Involvement of private sector for commercialization of *Bradyrhizobium* technology: Impact on soybean production in Bangladesh

Authors
Rajiv Pradhan[1], Country Director
Md Nurul Amin[1], Operations Director
Dr. Md. Enamul Haque[1], Team Leader, Conservation Agriculture Project
Dr. Md. Monowar Hossain[2], Project Director, Bradyrhizobium Production
Golam Sarwar[3], Bradyrhizobium Dealer

[1]International Development Enterprises (iDE), Apartment No. 202 & 302, House 21, Road 123, Gulshan-1, Dhaka 1212, Bangladesh.
[2] Bangladesh Institute of Nuclear Agriculture (BINA), Mymensing, Bangladesh.
[3] Sarwar Traders, Sonapur Zero point, Sonapur, Noakhali-3800, Bangladesh.

A biological fertilizer demonstration field of soybean treated with and without Bradyrhizobium (extract from BINA web site)

Abstract:

In Bangladesh the total demand for edible oil is around 1.3 million ton per year. Nearly 90% of demand is met by importing oil. The potential market for domestically produced oil is therefore considerable; technological innovations that support soybean cultivation could provide a significant incentive for poor 'char' based farmers to switch to this profitable crop. Like pulse, soybean takes atmospheric nitrogen out of the air through root nodule bacteria. *Bradyrhizobium* has been identified as the most effective biological fertilizer for soybean. It helps to improve soil fertility, increase grain yield by 20% and reduces the need for nitrogen fertilizer. Even so, *Bradyrhizobium* is still unavailable to farmers. BINA has produced a limited amount of *Bradyrhizobium* when there is demand from producers, however, studies (Ref.-Soybean value chain study- Asraf Siddiue and Md. Badrul Alam, iDE- Bangladesh**)** show that non-involvement of the private sector is the key cause of poor adaptation of *Bradyrhizobium.* According to these studies the system of producing bio-fertilizer is not well developed, nor has the supply chain been established for sustainable *Bradyrhizobium* production and distribution. In collaboration with private sector and BINA, iDE has implemented a pilot initiative for sustainable *Bradyrhizobium* commercialization, with the objectives of engaging local input seller and entrepreneurs; creating linkages between BINA, farmers and the private sector; and analyzing the scope of *Bradyrhizobium* business. Significant progress has been made with this pilot initiative resulting in 2000 kg of *Bradyrhizobium* being used for the first time in Bangladesh and grain yield increased by 15%. In this paper we will discuss the successful model of *Bradyrhizobium* technology commercialization and adaptation in Bangladesh.

1. Introduction:

Soybean has nearly 42% protein and 20% oil on a dry weight basis; it is also the most energy-packed major crop in the world. Soybean has nearly five times more protein than rice and nearly twice the protein of meat and most pulses. It is probably the most affordable and healthy solution for solving the chronic protein deficiency in the Bangladeshi diet. Because of the high-energy packed in 20% soybean oil, it can provide much needed fat / energy to the millions of manual laborers and farmers in Bangladesh. Compared to artery clogging saturated animal fats, soybean fat has a high percentage of unsaturated fat and, thus, a much healthier source of fat for human consumption. Soybean is the number one edible oil and protein source for poultry, fish and livestock as well. The end uses for soybean are growing very fast as are the demands for it. Almost all soybeans used in Bangladesh are imported. In Bangladesh the total demand for edible oil is around 1.3 million ton per year. Of this amount, less than 0.2 million ton comes from mustard while the rest is met with imported soybean oil and palm oil. In the 2009-10, soybean was grown in around 50,000 ha of land with an average yield of 1.5 t/ha in Bangladesh. Soybeans as a crop were introduced into Bangladesh during the 1960s and, beginning in the early 1980s, cultivation was promoted by the Mennonite Central Committee (MCC), an international voluntary organization working in Bangladesh. Largely as a result of MCC efforts, cultivation expanded somewhat, especially in the Noakhali area. According to Khaleque (1982), soybeans are a new crop in Bangladesh. They were introduced during the 1960s, but no attention was given to their improvement and expansion until 1974, when the Bangladesh Agricultural Research Institute (BARI) began to study their feasibility and performance as a regular crop. The results were so promising that in 1975 the government launched the Bangladesh Coordinated Soybean Research Project (BCSRP) under the Bangladesh Agricultural Research Council (BARC), to study the introduction, cultivation, and use of soybeans in Bangladesh. Serious work in each of these areas, including varietal improvement and local cultural practices, began immediately. Few farmers had grown soybeans before 1975, but with the introduction of short-season varieties, growing soybeans became more popular. By late 1980 only about 810 ha (2,000 acres) of soybeans were being grown, but a national target of 6,113 ha (15,000 acres) had been set for the second year plan. Average yields of 1,475 kg/ha were about 30% more than other legumes and 25% more than other oilseeds, except peanuts.

Soybean fixes atmospheric nitrogen through root nodule bacteria like other legume crops. The use of Bradyrhizobium for soybean can fix up to 270 kg nitrogen per hectare from the air, much higher than other legume crops (58 to 157 kg per hectare) generally grown in Bangladesh. Only 30 g of Bradyrhizobium is recommended for per kg of soybean seed. It helps to improve soil fertility not only for itself but also for the next cereal or non-legume crops grown in rotation thereby reducing the requirement of external use of nitrogen fertilizer. It also increases soybean grain yield with up to 20%. Bangladesh Institute of Nuclear Agriculture (BINA) has developed bio-fertilizers for most pulses crops including Bradyrhizobium for soybean in 1977 and successfully demonstrated in the different locations of Bangladesh through some projects. **BINA-SB-4** is one of the most promising Bradyrhizobium inoculants for soybean cultivation. Farmers can obtain 75-150% more seed yield by applying this Bradyrhizobium. (Ref.- BINA website). Bradyrhizobium in case of soybean fix N 210kg/ha which is equivalent to 467 kg urea fertilizer. (Ref.- Jibanu Shar Porichiti and Proyog by M.A. Sattar Mondol, BINA, Mymenshingh).

Due to lack of involvement of private companies for the commercialization of Bradyrhizobium bio fertilizer and the coordination among research institute and private companies, the adoption was minimal. During implementation of the Rural Enterprise Development (RED) component of Market Infrastructure Development Project in Charland Regions (MIDPCR), lead by Local Government Engineering Department (LGED), Bangladesh. We knew that BINA tried for privatization and worked with A-Khan Co. Ltd. The company was licensed but because of market and policy issues the company could not continue the production of Bradyrhizobium business. The demonstration results showed that there is a huge demand for Bradyrhizobium. However, this demand has not been met. A few studies were conducted to identify the reasons for non adoption and dissemination of Bradyrhizobium. These studies found that the causes of non adaptation are i) production and management of Bradyrhizobium; ii) unclear scope of the Bradyrhizobium market; iii) unavailability of Bradyrhizobium at soybean farmers level and iv) lack of publicity.

2. Materials and methods:

Findings from the previous studies, in collaboration with BINA and Srowar traders (local level private company), iDE has implemented a pilot initiative under the RED component during 2009 to 2012 in Noakhali and Luxmipur districts of Bangladesh. The pilot initiative gave emphasis to establishing organization linkages among researchers with private companies, involving whole sellers and retailers of the existing input market, and with soybean farmers; completing a subsector and value chain study of soybean and identifying the necessary intervention for the soybean Bradyrhizobium supply chain. The pilot initiative also analyzed the scope and mapped the Bradyrhizobium market; key players for the supply chain of Bradyrhizobium; identified soybean farmers who were interested to use Bradyrhizobium. This was done through literature review, formal and informal meetings, farmers group discussions, etc. Moreover, the pilot initiative has conducted farmers training and setup of Bradyrhizobium demonstrations in farmer's soybean fields.

3. Results and discussion:

3.1 Benefits of Bradyrhizobium for soybean cultivation:

$237- increase for soybean farmers (per hectare)- differential data for various groups

Below is the differential data between farmers who used Bradyrhizobium in soybean cultivation and a group of farmers that did not. The average area of land cultivated by this group is 133 decimal per farmer; increase yields is 2.1kg/ decimal (Tk. 60.30) and the reduced cost for less urea/decimal (Tk.2.60). The total average increase is therefore Tk. 63 per decimal/ Tk 8379/ $USD 116.38 per farmer per season.

The figure of $USD 237 was an increase per hectare of land.

3.2 Analyzed the Bradyrhizobium market scope:

The pilot initiative has mapped the soybean growing area (Map 1) from country perspective and identified local actors for Bradyrhizobium marketing form the MIDPCR working areas[1]. It also found that there is a potential market for Bradyrhizobium. It is estimated that (Ref. national news paper) in char land area there are about 700,000 ha of land that could be used for soybean cultivation. According to the Department of Agricultural Extension of Bangladesh, currently soybean is grown in 47000 ha of land. The present requirement of Bradyrhizobium is about 60,000 kg per year (1.25 kg per ha). In future if the soybean area will expand up to 700,000 ha the total requirement of Bradyrhizobium could be about 875,000 kg.

iDE Bangladesh started to implement the RED component under the MIDPCR in 2009. The situation analysis study has shown that soybean is one of the cash crops in this area with a good economic prospect. Furthermore the RED facilitated a pulse and oils subsector study and found that among oil crops, soybean is the most important.

In the study the component started looking for the major constraints to increase growth of the soybean value chain and identify root causes. Seed, fertilizer use (particularly Bradyrhizobium) and finance were the major constraints. Among these constraints Bradyrhizobium could be implemented easily and give quick results to the farmers. RED team facilitated the intervention to organize existing and potential value chain actors to develop local level supply.

We found that BINA and Bangladesh Agricultural Research Institution (BARI) are the only producers of *Bradyrhizobium* and only in a limited scale with support from donors. The projects of the research institution are not focused on commercialization of the technology though it has demand. Also private companies are not interested because of the limited market opportunities since the growing area and season, winter, are limited.

The demand of the soybean farmers encouraged RED team to start a dialogue with BINA and local input sellers to facilitate the B*radyrhizobium* supply chain. We found that the retailer selling seed, pesticide and fertilizer have a very good connection with the soybean producers. So we assisted the input sellers to survey the demand, listen to the farmers and negotiate with BINA to ensure supply of *Bradyrhizobium*.

We also discussed the possibilities of company investment from Lal Teer Seed Ltd., ACI Seeds, Syngenta Seed, Buyer Crop Science, etc. to promote Bradyrhizobium. We found that oil extraction companies, fish and poultry feed manufacturing companies and soya milk and food processing companies could be involved in the business as well.

Possible districts for soybean production are Noakhali, Lakshmipur, Chandpur, Feni, Barisal, Bhola, Faridpur, Patuakhali, Meherpur, Jessore in the south. Rangpur, Gaibanda, Bogra, Kurigram, Nilphamari,

[1] MIDPCR working areas: Barisal, Patuakhali, Bhola, Noakhali and Luxmipur districts.

Lalmonirhat, Dinajpur, Thakurgaon are possible districts in the north. And finally Tangail, Mymensingh, Jamalpur show potential in the middle part of Bangladesh.

3.3 Identification of key actors for developing Bradyrhizobium supply chain:

It was found from the soybean value chain study that there is huge potential to use Bradyrhizobium to increase soybean yields. Farmers are interested to use Bradyrhizobium but the product is not accessible in the farm level. The Bradyrhizobium is produced by BINA and BARI but no supply chain exists. Even BINA and BARI only produce Bradyrhizobium if they get an advance order from the farmers or buyers with a list of farmers.

We explored the opportunity in the soybean growing cluster by organizing focus group discussions with farmer and local level agri. input sellers. One input seller agreed to invest in selling Bradyrhizobium and collect farmers demand. The journey for commercialization of Bradyrhizobium in the farmers' level started from that negotiation. Later, all 18 local level input sellers were involved to sell Bradyrhizobium to the farmers in the RED focused soybean growing areas.

No big companies were interested to invest in this business, however we found that in 2012 APEX Bio-fertilizer & Bio-pesticide Ltd. started to produce Bradyrhizobium to use in their own soybean production farm. At present the key actors are- Apex group ltd., local seed sellers, fertilizer sellers, BINA and BARI.

3.4 Establishing linkage:

The RED team facilitated a workshop among the *Bradyrhizobium* suppliers (BINA, BARI and input sellers) and soybean producers to understand demand and supply opportunities of *Bradyrhizobium*. This was mostly derived by information acquired through organizing soybean farmers under the leadership of the local input seller. Initially facilitated demonstrations in collaboration with Department of Agriculture Extension (DAE) and input seller showed the result and a few progressive farmers were encouraged to use *Bradyrhizobium* for soybean production.

Simultaneously the RED team facilitated a visit for farmers and input sellers to the research institution to understand the complex supply system. Because of this, linkages were established between researcher, DAE, input seller and farmers. They also discussed pros and cons of the technology and its availability. This type of discussion lead to clarify the availability of the technology, the practices in the field, risks of the business and its impact on the productivity.

In the field, once farmers understood the result of increased soybean yield by using *Bradyrhizobium,* input sellers got more demand. BINA agreed to supply a limited amount of *Bradyrhizobium*. But the major concern is whether the volume and continuation of supply are still guaranteed after the project. We hope that APEX Bio-fertilizer & Bio-pesticide Ltd. could be one of the private sector actors who commercialize the technology in the country. For that to happen, the production and supply of Bradyrhizobium requires policy level support.

3.5 Involvement of Private Sector

RED focused on the value chain development of different subsectors thus the team explored the opportunity to involve commercial service provider. It was found that the local level input sellers would be the best option to arrange Bradyrhizobium supply chain up to the farm level. So the field team started discussion with BINA, the only prouder and supplier of Bradyrhizobium. The team facilitated business linkages among input sellers, BINA and farmers to start commercial selling of the Bradyrhizobium. Later on we found that the upazilla level input sellers and community based organizations (CBO) were involved in providing services to the farmers as well.

Table 1: Inclusion of input sellers

Year	**# of input sellers**
2009	6
2010	11
2011	16
2012	18

More input sellers (shown in the table 1) were interested get involved. They are not selling only Bradyrhizobium but are also increase sales of other inputs such as seed, fertilizer, pesticide, etc. The RED started with 6 input sellers in 2009 but over time the number of input sellers has increased up to 18.

APEX Bio-fertilizer & Bio-pesticide Ltd. also started to produce Bradyrhizobium in 2012 for use on their own farm (465 acres of land in northern districts). They do not sell to the market but hope in future they will be able to do this.

3.6 Identification of soybean growers interested in using Bradyrhizobium

The RED team indentified input sellers and soybean producers in the MIDPCR working areas. In 2009 and 2010 the RED staff worked to link farmers with input sellers and input sellers with BINA. The input sellers and the team jointly worked to increase the number of Bradyrhizobium users for soybean production and as a result the number of Bradyrhizobium users has increased (Table 2).

Table 2: Farmer used Bradyrhizobium

year	**# of farmer**	**Places**
2009	120	Noakhali & Luxmipur
2010	800	Noakhali, Luxmipur & Barisal district.
2011	1720	
2012	1900	

The RED started with 120 farmers in 2009, but due to increase of soybean productivity more farmers' showed their interest to use Bradyrhizobium. In 2012 the number of users increased to 1900. If private companies start to produce and sell Bradyrhizobium, more farmers will get access to this technology since a big base has been established.

3.7 Organizing farmers training on Bradyrhizobium use

The RED selected soybean for strengthening the value chain to increase farmers' income from soybean cultivation. The staff identified soybean clusters and shared the interventions with farmers. Soybean producers were selected by lead farmers, CBOs and input sellers. They formed groups to participate in the training.

The team also selected a trainer or resource person from the private company, public led extension agencies, BINA/BARI, and expert farmer from the community to facilitate the training and workshop. As of today 12 trainers were listed from MIDPCR areas. The team organized training and/or workshop before start of the season. The listed trainers or resource persons were conducting the training for the farmer. In the training a practical session has been conducted. As the technology is low cost and easy to use, farmers are encouraged to use Bradyrhizobium for soybean cultivation.

Table 3: Farmer participated in different capacity building events

year	**# of farmer**			**Places**
	Training	Workshop	Visit	
2009	40	76		Noakhali, Luxmipur, & Barisal district
2010	220	155	32	
2011	160	162	11	
2012	40	51		

The RED team organized three major events: training sessions, workshops and a visit to improve farmer capacity and establish linkages on soybean production and marketing. As of 2012 a total of 460 farmers attended the training, 404 farmer participated in the linkage workshop and 43 advanced farmers visited different research institutions, buyers and farmers fields. Those events were improve capacity of the framers and make them interest to use Bradyrhizobium for soybean cultivation.

As the input sellers saw this opportunity, they added Bradyrhizobium as a new product in their existing business. That has increased sales of other products and strengthened the relationship with soybean farmers. On the other hand, by using Bradyrhizobium, soybean production has increased. This is ultimately a win- win situation for both input sellers and soybean producers.

3.8 Facilitation of demonstration and farmers field day of Bradyrhizobium

Table 4: Demonstrations facilitated in the farmers field

Year	**# of demo**	**Places**
2009	3	Sadar, Subornochar,
2010	5	Subornchar, Ramgoti
2011	7	Subornchar, Hizla

The RED team discussed with input sellers and DAE to select farmers for set up of demonstrations in their field. Generally lead/advance farmers have been selected with the consent of other soybean

producers. The input seller monitored the progress with the help of RED staff. The demonstrations all had a control field which means that one plot is with Bradyrhizobium and another plot is without

Bradyrhizobium. The farmer didn't collect data from the demonstration but in different growth stages of the crop the performance was observed and discussed in the meeting. The indictors for measured demonstration performance are grain size, grain color and yield. After harvest the grain size, color and yield was compared with Bradyrhizobium treated and non treated plots.

3.9 Scaling up of the technology

The table shows that the adoption rate is increasing every year. It provides us the indication that if the supply chain of Bradyrhizobium established through private sector actors than the farmers will be able to access the technology. As a result the farmer uses the technology; increases productivity and can provide a substitute for the soybean import.

Table 5: Scaling up of the Bradyrhizobium technology

Year	**Amount of Bradyrhizobium (Kg)**	**# farmer**	**Land coverage (Acre)**	**Area coverage**			
				village	**union**	**upazilla**	**District**
2009	40	120	30	15	6	Noakhali sadar, Subarnachar, Ramgoti	Noakhali, Luxmipur
2010	362	800	280	40	14	Noakhali sadar, Subarnachar, Ramgoti, Hizla	Noakhali, Luxmipur, Barisal
2011	1200	1720	860	45	16	Noakhali sadar, Subarnachar, Ramgoti, Hizla,	Noakhali, Luxmipur, Barisal'
2012	1400	1900	1020	50	18	Noakhali sadar, Subarnachar, Ramgoti, , Hizla,	Noakhali, Luxmipur, Barisal,

3.10 Cost benefit analysis by using Bradyrhizobium and without Bradyrhizobium

The team collected profit measuring data from farmers who cultivate soybean using Bradyrhizobium and without Bradyrhizobium. It was found that the profit with Bradyrhizobium is approximately 75% higher than without Bradyrhizobium. The comparison data is shown in below table.

Table 6: Cost benefit analysis

Items	**With Bradyrhizobium (Tk./hac)**	**Without Bradyrhizobium (Tk./hac)**
Input cost	10290	12270
Labor , harvesting and marketing cost	18250	15000
Total cost	28540	27270
Total income	61250	45500
Profit	32710	18230

Selling price of the soybean is Tk. 35 per kg soybean
Yield calculation does not consider by products (Hay) of the soybean.

3.11 Data collection, analysis, reporting, etc

The data was collected during workshops, training sessions and meetings with individuals or focus group discussions (FGD) with the demonstration farmers and other soybean producers. The most important was the result discussion on the soybean harvesting day. During that meeting farmers compared the performance of the field between Bradyrhizobium treated and non treated plots.

4. Lessons Learnt:

- Whilst the DAE was effectively disseminating information and training on Bradyrhizobium, there was no established mechanism for dissemination of this input to the farmer level, despite awareness and demand. Thus, training and demonstrations are not enough to ensure commercialization.

- Involving the private sector to enhance access to improved technologies intensified the demand of farmers for increased and better quality extension. This acted as an effective farmer-DAE-research-private sector feedback mechanism, as the input suppliers engaged in dialogue with DAE and link with private companies.

- Inclusion of all stake-holders workshops is key. In order to ensure that buyers and/ or input suppliers understand the input/ output market demand they must be included in result sharing experiences with extension and the research institutions. The private sector should be seen as a commercialization of the technology to farmers following increase in yield demonstrated by research institutes and education/awareness raising by DAE.

5. Conclusion:

The demand for Bradyrhizobium is increasing but supply is still an issue because of the limited capacity of Bradyrhizobium production by BINA and BARI. The research institutions are not commercially focused and thus adaptation of Bradyrhizobium has been limited. However BINA, the research institute that developed *Bradyrhizobium*, attempted to transfer production and distribution to the private sector, however regulatory constraints coupled with a niche market deterred private sector investment.

It seems that *Bradyrhizobium* remained unavailable for farmers because of the fact that while DAE was raising awareness of the benefits of *Bradyrhizobium*, they were not responsible for distribution of the product, and no incentives existed to ensure its availability. Thus, with no mechanism of distribution,

Bradyrhizobium remained unavailable to smallholders and their soybean yield remained stagnant. RED's interventions created access to *Bradyrhizobium* that increased the agricultural productivity of poor and marginal soybean farmers. In enhancing the productive capacity of these farmers, the case demonstrated sustainable research- extension and private sectors linkage capable of increasing incomes for multiple stakeholders within the agricultural sector, whilst contributing to wider food security and economic development needs of Bangladesh.

5. Reference:

BINA web site: www.bina.gov.bd

Sattar Mondol M.A., “Jibanu Shar Porichiti and Proyog” 1999, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensing, Bangladesh.

Sarwar R., “Pulse and Oil Crops Subsector Assessment in the Charland of Barisal and Noakhali Regions - The Prospects, Challenges and Strategic Interventions for Growth” September 13, 2009

Siddique A. and Alam B., “Study report Soybean Value Chain Study” iDE- Bangladesh

Map of soybean growing areas