders who stopped by his shop and helped them choose other farm inputs such as pesticide and chemical fertilizer.

In this village, the leading farmers were not identified because all of the participants started planting Bt cotton in 1997 on a small plot of land. They also cultivated conventional cotton at the same time. Even though the yield of

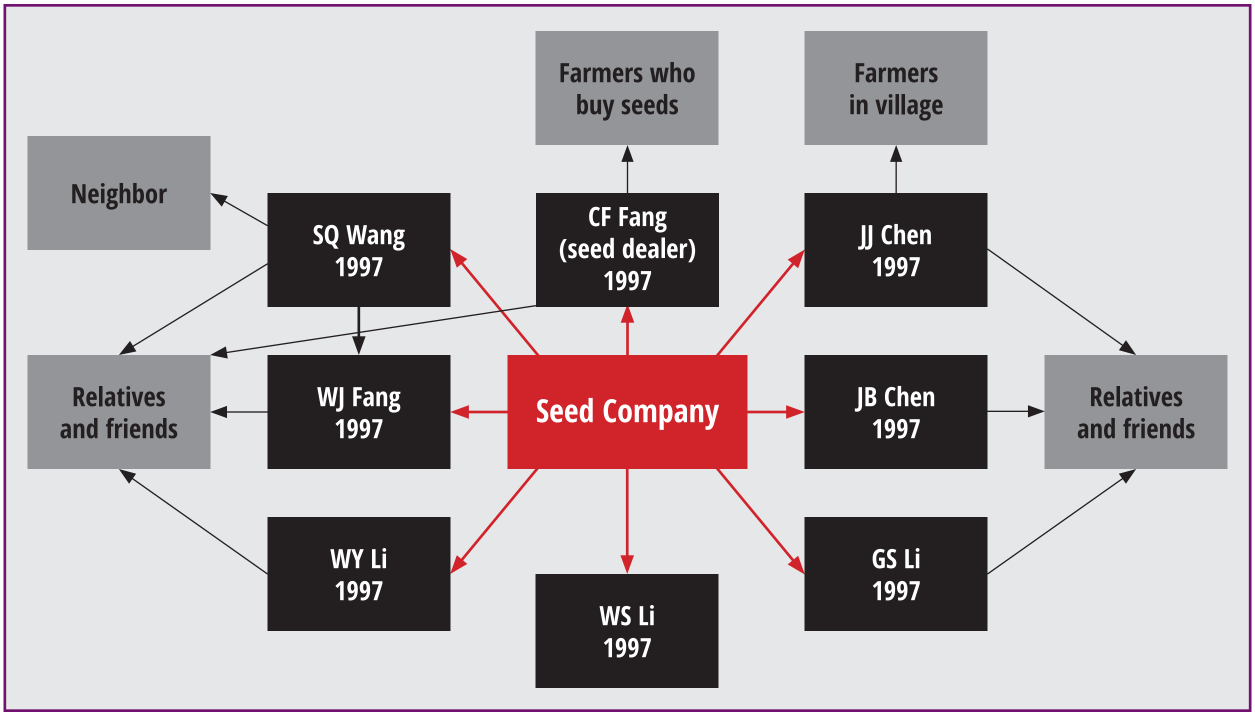


Figure 5. **Uptake pathway of Bt cotton in Dalisi village, Hebei province**

conventional cotton was very low, they were not yet familiar with biotechnology in the beginning, and thus they wanted to reduce production risk using a variety portfolio. Furthermore, during the first year, they could compare the performance of Bt cotton with that of conventional cotton under almost the same agronomic conditions and facing the same natural risks such as bollworm infestation and frost.

The rapid diffusion of Bt cotton in the village happened because all participants were eager to share biotechnology information with fellow farmers in the village, with neighbors, and with relatives outside the local community. They said some fellow farmers or relatives came to their fields to observe plant growth which they themselves did the year before. Bt cotton area doubled in 1998 and kept growing to more than two-thirds of total sown area in this village until 2006.

Dongmuzuo village, Hebei province (Figure 6)

After the introduction of the household responsibility system, equal land use rights were vested in households, but smallholders were requested to fulfill a quota tied with the land (Liu et al., 1998; Huang et al., 2011). The quota could be paid only in kind for a long time but later cash was accepted as well (Sicular, 1996). In this village, cotton is one important crop under the quota system. However, due to serious pest infestation, especially bollworm, all the smallholders stopped cultivating cotton, even though they had to fulfill their quota and had much experience in cotton production. However, at that time, notwithstanding bollworm infestation, smallholders in another village still cultivated conventional cotton before Bt cotton wass introduced in the field.

The source of Bt cotton information was the local seed company. One village cadre, JL

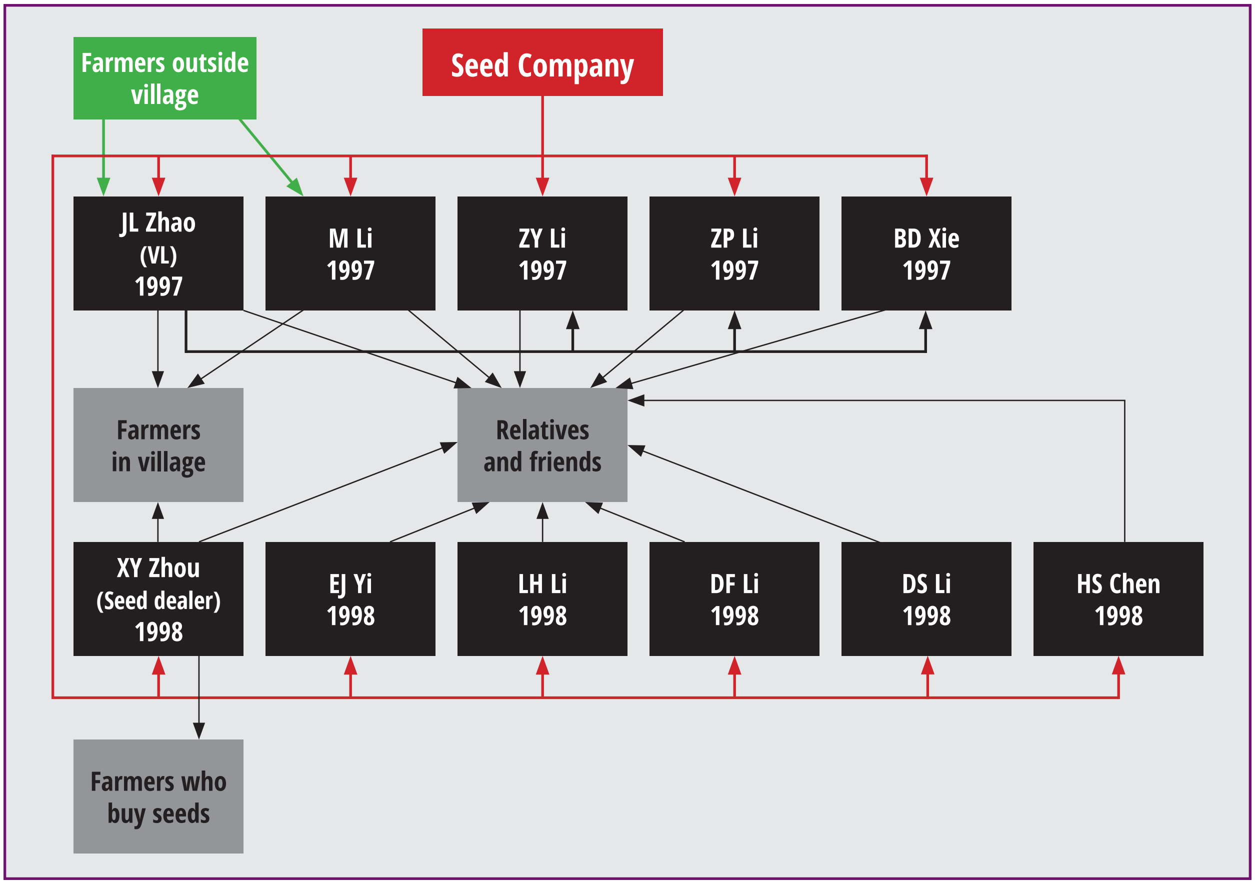


Figure 6. **Uptake pathway of Bt cotton in Dongmuzuo village, Hebei province**

Zhao, and farmer, M Li, were very impressed with the yield of Bt cotton on the demo field and with the enthusiasm expressed by other smallholders who worked on it.

Subsequently, the diffusion pathway of Bt cotton was promoted by village cadres under the constraint of equal land distribution system. In 1997, village cadres representing some farmers signed a breeding seed contract with the local seed company. Under the terms of the contract, a 10-hectare area would be used for breeding Bt cotton seed (actually a trial field). The seed company would buy all the Bt cotton seed at a certain price. The other contract terms dealt with compensation for risks and farmers saving the seeds. Under the current land distribution system, the trial field was divided among farmers in this village. To fulfill the breeding contract, village cadres convinced all of the households that own plots to take part as farmers are free to organize their own agricultural production. The leading farmers were those who owned one or more plots of land on this trial field. They started to cultivate Bt cotton in 1997 together with the village cadres, including JL Zhao.

It took 2 years for all participants in the village to adopt Bt cotton. The introduction of Bt cotton contributed significantly to the resumption of cotton production. Following the farmer leaders, other smallholders started to cultivate Bt cotton after stopping conventional cotton production in the early 1990s.They were motivated by the good performance of

Bt cotton in the trial field and were anxious to adopt Bt cotton after being informed of the benefits and cost of the new crop. All of them said they would not have cultivated cotton if Bt cotton was not offered in the market. They would not take the risk of crop loss in periods of serious pest infestation. Furthermore, they were also afraid that the bollworm on conventional cotton would also cause a negative impact on Bt cotton, suggesting that smallholders had limited knowledge about biotechnology. However, at the beginning of the adoption success, smallholders only cultivated Bt cotton on small plots of land. This is why the share of cotton area to total sown area was still lower than those in other counties at only 8% in 1997 and 17% in 1998.

The seed seller played an important role in the diffusion process. He started to cultivate Bt cotton and sell Bt cotton seed in 1998. He also extended this technology to local farmers and those outside his community through the marketing of seed and other inputs.

Qianhuo village, Shandong province (Figure 7)

It took about 3 years for farmer-respondents to adopt Bt cotton in the two villages located in Shandong province. Local seed companies at county levels were the major stakeholders in extending Bt cotton every year. In 1997, with the help of some village cadres, the seed company started to breed Bt seed in Qianhou village. However, the supply of Bt cotton seed by the local seed company did not meet the demand of smallholders. Some smallholders did not benefit early on because of the unavailability of Bt cotton seed in 1997. In the next 2 years, the local seed company sold Bt cotton seed to other smallholders, including the village cadres and the local seed seller.

However, breeding of seeds was not part of the field trial in this village because the members of the village management committee (*Cunweihui*, in Chinese) did not reach a consensus to organize the trial.[1] As the Chinese micro-level production is well documented, smallholders were able to organize production on their own. In coordinating the field trial, village cadres exerted great efforts to convince all farmers who have land use right to large pieces of land.

Furthermore, village cadres faced much uncertainty with respect to Bt cotton production. As a result, some smallholders, including two village cadres, started the adoption of Bt cotton by breeding seed for the local seed company on the basis of oral agreements. Some village cadres led in the adoption of Bt cotton, while others lagged behind. Based on descriptive statistics at the village level, adoption rate in the third year after initial commercialization was more than 90%. Until then, one village cadre started to cultivate Bt cotton.

When access to Bt cotton seed became a constraint, farmers would save seeds themselves and, to some extent, delay the rapid diffusion of Bt cotton. Smallholder YL Li mentioned that he did not adopt Bt cotton in 1997 because of the limited supply of Bt cotton seed. Despite the agreement not to save seeds for commercial or own use in the following

1 All of the current village cadres in the committee are also those involved in the 1997 survey.

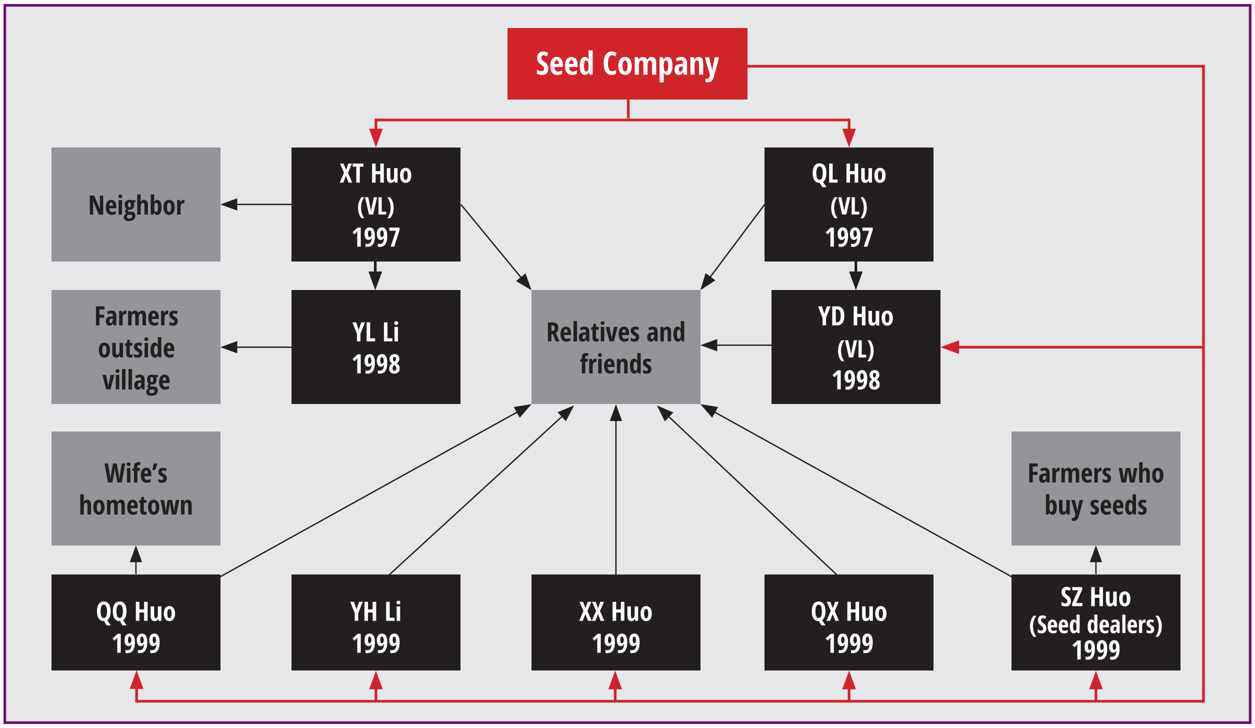


Figure 7. **Uptake pathway of Bt cotton in Qianhuo village, Shandong province**

year, he requested village cadre XT Huo to save some seeds for him. In 1998, he began cultivating Bt cotton. Furthermore, seed seller SZ Huo also had problems with the limited supply of Bt cotton in 1997 and 1998. He wanted to sell Bt cotton in his mini shop, but he could not source the seed either from local or other seed companies. It was not until 1999, that he was able to sell Bt cotton seed and diffuse this technology to fellow farmers.

The farmer-leaders also helped extend Bt cotton to neighbors and relatives, including the families of farmers' wives in or outside the village.

Liuxianzhuang village, Shandong province (Figure 8)

Evidences obtained from this innovation tree analysis were consistent with findings in other villages. The commercial release of Bt cotton in 1997 in Shandong province was based on a secured patent by CAAS. Because seed companies have better marketing chain and professional staff with marketing experience, the institute heavily depended on local seed companies to distribute Bt cotton seed. Unlike that in another village in Shandong province, the seed company located at the county seat organized a demo field with the help of a local technician. In 1997, the seed company first organized a training program for technicians in the township and some villages. The topics included traits of Bt cotton and production method. After the training program, one village technician volunteered to start a demo field in his own plots and asked some neighboring farmers to let him use their plots. The local seed company provided significant technology support to this technician by providing free Bt seed and giving him planting guidelines during the production process. Furthermore, the seed company bought all of the Bt cotton harvest from this technician and other farmers at a price higher than the market price of conventional cotton.

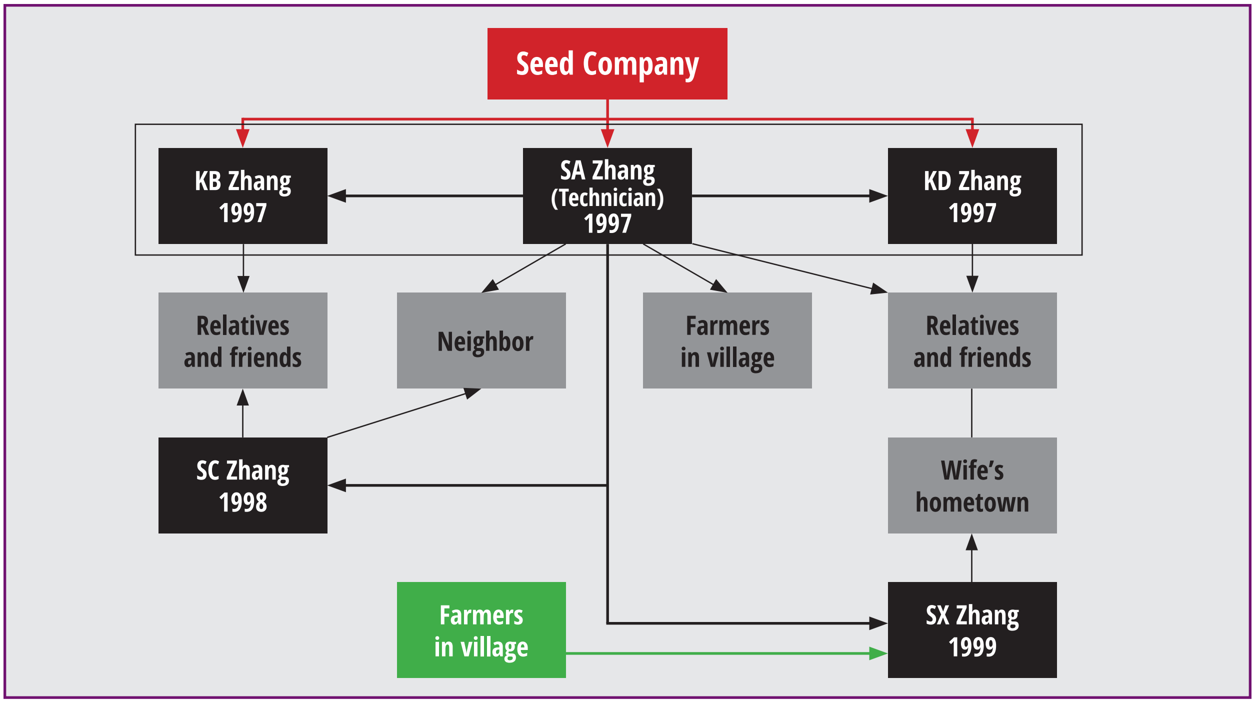


Figure 8. **Uptake pathway of Bt cotton in Liuxianzhuang village, Shandong province**

Even though there are only five participants in the FGD (one village technician and four smallholders), the diffusion pathway explicitly shows that the village technician was the important stakeholder in the diffusion process. All the other smallholders who started to adopt Bt cotton in the succeeding years were somehow influenced by the technician. As Bt cotton was completely new to other farmers, two participants cultivated Bt cotton under the guidance of the technician and the seed company.

Two reasons made Bt cotton adoption a reality. The first is the trust farmers bestowed on the technician who introduced the technology. He has given guidance on production for decades. The second reason is the serious pest infestation that occurred in the village. Chinese smallholders have always tried some new varieties in the market because they think new varieties adapt better to local agronomic conditions. During the first year of adoption, the technician invited other farmers to visit his plots to witness the performance of Bt cotton. Eventually, Bt cotton spread rapidly in the village.

Gonghe village, Henan province (Figure 9)

The initial commercial release of Bt cotton in Henan province was in 1999, but uptake lagged for 2 years. Some farmers obtained information on Bt cotton from farmers in neighboring provinces or from the mass media. In this village, one leading farmer who joined the FGD started cultivating Bt cotton earlier than the others (Figure 9). Even before extension service became available from the local seed company, village-level data showed that adoption rate was more than 50% in 1999. This, to some extent, suggests that the better traits of the biotech crop made farmers adopt it. Furthermore, even though the seed price of Bt cotton is higher than conventional cotton, the farmer decided to cultivate Bt cotton for

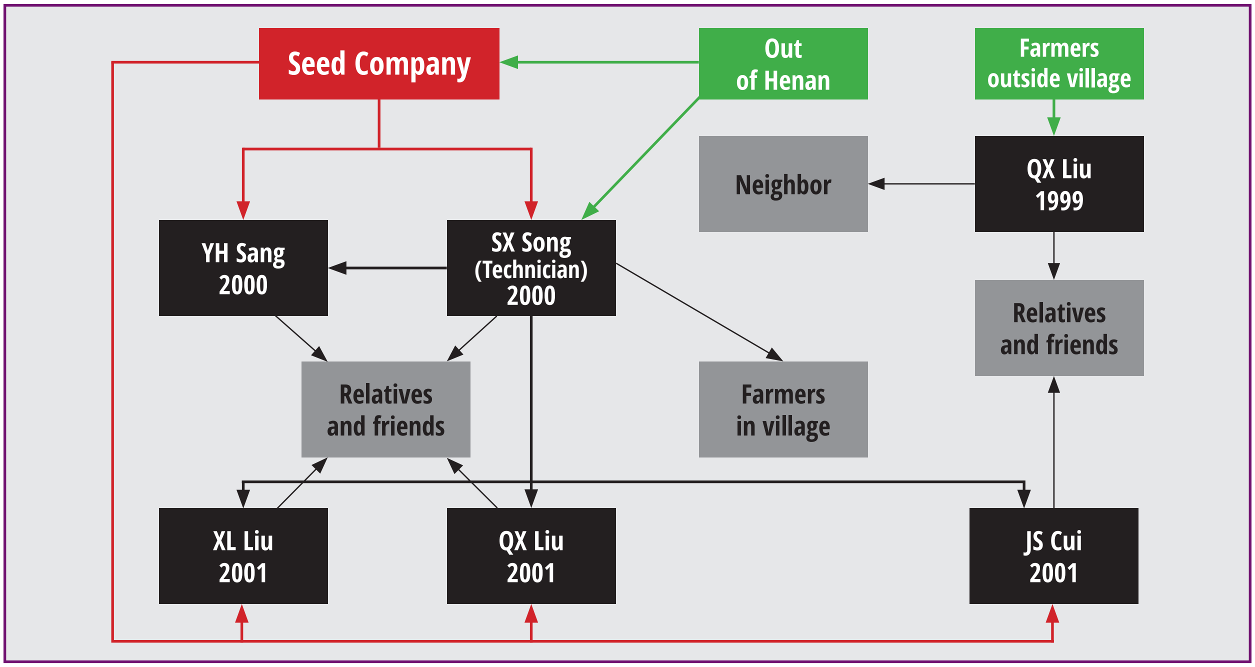


Figure 9. **Uptake pathway of Bt cotton in Gonghe village, Henan province**

the following reasons: first, he heard from other adopters in other provinces that farmers found it easy to sell Bt cotton at the same price as that of conventional cotton. Second, he learned from the newspapers that Bt cotton has traits that would reduce pesticide usage and increase yield unlike conventional cotton. Third, he experienced nausea and headaches after spraying pesticide, so he shifted to one that requires less pesticide. Finally, in his family, he and his wife are the ones working in the field and as they are aging, he wanted a labor-saving technology. In 1999, he bought Bt cotton seed from a neighboring county. During Bt cotton production, he shared his experiences with neighbors and relatives, but none of the participants learned about Bt cotton from him.

In the second year of official commercial release of Bt cotton in Henan province, the local technician obtained information on Bt cotton from two sources: one from the local seed industry and the other from farmers in neighboring provinces. From then on, Bt cotton expanded in the village rapidly, by more than 50% because of the efforts made by the technician and staff from the local seed industry. Their effort in the diffusion of Bt cotton paid off as adoption rate in this village increased to more than 90%. All the FGD participants appreciated the technician's willingness to answer all of their questions concerning production. Furthermore, this technician also helped them choose what Bt cotton variety to use that would suit the local environment. Until the end of 2002, there were five varieties in the market: DP99B from Monsanto and the others, including GK-12 from CAAS.

The following case studies demonstrate why some villages took longer to adopt Bt cotton.

Qianhe village, Henan province (Figure 10)

In this village, two diffusion pathways existed: one was through the technology extension system and the other was through the market chain of seed sellers. The technician from the township played an important role in the diffusion in this village (his hometown). CAAS has had production trials in Taikang county for decades, not only for its GM varieties but also for conventional cotton. The technician (TZ Yao) obtained the cooperation of the technicians working on these production trials as early as the 1980s. He started to work on the production trial in 1995 before the official commercial release and has been learning about production practices of Bt cotton from CAAS for 3 years. Even before the commercial release, he has shared his experience on Bt cotton production with fellow farmers in his home village.

Furthermore, he also managed to employ another farmer, Yao B, from his home village to work on the production trial. Due to the strict biosafety regulatory system, the technician did not save seeds for cultivation on his own plots, even though he knew that Bt cotton had better traits than conventional cotton. In the mid-2000s, with the rapid expansion of Bt cotton, the agricultural bureau at the county level announced on television the production guidelines, made forecasts of pest infestation, and described variations in temperature and wind. The production guidelines included proper timing of pesticide spraying, pesticide, quantity and quality of fertilizer and pesticide, and the prices of cotton seed and cotton.

Farmers without direct instructions from the technician obtained Bt cotton information from seed sellers. Furthermore, fellow farmers, trusting each other, decided to follow the leading farmers. Here, the roles of village cadres were neutral in diffusing Bt cotton

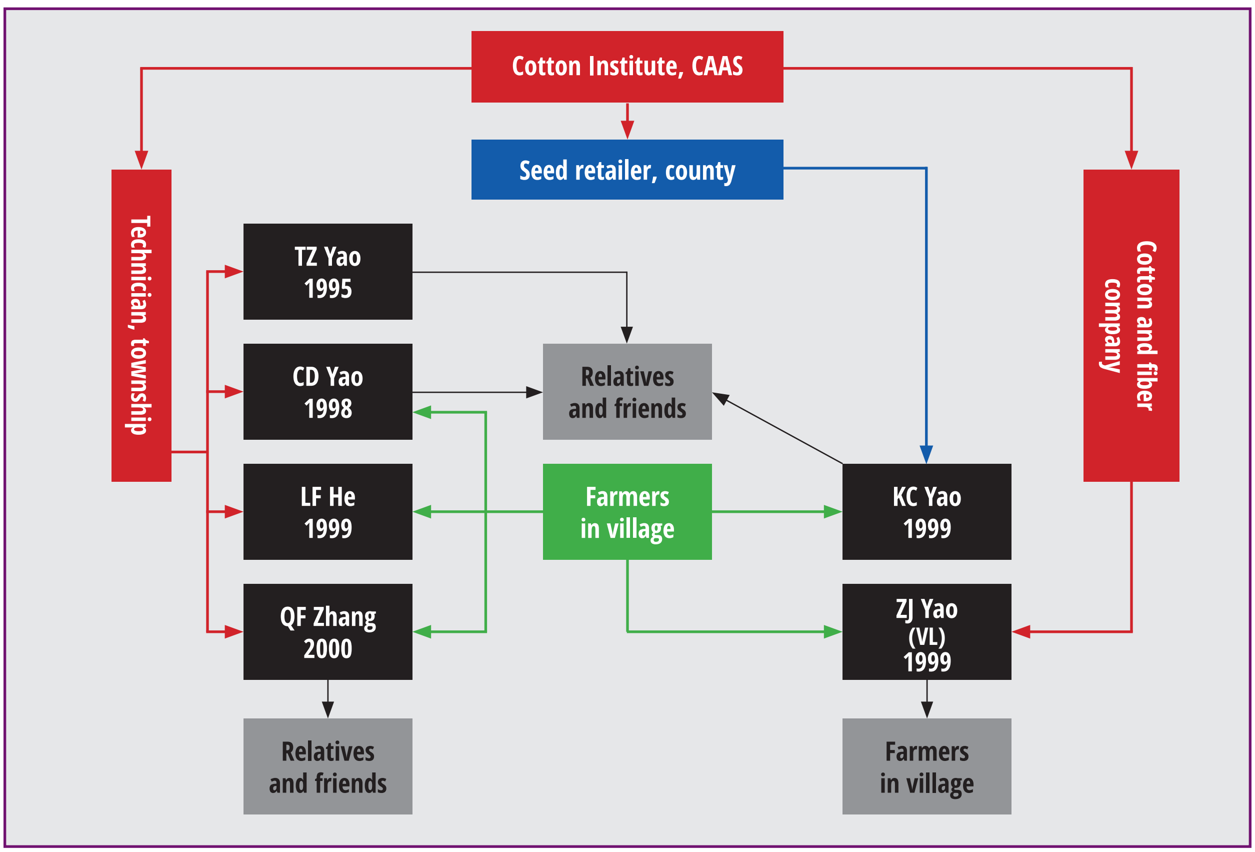


Figure 10. **Uptake pathway of Bt cotton in Qianhe village, Henan province**

and responded in the same way as the other smallholders. For example, the village cadre cultivated Bt cotton in 2000, when two-thirds of the area in this village was planted to Bt cotton. Bt cotton began when a contract to supply cotton to the Cotton and Fiber company at county level was made; this expanded production in 2000.

Because of pest infestations in 1997 and 1998, the share of cotton area to total sown area was reduced by more than 10%, from 50% in 1998 to around 36% in 1999. At that time, Bt cotton was offered in the market. The diffusion pathway explicitly shows that fellow farmers share their experiences and information about Bt cotton within the village. For all the participants in the FGDs, the sources of Bt cotton were diverse – the technician and from other farmers within the village as well. The mechanism of diffusion functioned well to convince smallholders to adopt Bt cotton. The cotton area, mainly driven by the growth of Bt cotton adoption, increased to 6% from 1999 to 2000.

Longtan village, Anhui province (Figure 11)

The commercialization of Bt cotton in Anhui province started in 1997. However, unlike the farmers in Hebei and Shandong provinces, no one adopted Bt cotton in the first year for two reasons. First, the farmers were not able to obtain Bt cotton seed due to limited supply in the market. Bt cotton seed was then only supplied by the institutes; it was not yet made available in the market. Second, without confirmation about the touted traits of Bt cotton, farmers would not take the risk to cultivate Bt cotton as bollworm infestation looms (it was as serious as those in Hebei and Shandong provinces). After the collapse of the technology extension system at the township level, farmers never saw any demo field. Furthermore, at that time, the market strategy of seed companies in these two counties was rather limited and no demo fields were set up for farmers[2].

Again, the availability of Bt cotton seed made adoption of Bt cotton possible. The sources were from the extension station in the township or the seed company in the county seat. In 1998, the farmer-leaders who were willing to cultivate Bt cotton bought seed from seed sellers within the village after learning about the good crop traits from the sellers themselves. Under village cadres in Hebei province, diffusion of Bt cotton was minimal. They were not against leading farmers adopting Bt cotton on their plots in 1998; but they themselves would not take the lead. The village cadre who attended the FGDs only followed suit in 2000 when the adoption rate increased to 50%.

Jiguan village, Anhui province (Figure 12)

The diffusion pathway seen in this village indicated that it takes a decade for all the participants to adopt Bt cotton since its initial commercial release in 1997. The following four reasons could explain the slow adoption: first, the technology extension station only organized one workshop to introduce Bt cotton in this village in 1997. Operating without the help of the village cadres, only a few farmers joined the workshop and many

2 In the late 1990s and early 2000s, the seed company was small, with only a few staff to sell seeds.

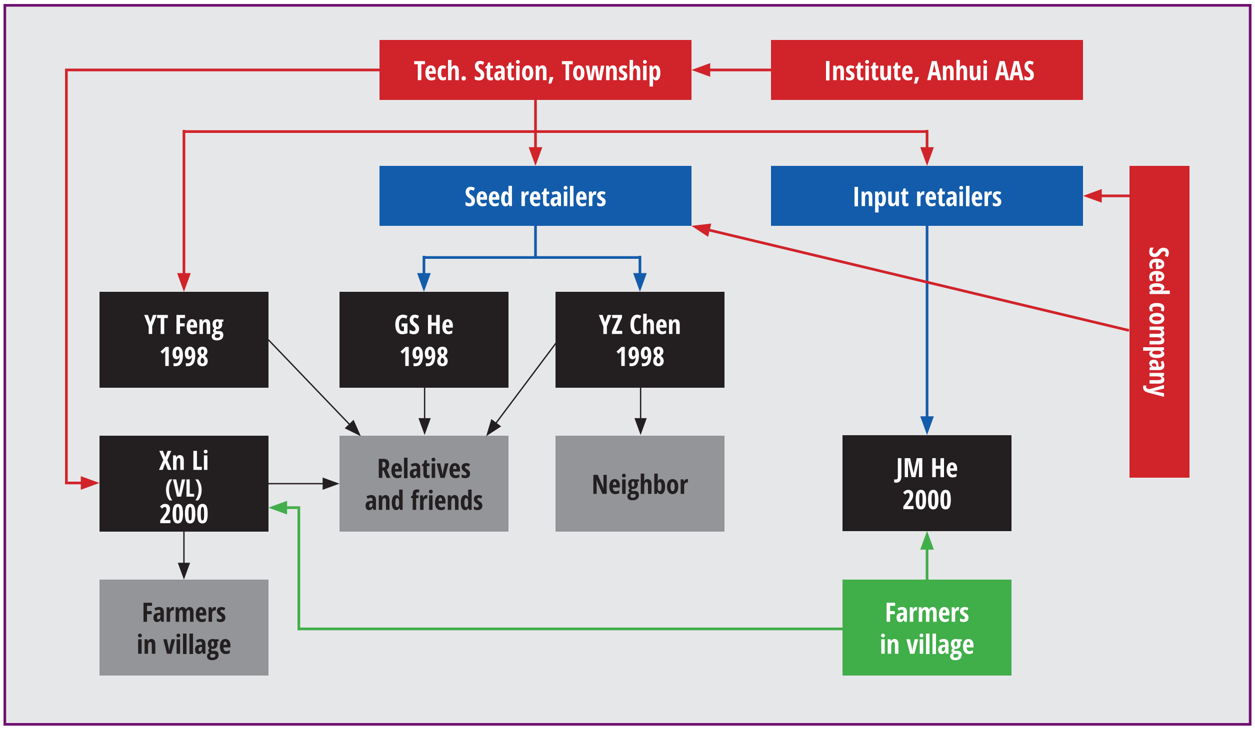


Figure 11. Uptake pathway of Bt cotton in Longtan village, Anhui province

did not understand the advantage of Bt cotton over conventional cotton. Second, Bt cotton seed could only be supplied through the chain of technology extension stations and the supply of Bt cotton seed hardly met the demand in this county. In 2001, when the three varieties developed by Monsanto became available, the shortage in supply of Bt cotton seeds had been addressed. Third, the motivation to adopt Bt cotton was dampened by misleading anecdotes. When news about Bt cotton was announced, farmers perceived the seed to be poisonous just because a gene is modified. This anecdote spread rapidly among smallholders, other cases were fabricated. Furthermore, the local Cotton and Fiber Industry refused to collect Bt cotton. Finally, the price of Bt cotton seed was much higher than that of conventional cotton. Without calculating the cost and benefit of Bt cotton and conventional cotton cultivation, farmers were not willing to grow the new crop.

There is no diffusion pathway among the participants even though both the village cadre and the village technician were involved in the innovation tree exercise. Smallholder WZ Xiao, who cultivated earlier than other participants, was informed about Bt cotton by farmers in neighboring villages and by participants in a workshop organized by technology extension stations in other villages. One year later, village cadre CS Tang and farmer KB Wang also learned about Bt cotton from a similar workshop and started to cultivate it. After 2000, the introduction of Bt varieties was accelerated and seed sellers in the village were able to supply Bt cotton seed from a county-based seed company. After a decade of almost 100% adoption rate of Bt cotton, the village technician started cultivating Bt cotton. If a technician does not understand the concepts in spite of being trained well, his role in diffusing biotechnology within a community is very limited.

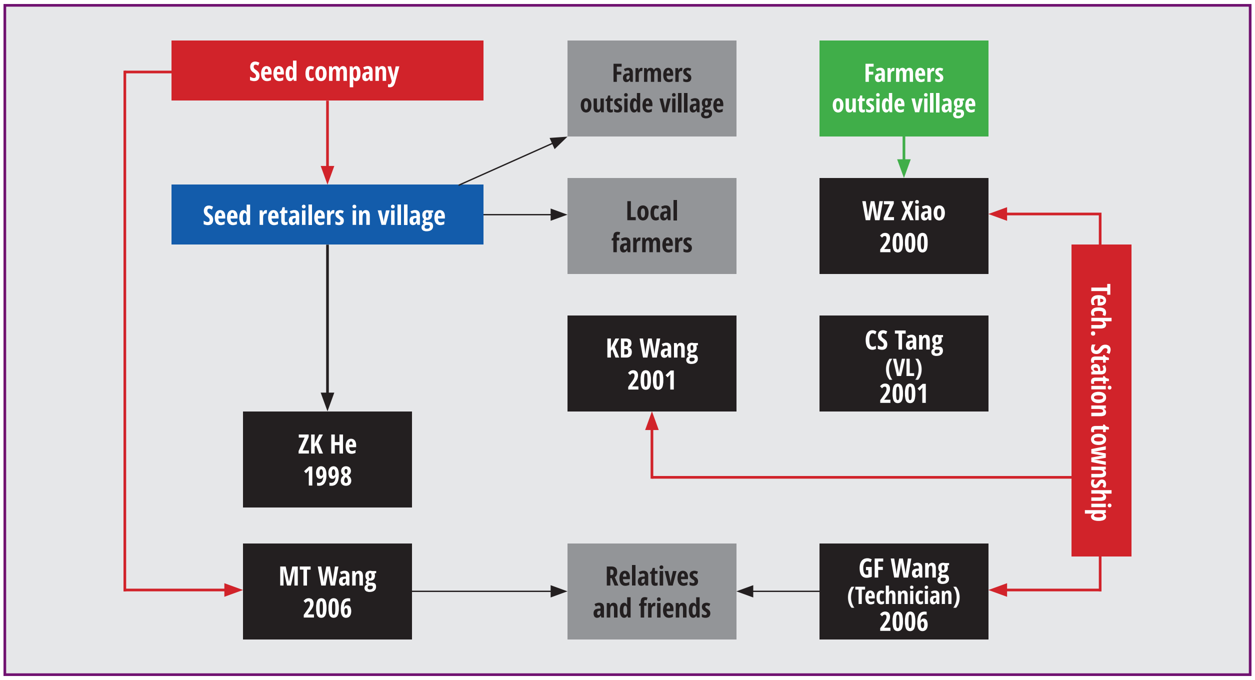


Figure 12. **Uptake pathway of Bt cotton in Jiguan village, Anhui province**

Farmers' decision to adopt Bt cotton was influenced by the attitude of village cadres and the technician. The attitude of village cadres toward Bt cotton was regarded neutral because they did not help the technology extension station to organize the training workshop in this village. However, they did not say no either. After attending the workshop, they themselves did not cultivate Bt cotton. Even until 2001, when the village cadre started to cultivate Bt cotton, he did not share his experiences with others. The attitudes of the village cadres and the technician made farmers doubtful of the merits of Bt cotton. Without the annual training workshops, the diffusion of Bt cotton took longer.

India

Two innovation tree exercises were done: one at Buldhana and the other at Akola, both in the district of Maharashtra. The two models showed the effectiveness of field demonstrations in disseminating information about new agricultural practices. Playing critical roles in the process were the progressive and risk- taking farmers, along with the institutional support of a private seed company, Mahyco. These farmers helped organize demonstrations and field days, mobilized fellow farmers, and disseminated Bt technology through the local media.

Mahyco, well known to farmers as a seed company that produces hybrid seeds of cotton, sorghum, pearl millet and vegetables, led the conduct of field trials and demonstrations of Bt hybrids in the cotton-growing districts in Maharashtra. In contrast to the green revolution technologies in wheat and rice, which were primarily supported by public-funded institutions in the seventies, the countrywide dissemination of Bt cotton was done by the private sector.

Also playing an important role was the network of dealers, distributors, and retailers of

companies who were known in the village. They mobilized farmers to see the demonstration farms on Bt cotton, popularized the technology using local languages, and conducted a series of trainings and workshops. Figure 13 shows the diagrammatic representation of adoption and uptake pattern in the two districts.

By 2005 (about 3 years after Bt cotton was introduced), local government officials, SAUs, and KVKs got involved in technology dissemination. The KVK or the Krishi Vigyan Kendra is a network of agricultural extension centers located in each of the 650 districts in India. It is run by the Indian Council of Agricultural Research. The SAUs are the state agricultural universities engaged in teaching and doing research in agriculture. Adoption level on a large scale in areas across different villages significantly increased at this stage. Other popular seed companies (Rasi Seeds, Ankur Seeds, and Nuziveedu Seeds) helped disseminate the technology faster by making available new hybrids in 2007-08. They also organized large-scale demonstrations of Bt cotton and disseminated information through a large network of technical personnel, distributors, dealers, and retailers. By this time, the technology has spread to a wider section of rural India.

The cooperatives and traders, particularly the cotton ginners, provided capital for Bt cotton cultivation in the early years and also helped disseminate the technology.

Several factors influenced the adoption and uptake pathways of Bt cotton. These were:

- Assurance of successful management of bollworm infestation
- Freedom from chemical sprays
- Assurance of high yield
- Reduced cost of production
- Choice of different Bt cotton hybrids
- Early harvesting and higher return
- Possibilities of successive crops
- Competition with fellow farmers to enhance yield, and
- Assured market support price; often, high market price for cotton

On the other hand, late adopters took a few years before they tried the technology. These farmers were influenced by older farmers who did not support the technology. They initially thought Bt cotton seeds were expensive.

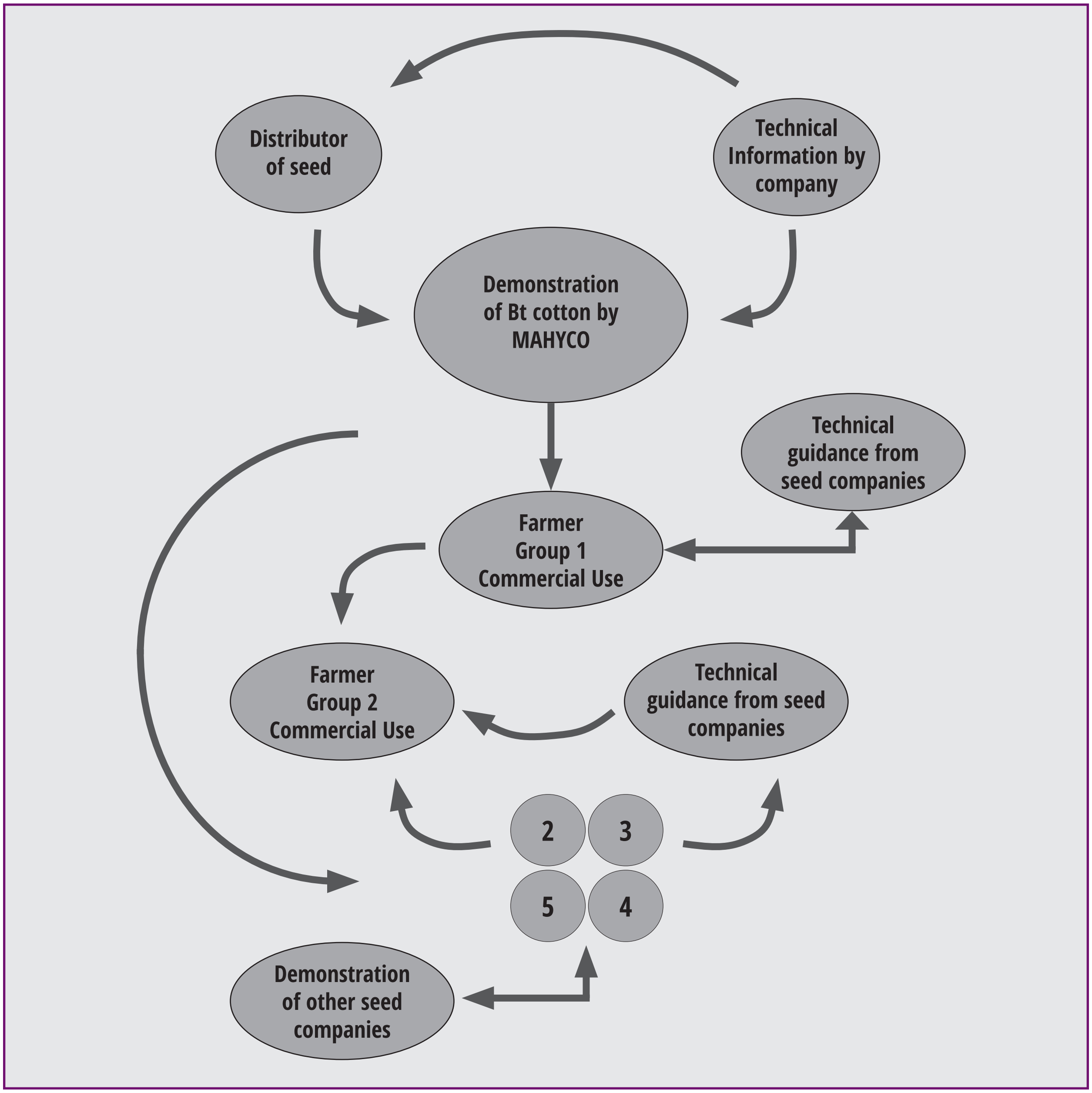


Figure 13. **Uptake pathway of the adoption of Bt cotton among farmers in India**

They also thought they did not have the capital to buy them. The technology was perceived to have been introduced mostly for large-scale farmers. Lack of access to accurate information on how Bt cotton controls bollworm was also cited as a reason for non-adoption.

Buldhana District Cluster Formation, Maharashtra

Figure 14 depicts the process by which a large cluster of farmers started to plant Bt cotton in Buldhana district. Farmer Motiram Navle dared to plant the first plot of Bt cotton in his village

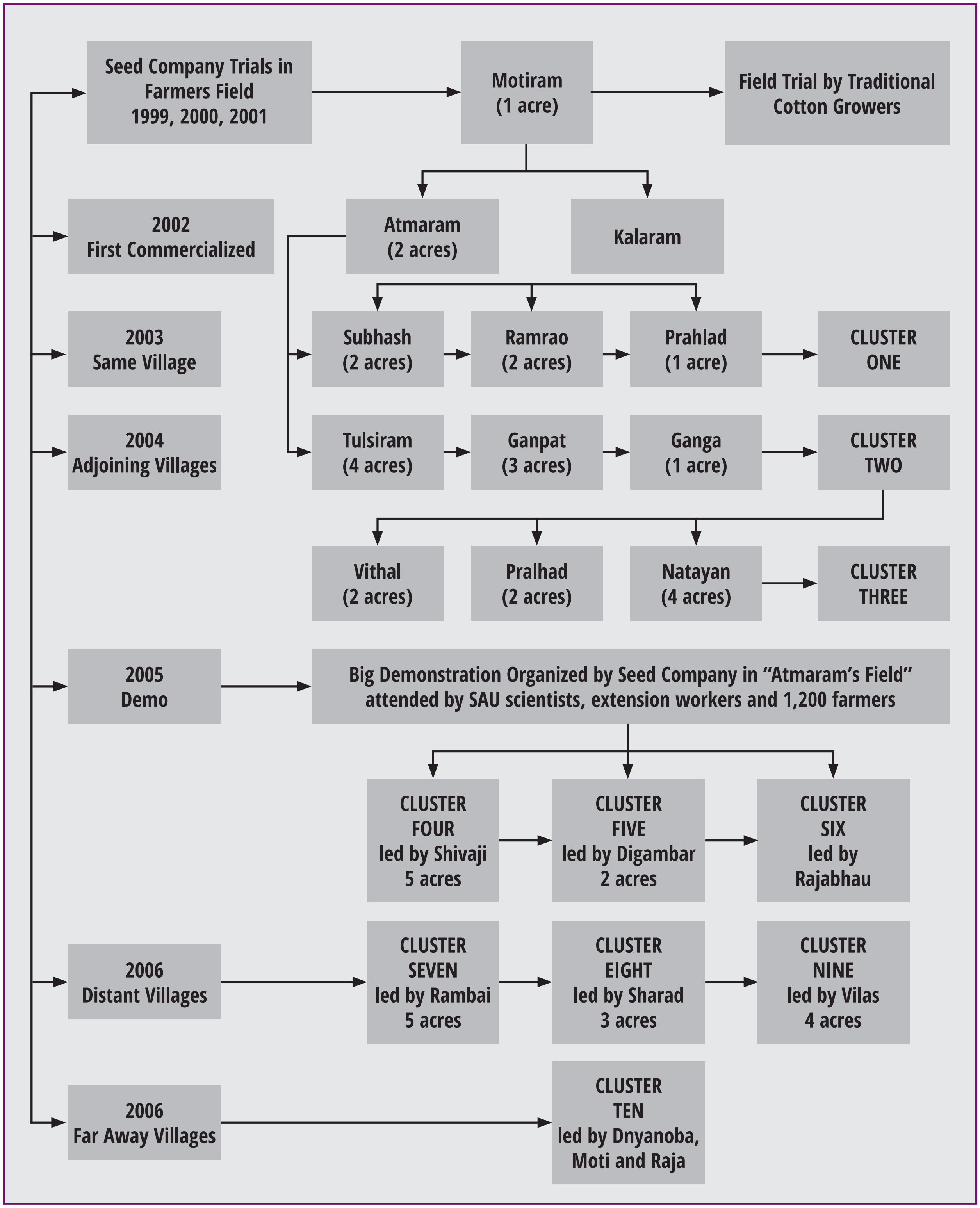


Figure 14. Uptake pathway of Bt cotton among farmers of Buldhana District, Maharashtra

or probably in the whole area. He engaged in Bt cotton trials on his farm on behalf of Mahyco in 2001 in his village (S. Kherda, located 70 km from Jalna, the headquarters of Mahyco). In 2002, Navle planted commercial Bt cotton on 1 acre of land after a satisfactory field testing. His son Atmaram was convinced and grew Bt cotton on 2 acres in 2003, but his other son, Kalaram, did not take up cultivation. From a 0.25 acres of experimental plot, Atmaram harvested nearly 4 quintals of seed cotton, which he used to get from 1 acre in the past.

In 2004, farmers Subhash, Ramrao, and Prahlad heard of Bt cotton and decided to cultivate Bt cotton in a nearby village. This became Cluster 1.

Farmer Atmaram's success induced farmers Tulsiram, Ganpat and Ganga to grow Bt cotton on 1 acre each in 2004 in the same village. This became Cluster 2. Inspired by the success of Atmaram, a new cluster in another village was formed with three additional farmers planting Bt cotton. This became Cluster 3.

At this juncture, other vigilant farmers could count the 9+1 farmers growing Bt cotton in three villages within a 10-km radius. In 2005, a large-scale demonstration of Bt cotton growing was organized by the seed company. This was attended by farmers, government extension personnel, SAUs, and KVKs. The demonstration underscored the legitimacy of Bt cotton and therefore adoption became widespread in nearby areas in 2005.

Clusters 4 to 6 were large clusters with lead farmers in all three villages (nearly 15-20 farmers chose to grow Bt cotton in 2005). In 2006, the new clusters in the block were evident, with additional 25 to 50 cotton farmers operating in different villages. Additionally, farmers in all clusters continued to cultivate and expand the area planted to Bt cotton year after year. This increased total Bt cotton area in the respective clusters. By 2006, a large

number of farmers and fields across several villages were growing Bt cotton, resulting in the formation of a districtwise cluster of Bt cotton in Buldhana.

Adoption was slow in the first 2-3 years as majority of the farmers were cautious and sometimes skeptical about cotton and Bt technology. At that stage, farmers around the village were observant and vigilant. They did not want to make any decision to grow Bt cotton in haste before getting first-hand results from the fields of the risk-taking farmers. In this case, the "seeing is believing" paradigm was followed. In 2005, a massive demonstration of Bt cotton was held and participated in by government officials which generated immense interest among Bt cotton farmers in and around the village. Farmer Atmaram shared his jubilation by welcoming his relatives from other villages to his Bt cotton farm.

This exercise confirmed the general hypothesis that technology adoption is driven by risk-taking farmers and followed by risk-averse farmers. Demonstration plots (seeing is believing) in farmers' fields and experiences (doing is knowing) of risk taking farmers were two vital components of a nationwide strategy to adopt and establish uptake pathways for Bt cotton in the country.

Akola District Village Hub Model

Like Atmaram, farmer Vijay Ingle of Chitalwadi village of Akola conducted the first field trial cum demonstration of Bt cotton of Mahyco in 2001, against the advice of his family, relatives, and fellow farmers. After being convinced of the results of the Bt cotton trial, he was the first to buy Bt cotton seeds and plant the crop on 2 acres of plot in the first year of commercialization of Bt cotton in 2002.

In 2003, Bt cotton technology spread to all corners of Chitalwadi village. Vijay's friends who regard him as a progressive and risk-taking farmer were the first to heed his advice and planted Bt cotton too. Farmers Pappu and Bhima planted Bt cotton on the east side area while farmers Baba, Bhiku, Sakhu and Sairam grew the crop in the west. Farmer Waman cultivated Bt cotton in the south of the village.

Subsequently, an additional five farmers (with more than 5-10 acres of land) planted Bt cotton. By 2005, a few more took up cultivation of Bt cotton in the village, and, by 2006, several of them adopted the technology in Chitalwadi village.

Additionally, the local media who projected Vijay Atmaram Ingle as the "architect" of Bt cotton, triggered the rapid adoption of Bt cotton technology in his village. Farmer Vijay was recognized and awarded by the government for having the highest cotton yield during the early years of adoption of Bt cotton. These events resulted in faster dissemination of Bt cotton in his village. Interestingly, farmer Vijay organized a large demonstration celebrating the 10th "Bt cotton birthday" in his village, which was attended not only by local farmers but also by a large number of government officials, media, and companies supplying seeds and irrigation equipment. He demonstrated to fellow farmers the power of technology by harvesting the highest yield (25 quintals per acre) with the help of Bt cotton

hybrids and a new and evolving method of drip irrigation. In 2011-12, around 125 farmers representing the majority of farmers of Chitalwadi village grew Bt cotton hybrids produced by different companies.

Figure 15 illustrates the formation of a village hub of Bt cotton adoption and the chain of uptake pathways.

Philippines

Innovation tree exercises were conducted in eight villages of the three provinces of Pampanga, Iloilo, and South Cotabato. Figure 16 is a summary of how adoption of biotech corn was scaled up using observed patterns across the study areas. The crop was introduced to farmers by technicians from multinational seed companies. These farmers were initial cooperators in demonstration farms, while the technicians conducted seminars on the crop and its benefits. Those who participated in the demo farm activities and seminars eventually adopted the technology and influenced other farmers within and outside their communities to adopt as well.

Local traders who were also financiers or seed retailers had direct influence on the farmers' decision to adopt Bt corn. Farmers relied on them for capital and initial farm inputs. The

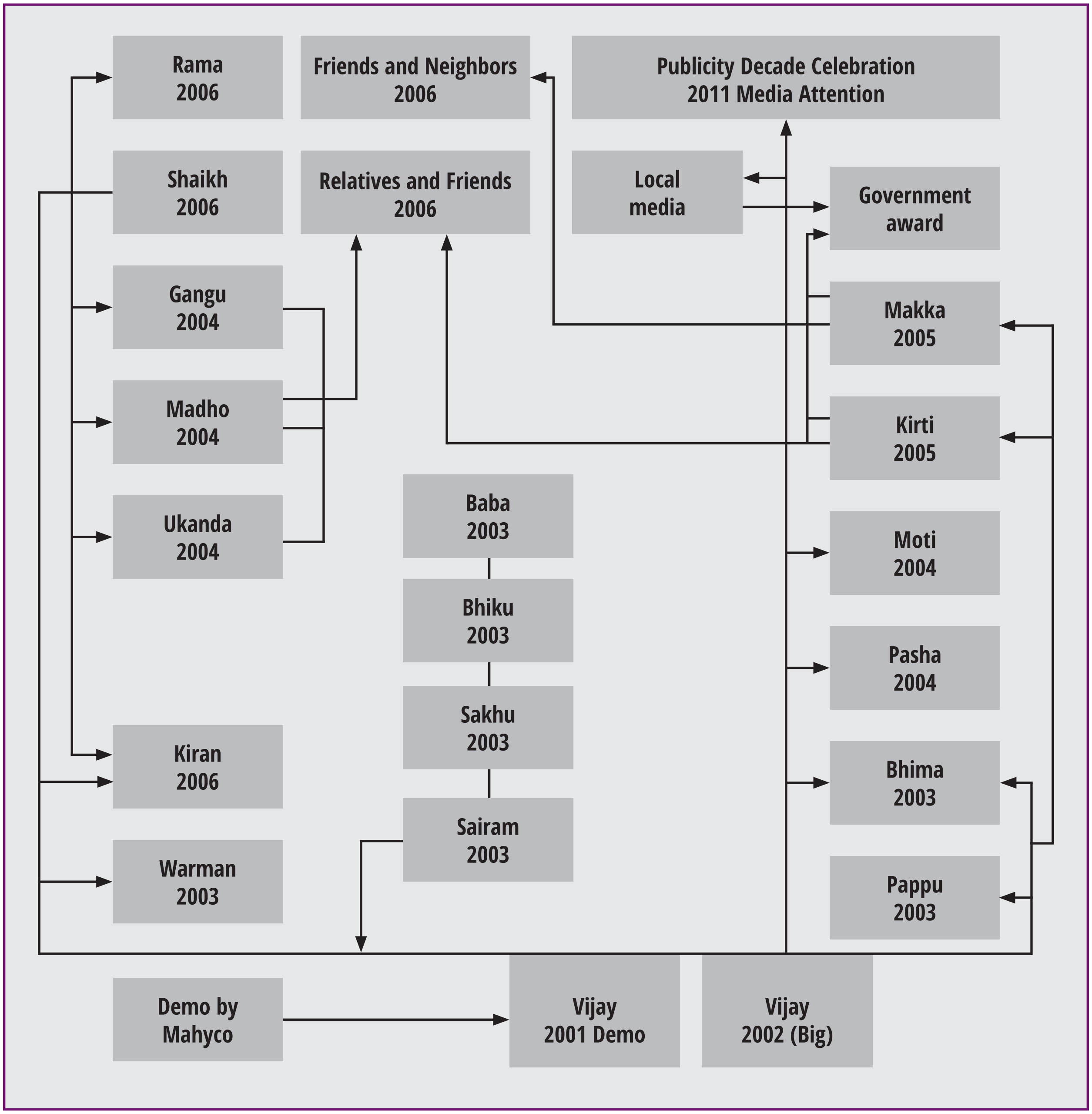


Figure 15. Uptake pathway of Bt cotton among farmers of Akola District, Maharashtra

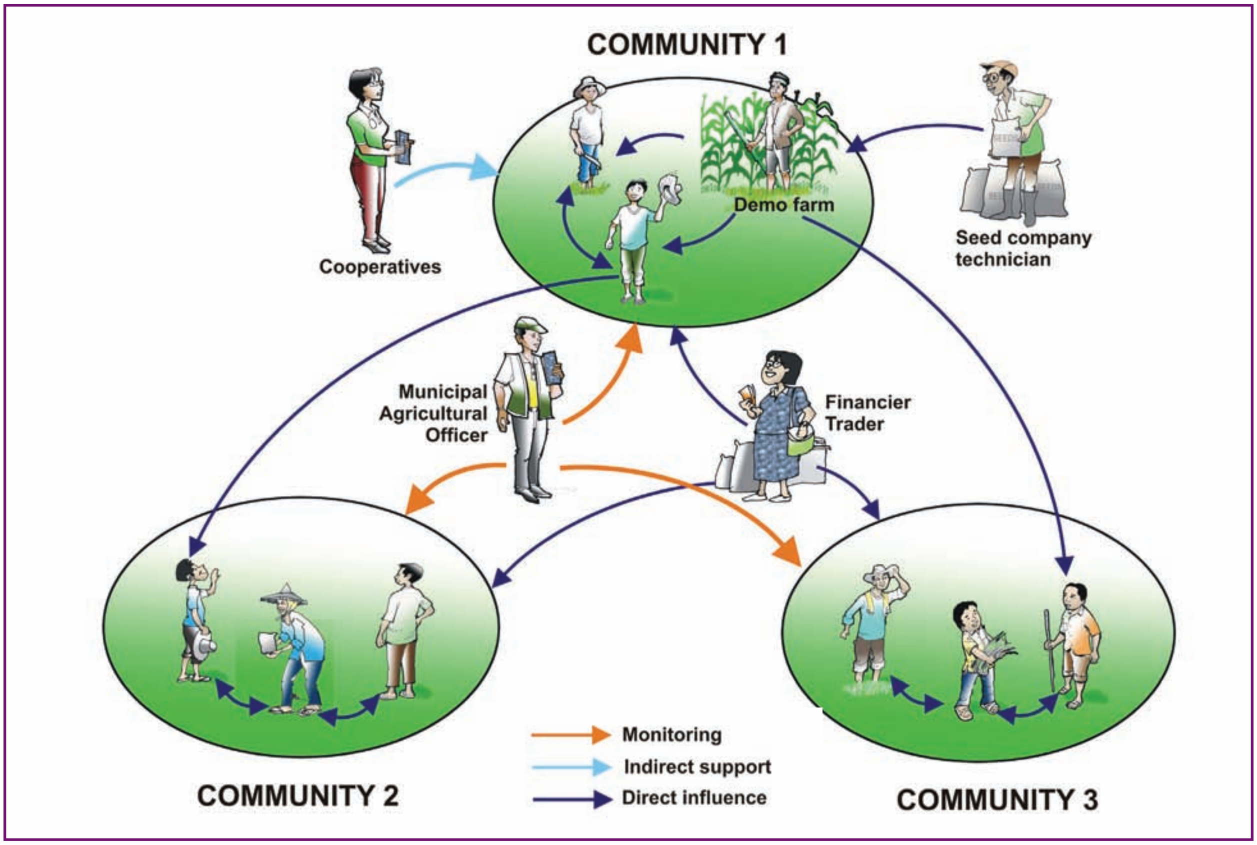


Figure 16. Overall pattern in the uptake pathway of biotech corn among small and resource-poor farmers in the Philippines

Office of the Municipal Agriculturist did not play a significant role, although it provided technical information during seminars or farm visits. The staff also monitored the pest and disease incidence in the area. Farmer cooperatives had indirect influence, mainly through a progressive member who persuaded other farmers to plant the crop.

Brgy. Escaler, Magalang, Pampanga

Figure 17 summarizes the farmers' uptake of biotech corn in Escaler, Magalang. Farmers in this community claimed they had been into biotech corn as early as year 2000. They must have been referring to the period when biotech corn was still being field-tested because commercialization of the crop occurred only in 2003.

Among the 11 participants in the innovation tree exercise, the very first farmer who planted biotech corn in the community was Ferdinand. He came to know about the technology in 2000 from a farmer in another town. He planted the new variety in 2000 and experienced good harvest during his first try. So he was encouraged to continue planting it. In 2001, Cresencia also planted the crop after hearing about it from a relative. Like Ferdinand, she also did not share it with other farmers, thinking that her fellow farmers already knew about it.

A seminar conducted by a seed company in 2001 started to create the wave of adoption. Without second thoughts, Emiliano immediately planted biotech corn that same year. And he shared his good experience

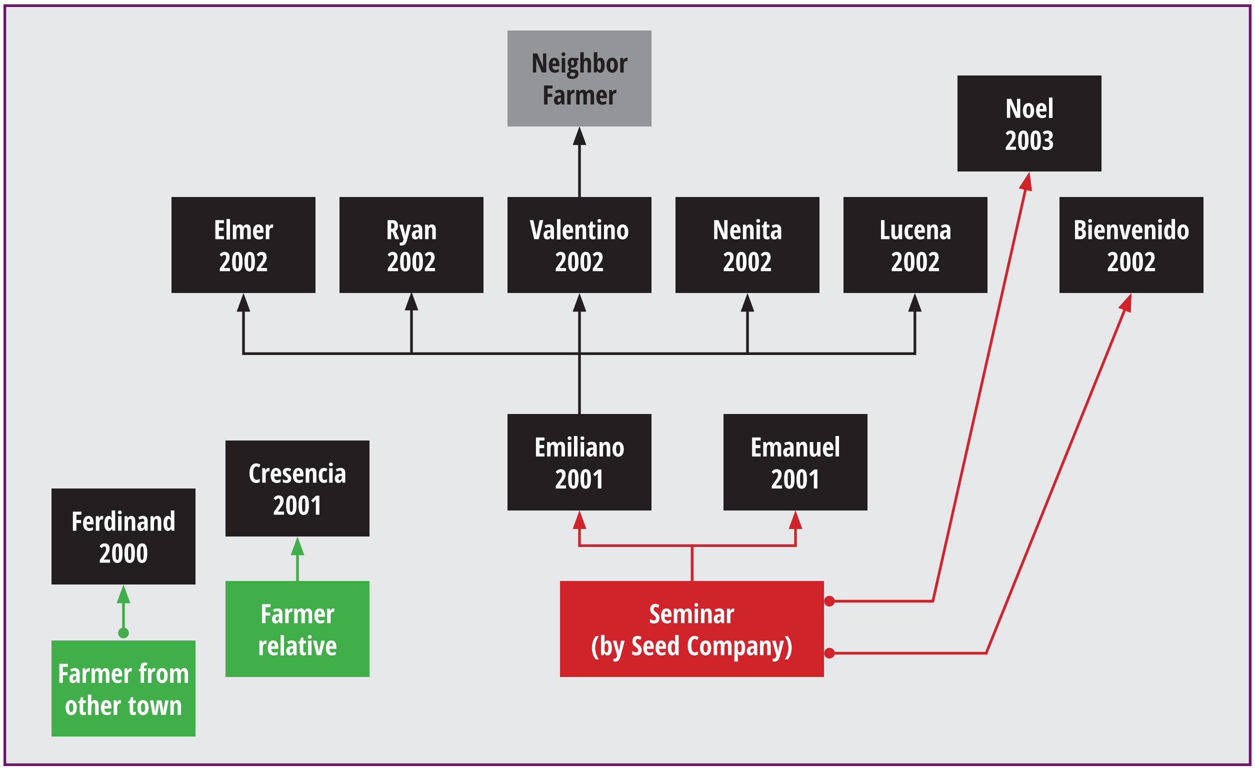


Figure 17. Uptake pathway of biotech corn among farmers in Brgy. Escaler, Magalang, Pampanga

immediately with five other farmers (Elmer, Ryan, Valentino, Nenita, and Lucena) who planted the same in 2002. These five farmers then spread out the good news to farmers in neighboring towns. However, not all of those who participated in the seminar immediately planted biotech corn. One of them, Bienvenido, tried it one year after, while Emmanuel tried it two years after (2003) due to lack of capital.

Based on yearly intervals, adoption was rather immediate and fast as it took only 1-3 years for the technology to be adopted by many. Farmers in this group can be labeled as early adopters. Early adoption of the technology was attributed to the proven quality of biotech corn and the high price it commanded in the market. They also noted the less expense involved for farm labor. All these subsequently resulted in higher income for the farmers.

Because of their adoption of biotech corn, some farmers said they were able to send their children to school, repay their loans, put up a business (such as a *sari-sari* or variety store), and afford a church wedding. The last item referred to a few farmers who had to forego their church wedding or had a civil wedding instead or just lived in with their partners due to financial constraints. Some were able to buy motorcycles and even home appliances, such as television, refrigerator, and karaoke set.

The FGD participants expressed the need to improve their corn business. These included farm-to-market roads, irrigation, and tractors. They also wanted concerned officials to look into regulating the prices of farm inputs, such as seeds and fertilizers. They said the government should refrain from importing corn so that the price of corn in the market would increase and favor farmers like them.

Brgy. San Ildefonso, Magalang, Pampanga

The uptake pathway of biotech corn in San Ildefonso, Magalang was initiated by the Department of Agriculture (DA), seed companies, and fellow farmers (Figure 18). The farmers came to know of the biotech corn's performance through demonstration farms jointly established by the DA and seed companies. As early as 2000, when these demo farms were proliferating, farmers like Ernesto, Rustico, Jesus, and Indolencio tried out the crop in their own farms. They also shared information about the crop with their other fellow farmers. Since then, everybody else in their community had engaged in biotech corn planting.

Other farmers, like Conrado and Honorio, took 2 years (2002) before trying the new variety. Succeeding adopters came into the picture at a much later date: Leopoldo in 2006 and Carmen in 2008. The lull in the spread of the technology

was due to the farmers' non-ownership of the land/farm at the time they first heard of the technology.

The participants in the innovation tree exercise agreed that immunity to borers, easy crop management, and higher income were some of the advantages of the biotech corn. Some of them were able to build their own house, own a tractor, and repay their loans due to

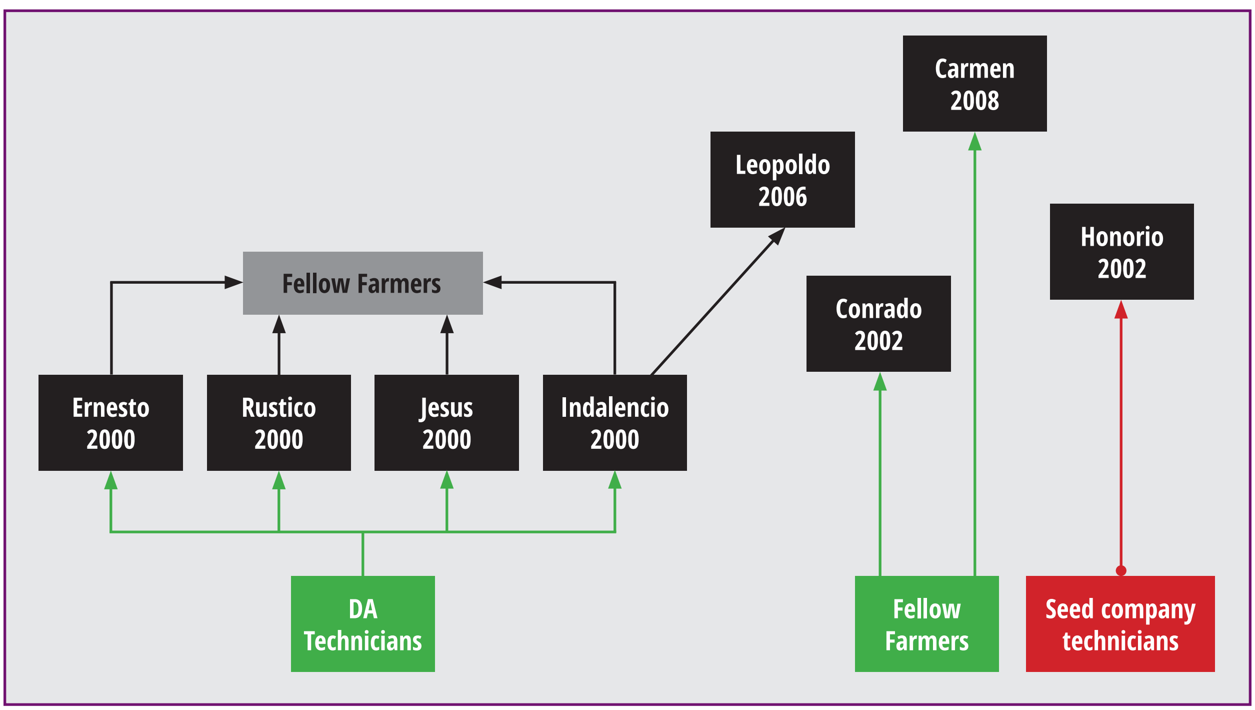


Figure 18. **Uptake pathway of biotech corn among farmers in Brgy. San Ildefonso, Magalang, Pampanga**

the increased income from biotech corn. Among the expressed needs of the farmers were farm-to-market roads, drying facility, and subsidy for farm inputs. They also expected the government to set policies lowering the price of corn seeds and fertilizers and putting an end to corn importation.

Brgy. Anao, New Mexico, Pampanga

The uptake pathway of biotech corn in Anao, New Mexico may be considered a unique case. All innovation tree participants attributed their decision to go into corn production to one person – a former municipal councilor fondly called "Kong Carlos" [or Kuya (Big Brother) Carlos Guevarra] by his fellow farmers. Kong Carlos started to engage in corn production in 1990. He was once recognized as Farmer of the Year at the national level. In 2000, two seed companies gave the farmers of Anao, separate seminars about biotech corn. Kong Carlos tried planting the crop and harvested/earned double the amount of what he used to harvest using the old variety. Soon, the DA even made Kong Carlos' farm the show window of biotech corn in the area. Aside from his commendable experience, he was also considered a pioneer in corn production in their locality. This has encouraged other farmers in the *barangay* (village) to also try planting biotech corn. In a way, it was Kong Carlos whom the farmers looked up to as the champion of biotech corn in their community.

Figure 19 traces the uptake pathway and adoption of biotech corn in this *barangay*. Among the 11 participants in the innovation tree activity, two started planting biotech corn in 2001, six in 2002, two in 2004, and

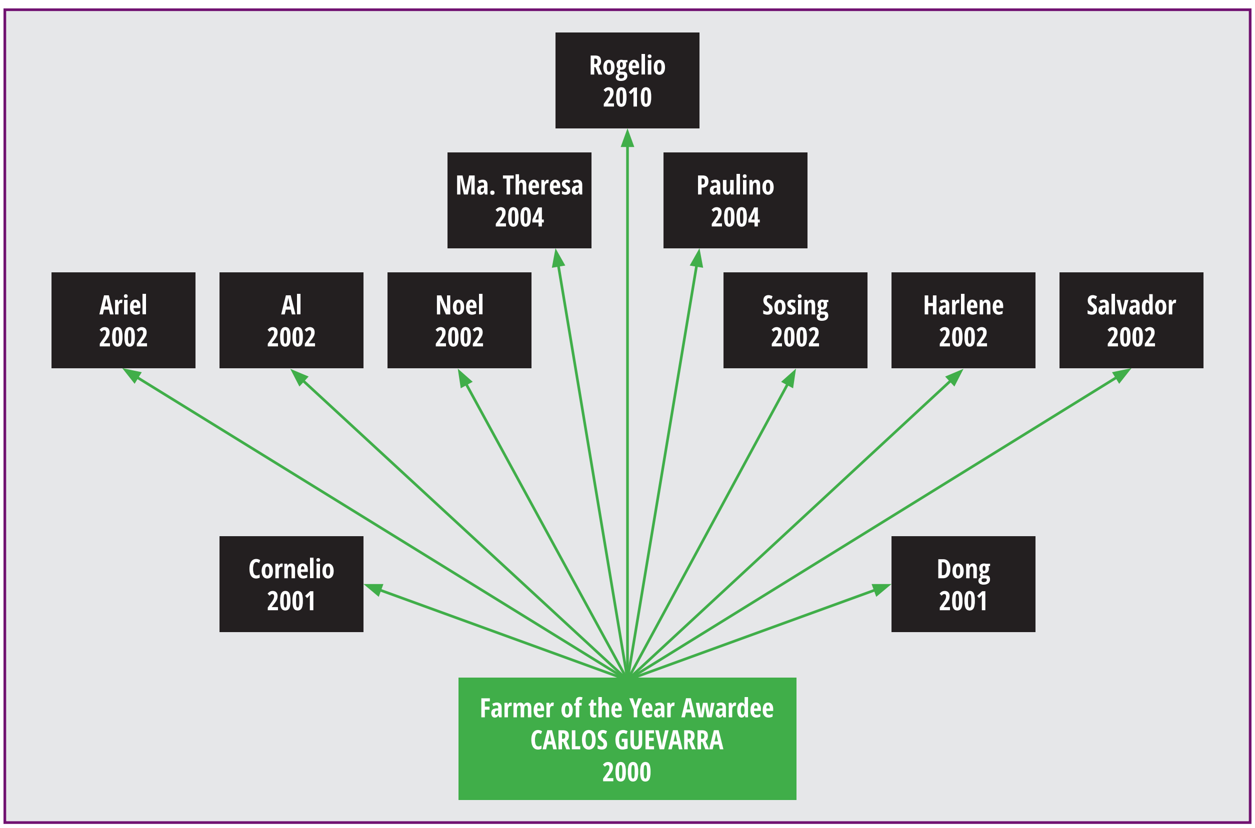


Figure 19. **Uptake pathway of biotech corn among farmers in Brgy. Anao, New Mexico, Pampanga**

only one in 2010. The fastest pace occurred in 2002, when the crop was to be eventually approved for commercialization in the country. Since then, all farmer-participants claimed that biotech corn had doubled their income. Cornelio and Dong, the early adopters, cited high income as the prime motivator for adoption. Rogelio, a late adopter, on the other hand, explained that his farm was not suitable for corn production at the time he came to know about biotech corn. The rest did not readily adopt the technology because they preferred to plant white corn before. Others were constrained by expensive inputs involved in biotech corn planting.

Asked about the advantages of biotech corn production, the farmers enumerated the following: it was more profitable, it needed less input since application of pesticide was not necessary, and they were more assured of a good harvest. As with the other biotech corn adopters, the Anao farmers were also able to send their children to school, build their own houses, own a tractor, and buy personal gadgets such as cellular phones.

The farmers wished for low prices of farm inputs, better markets where they could sell their produce at a higher price, and availability of machineries, specifically tractor for plowing, as well as irrigation facility. They also expressed their need for seminars on the proper use and planting of biotech corn as this has not been taken up with them in the previous seminars they attended.

Brgy. Palinlang, Arayat, Pampanga

As shown in Figure 20, the earliest adopters, Avelino and Reynaldo, were introduced to the crop in 2001 through a farmers field school (FFS). That was even before the crop was approved for commercialization in 2003. Romeo was also a product of FFS, but at a later year (2006). This was followed in 2002 by a seed company's seminar in the barangay, after which Vitaliano, Remigio, Jose, and Nelson shifted to the new biotech corn variety in the same year. But it took 2 more years (2004) for Robert and Carlito to get into biotech corn planting. Still, the latest adopters, Tolentino and Eugenia, shifted to the crop only in 2006. Source of capital and fear of "usurious" rates imposed by financiers were the factors that prevented farmers from readily adopting the crop. Antonina came to know about biotech corn from an agricultural supply store in 2002. There was an almost 2-year gap in between generations of adopters. The FFS and the seed

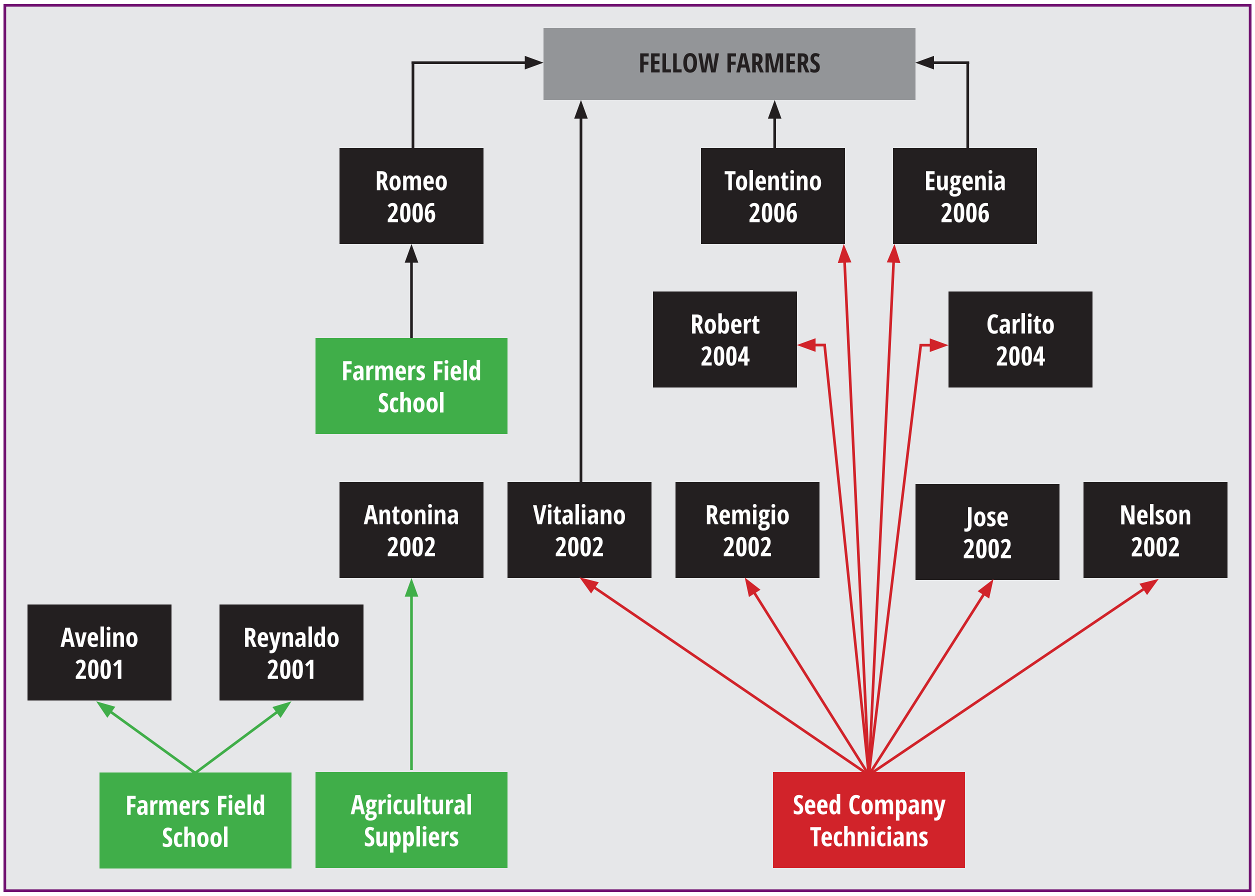


Figure 20. **Uptake pathway of biotech corn among farmers in Brgy. Palinlang, Arayat, Pampanga**

companies eventually produced many biotech corn converts.

Farmers planted biotech corn for various reasons – due to lesser expenses for farm inputs, higher income/profit, less need for irrigation, and more guaranteed harvest. As a result of adopting the technology, they have repaid their loans and bought some home appliances. The farmers in the area believed that their corn production could be improved if they would be provided a drying facility and the necessary farm machinery, especially for plowing. They were interested in seminars on corn technologies. They were also hopeful that the government could subsidize some of their farm inputs and could provide some financial assistance to organize a cooperative that would help them refrain from borrowing capital from usurers.

Iloilo

Only one innovation tree exercise was conducted in Iloilo because farmers came from the upland areas, which are difficult to reach. Figure 21 shows the flow of biotech corn uptake based on the stories of 11 farmers who participated in the innovation tree activity. It should be noted that, in addition to the seed companies, another major player in the uptake pathway was the MODEL farmers' cooperative, where all the respondents interviewed are members.

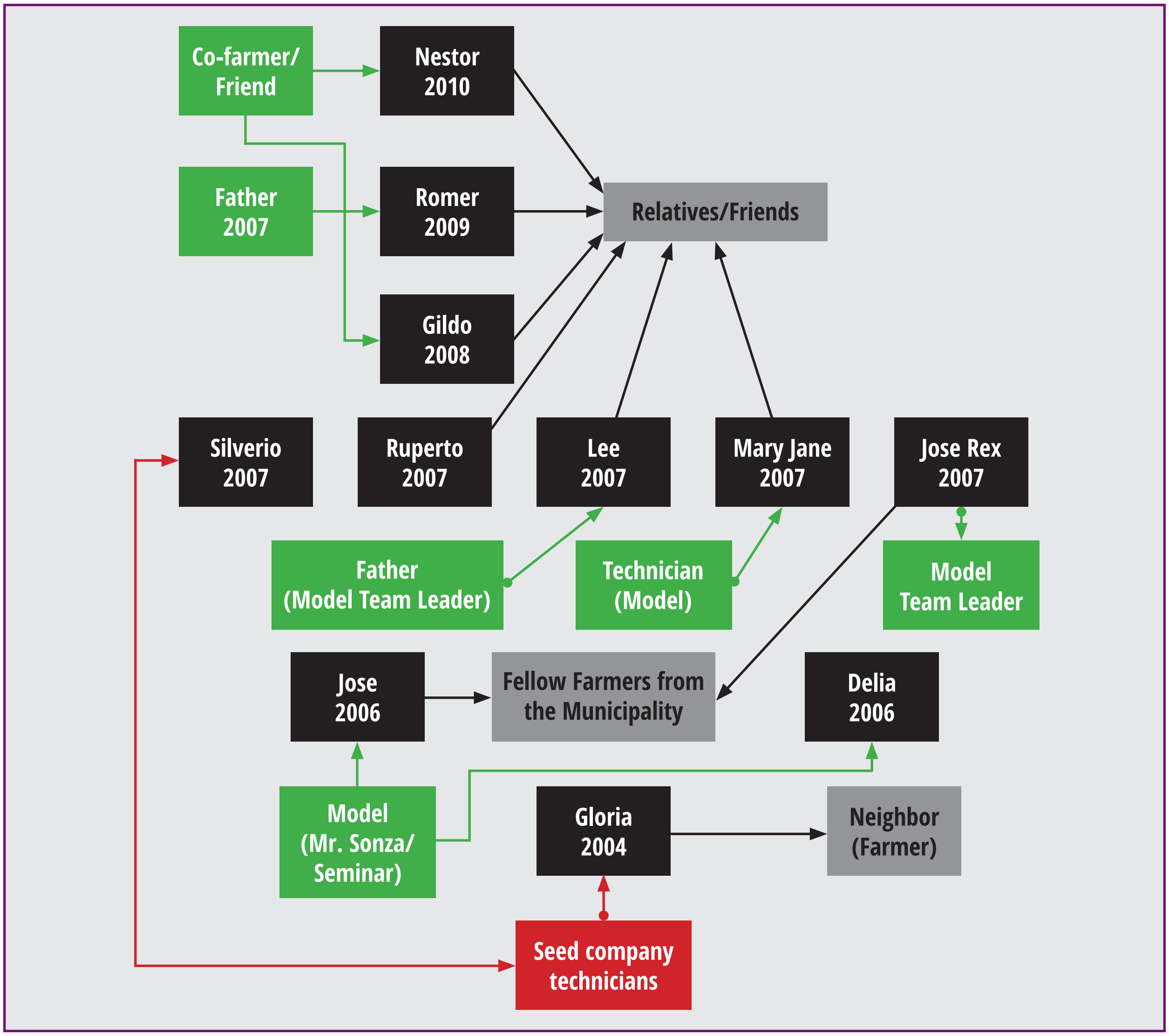


Figure 21. **Uptake pathway of biotech corn among farmers in Sara, Iloilo**

Biotech corn farming came much later in this Visayan area compared with Pampanga in Luzon. While the crop was commercialized in 2002, Gloria and Silverio first learned about biotech crop from a technician of a seed company only in 2004. Gloria started planting right away. Silverio, on the other hand, adopted the technology in 2007, three years after Gloria did. Being risk-averse, he had second thoughts about it and he wanted to make sure that biotech corn would indeed give him more profit. Once they had proven the performance of the crop, they brought the good news to their co-farmers, relatives, and friends in adjacent farms and neighboring *barangays* and towns.

Taking another track, Delia and Jose were convinced to try biotech corn in 2006 by the MODEL Farmers Association through its head, Delson Sonza. Also a corn farmer himself, Sonza started growing biotech corn in 2005. He organized the farmers' association to bring more benefits to corn farmers.

Lee, Mary Jane, and Jose Rex were convinced by team leaders and technicians of the MODEL Farm Association. According to these farmers, the team leaders assigned to the different barangays and towns regularly visited and monitored the farmer-members. The participants added that Sonza, trader and leader of the association-cum-multipurpose cooperative, who has been successful in planting the Bt corn variety, convinced them to adopt the technology. So it took an experienced farmer and a trusted leader like Sonza to involve many farmers in biotech corn production.

The late adopters only started planting Bt corn in the 2007-2010 period. They were convinced by other fellow farmers to adopt the technology. The late adopters had known about biotech corn since 2006, but they did not immediately adopt it because of inadequate capital and lack of land. They also wanted to make sure that biotech corn would indeed increase their income. The favorable experiences of the early adopters eventually convinced the late adopters to shift to biotech corn.

Most of the participants confirmed that income derived from biotech corn was much bigger, by leaps and bounds, than that obtained from native corn. They added that corn farming has become less laborious, thus, giving them more time for their respective families and other productive activities. From their income, they were able to buy a motorcycle (a treasured family possession), send their children to school, and renovate their houses. A motorcycle was an important investment among biotech corn farmers because it served as their all-purpose mobility vehicle. Being in the uplands, they found the motorcycle a very dependable form of transport for farm inputs, crops, family members, farm implements, even construction materials.

Brgy. Rang-ay, Banga, South Cotabato

Banga is one of the biggest corn-producing municipalities in South Cotabato. One of its most productive *barangays* in corn production is Rang-ay. Most of the farmer-participants in Brgy. Rang-ay first learned about biotech corn in 2003 from seed technicians of a multinational agricultural biotechnology corporation operating in the Philippines. One of the farmers, Alfonso, was contracted by the seed company to establish a demonstration farm on biotech corn variety in their barangay in December 2003. He served as an ambassador of the company during and after the demonstration.

Several farmers who were members of a local cooperative and neighbors of Alfonso also participated in the farm demonstration as observers. They regularly visited the farm and listened to company technicians who explained the steps in and benefits from cultivating the crop. Since synchronized farming was practiced in Rang-ay, majority of the corn farmers started planting biotech corn in 2004 upon observing that it resisted corn borer attack and yielded more harvest than the white corn variety. This triggered the high rate of adoption of biotech in 2004 as reflected in Figure 22. Aside from Alfonso, six other farmers adopted biotech corn that year. They had been cultivating local varieties of white corn and non-transgenic yellow corn before Bt corn was introduced to them in 2003.

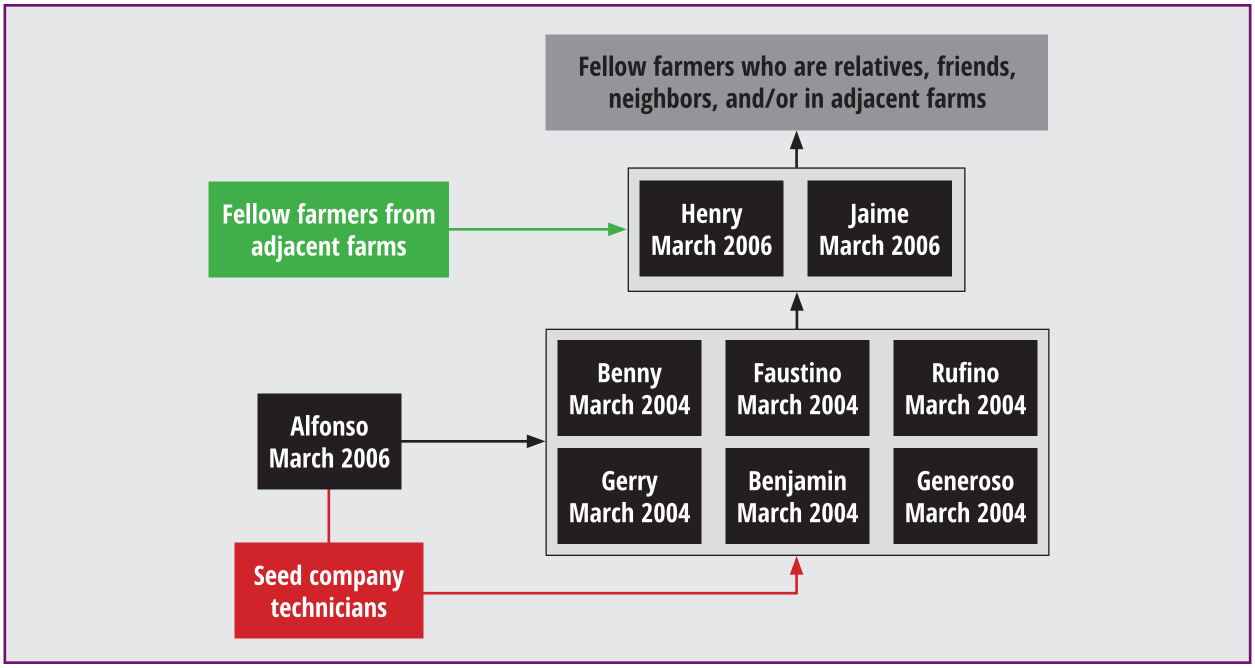


Figure 22. **Uptake pathway of biotech corn among farmers in Brgy. Rang-ay, Banga, South Cotabato**

According to the participants, many farmers in the *barangay* were easily influenced by their fellow farmers in the adjacent farms. Word about benefits of biotech corn easily spread in the neighborhood. In addition, farmers learned about the crop and its benefits during their cooperative meetings.

Henry and Jaime adopted Bt corn 2 years later. They explained that delayed adoption by some farmers was often due to doubts about the efficacy of the crop. They observed farms planted to biotech corn first to see if these would not really be infested by corn borer and would indeed give good harvest. Several farmers even thought at first that it was not good for human and animal health, an issue raised by the Catholic church and other social activist groups in their area. In South Cotabato, the church actively campaigned against transgenic crops in the late 1990s and early 2000s. It was even mentioned by one farmer that some individuals told them that biotech corn is poisonous. The other reason for the delayed adoption was that some farmers prioritized cassava over biotech corn for several years before they decided to try the latter. Farmers explained that cassava, as an alternative feed source, is easier to cultivate and gives them higher income.

Most of the farmers claimed that income from biotech corn was bigger than that from white corn and non-biotech yellow corn varieties. The difference, some of them said, was about PhP 3,000-4,000/ha. One argued that there was not much difference in income, but it was easier to cultivate biotech corn, especially when the herbicide-tolerant variety (i.e., resistant to weedicides being sprayed on corn plants during the growing stage) was introduced to them. They claimed that corn farming became less laborious, and they could spend more time in other farm ventures, such as cultivating vegetables, guavas, and bananas, which were often intercropped with corn. More importantly, they gained more time to spend with their respective families.

Those with larger farms (3 ha and above) often earned at least three times more than those farming 1 ha and below. For instance, Alfonso had more than 10 ha of owned and rented land planted to biotech corn. Hence, he is considered the most successful biotech corn farmer in Rang-ay.

As mentioned by the farmers, some of the factors that facilitated adoption were the following: (a) setting up of a demonstration farm on biotech corn; (b) information sharing about the benefits of biotech corn; (c) presence of private traders who provide farm capital; (d) information sharing on how biotech corn is cultivated; and (e) synchronized farming in some areas. Meanwhile, delayed adoption was attributed to: (a) inadequate farming capital, (b) lack of information on how to cultivate biotech corn, (c) negative information about the transgenic crop, and (d) unfavorable weather conditions.

The farmers thought that the following would help them improve and scale up biotech corn production in the *barangay*: (a) a strong federation of corn farmers that could negotiate with big traders regarding selling prices; (b) postharvest facilities to store their harvest for a longer time, that is, until the market selling price of corn increases; and (c) regulation of prices of farm inputs, especially seeds and fertilizers.

Brgy. Klinan-6, Polomolok, South Cotabato

Many corn farmers in Polomolok, South Cotabato, were among the first adopters of biotech corn after it was commercialized in the Philippines in December 2003. In Brgy. Klinan-6, the early adopters learned about biotech corn in 2003 from various sources: Alfredo, Florencio, Buenaventura, Ulysses, and Josefina; technicians of a seed company; Mila, a local private trader selling seeds and other farm inputs; and Feliciano, member of a local cooperative called UKL, which was in contact with another seed company (Figure 23). Several of them also heard about Bt corn from the radio because biotech crop is a highly contentious issue in the province between organizations promoting its adoption and those opposing its commercialization (i.e., Roman Catholic Church, environmental groups).

Despite the strong opposition movement to biotech corn in South Cotabato, many farmers still started planting the transgenic crop after it was approved for commercialization in December 2003. Most of the farmers agreed that the promise of good harvest and higher income was the primary reason for trying biotech corn. The realization of this promise convinced other farmers to plant the crop as well. They explained that adoption was facilitated by the fact that farmers often talked with one another regarding their farm activities almost every day.

The innovation tree participants shared that some of their fellow farmers adopted one or more years later because they had second thoughts about biotech corn. They opted to observe first the farms of their neighbors and friends to see if the biotech crop would really perform exceptionally better than the white corn variety, which was popular in the area then. Lucrecia and Evelyn admitted that the Catholic church also influenced their decision not to plant biotech corn for several years after it was introduced in the community. They

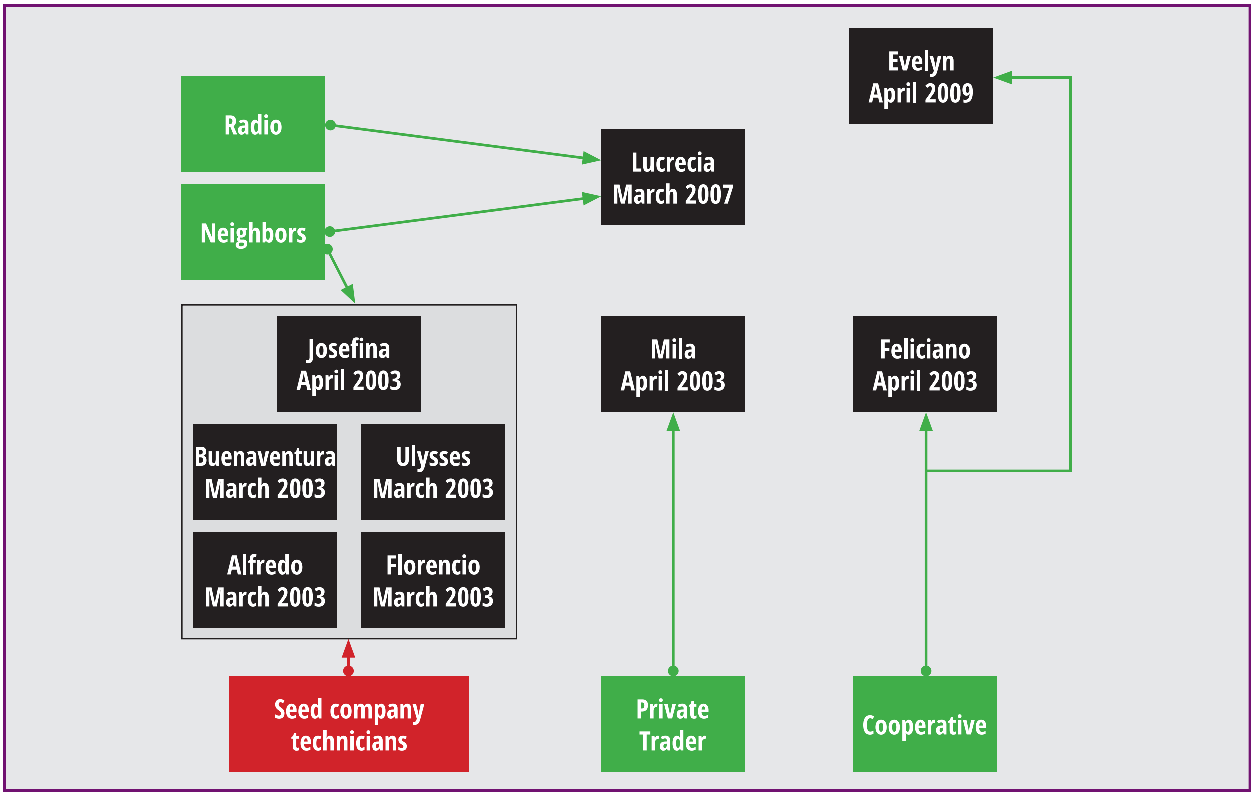


Figure 23. **Uptake pathway of biotech corn among farmers in Brgy. Klinan-6, Polomolok, South Cotabato**

explained that the church opposed biotech corn and discouraged them from planting it. They changed their minds, however, after fellow farmers attested that biotech corn had agronomic and economic benefits that conventional varieties could not give them. Lucrecia, for instance, noticed that her farm was always attacked by the notorious Asian corn borer (ACB), while her neighbors' farms were not. In 2007, she finally decided to cast aside the advice of her church leaders and started planting biotech corn. In Evelyn's case, it was the local UKL cooperative that eventually converted her into a biotech corn farmer in 2009.

Fellow farmers and seed company technicians were the most influential persons in the adoption process in Brgy. Klinan-6. They were often the sources of information on biotech corn as well. A few of them explained during the FGDs that there was a strong tendency among farmers to "copy or replicate" what others were doing in their farms, especially when results were good and favorable.

On the other hand, farmers cited a number of problems in biotech corn production that hampered adoption rate and could discourage them from continuing to plant the crop: (a) very low market price during harvest season; (b) inadequate capital to enable them to afford the costly farm inputs; (c) lack of financial and material support from government, as well as private organizations; (d) absence of irrigation; and (e) greater frequency of drought or dry season. The needed support that they identified were as follows: (a) subsidy for farm inputs; (b) government regulating the selling price, especially during harvest season; (c) farm-to-market roads; and (d) drying facilities.

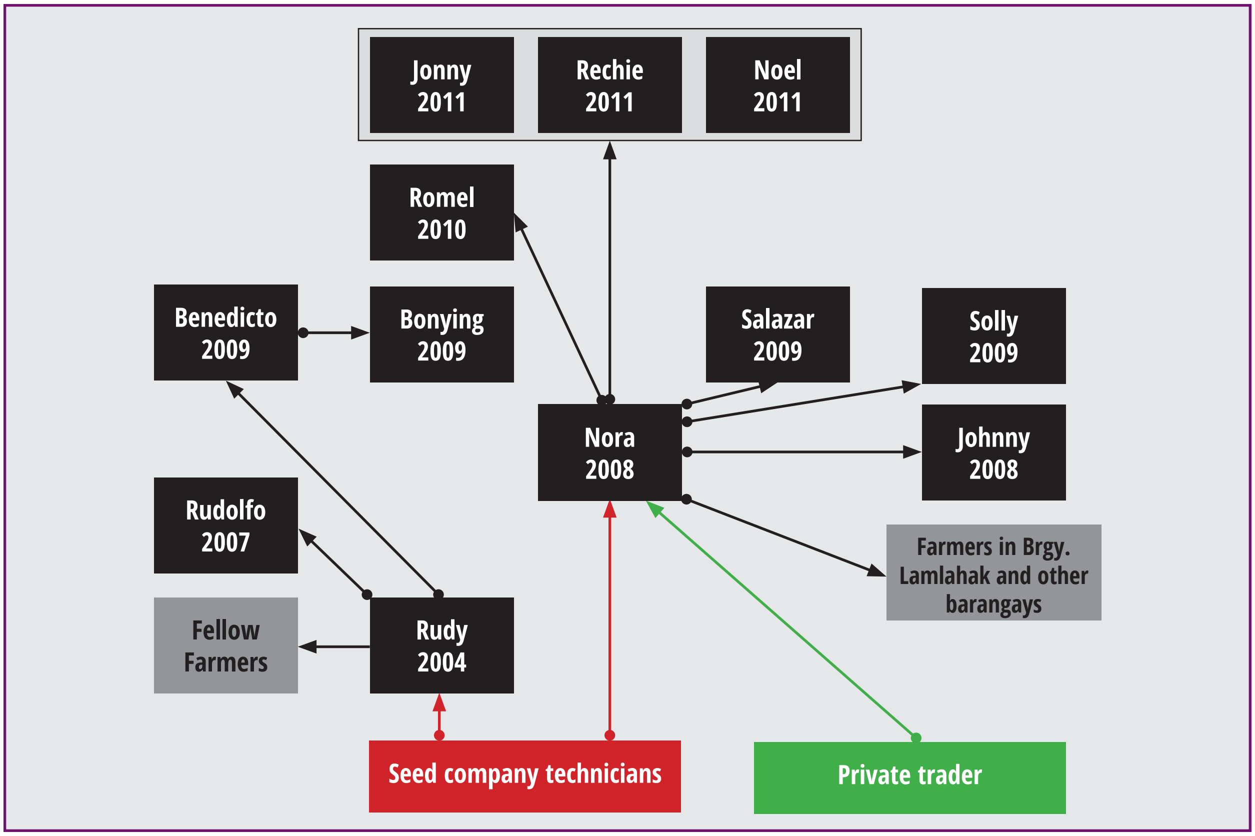


Figure 24. **Uptake pathway of biotech corn among farmers in Brgy. Lamhalak, Lake Sebu, South Cotabato**

Brgy. Lamlahak, Lake Sebu, South Cotabato

The good word about biotech corn did not spread as fast among farmers in the early years of its commercialization. Farmers were generally late adopters. Rudy, for example, was the earliest adopter among the 12 participants in the innovation tree activity (Figure 24). He learned about biotech corn from technicians of a seed company in 2004, the time when farmers in other parts of the country had already been planting the crop. And even then, the succeeding adopters, namely Rudolfo, Nora, and Johnny, started planting biotech corn only in 2007 and 2008. They claimed that it was only in 2007 and 2008 that the two seed companies established demonstration farms in their *barangay*.

Then they passed on their experience to Benedicto, Bonying, Salazar, and Solly who, in 2009, also started planting the biotech corn variety. Romel followed suit in 2010, and he relayed the technology to Jonny, Rechie, and Noel, his fellow farmers in the adjacent farms. A few farmers were informed by private traders when they were availing themselves of loans for corn production. One of them was Nora, who served as a model farmer in Brgy. Lamlahak and became influential in the decision of many other farmers in the barangay to adopt biotech corn.

Adopters relied on the following people for information on biotech corn: fellow farmers, agricultural technicians, technicians of seed companies, and traders. Knowledge of biotech corn was also often shared with fellow

farmers, neighbors, and family members. After cultivating the crop for at least one season, these farmers informed and convinced their relatives, neighbors, and friends in Lamlahak and other barangays of Lake Sebu. Aside from the promise of good income, factors such as less expenses and reduced time and effort for weeding led the farmers to adopt.

Some of the late adopters mentioned that they were already aware of biotech corn more than a year before they decided to adopt it. Their delayed adoption was due to lack of capital, unaffordable farm inputs (such as seeds), and lack of assurance or proof of good income. Some observed others as they grow the crop first to see if it would really give good harvest and income. In the area, farmers noted that about 30% of farmers in their barangay were not yet biotech corn adopters due to lack of capital.

The problems identified in biotech corn production were the following: (a) absence of support services from government and private institutions; (b) lack of infrastructure and machinery; (c) infestation of biotech corn plants by rats, aphids, and leafhoppers; and (d) lack of trainings or seminars on better farming practices to increase harvest. Some farmers also stopped growing biotech corn for 1-2 years because of lack of capital and debts incurred from income losses in one or more cropping seasons.

The needs identified by the research participants in relation to biotech corn farming were: (a) irrigation; (b) machinery, such as tractor and dryer; (c) equipment, such as knapsack sprayer; and (d) training on proper cultivation of Round-up Ready corn variety.

General Pattern of Adoption and Uptake Pathways of Biotech Crops

Each village and each country presented a unique story of how biotech crops were introduced, accepted, and adopted by farmers, and how they eventually spread out to places beyond the initial sites. But while they face different socio-cultural, political, and environmental conditions, some general patterns emerge.

The first biotech crops, Bt cotton in China and India, and Bt corn in the Philippines, were mostly products of private companies or smaller local seed companies at the state (India) or country (China) level. These companies took an active role, through their technicians, in introducing the crops mainly through the conduct of field trials and demonstration farms with the help of progressive farmers or village leaders. They also provided training in some areas, again with the assistance of village leaders. These demonstration areas proved to be very effective in attracting farmers' attention to the possibilities of adopting the technology. Farmers were able to observe the differences in agronomic conditions and yields as well as in response to pests and diseases between the biotech crop and its conventional counterpart.

Most of the farmer cooperators who participated in the open field trials eventually became the first adopters in their communities. They usually influenced their peers, relatives, and friends outside their communities. Other farmers followed, some quickly while others took a much longer time due to financial barriers to purchase seeds and farm inputs.

Eventually, as more farmers took interest, seed companies would partner with agriculture offices of local government units, village leaders, or even with scientists of SAUs to set up more demonstration areas. Farmers from neighboring villages would visit or hear about the success stories in the use of the new technology. Other key players in the adoption process are the private traders who are involved in selling seeds and other farm inputs. They help mobilize farmers to participate in field trials, lend money and farm inputs, and buy the produce. Hence, the combined efforts of the private sector, the village leaders, and the extension system produce a multiplier effect, and widening the sphere of those who would benefit from trying out a new crop.

What convinced the farmers to adopt the technology? Foremost was economic reasons - where financial benefits from higher yield and a good harvest enabled farmers to improve not only their quality of life but also that of their peers and neighbors. The presence of private traders and other financiers who provided capital or farm imputs and assured a ready market motivated farmers to try the technology and continue doing so in succeeding cropping seasons. The political support of village leaders also boosted acceptance as farmers looked up to their trusted peers. The direct involvement of these progressive farmers in demonstration fields and their ability to take the risks helped make other farmers consider the new technology. Finally, strong interpersonal relations among farmers and a collective feeling for the common good contributed to the rapid spread of the technology.

Just as there were farmers who were easily convinced to try biotech crops, a few were indecisive in the beginning or took some time to adopt. Lack of capital was a major reason due to the high initial costs of farm inputs such as seeds. Those who could not obtain financial support chose to delay their venture into the new technology. Availability of seeds, particularly when supply does not meet demand, also became a problem. The opinion of elders and religious groups as well as indecisive politicians whose support of the technology was not clear also contributed to non-adoption. This was aggravated by the lack of knowledge and wrong information about biotech crops.

Figure 25 is a diagram of the general pattern of adoption and uptake pathways of biotech crops in the three countries.

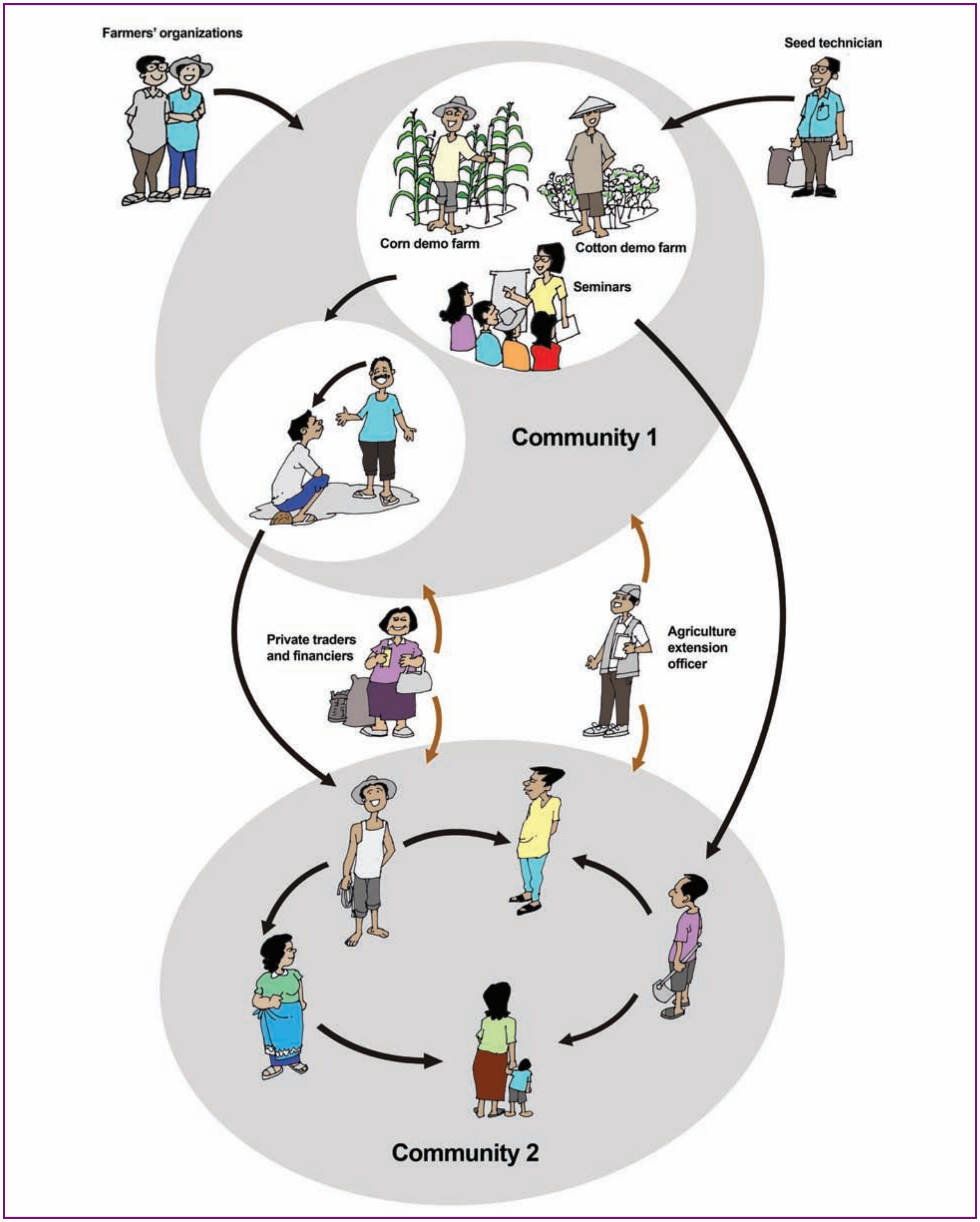
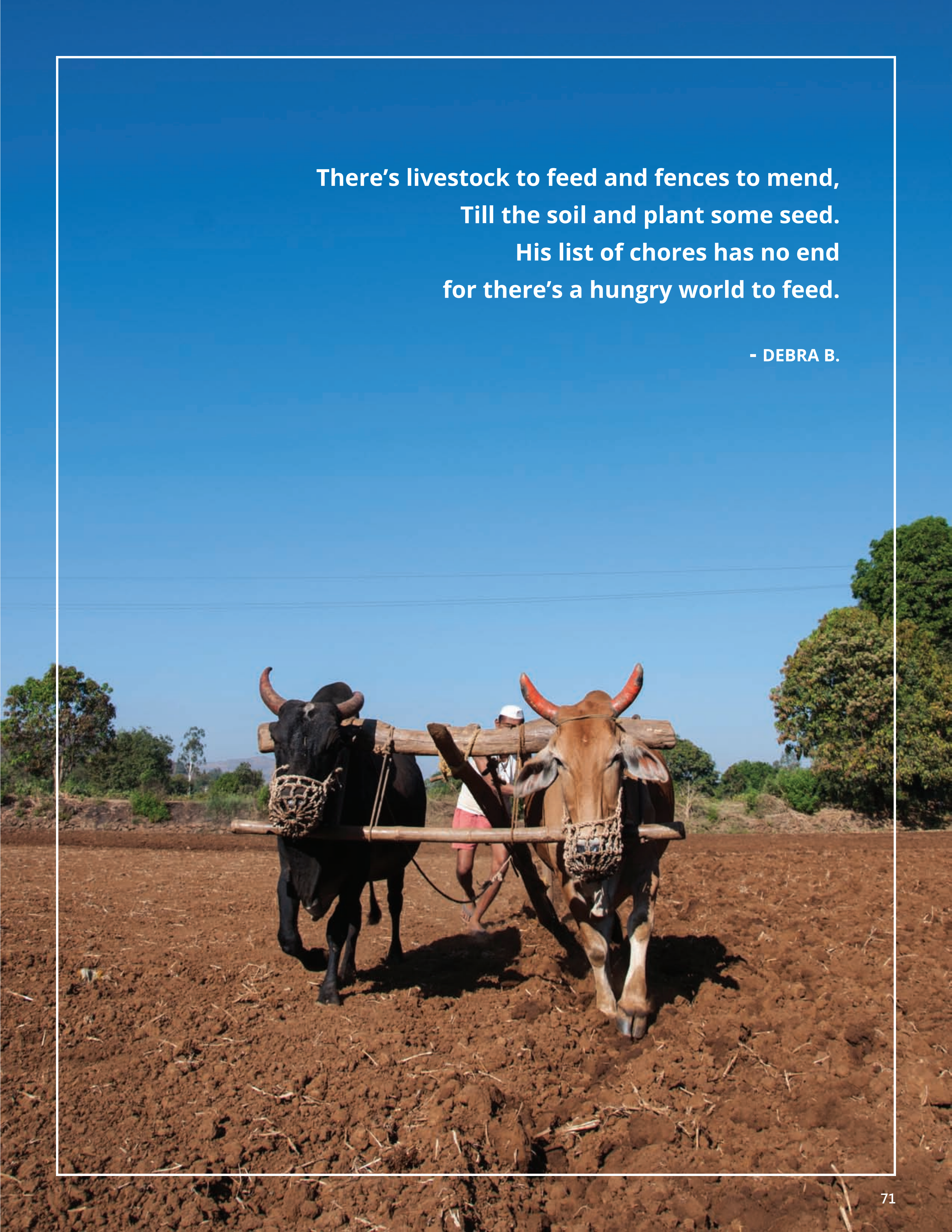


Figure 25. **General pattern of adoption and uptake pathway of biotech crops in China, India, and the Philippines**



There's livestock to feed and fences to mend,
Till the soil and plant some seed.
His list of chores has no end
for there's a hungry world to feed.

- DEBRA B.

5 Conclusions and Recommendations

The rapid spread of biotech crops among small-scale, resource-poor farmers is a concrete proof that modern technology can improve the lives of end users and the community they live in.

Through a multiplier effect of farmers and villages sharing information and learning from each other, districts, provinces, states, and countries collectively benefit from the bounty. *Adoption and Uptake Pathways of Biotech Crops by Small-Scale, Resource-Poor Asia Farmers: Comparative Studies in China, India, and the Philippines* is an empirical contribution to understanding the farmers who are involved in biotech crop cultivation and how their voluntary participation in the adoption process have enabled them to change their quality of life and address issues related to poverty alleviation, sustainability, and development.

The research attempted to 'humanize' the figures by meeting some of these farmers up close and interacting with them to get a glimpse of who they are, how they are introduced to the new crop, how the technology is able to improve their quality of life and that of their peers, and what problems they face in growing the crop.

The study in India is considered one of the largest and most comprehensive surveys undertaken on Bt cotton in rainfed and irrigated cotton areas of the country. A total of 2,400 farmers from Maharashtra, Andhra Pradesh, and Punjab representing three distinct agro-ecological States were surveyed.

The study in China, which has a relatively similar land-labor ratio as India, centered on a dataset of 483 respondents from the China National Cotton Survey that has been gathered in several waves since 1999. Hebei, Sandong, Anhui, and Henan provinces located in Huang-Huai-Hai cotton production zone were the sites covered. These are known to have been the first areas that commercialized the crop as early as 1997 or 1999.

The Philippine study had three major corn-producing provinces to represent the major islands of the country: Pampanga, Iloilo, and

Cotabato. A total of 409 respondents were surveyed.

Consolidated Findings

Farming in developing countries has traditionally been regarded as a back-breaking and low-income venture. Farmers, particularly those who have small parcels of land and little capital, are content with meeting domestic needs and having a little more to live by. They pray, hoping that their efforts will not go to waste as the reality of weather disturbances, pest infestation, poor yields, and market problems loom overhead.

But modern technology is fast changing that landscape. More than 90% of cotton farmers in China and India are now planting Bt cotton, while 80% of yellow corn farmers in the Philippines are cultivating biotech corn. Higher economic and yield benefits, freedom from or reduced bollworm or corn borer infestation, and dramatic reduction in pesticide use are motivating these farmers to sustain biotech crop production. By being examples themselves, these farmers in turn are influencing a wider number of farmers to try the technology. How can farmers who are risk averse and are now earning two to three times their previous income be wrong?

Farmer Profile

Highlights of the research showed that, while farming has always been a male-dominated venture, there is growing involvement of women in biotech crop commercialization. This has been noted in China where more and more women are attracted to it as there is less labor involved, which would otherwise be spent for pesticide application. Now that there are more women in Bt cotton production, the men have been able to take other jobs. Wives of farmers in the Philippines are taking a more active role in managing the finances and making decisions regarding what crops to plant and what inputs to buy. In India, work distribution depends on the farm operations involved. While the male farmer takes care of land preparation and spraying, the wife is involved in weeding, picking, and cleaning.

Farmers venturing into this new technology in India are young, with more than 50% in the 21-40 age bracket. This is good news as the technology seems to be attracting the young, thus assuring sustained adoption. In addition, India has seen 50% or more smallholder farmers from what they refer to as the “other backward class” category or lower strata of society. This confirms that Bt cotton is a scale-neutral technology that can provide the same level of protection against bollworm, irrespective of who cultivates Bt cotton.

Uptake Pathways of Biotech Crops

Multinational and local companies developing, producing and/or selling biotech seeds are among the first to introduce biotech crops in the community during the first year of commercialization. This is to be expected as the seeds are sold by these companies. Technicians talk with village chiefs and farmer leaders to discuss the benefits of the new

biotech products. They are technical staff of big multinational companies as in the case of the Philippines. In the other two countries, many of them also come from smaller local seed companies at the state (India) or county (China) level.

Complementing these talks are field demonstrations set up by the companies with farmer cooperators who are willing to use their farms to try the new technology. In other cases as in the Philippines, seed companies partner with the agriculture offices of local government units to establish demonstration farms. Many farmers personally observe the advantages of biotech crops over their non-biotech counterparts particularly the improved physical characteristics of plants, higher yield, and greater resistance to pests. Most of the farmers who participated as cooperators or become observers were the first adopters of biotech crops in their communities. They would either try the technology during the next cropping season or wait for a few years when they are able to raise funds or obtain loans to buy the more expensive seeds and farm inputs. Availability of capital for farming inputs often hinder immediate adoption.

Seed company technicians also organize local seminars to inform farmers about the technology, particularly about issues related to its benefits and safety to human health and the environment.

In China, village cadres and extension technicians are tapped to help introduce biotech cotton to farmers and manage the field trials. In India, big field demonstrations are set up through the participation of farmers, scientists of state agricultural universities, and extension workers.

Three common factors facilitate the early adoption in the three countries where biotech crops are introduced within a year after commercial release: 1) approval by trusted village chiefs, farmer leaders, and agricultural technicians of biotech crop production; 2) close ties among farmers; and 3) avoidance of heavy losses incurred by farmers in cultivating non-biotech crops before.

The role of trusted community leaders is significant in influencing farmers to adopt or not adopt biotech crops. In China, where cadres of village chiefs are among the first adopters, it is most likely that other farmers would also quickly adopt the technology. In villages where the cadres do not give outright support for the crop, adoption is slower. In the Philippines, it is generally the farmer leaders who convince other farmers to go into biotech corn after it is approved for commercialization.

Aside from community leaders, farmers influence their peers to go into biotech crop production — the result of the value and trust placed on strong community ties. In the Philippines, the decision to plant biotech corn is made upon learning that close relatives, neighbors, or friends have done so. Some farmers decide to switch to biotech crop farming not only because of the good news about the crop's strong performance but also because of the peer assurance that they would also adopt the crop.

Meanwhile, the farmers' previous experience of heavy losses incurred from planting non-biotech crops can also motivate them to try crops that resist pests and weeds. In China's case, for example, many of the early adopters were those who had problems about bollworm infestation in non-biotech cotton.

Adoption Pattern

Farmers, whether from China, India, or the Philippines, are risk-averse. They need to be sure that, if they venture into a new technology, they would gain and recoup their initial investment. Hence, the role of demonstration fields set up by private or local seed companies and the participation of progressive farmers as initial adopters are important. Farmers take a wait-and-see attitude and take time to see how things progress. However, it takes only convincing results of higher yields and bountiful harvests for them to quickly adopt. Farmer leaders or village cadres become local champions of the technology as they bear the burden of trying it out. Interestingly, progressive farmers do not keep the evidence of benefits to themselves. Due to the prevailing strong peer system among farmers, they take it upon themselves to share what would benefit the greater good.

Nevertheless, it is important to note that, while the motivation to try new technology is there once a farmer is convinced that there are more benefits than risks, other factors can impede adoption. In China, for instance, many farmers want to plant Bt cotton when it was first introduced. However, the supply of seeds is short of the demand. In the process, farmers eager to use the technology resort to using saved seeds or getting seeds from other farmers who plant the crop the previous year. This does not ensure seed quality that the new technology offers. In addition, farmers have limited information about the technology which creates delay in adoption. Farmers from India and the Philippines cite capital as an impediment as they do not have the resources or have access to financiers. However, even with financiers, price fluctuation is also a problem as those who lend money or inputs are often those who buy the produce in their own terms. Indeed, institutional support to meet information as well as capital and market needs must be secured.

Recommendations for Stakeholders

Individual country recommendations for stakeholders and policy implications were forwarded:

China

Public-private sector partnerships. Facilitating the rapid diffusion of biotechnology to farmers requires the synergistic participation of both public and private sectors. Seed companies must address the demand requirement as this affects the scale of initial adoption and the number of farmers who can plant the new crop. Local village leaders can arrange for the purchase of biotech crop seed so that farmers can easily acquire them. Technology developers from either public research institutions or biotech institutions play an important role in the initial introduction of the technology. They need to put up field trials and demonstration areas that will allow farmers to see how the new biotech crop

compares with conventional varieties. These mechanisms have been identified as ways to attract the interest of individual farmers and groups of farmers moving them to adopt the technology in their own villages. Obviously, an understanding of the social network in the community is important.

Extension service and training need to be sustained to keep farmers updated on the new varieties that are available for their use. Training should address specific concerns and provide appropriate information so that farmers can benefit fully from the technology.

India

Farmers. The recommended package of practices in cultivating Bt cotton should be followed to obtain the maximum yield potential of Bt cotton hybrids. Farmers often do not set up a refuge system and opt to modify some recommended practices. Excessive spraying of pesticides should be guided by a more objective science-based methodology of using economic threshold levels rather than by subjective assessment of pest infestation. They should actively participate in outreach activities to raise their awareness and understanding of the cotton value chain. An alert farmer is an affluent farmer.

Extension system. An active and functional system will provide a support mechanism for farmer adoption. Non-compliance with the refuge requirement in Bt cotton fields and other farm practices as well as the countrywide prevalence of confusion over the selection of appropriate Bt cotton hybrids are attributed to the weak participation of the extension system. State agricultural universities and agricultural science centers (SAU and KVK) should organize field demonstrations and hold field days for farmers. In addition, they need to gather feedback from farmers about field experiences on the use of cotton hybrids in order to further improve technology delivery. To constantly update the extension system, training and information briefings should be provided. Partnerships between the private sector and the government extension system can be strengthened to maximize their individual contributions.

Policymakers at the state level. The quality and purity of Bt cotton hybrids should be ensured to meet quality standards under the Seed Act. Corrective measures should be taken against suppliers selling substandard hybrid varieties to the farming communities. The state should play an active role in acknowledging and popularizing the technology's benefits and report them to the people in the countryside.

Seed companies. Issues of technology stewardship and oversight should be tackled to sustain the technology in farmers' fields. Specifically, efforts should be done to strengthen quality control and purity checks so that substandard seeds do not enter the market. Seed companies, in consultation with seed associations and suppliers, need to arrive at a reasonably acceptable price for seeds that are sold to farmers. It is also important that results of studies on the new technologies be communicated to the broader section of society prior to large-scale commercialization.

Philippines

Farmers. Farmer-to-farmer education must be promoted and sustained. Linking farmers with those who have appropriate information and relevant experience will draw inspiration through examples. The more perceived commonalities and/or emotional attachments between and among farmers, the more likely for them to learn from one another. Linking farmers with experts through seminars can assist them to address concerns such as persistent pests and diseases (other than borers that can also attack corn).

Efforts must be done to professionalize farming so that farmers are enabled to do certain tasks such as record keeping. This will rationalize their income and profit and help them make better decisions on the use of inputs and expenditures. Progressive farmers or those who took the risk as initial adopters need to be recognized as local champions and tapped as channels for uptake and adoption of biotech crops.

Policymakers. The government needs to intervene in setting up a minimum buying price for a biotech product. This will assure that farmers get a fair return on their investment and that traders are prevented from taking advantage of farmers as they buy their produce. Relevant government authorities can help set up the local selling price and monitor any changes over time. Alternative credit systems for farmers have to be explored so that they do not become victims of financiers or traders that provide initial capital or inputs and capture the market for produce.

Seed companies. Private companies need to assure the quality of seeds that they sell to farmers. Standards have to be set and followed so that farmers will obtain the potential yield expected from the crop, which was the promise given by the technology developers.

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