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ORIGINAL PAPER

Putting the poorest farmers in control of disseminating improved wheat seed: a strategy to accelerate technology adoption and alleviate poverty in Bangladesh

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Abstract This paper reports on a 'bottom-up' system of wheat seed technology transfer that was piloted in north–west Bangladesh with 45 mainly marginal (food insecure) farming families during the 2004–2005 wheat season, then scaled out to a further 545 mainly marginal, farming families during the 2006–2007 season. The system was devised following a survey which indicated that such farmers can obtain a 52% increase in wheat grain yield and extra income by switching from the old *Kanchan* variety to the newer, heat and disease-tolerant *Shatabdi* variety. The bottom-up wheat seed dissemination system involved the creation of an enabling environment which allowed poor and ultra-poor farmers to store and sell selected seed of recently-released wheat varieties that they produced in 20 decimal (0.08 ha) plots. During the pilot phase of the project in 2005, farmers produced 7, 976 kg of grain and more than 50% of this was selected as high quality seed, stored during the monsoon season and marketed to other farmers just prior to the following wheat season. This seed was sold at Tk25–30/kg and realised profits averaging Tk3,002 (€38.49; exchange rate was 78:1 in October 2005) per household. In 2007, the seed price had risen to Tk33–50/kg and a larger group of farmers produced, stored and marketed 168,800 kg of high quality wheat seed, which realised profits averaging Tk5,080, equivalent to €51 (exchange rate was 99.6:1 in October 2007), per household. This bottom up seed production and dissemination system met the wheat seed requirements of more than 1,400 neighbouring farmers in areas with a deficit of wheat seed for planting, and enabled poor and ultra-poor farmers to earn more than 50% of the income they needed to cross the local poverty line.

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Introduction: the importance of wheat in Bangladesh

Wheat is the second most important food crop in Bangladesh. It is most commonly ground into flour and processed as chapattis. The current annual requirement of wheat in Bangladesh is 3.5–4.2 million tonnes. However, on average, there is a shortfall of 2.0–2.2 million tonnes which is met through imports, which with prices current in May 2008 would cost the country US$660 million per year. The rate of increase in wheat consumption is about 3%/year (Sufian 2005).

According to the Rice–Wheat Consortium (2006) the irrigated and highly productive rice–wheat systems of the Indo-Gangetic Plains are subject to significant and increasing forces of change, such as land degradation, stagnating yields, inefficient use of chemical inputs, unsustainable use of water and emerging or worsening pest problems. Environmental and biological constraints that increasingly affect the production of wheat in the Eastern Gangetic Plains include heat stress, soil physical degradation, declining soil nutrients, Spot blotch (syn. Leaf Blight) and urbanisation (e.g. Chatrath et al. 2007; Barma et al. 2008). Global warming trends are projected to put further pressure on wheat production in the region (Sharma et al. 2007).

The wheat variety *Kanchan* was released in Bangladesh in 1988 and it became the most widely planted and high yielding wheat variety in the country during the mid-1990s. With *Kanchan*, Bangladesh wheat production reached a peak in 1998/99, when 1.9 million tonnes of grain were produced on 0.85 million hectares. Although still widely grown into the 2000s, the expected yield from this variety declined substantially due to increasing susceptibility to diseases, in particular Spot Blotch caused by *Cochliobolus sativus* (anamorph. *Bipolaris sorokiniana*) and Leaf Rust (*Puccinia triticina*), and the risk of spike sterility due to boron deficiency, which is induced under cloudy skies and during cold winters. Climate change has resulted in shorter *Rabi* (cold) seasons which culminate in heat stress during the grain filling phase (Sharma et al. 2007). This seriously affects yields if sowing is delayed (Badaruddin et al. 1994). The wheat area and total production have also been decreasing in Bangladesh since 2000 (Barma et al. 2008). This was due to reduced yield expectations described earlier, competition with other more lucrative dry season crops such as maize and the drudgery that is associated with hand threshing wheat. In the 2005–2006 wheat season, the area was reduced to 0.48 million hectares with production of 0.76 million tonnes. At the same time, the national average grain yield went down to 1.88 t/ha in 2005–2006, compared with 2.24 t/ha in 2000–2001 and 2.16 t/ha in 2001–2002.

In order to address the problem of declining wheat yields, a series of new, improved varieties were recently developed to replace *Kanchan* (Barma et al. 2008). The first to be released was '*Shatabdi*' (or 'Millennium') in 2000. A further three varieties, *Prodip*, *Sourav*, and *Bijoy*, were released more recently and are now being made available to farmers. These varieties were developed from a series of crosses[1] between parents originating from CIMMYT in Mexico and were selected by breeders from the Wheat Research Centre[2] (WRC) of BARI in Bangladesh. The new varieties are semi-dwarf types with good tillering ability and a duration of 105 to 110 days to ensure maturity before the end of the short cold season. They have varying degrees of resistance to Leaf Rust and tolerance to Spot Blotch (Siddique et al. 2006).

A widespread lack of awareness of the new varieties among farmers and limited access to seed of new varieties have been repeatedly cited during the 2000s as among the most serious constraints to maintenance of wheat production in Bangladesh (Barma et al. 2008; Baksh 2004; Baksh et al. 2006). On-farm demonstrations of the new varieties have been mounted by the Department of Agriculture Extension in some areas. More innovative approaches to participatory selection of varieties with farmers have been successful in raising awareness and encouraging uptake of these new varieties (Pandit et al. 2007) but these initiatives have been conducted in just a few villages. Community-based, bottom-up seed production and marketing initiatives are new for wheat in Bangladesh but have been tried with varying degrees of success elsewhere, e.g. in India and Africa on other crops (Joshi and Witcombe 1996; Craufurd et al. 2004).

Operational framework

Rural poverty in Bangladesh

Eighty percent of rural households own no more than 0.02 ha of arable land, while almost 50% are considered to be landless (Rahman and Manprasert 2006). These households are classified as 'poor' or 'ultra-poor' and, using income and exchange rates from October 2007, poor households earned less than Tk9,176[3] (€93) per year from either farming or other activities, while the ultra-poor are without either land to grow food or other assets which could enable them to generate income. Both poor and ultra-poor farmers are obliged to work as casual labourers at a rate of Tk60 (€0.5) per day, in order to buy supplementary food and other essential items. Many of these families are indebted to food surplus farmers, often the result of borrowing money to pay for urgent medical treatment.

Impact of improved technologies on the poorest farmers

According to the Rice–Wheat Consortium (2006), improved crop varieties and use of fertiliser and other

[1] CM 98472 pedigree (Maringa/Buckbuck//Bolillo/Pavon/3/Punjab81).

[2] Part of the Bangladesh Agricultural Research Institute (BARI).

[3] Bangladesh's poverty line varies according to the 'cost of basic needs' such as food and other essential items (Bangladesh Bureau of Statistics and World Bank Poverty Assessment, 2002). Tk9,176 was calculated as being the 'cost of basic needs' in October 2007 by Dipak Kumar Ghosh of PROSHIKA.

improved practices have failed to make an impact with the poorest farmers in risk-prone, resource-poor regions of South Asia in recent decades and there is need for more delivery pathways to speed up the adoption of ready-to-use practices that boost system productivity amongst the poorest farmers in the Eastern Gangetic Plains.

Improved technologies have had limited impacts on poor farmers because they are usually disseminated via on-farm demonstrations and field-days, on land belonging to richer farmers; farmers who have sufficient land to guarantee food security and can bear the risk of adopting the new technologies, are invariably invited to participate. While this procedure encourages a high adoption rate amongst the participants, it also serves to widen the gap between rich and poor/ultra-poor farmers, i.e. between those who can take risks and those who are risk averse. In order to disseminate beneficial technologies more widely and reach the poorest farmers in particular, it is necessary to reduce the risks associated with technology adoption. The best way of doing this is to enable risk-averse farming families to generate income by providing a service which is linked to the adoption and spread of a particular new technology. This type of intervention normally requires injections of human capital, in the form of training, and financial capital, in the form of micro-credit, from specialist NGOs.

Methods and results

Targeting the poorest farmers

The adoption of new technologies, including seed of new varieties, could threaten the livelihoods (as measured through household food security and financial income) of resource-poor farming families. Only those families with sufficient land or earnings to guarantee food security throughout the year can take this risk. To target the poorest groups with our research, farming families were categorised according to their ability to take risk:

Landless/food insecure, ultra-poor family Must rent land to grow food or do paid labour to buy food and pay for other necessities. *Cannot take any risks*.

Marginal/food insecure farming family Has insufficient land to achieve household food security. Regular shortages of food and cash. Must do labour to buy additional food, inputs and other basic necessities. Can enter a downward spiral into extreme poverty very easily. *Cannot take any risks*.

Subsistence/self-sufficient farming family Has sufficient land to meet basic food needs under normal conditions. May need to do labour to pay for inputs and other necessities (including school fees). Remains vulnerable to economic and environmental shocks. *Is risk averse*.

Food surplus farming family Has sufficient land to guarantee household food security on a regular basis. Able to produce surplus grain and cash crops for sale to buy inputs, send children to school and accumulate 'middle class' assets, e.g. bicycle, TV, electric fan. *Able to take risk*.

According to this classification, only 'subsistence' and 'food surplus' farmers are able to take risk and therefore it is these farmers who are most likely to adopt new technologies

In order to target the poorest, risk-prone, marginal and landless farming families it was necessary to classify them according to their ability to be food secure. The method used for this process involved calculating the Rice Self-Sufficiency Index (RSSI) for each household, since these families depend on rice for their food security. This was based on their landholding (i.e. the area of land that they own), number and ages of dependents and expected yield of unprocessed, rice paddy, according to the following formula (modified from Page and Chonyera 1994):

$$\text{Rice Self} - \text{Sufficiency Index (RSSI)} = \frac{\text{Potential paddy yield (kg/ha)}}{\text{Annual paddy requirement (kg)}} \times \text{Landholding (ha)} \times 100.$$

The annual rice paddy requirement of each household is calculated according the mean, minimum, recommended daily energy intakes for adults, adolescents over 10 years and children under 10 years.[4] This is 2,500 kcals, equivalent to 365 kg of (unprocessed) paddy rice per year[5] for an active adult, 2,000 kcal, equivalent to 274 kg of paddy rice per year for an adolescent 10–18 years and 1,500 kcal, equivalent to 183 kg/year for a child under 10 years. The farmer's own yield data in terms of kilograms of paddy per hectare is used to calculate the RSSI for his household.

The Rice Self Sufficiency Index (RSSI) for landless farmers will normally be zero, while the RSSI for marginal farmers will always be less than 100%. For the purposes of this research, the RSSI for subsistence farmers was set at between 100% and 200%, while farming families who had RSSIs of more than 200% were classified as food surplus/cash-cropping farmers, see Table 1. This poverty assessment method is both quick and accurate to use in the field since it requires only five simple statistics: the numbers of adults,

[4] According to FAO/WHO/UN human daily energy requirements vary as follows: 2,780kcal for a male subsistence farmer; 2,235kcal for a rural woman in a developing country (2,585–2,977kcal during pregnancy and lactation); 1,140kcal for girls aged 1–10years; 1,200–2,150kcal for boys aged 1–10years; 2,300–2,340kcal for adolescent girls aged 10–18years and 2,500–3,100kcal for adolescent boys aged 10–18years (FAO 1985).

[5] Unprocessed rice contains 360kcal/100g (Saunders and Betschart 1979).

Table 1 Comparison of yields of *Kanchan* and *Shatabdi* wheats in Daulatpur and Jagdal villages, north-western Bangladesh, reported for the 2002–2003 season

Wheat farmers	Rice self-sufficiency index (%)	Landholding (ha)	*Kanchan grain* yield (kg/ha)	*Shatabdi grain* yield (kg/ha)	Number of farmers regularly visited by extension
Marginal farmers					
Mean of 9	72	0.50	1,869	n/a	2
Mean of 7	61	0.56	n/a	2,844	0
Subsistence farmers					
Mean of 3	124	1.10	2,083	n/a	1
Mean of 4	139	0.93	n/a	2,885	2
Food secure farmers					
Mean of 6	362	2.85	2,008	n/a	3
Mean of 6	335	3.03	n/a	2,933	4

adolescents aged 10–18 years and children aged <10 years in the household, the landholding and the most recent rice paddy yield per unit area. These can easily be re-called by farmers.

Determining whether poor farmers benefited from using improved wheat seed[6]

New technologies may not benefit all socio-economic groups equally so it was necessary to determine whether poor farmers had benefited from using the improved wheat seed. This was done by means of a short survey that was conducted with farmers who had planted either *Kanchan* or *Shatabdi* wheat during the previous season.

During the *rabi* season ending in November 2002, scientists from WRC had worked with the Department of Agricultural Extension (DAE) to set up demonstration plots of *Shatabdi* wheat under the PVS (Participatory Variety Selection) programme in the villages of Daulatpur (Ref. 25° 968′×88°505′) in Sader Upazila (sub-district) of Thakurgaon district and Jagdal (Ref. 25°83′×88°64′) in Birgonj Upazila of Dinajpur district, which were attended by marginal, subsistence and food surplus farmers. Farmers who had attended the demonstration received 2 kg of this seed from WRC at no cost. Some of these farmers were interviewed 10 months later in order to assess the impact that switching to *Shatabdi* had had on their wheat yields. The productivity of 17 of these farmers was then compared with that of 18 neighbouring farmers who had not attended the demonstration and had thus continued to grow the old *Kanchan* variety: both groups of farmers were questioned in order to determine their RSSIs and asked to recall their grain yields from the previous season. Sixteen of these farmers were from marginal households: nine of them had grown *Kanchan* wheat, while seven had grown *Shatabdi* wheat. Those who had grown *Kanchan* had obtained a mean grain yield of 1,869 kg/ha, while those who had grown *Shatabdi* had obtained a mean yield of 2,844 kg/ha, an increase of 52%. Seven of the farmers were from subsistence households: three of these farmers had grown *Kanchan* and obtained a mean grain yield of 2,083 kg/ha, while four had grown *Shatabdi* and obtained a mean yield of 2,885 kg/ha; an increase of 39%. Twelve of the farmers were from food surplus households: Six of these farmers had grown *Kanchan* wheat and obtained a mean yield of 2,008 kg/ha, while six had grown *Shatabdi* and obtained a mean yield of 2,933 kg/ha; an increase of 46%. Overall, the farmers who had produced *Shatabdi* wheat gained 46% more grain than their neighbours who had continued to rely on *Kanchan* (Table 1). While there was variation between the rates of fertilizer used by individual farming families, the amounts used on each of the two wheat varieties were not significantly different and could not be responsible for the wide yield differences achieved. Instead, the lower yields with *Kanchan* were attributed to the poor quality of the farmer-saved, *Kanchan* seed (some farmers indicated that they had been recycling their seed for more than 10 seasons) and the high incidence of spike sterility and foliar disease in the maturing *Kanchan* crop.

These data suggested that all socio-economic groups of farmers could potentially benefit from switching to *Shatabdi* wheat. However, farmers who were continuing to grow the old *Kanchan* variety reported that they had not attended the demonstration where *Shatabdi* seed had been distributed and that this seed was not yet unavailable in their area.[7] As marginal and landless farming families are less likely to receive advice from the local extension service or attend field-days, with this project we attempted to reverse the conventional 'top-down' approach by creating a new, 'bottom-up' system of technology transfer in which farmers who are the most vulnerable to risk would be the first to benefit.

It was anticipated that poor farmers could assist in the rapid dissemination of seed to all socio-economic groups of farmers by producing and selling the seed of improved

[6] Funded by DfID UK: see Page et al. 2006.

[7] The national seed supplier, Bangladesh Agricultural Development Corporation (BADC) is only able to provide 15–20% of the country's wheat seed requirements.

wheat varieties. This new system would depend on developing human capital amongst marginal and landless farming families through the provision of skills in the selection, storage and marketing of high quality seed of new varieties that are in high demand. These farmers would be able to take advantage of Bangladesh's seed policies that allow farmers to sell 'truthfully labelled' seed.[8]

Enabling the poorest farmers to take control of the production and marketing of Shatabdi seed

Pilot study with 45 farmers[9]

To establish a 'bottom-up' system of seed dissemination, 45 mainly marginal farming families were selected from the villages of Bakultala (25°85′×88°48′) in Buchagonj Upzila and Brahmanvita (25°98′×88°62′) in Birgonj Upzila of Dinajpur districts, to participate in a pilot study which aimed to train them as wheat seed producers and traders. Each of these families was required to own or rent 20 decimal (0.08 ha) of arable land. This small plot size was chosen to keep input costs low, particularly for landless farmers who were obliged to rent land for agricultural production and so that the area, when cultivated, could be easily managed using only family labour.

Field officers from a local NGO, Dipshika, with support of WRC scientists, facilitated two sessions of 'whole family training'[10] in each village to improve practices both for wheat management in the field and for the selection and storage of high quality wheat seed, see Fig. 1. The most crucial part of this enterprise was to persuade and help farmers to store their seed at home for 5–6 months in order to maximise their profits, rather than sell it immediately after harvest to pay off debts, as would be the normal practise. The farmers were able to sell small amounts of discarded seed as grain immediately after harvest, however.

The first 4-h whole family training session was held in November 2004, a few weeks prior to the recommended planting date for wheat and focused on land preparation, seed sowing, timely application of inputs and irrigation, while the second session, which was held 4 months later, focused on roguing out off-types, harvesting, threshing, drying, seed selection and storage. WRC scientists prepared the training curriculum and an accompanying, fully illustrated, wheat seed producers' handbook. The field workers also undertook five follow-up visits, advising farmers on planting and irrigation times, as well as record-keeping and marketing, at intervals throughout the wheat growing season.

Following the first whole family training session, each family was given a loan of 2 kg of *Shatabdi* wheat seed, sufficient to cover the 20 decimal (0.08 ha) plot, on the understanding that it would be replaced by seed selected from the subsequent harvest. Each family was given the opportunity of taking a loan from their supporting NGO in order to purchase the recommended inputs, amounting to an average of Tk1,394 (range Tk1,149 to 1,847). In most cases the production costs were highest for landless families as they were obliged to rent land for growing wheat.

In due course, the grain was reaped by hand and threshed either by hand or by the village drum threshing machine. Yields ranged from 209 kg (equivalent to 2,613 kg/ha) to 330 kg (equivalent to 4,125 kg/ha) with an overall mean of 267 kg (3,338 kg/ha). The correct drying point of 12% was reached when farmers could "crack" individual grains between their teeth. The farmers then selected the healthiest grains as seed (i.e. those that were large and heavy with bright, unblemished seed coats) and either used the discarded grain as

Fig. 1 Whole family training: child care is shared

[8] In 1997 the government signed the national seed act which allows farmers to sell so-called 'truthfully labelled' seed as long as they take legal responsibility for its quality (Danielsen et al. 2005). As a result hundreds of farming families have been linked with suppliers of foundation seed and trained to produce good quality rice seed in several areas of Bangladesh by the Grameen Krishi Foundation (Van Mele *et al*. 2005) and the Rangpur Dinajpur Rural Service (RDRS) (Samsuzzaman and Van Mele 2005). In some cases, these farmers have organised themselves into seed-selling groups to maximise profits. Similar practices are possible with wheat seed production and marketing by small farmers in Bangladesh. The project we describe here was developed to help very poor farmers take advantage of the opportunities provided by this innovative policy.

[9] Funded by DFID UK, see Page et al.(2006).

[10] This involves training families as wheat-producing units in recognition of the fact that all immediate family members participate in the production cycle and are affected by production decisions and results. Husband and wife, or mother and eldest son most commonly attend. Modesty is preserved by encouraging husbands and wives to sit together and adjacent to a member of the same sex. This arrangement also promotes the sharing of child care during training sessions, see Fig. 1. Women are also encouraged to participate in any field work. The methodologies were specifically designed by the WRC to be participatory, gender unbiased, and comprehensible for all educational levels. Formal classroom settings and teaching styles are discouraged. Instead, training rooms are arranged with semicircular seating to encourage maximum interaction and informal training methodologies are advocated. Evaluations have recorded 100 per cent comprehension of key messages, and nearly all wheat recommendations had a tested adoption rate of 90% to 100% (Meisner et al. 2003).

food or sold it to raise cash for debt repayments. All farmers saved some seed for their own use and to repay the amount that had been loaned to them. The seed was stored in either heavy duty, air-tight (double) plastic bags, protected within jute sacks that had been provided by the project and/or in plastic containers that had been made available for sale, until October/November, just prior to the next wheat planting season. In order to ensure that the seed was pest-free and had a germination rate of more than 92%, farmers were advised to conduct spot checks and carry out seed viability tests using moist jute patches or soil-filled, banana petioles as substrates.

In order to create demand for the new seed, WRC scientists designed and distributed 1,500 posters showing a crop of *Shatabdi* wheat and featuring one of the trained farmers praising the new variety. Sponsorship provided by Dipshika allowed 10 of these posters to be enlarged and placed on large billboards in prominent positions at bus stops, cross-roads and market places in Upazilas of Dinajpur, so that the message would reach as many farmers as possible, see Fig. 2. As a result, there was strong demand for the *Shatabdi* seed and in October/November 2005, the market price was unexpectedly high, at between Tk 25 and Tk 30 (€0.16–0.19) per kilogram.

Results of pilot study

Income from grain and seed sales Table 2 shows the mean yields, production costs, grain and seed sales, income and profit for each socio-economic group (landless, marginal and subsistence) of farming families as a result of selling their wheat grain (at Tk11/kg) and carefully selected seed to 131 neighbouring farmers: of the two ultra-poor, landless farming families, one family made a loss of Tk288 (€2.76) because they had chosen to retain at total of 55 kg of grain for food and 200 kg of seed for their own use, selling only 20 kg of seed to neighbouring farmers. However, the other landless family sold 218 kg of seed at Tk30/kg, which realised a profit of Tk5,815 (€55.74) which was the biggest

Fig. 2 Farmers viewing the WRC poster advertising Shatabdi seed

profit overall. Seventeen marginal farming families sold an average of 47 kg of grain (range 24 to 70 kg) and 149 kg of selected seed (range 85 to 210 kg) and made an average profit of Tk3,265 (€31.29) (range €16.84 to €46.1). Seven subsistence farmers sold an average of 42 kg of grain (range 35 to 52 kg) and 143 kg of seed (range 70 to 269 kg). This produced a mean profit of Tk2,907 (€27.86) (range €8.42 to €52.52) (Table 2).

Assessing impacts on livelihoods The impacts of development interventions on farmers' livelihoods can be measured by assessing changes in their human, social, natural, physical and financial capitals (Department for International Development 1999): Despite the small-scale nature of this project it was found to have produced a wide range of effects and benefits on livelihoods. Following the terms used in the DFID framework, by increasing the skills required to produce, select and store wheat seed, human capital was accumulated, while the profits made from seed sales contributed to social, financial and physical capitals: farmers gained respect from neighbours who bought their seed and invested their profits in agricultural inputs for the following season's crops and bought household items (including saris for their wives). In addition, the poorest farming families settled debts and paid for school fees, medicine and hospital treatment. Other investments reported included livestock, land, tree saplings, bicycles, tin roofs and water pumps, see Fig. 3.

Scaling up to 545 farming families[11]

This work was scaled up during the 2006–2007 season when 545 more, mainly marginal farming families (RSSI< 100%) were selected for whole family training (see Table 3, a–f). In this case WRC scientists enlisted the DAE and five local NGOs, namely, Augnishika, Solidarity, Brif, Protashha and Dipshika to facilitate this larger effort. A planning meeting was held with DAE and NGO field workers at WRC, Dinajpur in November 2006, when they were briefed on good wheat management practices and training methods suited to smallholder production of this crop. They also each received a 20 page, illustrated, training manual that had been specially written by WRC scientists, which could be referred to during future farmer training sessions.

Between November 2006 and March 2007, 36 whole family training sessions in wheat seed production were conducted by trained DAE and NGO staff and focussed on the same topics as before. Each session involved 10–20 families: DAE trained and followed up 170 farming families, while each NGO trained and followed up between 20 and 177 farming families throughout the growing

[11] Funded by Swiss Agency for Development and Co-operation.

Table 2 Mean financial benefits of producing, storing and selling Shatabdi grain and seed for three socio-economic groups of farming families in northwest Bangladesh during the 2004–2005 season

	Shatabdi grain yield (kg/0.08ha plot)	*Shatabdi* grain yield (kg/ha equiv.)	Production and storage (cost/plot Taka)	Grain sold (kg)	Income from grain (Taka)	Seed own use (kg)	Seed sold (kg)	Seed selling price /kg (Taka)	Income from seed sold (Taka)	Total income (Taka)	Profit (Taka)	Profit (Euro)
Landless farmers (2)	289	3,613	1,493	63	688	108	119	30	3,570	4,258	2,765	26.50
Marginal farmers (17)	267	3,338	1,400	47	519	70	149	28	4,146	4,665	3,265	31.29
Subsistence farmers (7)	262	3,275	1,351	42	462	77	143	27	3,796	4,258	2,907	27.86

season. Credit for inputs was made available and each family was loaned 2 kg of seed of one of the following improved wheat varieties: *Shatabdi*, *Prodip*, *Bijoy* or *Sourav* at the beginning of the rabi (cold) season. Farmers' rallies were organised in 16 villages just prior to harvest time in order to show off the performance of the farmers and their wheat crops. Each of these was attended by up to 250 neighbouring farmers.

Results of scaling up

In this larger promotion effort, wheat yields obtained by the trained farmers ranged from 80 to 402 kg (a mean of 251 kg) per 0.08 ha plot. This is equivalent to 1,000–5,025 kg/ha (a mean of 3,138 kg/ha). One landless farming family retained 80 kg of grain for food, while all other families retained less than 50% of this amount (a mean of 9 kg of grain per family overall). Families also sold an average of 122 kg of grain at a rate of Tk19/kg, once they had selected out the best quality grains for seed using the same methods as previously described. This provided an immediate, average income of Tk2,124 (€20). 543 out of 545 families stored an average of 130 kg of selected seed (a range of 20 to 320 kg) in airtight (double) plastic bags, protected within jute sacks or sealed plastic containers for 6 months, i.e. until the beginning of the 2007/2008 wheat season as recommended during the training, see Fig. 4. By this time the price for *Shatabdi* seed had increased to Tk25–32/kg, while seed of *Prodip* and *Bijoy* was worth Tk45–50/kg.

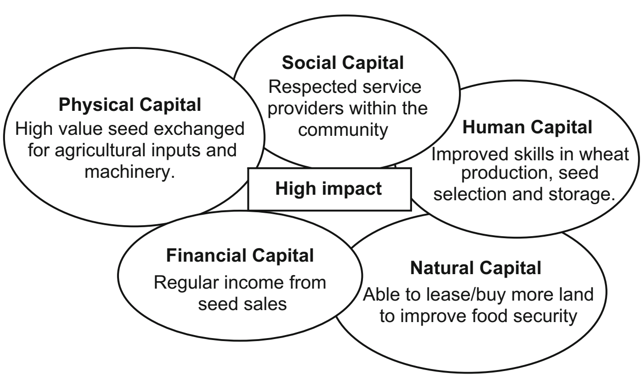

Fig. 3 Impact of marketing Shatabdi wheat seed on farmers' livelihoods

WRC scientists arranged for 1,500 more posters to be displayed in prominent places in order to advertise the benefits of these new varieties. As a result there was extremely high demand for the seed and all farming families who participated in the training programme gained financially from selling both wheat grain and seed to neighbouring farmers. Overall, each family made profits ranging from Tk632 to Tk12,481, equivalent to an average of €51. Eleven of the farming families (2%) earned €4–19, 213 families (39%) earned €20–45 and 305 families (56%) earned €46–92. This was a mean return on investment of 3.9 i.e. profit divided by investment costs. As a result, the majority of families earned more than 50% of the annual income needed to reach the poverty line, which in October 2007 was Tk9,176 (€93). Fifteen families (3%) who had been able produce yields of more than 315 kg of *Shatabdi* or 250 kg of *Prodip* per 0.08 ha, were able to earn more than this amount, see Fig. 5.

In total, these trained farmers produced 168.8 t of high quality, improved wheat seed which they marketed to more than 1,500 other farmers, who had previously been unable to access seed of the new wheat varieties. As before, the farmers reported that they had used their profits to settle debts, pay school fees and rent more land in order to increase seed production next season.

Conclusion

An improved strategy for technology dissemination in the Eastern Gangetic Plains

Many authors have acknowledged that the Green Revolution in South Asia has largely by-passed poor farmers (e.g. Lipton and Longhurst 1989; Jiggins 1986) and that the first strategic priority for halving the extreme poverty and hunger[12] that continues to afflict the Eastern Gangetic Plains

[12] First United Nations Millennium Development Goal.

Table 3 a–f: Comparative productivity of 545 wheat seed farming families, trained by DAE and five NGOs during the 2006–2007 wheat season in northwest Bangladesh

Socio-economic group	No. of families	Wheat yield/ 0.08 ha plot	Grain			Seed			Total income (grain+seed)	Input costs (Tk/0.08 ha plot)	Profit	
			Eaten (kg)	Sold (kg)	Income (Tk)	Sold (kg)	Price (Tk/kg)	Income (Tk)			(Taka)	(Euros)
a) Augnishika's farmers in Dinajpur district												
Landless	5	263	5	68	1,292	190	34.00	6,460	7,752	1,397	6,355	61.33
Marginal	31	290	5	61	1,105	224	34.00	7,629	8,734	1,489	7,246	69.93
Subsistence	4	323	8	100	1,891	215	34.00	7,310	9,201	1,585	7,616	73.50
Means		292	6	76	1,429	210	34.00	7,133	8,562	1,490	7,072	68.25
b) Solidarity's farmers in Kurigram district												
Landless	2	247	47	100	1,900	100	35.00	3,500	5,400	1,558	3,843	37.09
Marginal	45	305	9	168	3,190	129	37.28	4,836	8,026	1,561	6,466	62.40
Subsistence	11	340	7	189	3,584	144	39.09	5,736	9,320	1,578	7,743	74.72
Means		297	21	152	2,891	124	37.12	4,691	7,582	1,566	6,017	58.07
c) DAE'S farmers in Dinajpur, Punchagaor, Thakurgaon, Rangpur, Nilphamari and Lalmonirhat districts												
Landless	14	242	6	122	2,321	107	34.21	3,779	6,099	1,348	4,751	45.85
Marginal	102	233	5	93	1,762	135	34.61	4,704	6,466	1,343	5,123	49.44
Subsistence	48	235	5	74	1,412	155	35.27	5,498	6,911	1,343	5,568	53.73
Food surplus	6	247	10	53	1,013	183	33.00	6,050	7,063	1,332	5,732	55.32
Means		239	7	86	1,627	145	34.27	5,008	6,635	1,342	5,294	51.09
d) Protashha's farmers in Dinajpur district												
Marginal	10	222	9	110	2,081	104	46.00	4,870	6,951	1,297	5,654	54.56
Subsistence	8	190	8	106	2,007	77	42.50	3,338	5,344	1,210	4,134	39.90
Food surplus	2	235	15	150	2,850	70	50.00	3,500	6,350	1,351	4,999	48.24
Means		216	11	122	2,313	84	46.17	3,903	6,215	1,286	4,929	47.57
e) BRIFs farmers in Dinajpur, Nilphamari districts												
Landless	1	280	0	180	3,420	100	33.00	3,300	6,720	1,378	5,342	51.55
Marginal	161	235	6	135	2,556	95	34.49	3,260	5,816	1,344	4,471	43.15
Subsistence	15	237	6	136	2,590	95	33.00	3,124	5,714	1,352	4,362	42.10
Means		251	4	150	2,855	97	33.50	3,228	6,083	1,358	4,725	45.60
f) Dipshika's farmers in Dinajpur district												
Landless	10	182	3	69	1,307	110	36.30	4,056	5,363	1,322	4,042	39.01
Marginal	53	221	3	94	1,792	123	35.98	4,459	6,251	1,390	4,861	46.91
Subsistence	17	229	4	94	1,794	131	34.82	4,550	6,344	1,428	4,916	47.44
Means		211	3	86	1,631	121	35.70	4,355	5,986	1,380	4,606	44.45

Fig. 4 Roy family in front of their house and wheat seed store in Madhobpur village (the seed is stored in sealed double plastic bags, inside Hessian sacks)

should be to accelerate the uptake of various previously developed, beneficial technologies (Rice–Wheat Consortium 2006). Where aversion to risk is preventing farmers from adopting new technologies, it is necessary to eliminate this

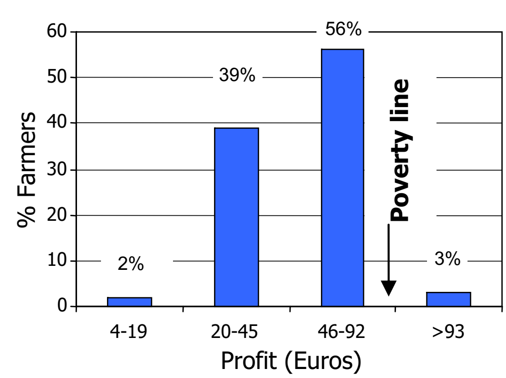

Fig. 5 Farmers' profit relative to poverty line

risk through training and/or an injection of financial capital. This work has shown that a bottom up approach can also accelerate the adoption of new technologies by very poor people and, at the same time, make a significant impact on their livelihoods. By developing a strategy for wheat seed production based on access to 0.08 ha plots, input costs were kept low and risk was minimised. This led to more than 50% of the families earning more than half of the income required to reach the local poverty line. Farming families that were trained in 2004 have since applied their knowledge on seed selection and storage to other crops such as rice and pulses, with some farmers investing the profits they had earned from wheat seed production in the hiring or purchase of more land and have established seed trading and other agro-service provision enterprises see Box 1.

Similar targeted dissemination strategies could be used to accelerate the uptake of many other valuable technologies in the South Asia rice–wheat farming system and alleviate poverty across the Eastern Gangetic Plain (Conroy and Sutherland 2004). These could involve the provision of training and small-scale loans to enable landless and marginal farmers to become service providers and thus benefit from machines such as threshers, irrigation pumps and power tillers. Such 'win–win' strategies, are characterised by improved access to new technologies for poor (food insecure, risk averse) farming families as well as for rich (food surplus) farming families, but with the rich farmers paying for the service rather than being the exclusive beneficiaries of a top-down technology transfer system.

The process of empowering poor farmers as seed traders was assisted by Bangladesh's progressive seed laws which uphold farmers' rights by allowing them to sell 'truthfully labelled' seed. This approach could be expanded to other crops, particularly other self pollinating crops, where seed production and marketing is relatively simple, e.g. various grain legumes/pulses and some vegetables, to gain more income while providing a useful product and service to other farmers.

In view of the rising world price of wheat during 2007 and 2008, and recent food riots in Bangladesh, there is an urgent need to scale this work up to reach thousands of marginal farming families who are keen to produce and market wheat seed: 10,000 marginal farming families could climb out of poverty by producing 1,200 t of seed of recently-released improved wheat varieties for sale. This large amount of seed could be used by food surplus farmers with more land to produce sufficient surplus grain to reduce Bangladesh's national wheat deficit by more than 1%, thus saving the nation up to €6 million per year in import costs.

Box 1.

In 2004, **Gopal Mahanta**, his wife, two children and elderly father were only able to produce 50% of their annual food requirement. Following whole family training the family harvested 317kg of *Shatabdi* from their 0.08ha plot and sold 269kg of the selected seed to neighbouring farmers. They used the Tk5,558 (€53) profit to buy medicines. This success was repeated the following year and this time they followed the wheat seed crop with mung bean and used their new skills to select and store high quality seed from this crop also. In 2006, the Mahanta family used part of their profit to lease 1.2ha and went on to produce a total of 4.8t of wheat seed (*Shatabdi, Prodip and Bijoy*) and 200kg of mung bean seed. The seed from these crops raised Tk134,000 (€1,284). This money was used to purchase essential household items and a new tin roof for their house, 23 plastic seed storage drums, a mobile phone, a bicycle, a wheat threshing machine and an irrigation pump set. They also increased local prosperity by paying for 400 days' labour. In 2007, the family leased 2.63ha and were expecting to produce 10.52t of wheat seed, worth Tk368,200 (€3,529). This family is now food secure and was recently invited to tell their story on local TV.

Md Ruhul Amin lives in Brahmanvita village with his wife and two young children. Before participating in the training in 2004 his household was only 63% food secure and Md Amin had to work as a labourer in order to buy additional rice. After the training, Md Amin and his wife produced 260kg of *Shatabdi* wheat seed and 70kg of grain, worth Tk6,780 (€65) from their 0.08ha plot. In 2005, the family increased the size of their plot and produced 520kg of *Prodip* seed, which earned them a further Tk20,000 (€192). The following season they gained Tk48,000 (€460) from1,200kg of wheat seed produced from 0.3ha. As well as paying for school fees and a new sari for his wife, Md Amin purchased a tin roof, a threshing machine, an irrigation pump, a hand tube well and 0.02ha of land. The family now earns approximately Tk10,000 (€96) per year by hiring out their threshing machine and irrigation pump and can also afford to hire labour. In 2007-2008, the family planted wheat on 0.3ha and were looking forward to processing 1,400kg of seed, valued at Tk48,200 (€462).

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